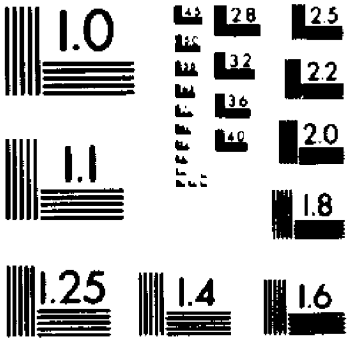


University Microfilms Inc.
300 N. Zeeb Road, Ann Arbor, MI 48106

INFORMATION TO USERS

This reproduction was made from a copy of a manuscript sent to us for publication and microfilming. While the most advanced technology has been used to photograph and reproduce this manuscript, the quality of the reproduction is heavily dependent upon the quality of the material submitted. Pages in any manuscript may have indistinct print. In all cases the best available copy has been filmed.

The following explanation of techniques is provided to help clarify notations which may appear on this reproduction.

1. Manuscripts may not always be complete. When it is not possible to obtain missing pages, a note appears to indicate this.
2. When copyrighted materials are removed from the manuscript, a note appears to indicate this.
3. Oversize materials (maps, drawings, and charts) are photographed by sectioning the original, beginning at the upper left hand corner and continuing from left to right in equal sections with small overlaps. Each oversize page is also filmed as one exposure and is available, for an additional charge, as a standard 35mm slide or in black and white paper format.*
4. Most photographs reproduce acceptably on positive microfilm or microfiche but lack clarity on xerographic copies made from the microfilm. For an additional charge, all photographs are available in black and white standard 35mm slide format.*

*For more information about black and white slides or enlarged paper reproductions, please contact the Dissertations Customer Services Department.

UMI University Microfilms International

Fried, Alan William

SCHEDULE-INDUCED BEHAVIOR IN THE CHINCHILLA

City University of New York PH.D. 1986

University
Microfilms
International 300 N. Zeeb Road, Ann Arbor, MI 48106

SCHEDULE-INDUCED BEHAVIOR IN THE CHINCHILLA

by

ALAN WILLIAM FRIED

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

1986

This manuscript has been read and accepted for the Graduate Faculty in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

Jan. 30, 1986 — Robert S Thompson

date — Chairman of the Examining Commitee

Jan. 30, 1986

date — Executive Officer

Sheila Chase

John Falk

Nancy Hemmes

Donald Mintz

Supervisory Commitee

The City University of New York

Abstract

Schedule-Induced Behavior in the Chinchilla

by

Alan William Fried

Advisor: Professor Robert L. Thompson

In experiment 1 the species generality of schedule-induced polydipsia was investigated by exposing two chinchillas (Chinchilla lanigera) to a series of fixed-interval schedules ranging from 15 to 180 seconds and exposing four other chinchillas and two Long Evans hooded rats to a series of fixed-time schedules ranging from 15 to 180 seconds for two chinchillas and 15 to 240 seconds for the other subjects. It was found that all subjects increased their water intake over apparatus baseline levels when exposed to the intermittent schedules, that the rats drank more than any chinchilla subject, and that the chinchillas exposed to the FI schedules drank more than the chinchillas exposed to the FT schedules, but, conclusions on the effects of a response requirement would be premature. An analysis of the temporal distribution of licking after food delivery showed that chinchillas tended to drink in the first 30 seconds post-food, but that licking occured at later times also. In experiment 2, four other food-deprived chinchillas were exposed to 100 sessions of FT 30 then 100 sessions of FI 30 in an environment that provided the opportunity to drink, run, sand-bathe, socialize, tunnel, gnaw, eat, and lever press. The proportion of time occupied by these responses in a session, the temporal distribution of responses within the interfood-interval, and the sequencing between response categories were measured. It was found that chinchillas exposed to FT and FI 30 schedules of food delivery developed reliable patterns of responding in the inter-food interval. These patterns varied from chinchilla to chinchilla and between schedule types. Drinking was found to be enhanced on both schedules. The sequential analysis of responding found that the FI schedule produced more switches among responses and that the sequencing of responses was determined by food delivery, while the sequences found during baseline were reflected response preference. The results of experiment 1 and 2 are discussed in terms of the current controversy over what constitutes a schedule-induced response.

Dedication

In memory of Louis Fried whose love of education is embodied in this work.

To Laurie Fried who was more helpful than she could ever know.

To Claire Fried, Edward Fried, and Philip Fried for providing an environment for my intellectual and emotional growth.

I am deeply grateful.

ACKNOWLEDGEMENTS

I would like to thank my committee members, Dr. Robert L. Thompson, Dr. Sheila Chase, Dr. John L. Falk, Dr. Nancy Hemmes, and Dr. Donald Mintz.

As my Advisor, Dr. Robert L. Thompson assumed leadership in my graduate training. He taught me how to phrase an experimental question and create the design to answer it, to be concerned with the least aspect of an experimental design, and how to view data from many perspectives. This knowledge is invaluable.

I thank Dr. Falk for teaching me not to believe everything I read.

I especially thank Drs. Chase, Hemmes, and Mintz for participating on a committee that did not involve a topic that directly concerned their own work or expertise. Their diverse backgrounds were critical in the understanding of the experimental findings.

I would like to thank Dr. George Gourevitch for conversations on design, equipment, and animal care. To my lab mates Suzanne Calhoun and Pat Kenny, who made day to day life in the lab fun. Special thanks are due to Stewart Riegler and Laurie Fried for technical assistance and companionship.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES, Continued

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS, Continued

LIST OF ILLUSTRATIONS, Continued

LIST OF ILLUSTRATIONS, Continued

LIST OF ILLUSTRATIONS, Continued

LIST OF ILLUSTRATIONS, Continued

Introduction

Terminology and definitions.

Adjunctive, interim, and schedule-induced are names that have been used for the characteristic patterns of behavior that occur when a primary reinforcer is delivered intermittently, but which are not necessary for obtaining the reinforcer. However, a definition of these terms that is both precise and widely accepted has yet to be arrived at (Roper, 1981; Staddon, 1977; Timberlake, 1982; Wetherington, 1982; Wetherington & Brownstein, 1982). Further, their relationship to the mediating or collateral behavior often reported in conjunction with temporal schedules (Laties, Weiss, & Weiss, 1969; Zuriff, 1969), to displacement activities (Falk, 1971; 1977), and to superstition (Skinner, 1948; Staddon & Simmelhag, 1971) has also to be assessed.

Falk (1971), described adjunctive behavior associated with intermittent food presentation as having seven properties: 1, the magnitude of adjunctive responding is an inverted U-shaped function of the interfood interval; 2, responding is an increasing function of the subject's food deprivation level; 3, the responding is excessive and persistent; 4, responding occurs shortly after pellet delivery (approximately within 10 seconds) and is therefore a post-reinforcer event ; 5, a response requirement for obtaining the scheduled reinforcer is not necessary; 6, the subject will perform an operant response to gain accsess to the adjunct; and 7, the magnitude and type of adjunct is dependent on environmental opportunity. For example, schedule-induced polydipsia (Falk, 1961) meets all seven adjunctive criteria. In fact, research on schedule-induced polydipsia by Falk and others provided the model case generating these criteria.

A reading of the literature on adjunctive behavior leaves the reader with the impression that the terms schedule-induced and adjunctive are synonomous. All schedule-induced responses have been called adjunctive although only schedule-induced polydipsia and schedule-induced aggression have been studied with respect to all seven adjunctive criteria. Staddon (1977) and Roper (1981) have attempted to separate the two terms by explicitly defining schedule-induction. Staddon defined induced (interim) activity as facilitated by an intermittent schedule of reinforcement when compared to a pre- and post-schedule baseline when no reinforcer is delivered. Roper defined schedule-induced behavior as above with the addition of a baseline that includes the reinforcer presented in mass at the start of the session. These two definitions make schedule-induced behavior a subclass of adjunctive behavior. Thus, a behavior need only be facilitated, meeting Falk's (1971) third criterion (persistence and excessiveness), to be considered schedule-induced.

Staddon and Simmelhag (1971), Staddon and Ayres (1975), and Staddon (1977) introduced the terms interim, facultative, and terminal to clasify the temporal distribution of behaviors on schedules of reinforcement. An interim activity is an induced activity (therefore facilitated) that occurs at times when the scheduled reinforcer is at a low probability of delivery. Other activities that occur when the scheduled reinforcer is at high probability are called terminal, and activities that do not appear to be under the control of schedule parameters are called facultative. Thus, terminal responses are not adjunctive because they are, at least, not post-reinforcer events. Facultative responses cannot be adjunctive in that they are not under the control of schedule parameters as are terminal or interim responses. Because they are facilitated and post-reinforcer events, interim responses are more nearly adjunctive than other induced activities.

There remains the question of collateral (Richardson & Loughead, 1974), concurrent (Skinner & Morse, 1957) and mediating behavior (Laties, Weiss, Clark, & Reynolds, 1965). Collateral behavior is defined by Catania (1968) as "behavior that appears in a consistent sequential relation to reinforced behavior while not itself instrumental in producing reinforcement." This is similar to the description of interim, facultative, and (some) terminal responses, although it lacks the requirement for facilitation of the responses. The word concurrent has been used least frequently of these terms and until it became identified with the schedule of the same name, was probably a synonym for collateral behavior. Mediating behavior appears to be a special case of collateral behavior in that it is not necessary for obtaining the scheduled reinforcer but makes the obtaining of that reinforcer more reliable by its occurrence. Mediating responses appear to occur on schedules where timing is of critical importance in obtaining a reinforcer such as differential reinforcement of low rates (DRL) (Zuriff, 1969).

It has been argued by Falk (1977) that displacement activities are the ethological equivalent of adjunctive behavior. Both appear to stabilize behavior in situations that are partially aversive, they appear exaggerated, and both are supply pools of behavior from which the organism can draw responses in conflict situations. However, there is some evidence that the prototype adjunct, schedule-induced polydipsia, does not depend on a disinhibition mechanism that is thought to underlie displacement activities (Roper & Posadas-Andrews, 1981).

In summary, the term adjunctive behavior subsumes the terms schedule-induced and interim. Collateral (concurrent) behavior includes all adjunctive, interim, and facultative behavior, and is therefore a more general term than adjunctive. Mediating behavior is a special case of collateral responding which appears to depend on the type of schedule in effect and stabilizes performance on that schedule.

SIP and its parameters.

In 1961, Falk, using food pellets as reinforcers and a variable-interval 60 second schedule (VI 60), reported that all of his rats (N=14) drank excessive amounts of water within sessions when a water bottle was available. During each session bouts of drinking occurred shortly after food delivery. Falk named this phenomena "schedule-induced polydipsia" (SIP). Falk differentiated SIP from prandial drinking in that his rats drank approximately 90 ml (*SD*=23.8 ml) in a three-hour session. His rats averaged 264 grams in body weight and showed an average ordinary daily water intake of approximately 26 ml (*SD*=7.3) in their home cages.

Since 1961, many experimental parameters have been investigated for effects on the development and maintenance of SIP. These have included deprivation (food & water), meal size and type, schedule type and interreinforcement interval, the solution available for drinking, drug effects, and species.

Deprivation

Food. The effect of hunger has been investigated by Falk (1969, 1971). While keeping a 19-hour deprivation regimen, Falk varied the body weight of rats from 70% to 100% of *ad lib* weight while subjects were on a FI 90 second schedule of food reinforcement.

He found no attenuation of SIP until animals reached 95% body weight. When he increased weights from 95% to 105% of *ad lib* weight, SIP decreased linearly to about 20% of its initial level, while operant response rate remained unchanged until 104% to 105% of normal weight.

Water. SIP has been viewed from a theoretical framework in which the variable of interest was thirst (Stein, 1964). Brush and Schaeffer (1974) found 12 to 22.33 hours water deprivation did not increase the asymptotic intake level or the number of sessions necessary to produce polydipsia. Preloading rats with water has been found to attenuate the acquisition of SIP (Chapman & Richardson, 1974) but does not affect SIP that has already been acquired (Falk, 1969). Recently, Roper and Posadas-Andrews (1981) found that rate of acquisition was unaffected by water deprivation, but contrary to Brush and Schaeffer (1974), found higher asymptotic levels of water intake with increasing deprivation. Drinking was found to be more affected by food deprivation than by manipulation of "thirst" variables. Roper and Posadas-Andrews concluded that SIP appears to be more under the influence of a causal factor pertaining to eating than those related to drinking.

Schedule type and intermittency.

Type. As previously mentioned, Falk (1961a, 1961b) discovered SIP on a VI 60 schedule of food reinforcement. Since then SIP has been found on fixed interval (FI) (Falk, 1966b; Stein, 1964); DRL (Segal & Hollaway, 1963); fixed ratio (FR) (Burks, 1970); variable ratio (VR) (Shumake, 1968); and second order schedules (Rosenblith, 1970). SIP has also been found on schedules that do not require an operant response such as, fixed time (FT) (Segal, Oden, & Deadwyler, 1965) and variable time (VT) (Everett & King, 1970). These two schedules produce SIP at the same levels as FI and VI schedules. A study by Millenson (cited in Staddon, 1977) found that schedule-induced polydipsia was absent from rats placed on a random interval schedule (RI) that keeps the probability of food constant but the length of the interval varies.

Intermittency. The effect of varying the intermittency of food on the above schedules produces profound effects on the magnitude of SIP. Falk (1966b) noted that SIP appeared to be an inverted U-shaped function of the interval value. The first bouts of drinking appear in interreinforcement intervals longer than 20 seconds (in rats), increases to a maximum in interval lengths of 90 to 120 seconds (Falk, 1966a; Flory, 1971), and decreases to zero at interval lengths of 480 seconds or more. This has been found on FT, VT, FI and VI schedules. Fixed and variable ratio schedules also support SIP. It has been found that increases in the ratio requirement increase drinking in much the same way as interval schedules do (Carlisle, 1971; Shumake, 1968).

Solutions.

Animals develop SIP when solutions other than water are proffered. Solutions that have been found to support SIP are: saline (Falk, 1964), alcohol (Falk, 1972; Lester, 1961; 1966), saccharin and quinine (Segal & Deadwyler, 1965).

Saline. Falk has found (1964; 1966a) that rats drank larger volumes of saline than water during SIP sessions, but, the concentration of saline was found to be an important factor. A concentration 0.3% saline was found to be optimal for SIP while solutions in excess of 0.9% reduced intake. Higher concentrations reduced the number of drinking bouts but not the length of the bouts (Falk, 1964). Bout lengths are the same for all concentrations and at low and medium concentrations there are no differences in number of bouts. Therefore, it appears that ingestion-rate increases accounted for the heightened intakes.

Alcohol. When an alcohol solution was substituted for water rats became polydipsic (Lester, 1961). As the concentration of ethanol in th drinking solution was increased, the volume of liquid consumed decreased in a dose-related fashion (Githens, Hawkins, & Schrot, 1973). This appears to be due to the pharmacological effects of the solution and not its taste. Gilbert (1973) found that SIP can be attenuated by interperitoneal doses of ethanol that do not effect lever pressing. Furthermore, Colotla and Keehn (1975) found that water and 5% alcohol were ingested in similar amounts during SIP sessions and that drinking occured in the same number of interpellet intervals for both solutions. However, the latency to drink, after pellet ingestion, was greater for ethanol than for water. When water was available bouts of drinking occured within the first 10 seconds post-pellet. When ethanol was available only 50% of the bouts occured with the above latency.

Saccharin. When saccharin was added to the available water source the volume of fluid ingested increased during SIP sessions (Segal & Deadwyler, 1965). Yet, this increase was found to be due to extra drinking bouts that occur at times other than the polydipsic bouts (Keehn, Colotla, & Beaton, 1970). Extra bouts occur rarely when water is available and have not been reported with any of the other solutions tested. Presatiation with a saccharin solution tended to remove these extra bouts but left polydipsic drinking intact (Keehn etal., 1970). With the reduction of extra bouts, saccharin was found to produce the same volume intakes as water. The non-polydipsia bouts of saccharin intake have been attributed to the high palatability of the solution (Keehn etal., 1970).

Quinine and Acetone. Even aversive fluids may be ingested during SIP. While on a DRL 30 schedule, rats drank similar amounts of two quinine solutions (0.008 and 0.016%) and water (Segal & Deadwyler, 1965). But Wayner and Greenberg (1973) reported that 0.008% quinine reduced fluid volume ingested by 40%, but animals were still polydipsic. Freed and Lester (1970) found decrements in SIP when acetone solutions were solely available and, given a choice, water was ingested in preference to 5.6% acetone (Freed, 1974).

Temperature of solution. Carlisle and Landenslager (1976) found that the temperature of the solution proffered also affects the level of SIP. Peak water intake occurred at 30° C with decrements in intake when the temperature was varied above or below (approximately 35% less at 5° C and 24% less at 40° C). As the temperature was increased above 30° C the number of drinking bouts decreased, as the temperature was decreased the amount of water per bout was decreased. They suggested the cooler temperatures were more satiating and therefore produced shorter bouts and that the very warm (>30° C) was ineffective in satiating the subject.

Food type and Meal size.

Food type: Dry. Table one summarizes the types of dry food pellets-and some liquid foods-that have been used in SIP studies (Christian, Schaeffer, & King, 1979). Generally, the higher the sugar content of a pellet the greater the attenuation of SIP. Although, sucrose contents of up to 32% were found to support SIP (Christian & Schaeffer, 1973). Decreasing the nutritive value of the food pellet also affects SIP. Freed, (1971) using non-nutritive sweetened pellets (approximately 50% of a standard 45 mg Noyes pellet) found that SIP was reduced by 24%. Sugar appears to be an important factor in the production of SIP, but whether this is due to postingestinal factors or taste is still unknown (cf. Freed etal., 1977).

Food type: Liquid. Early studies using liquid reinforcers failed to produce SIP (see Table 1). Falk (1967) and Hawkins, Schrot, Githens, and Everett (1977) had success with a standard liquid monkey diet fed to rats (Nutritional Biochemicals). Falk (1967) found 22 mg of the above diet engendered the same amount of SIP as 45 mg Noyes pellets. Hawkins et al., (1972) used 90 mg portions and found substantial SIP although, the SIP developed more slowly and reached a lower asymptote than that attained with 45 mg Noyes pellets.

There are two possible reasons for the decrements found with the liquid reinforcers. One is the sugar content of the foods used and two is the fact that some liquid is supplied by the reinforcer. A 90 mg preparation of the monkey diet would contain 30 mg of water. This could account for only 10% of a sessions decrement. However, the monkey diet also contains 51% sucrose dry weight (31% wet weight). Christian and Schaeffer (1973) found that food pellets containing 32% sucrose attenuates SIP by approximately 32%. These two percentages totaled are very close to the mean decrement found by Hawkins et al., (1972).

The question of why other liquid reinforcers do not support SIP has no satisfactory answer. Falk (1969) suggested that the reinforcers were poor diets and that their poor nutritional properties produced motivational difficulties. Yet, the liquid reinforcers that do not support SIP also do not support prandial drinking. Falk (1967) found when rats (deprived to 80% of free feeding weight) were given various diets while water was available freely, their wate intake decreased in the order: Noyes pellets, dextrose pellets sucrose pellets, liquid monkey diet, metrecal, 30% sucrose solution. Falk (1971) suggested that SIP involves an increase in the rate of behavior that occurs at some baseline rate already in the situation and that it is not necessary for the reinforcer to elicit drinking for SIP to develop.

Meal size. It was found that when meal size was decreased there was a decrease in SIP (Bond, 1973; Falk, 1967; Flory, 1971). This decrease may be due to the increased sugar available in larger meals or to procedural variables. The studies that increased meal size also decreased the number of interpellet intervals (IPI's) in a session (Flory, 1971) or increased IPI length (Bond, 1973). Thus, nutritional value and opportunity were confounded.

Species generality.

One parameter to receive limited attention prior to 1975 was the generality of SIP to species other than the rat. Table 2 shows subjects tested for SIP. From 1966 to 1975 a variety of rat strains (both male and female) were tested and found to demonstrate SIP. In fact, a survey of 75 SIP studies reported prior to 1974 found 55 used male albino rats while the others used females (Christian, 1974). Other species tested have included rhesus monkeys (Mello & Mendelson, 1971), mice (Palfai, Kutscher, & Symons, 1971), pigeons (Shanab & Petersen, 1969) and human schizophrenics (Kachanoff, Leveille, Mclelland, & Wayner, 1973).

Since 1975 the number of species presented with the generating conditions for SIP has expanded. Other rodent species have been the most popular. Mongolian gerbils (Prter & Bryant, 1978), guinea pigs (Porter, Soyzer, & Moeschl, 1977), degus (Fischer & Porter, 1979), golden hamsters (Wilson & Spencer, 1975), wild-caught norway rats (Hoppman & Allen, 1979) and cotton rats (Porter, Hastings, & Pagels, 1980) have been tested. No other bird species, but more primates have been investigated. Barret, Stanely and Weinberg (1977) tested squirrel monkeys and Wallace, Singer, Wayner, and Cook (1975) tested college students.

Of the species tested not all demonstrate SIP under conditions that produce it in the rat. Shanab and Petersen's (1969) results from a white carneaux pigeon was found to be unrepeatable by Miller and Gollub (1974); and Wilson and Spencer (1975) were the first to report on a rodent species (golden hamsters) that did not develop SIP under standard conditions. Another failure was the degu, a South American arid lands rodent (Fischer & Porter, 1979). The failure to find SIP in these latter two species might support a hypothesis that SIP is a product of the regulatory properties of the drinking patterns of the animals tested. The above two species are desert or semi-arid living rodents. However, the mongolian gerbil (Porter, & Bryant, 1978) and the chinchilla (Fried & Thompson,

1982) both show SIP and are arid or semi-arid lands animals, respectively. The failure to find SIP can be traced to the procedures. Shanab and Petersen (1969) used only one pigeon as a subject, Fischer & Porter (1979) used only one generating schedule, and Wilson and Spencer (1975) never obtained appropriate baselines.

Although these difficulties in generating SIP may be procedural, the SIP that is produced in species other than the rat may be different in that variables affecting the development, maintenance, magnitude, and patterning of the phenomenon may have differing effects on different species. For example, the rat drinks maximally at interpellet intervals of 90 to 120 seconds while the mongolian gerbil doesn't develop polydipsia until exposed to a FT 180 schedule. Porter, Sozer and Moeschl (1977) found SIP in two of three guinea pigs on FT 60, and this drinking was directly post-pellet, but their subjects drank in only 65% of the intervals while rats have been found to drink in approximately 90%. Therefore, species may not be easily divided by ecological niche or regulatory drinking patterns. The differences between species are more subtle, being expressed as differences in pattern, magnitude, or optimum schedule length.

Other schedule-induced responses.

During the two decades after the discovery of SIP, attention began to be directed toward other unprogrammed behavior that may be induced by intermittent schedules of appetitive or aversive reinforcers.

Other than SIP, schedule-induced aggression has recieved the most attention by investigators. Azrin, Hutchinson, and Hake (1966) reported that pigeons exhibited post- reinforcement attacks on a restrained target pigeon when periods of extinction alternate with periods of continuous reinforcement (CRF). During CRF no attacks occured, after the last reinforcer on CRF a bout of pecking would be directed at some part of the apparatus if no target was present, as soon as a target pigeon was introduced the pecking became directed toward the target. Knutson and Kleinknecht (1970) found that attacks would occur throughout the interreinforcer interval on DRL schedules. Flory (1969) found an inverted U-shaped function relating number of attacks to the size of the interreinforcer interval on FT 15-960 schedules. Attacks reached a maximum at FT 60 for one pigeon and 120 for the other. Cohen and Looney (1973) extended Flory's findings to FR schedules. They also found maxima between 60 and 120 seconds using pigeons. The target in their study was a mirror. Squirrel monkeys also demonstrate schedule-induced aggression. As measured by biting on a rubber hose (Hutchinson, Azrin, & Hunt, 1968).

Although, pigeons and monkeys demonstrate schedule-induced aggression, there is little evidence of it in rats. Hymowitz (1971) placed rats on a FR schedule that would produce SIP, but instead of a water bottle another rat was placed in the chamber. The rats never engaged in fighting.

Wheel running. Skinner and Morse (1958) placed rats on a FI 5 minute schedule of food reinforcement with a running wheel concurrently available. They found that rats ate the obtained pellet, waited, ran, and then started their lever pressing. They called this concurrent behavior and this was probably the first citing of an induced behavior. To investigate the relationship between wheel running and SIP, Levitsky and Collier (1968) placed rats on a VI 60 schedule with either a water bottle, running wheel, or both. When water was available, SIP developed. When the wheel was available running would occur throughout the IPI. The pattern that developed when both were present simultaneously was licking first, then running, then bar-pressing and eating. Both responses were reduced when subjects were placed on CRF or extinction. Segal (1969) also found the eat-drink-run-eat pattern when rats were on FI 90. She also noted that the pattern could be reversed with deprivation of running, but only for a few sessions. Running seems to occur between the two major classes of behavior, drinking and eating.

Pica, eating, airlicking, and licking of cold metal.

Pica. The schedule-induced eating of non-food items was fortuitously observed by Freed and Hymowitz (1969). Rats on FI 60 were found to stop their SIP. On close inspection, they found that the rats had managed to reach the bedding in the excreta tray and spent their time shredding, eating, and/or manipulating it. When the bedding was removed, SIP reappeared.

Eating. Investigations into the reversal of the eat-drink pattern of SIP have met with inconsistencies. Carlisle, Shanab, and Simpson (1972) found that pigeons did not develop schedule-induced eating when water deprived and on schedules producing SIP in the rat. On the other hand, Wetherington and Brownstein (1979) found similarities between schedule-induced eating and SIP when water deprived rats were placed on SIP producing schedules with food freely available and water programmed. Eating was a post-drinking event and decreased in probability with relative time in the interwater interval, and Bellingham, Wayner, and Barone (1979) found schedule-induced eating in water deprived rats but the placement of the food source must be proximal to the water source.

Airlicking. Rats also demonstrate schedule-induced airlicking. To investigate the possibility that oral-lingual moistening was a reinforcing factor in SIP, Mendelson and Chillag (1968) replaced water bottles with a stream of air through a standard water bottle tube. The stream of air would evaporate oral liquids. They found robust air licking which occasionally competed with the programmed food reward (Mendelson & Chillag, 1970). Apparently, thirst is not necessary for the development of SIP.

Cold metal palpation. Guinea pigs have been found to orally palpate a cold metal rod while rats and hamsters are less consistent (Mendelson & Plotsky, 1974). Mendelson (1977) reported several studies of schedule-induced cold metal licking in guinea pigs. Using schedules that produce SIP in rats he found no SIP, but when the bottle was replaced with a cold metal rod he found robust licking.

Schedule-induced escape.

At the time Falk discovered SIP, Azrin (1961) reported that pigeons would initiate time outs during FR pauses, depending on the ratio size. Azrin described these time out episodes as escape behavior. Other investigators have not necessarily found this dependency on ratio size, but report that the stimulus change in the environment controls the frequency and duration of time outs (Appel, 1963; Zimmerman & Ferster, 1964). Brown and Flory (1972) exposed pigeons to FIs ranging from 30 to 960 seconds. They found escape to be a post-reinforcer event and that the rate and percent session time spent in escape depended on FI length, larger intervals producing more escape responses.

Schedule-induced escape has also been found in humans and rats. Miller (1968) presented hospitalized humans (psychiatric) with a VI 60 or various FR schedules of food reinforcement. He found escape also to be a post-reinforcer event and to increare with increasing FR requirement. Thompson (1964) placed rats on various FR schedules and found the same results as Azrin (1961) and Miller (1968).

Hypotheses concerning SIP.

Various attempts have been made to understand the nature of SIP. These have concentrated on two areas; physiological and behavioral. The physiological accounts have been found lacking. Examples of such accounts include the hypothalamic cooling hypothesis (Carlisle and Laudenslager, 1976), Stein's (1964) thirst hypothesis, and Freed, Zec, and Mendelson's (1977) insulin hypothesis. The failure of physiological accounts of SIP has prompted the search for a behavioral explanation. The earliest behavioral explanation was the adventitious or superstitious conditioning of drinking (Clark, 1962) or that the response had a mediating function (Segal & Deadwyler, 1964). Currently, the theoretical thrust of investigators has concentrated on aspects of post-reinforcement time (e.g., Lashley & Rosselini, 1980; Staddon & Simmelhag, 1971; Staddon & Ayres, 1975); arousal (Killeen, 1975; Killeen, Hanson, & Osborne, 1978); and the similarities between SIP and displacement activities (Falk, 1971; 1977; Wuttke & Innis, 1972). Both the physiological and behavioral accounts of SIP are briefly described below.

Thirst. Stein (1964) found evidence that SIP was a response to the dry food reinforcer. He suggested SIP resulted from relieving the dry mouth produced by eating the food pellets. King and Schaeffer (1973) reported that when subjects were given the same number of pellets that they obtained during a SIP session, on a free food baseline of the same session length, rats would drink 1/12 th the amount of water. Therefore, if each bout of drinking was solely determined by the dry mouth qualities of eating dry food pellets, then animals in the free food condition should have ingested the same amount of water as subjects on the schedule. Stricker and Adair (1966) found that SIP subjects continue to drink long after body tissue needs are met, and, as previously mentioned, some liquid reinforcers support SIP. These three lines of evidence argue against the thirst explanation.

Hypothalamic cooling. Carlisle (1971) suggested SIP may be caused by increases in hypothalamic temperature found in the rostral hypothalamus during intermittent reinforcement. He found that lever pressing was correlated with higher hypothalamic temperatures (39.6° c) while drinking and pauses were associated with decreases. In 1973, Carlisle found that cooling the preoptic hypothalamus attenuated the development of SIP and the asymptotic level of drinking but the effects on the asymptotic level were but one-third of the developmental effect.

Carlisle (1973) and Carlisle and Laudenslager (1976) have also found that SIP covaries with ambient temperature and the temperature of the solution proffered, but that the temperature of the solution was the important factor. The above findings relate to different aspects of drinking. Hypothalamic cooling affects both the frequency and duration of drinking bouts while water temperature affects the amount of water imbibed per bout. Carlisle and Laudenslager (1976) concluded that these two effects are mediated by different temperature receptors: peripheral receptors controlling amount of water ingested, cental receptors controlling frequency and duration of bouts. Unfortunately, heating the hypothalamus is not necessary for the development of SIP (Freed, Zec & Mendelson, 1977), but this hypothesis does suggest a variety of experiments to investigate neural factors.

Insulin. Freed, Zec, and Mendelson (1977) suggested that an excessive increase in insulin release may underlie SIP specifically, and other induced behavior in general. Insulin secretion is conditionable to external cues associated with food (Deutsch, 1974; Goldfine, Abraira, Gruenwald, & Goldstein, 1970; Penick, Prince, & Hinkle, 1966). Therefore, the spaced feeding schedules that support SIP come to produce insulin secretion in response to each pellet and this release is excessive in relation to the amount needed to cope with the ingested food, thus producing hypoglycemia. It is this hypothesized hypoglycemia that produces SIP. The insulin hypothesis suggests a reason for the attenuation of SIP found by Falk (1967) with sucrose pellets. Larger concentrations of sugar offset the hypoglycemia produced by the intermittent schedules. This hypothesis also suggests how hypoglycemia could account for the gradual development of SIP and its appearance on second order schedules. SIP generally takes aproximately three sessions to develop (given appropriate generating conditions). During these three sessions, insulin secretion is conditioned by the intermittent food deliveries. In the case of second-order schedules (Rosenblith, 1970), SIP occurs right after the stimulus that predicts food, is consistent with the hypothesis that while the normal prandial effects of the food pellet are missing, the neutral stimulus should still produce conditioned insulin release while suppling no food to aleviate the consequences of this release. Two arguments against the generality of the insulin hypothesis come from Berrios, Carlson, Sawchenko, Gold, and Mui (1979) and Hudson and Singer (1978). Berrios, etal. found no mediation of SIP when they manipulated insulin levels in rats and Hudson and Singer found some SIP when using visual displays as the scheduled reinforcer for monkeys. These two findings show that the production of SIP is not a function of insulin release, in that, SIP is not enhanced by insulin administration nor should insulin be necessairily be released in response to visual-displays.

Superstition. The first behavioral explanation of SIP was that it developed due to accidental pairing with the food pellet and was thereby reinforced (Segal, Oden, & Deadwyler, 1965; Clark, 1962). Drinking would then become first in a chain of superstitiously reinforced responses. As other responses were added to the chain (superstitiously) drinking would eventually become a post-pellet phenomena. No evidence has been reported to date showing the movement of drinking from pre- to a post-pellet position. SIP subjects always drink early in the interval from the beginning of SIP and this drinking has been shown to occasionally interfere with the obtaining of food pellets (Wallace & Singer, 1977). Falk (1961b, 1964) used a 15 second delay contingency between the last lick at the presentation of the reinforcer, SIP was still obtained.

Ethological. An ethological explanation of SIP has been proposed by Falk (1972), Denny and Ratner (1970), and Wuttke and Innis (1972). These researchers have been struck by the similarity between displacement activities and conditions surrounding the production of SIP. Displacement activities occur when the consummatory act appropriate to a particular motivated state is thwarted by the absence of the proper releasing stimulus. The thwarting activates some secondary response either by increasing the responses action-specific energy or by lowering its activation threshold. This secondary response is called a displacement activity if it does not make the original consummatory act possible. The secondary response that occurs depends on internal factors such as the relative action-specific energies of other responses and external stimulus factors such as the presence of releasing stimuli. Thus, animals in the SIP paradigm are food-deprived, producing increased motivation for the consummatory act of eating. Intermittent food schedules and small meal (pellet) sizes block this consummatory response. Animals that are food deprived are also _de facto_ water deprived and with a water bottle in the environment, SIP developes. This explanation applies to other induced responses as well. If the water bottle is removed and replaced with some other environmental stimulus such as paper, schedule-induced pica would develop.

Mediation. SIP has been found to increase the number of reinforcers obtained on DRL schedules and can therefore be considered a mediating behavior. The fact that a response of one kind may enhance performance of another kind of response does not mean that it functions as such under all conditions. Falk (1969) reported that SIP has motivating qualities of its own and sustained an FR 50. He concluded that SIP was not just a mediating response.

Motivational hypotheses. Some researchers have suggested that SIP is produced by the aversive qualities of intermittent schedules of positive reinforcement (Azrin, 1961). Brown and Flory (1972) reported that pigeons responded to change the stimulus conditions during FI's ranging fron 30 to 960 seconds. Azrin (1961) found that pigeons would also initiate time-outs during FR pauses, depending on the ratio size, and Terrace (1966) reported that pigeons engage in "emotional" behavior such as wing flapping during extinction components of multiple schedules. But, Innis and Honig (1979) found that when pigeons were given the opportunity to terminate sections of fixed intervals, responding often occurred late in the interreinforcer interval. They suggested induced responding may not be a consequence of the aversive qualities of extinction because pigeons did not terminate S-delta early in the interval but did so later when, according to Staddon, facultative responding would occur.

Arousal. The arousal hypothesis (Killeen, 1975; Killeen, Hanson, & Osborne, 1978) differs from other timing or temporal control hypotheses in that it focuses on the rate of response induced by pellet delivery and not on the discriminative properties of post-pellet time. The hypothesis agrees with Staddon and Simmelhag (1971) and Falk (1972) that the source of adjunctive responses is from the naturally ocurring response repertoire of the organism. Killeen (1975) and Killeen et al. (1978) found that pigeons placed on intermittent schedules of food reinforcement increase their rate of pacing as a function of the interfood interval (IFI). As IFI decreases, pacing increases and the placement of pacing within any interval appears to be a constant proportion of the time elapsed within the interval. Others have also shown this proportional timing of schedule-induced responding (Cohen & Campagnoni, 1981; Campagnoni & Cohen, 1983). In their studies approximately 30-35% of the interval elapses before the rate of pacing peaks. Killeen suggested, that on intermittent schedules each reinforcement produces a level of arousal, and if the reinforcers are spaced close enough together in time, this arousal can accumulate producing the excessive adjuncts sometimes seen on intermittent schedules. This hypothesis suggests an explanation for the decline in the excessiveness of adjuncts seen at long interreinforcer intervals. The intervals are too long for arousal to accumulate and therefore, adjuncts are no longer excessive, and may be totally absent.

Other temporal control hypotheses. Currently, investigators have focused on the discriminative properties of the time after pellet delivery. Staddon and coworkers (see Staddon, 1977, for review) have found that periodic reinforcement schedules produces two different behavioral patterns within the interreinforcer interval. These have been named "terminal" or reinforcer-oriented responses, which occur prior to reinforcer delivery, and "interim", which occur post-reinforcer and seem to depend on the subjects species and the availability of some object in the environment. These two response classes are hypothesized to have two separate but competing underlying states (Staddon, 1977; 1978) and the state that is active at any time depends on the subjects expectancy of reinforcement. If sufficient time has elapsed since the last reinforcer, subjects found to engage in terminal responding (Anderson & Shettleworth, 1977; Staddon & Simmelhag; 1971), if the reinforcer was recently delivered subjects engage in interim responding (Staddon & Ayres, 1975). Therefore, a stereotyped pattern of behavior developes because the time since the last reinforcer acts as a cue for the next food delivery (Minor & Coulter, 1982). As previously mentioned, Staddon's view does not focus on the excessiveness of the interim response but on its temporal location in relation to reinforcing events.

Lashley and Rosellini (1980) have offered a Pavlovian conditioning account of SIP. The delivery of the reinforcer signals a period during which the probability of reinforcement is small, i.e., it produces a predictive contingency between the post-reinforcer period and the zero or low probability. Thus, the post-reinforcer period becomes an inhibitory conditioned stimulus (CS-), inhibiting reinforcer-related responses and produceing time for other responses to occur. A problem with this hypothesis is that rats drink similar amounts of water on VI, FT, and random time (RT) schedules (Shurtleff, Delamater, & Riley, 1983). According to Lashely and Rossellini, SIP should not be found on RT schedules which have no predictive contingency between probability of reinforcement and absolute post-reinforcer time.

These hypotheses were either particular to SIP (e.g., thirst) or induced behavior in general (e.g., displacement activities). They have focused on the excessiveness of the response or the temporal location of the response. As previously mentioned, there is a current dialogue in the literature as to which aspects of induced-behavior are the most fundamental. The next section describes some studies that have presented subjects with more than one environmental opportunity to respond. These studies allow for assesment of qualitative and quantitative interactions among adjuncts.

Choice studies.

A few researchers have investigated the types of schedule-induced behavior a particular species may engage in. Fewer still, have investigated the interactions between simultaneously presented adjunctive opportunities. In 1971, Staddon and Simmelhag studied the types of behavior pigeons engaged in while on a FT schedule. In this classic study there were no special items, such as a water bottle, explicitly available that were expected to induce adjunctive activities. They found that the pigeons pecked the walls of the chamber, paced back and forth, etc. Others have also studied pigeons (Reberg, Innis, Mann, & Eizenga, 1978) and hamsters (Anderson & Shettleworth, 1976) under similar circumstances and found their subjects also engaged in various responses that appeared to be under the temporal control of the schedule and which also depended on the type of reinforcer scheduled.

Other researchers have investigated the types of schedule-induced responses that appear on schedules when more than one environmental opportunity was specifically made available. Freed and Hymowitz (1969) reported that five polydipsic rats had stopped lever-pressing on an FI60 schedule. They found that each of the rats had managed to reach the cellulose drop pan lining material and were busy shredding it. When the litter was removed the characteristic pattern of polydipsia returned. When a water bottle and running wheel were made concurrently available on a FI 90 food schedule, Segal (1969) found that rats would drink shortly after obtaining a pellet, then run in the wheel for varying durations, then leave the wheel and start lever pressing for food. Pigeons have also been presented with concurrent opportunities to attack and drink (Yoburn & Cohen, 1979). Pigeons spend more time attacking targets than drinking on schedules that normaly produce schedule-induced aggression, in fact drinking was suppressed by these schedules. These studies raise the question of what determines the type of adjunct a species will engage in, and how these activities interact. In the case of Freed and Hymowitz (1969) we find competition between the two responses while Yoburn and Cohen (1979) found an intermediate amount and Segal (1969) found little or no competition. (Competition was assumed if the removal of one of two concurrently available response opportunities increased the frequency or magnitude of the other available response.)

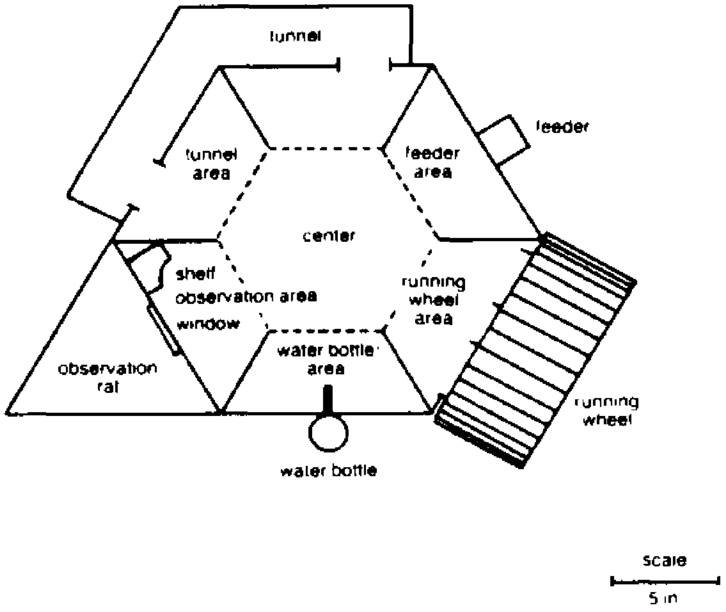
Some responses may be more substitutable than others. Roper (1978) suggested that if two responses don't overlap temporally in an interpellet interval when studied on separate schedules, there should be little competition or substitutability between them when they are available concurrently. Unfortunately, very few studies have any information on the temporal properties of the activities available.

In 1975, Staddon and Ayres attempted to gain quantitative information on the selection, type, and sequencing of responses. They used a FT 30 schedule of food reinforcement and presented rats with five environmental opportunities: food, water, a running wheel, a tunnel, and a caged conspecific (see Figure 1). Briefly, they found a regular temporal sequence of activities in the interpellet interval: drinking, running, and food anticipation, in that order. They found that these activities were not described by a Markov chain, but by some other stochastic process. They concluded that post-food time was one of two important factors determining the onset or ending of each activity. The other factor, called "momentum," described how an activity would persist for a "preferred" duration related to the interpellet interval length.

Roper (1978) has also investigated the diversity of schedule-induced responding by presenting rats with a water bottle, wood block, and running wheel all attached to a standard operant chamber. He expanded Staddon and Ayre's (1975) procedure by using three response-dependent schedules of food reinforcement:

Figure Caption

Figure 1. Plan view of the apparatus of Staddon and Ayres (1975).


tunnel
tunnel area
feeder
feeder area
center
shelf
observation area
window
running wheel area
observation rat
water bottle area
running wheel
water bottle
scale
5 in

FR1, FI 30, and FI 60. When water was available alone on FI 60, the water intake increased for all subjects above that found when water, running, and wood were presented concurrently. Generally, it has been found that running occurs later in the interval than drinking (Levitsky & Collier, 1968). It should, therefore, not interfere with drinking, but as IPI increases so does the bout length of drinking and this could bring drinking into the temporal domain of running. Roper suggested that the diminished SIP was due to this temporal competition. In FI schedules, the dominant induced response (most frequent) depended on schedule length. Competition between responses occured only if the responses occured at similar times within the interfood interval. Responses that don't occur at similar times cannot substitute for each other.

The two previous studies have used food reinforcers on either response-independent or response-dependent schedules. Dunham (1971; 1972; 1977; 1978) and Dunham and Grantmyre (1982) investigated what they called "multiple response baseline" procedures using response contingent shock. Two rules were formulated. The "punishment rule" states that response-contingent shock supresses the shocked response. Second, and more to the present topic, is the "implicit avoidance rule" that encompasses the generalization that the shock increases the most probable of the unpunished responses while other alternatives maintain their baseline levels (Dunham, 1977).

Dunham (1978) later found that an unpunished response (digging) declined when eating was punished, seemingly inconsistent with the rules. Dunham and Grantmyre (1982) suspected that some sequential dependencies developed during baseline sessions, and hypothesized that two sequentially dependent responses would be affected in the same direction by punishment. Using gerbils, with the opportunity to eat, groom, dig, and run, they found that the most probable unpunished response increased (implicit avoidance rule) but also that the response that most closely followed the punished response was also suppressed.

There are two reasons for introducing Dunham's work: the implicit avoidance rule looks behaviorally like schedule-induced responding found in food-deprived animals on food schedules, and secondly, for its emphasis on the sequential dependencies between responses that Staddon and Ayres (1975) were concerned with.

The present study.

The work that follows is in two parts. The first, Experiment 1, attempts a systematic replication and extension of the general relationships between interfood intervals and schedule-induced drinking using chinchillas as subjects. The second, Experiment 2, replicates systematically the work of Staddon and Ayres (1975) on the distribution of activities in fixed time and fixed interval schedules of food delivery. Chinchillas again serve as subjects.

Experiment 1

SIP is a well documented laboratory phenomenon, but the extent to which it applies to species other than the rat and its integration with behavior theory is far from established. SIP has not been detected reliably in hamsters or degus and is inconsistently observed in several other species (Fischer & Porter, 1979; Miller & Gollub, 1974; Wilson & Spencer, 1975). Hamsters and degus both occupy seasonally semi-arid biotopes. The chinchilla lives in a semi-arid environment and derives most of its water by eating plants rather than drinking directly (Mohlis, 1978).

The purpose of Experiment 1 was to determine whether food deprived chinchillas presented with schedules of food reinforcement that reliably produce SIP in rats would develop SIP. The magnitude of fluid intake and the temporal distribution of licking were analyzed.

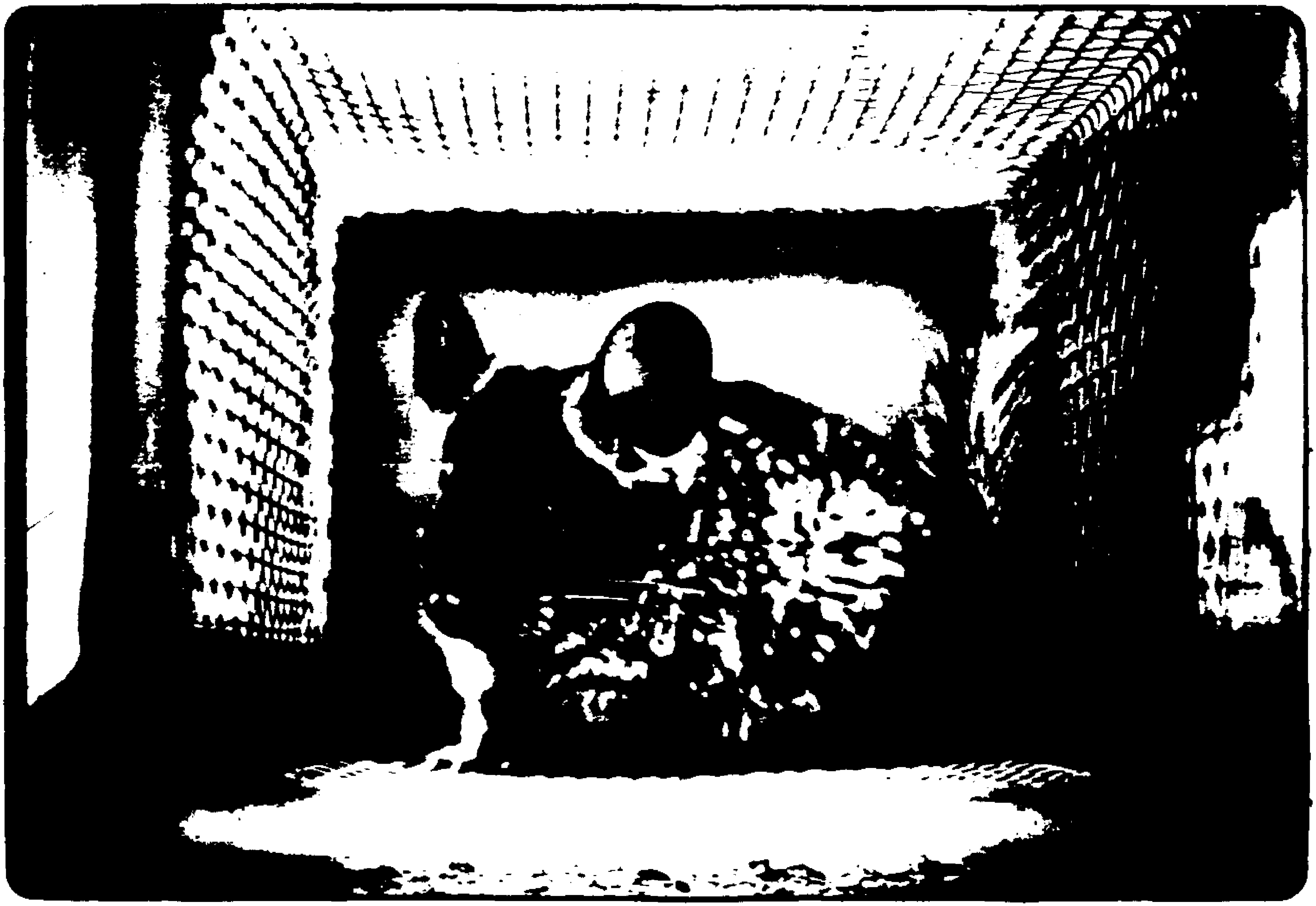
There are two criteria traditionally used for determining the presence of SIP. The first requires that the subject's intrasession water intake exceed a home cage, 24-hour, baseline of water intake measured while the animal was at its experimental body weight. The second requires that the subject's experimental intake exceed a baseline obtained in the apparatus. This baseline is determined under conditions in which the number of food pellets normally obtained during an experimental session is placed in the feeder prior to the session or delivered on a FR 1 schedule. This baseline controls for session length provided that only one schedule value is used in the experiment proper.

Method

Subjects. Six male, three-year old *Chinchilla lanigera* (see Figure 2 and Appendix D) and two male, 160-day old Long Evans hooded rats (*Rattus norvegicus*) were food deprived to 80% of free feeding weight. The experimental weights were 380, 345, 429, 461, 392, and 384 grams for chinchillas G1, G2, G3, W3, C1, and C2, respectively, and 344 and 322 grams for rats R1 and R2. Water was available freely. The chinchillas were obtained from Kline Chinchilla Research Foundation, Utica, IL, and the rats were obtained from Blue Spruce Farms, Altamont, NY. The chinchillas were housed individually in home cages with dimensions: 22 cm wide, 17 cm high, 37 cm long with a small white pine gnawing block and a salt ring continuously available. The chinchillas home cage food was Purina ChinChow. The rats were also housed individually in home cages with dimensions: 20 cm wide, 22 cm high, and 25 cm long. The animals were maintained on a 12-hour light-dark cycle and run during the daylight hours. Room temperature ranged from 21 to 27 °C. Humidity was not controlled

Figure Caption

Figure 2. Photograph of an adult male *Chinchilla lanigera*.



other than by a window air conditioner.

Apparatus. The operant chambers were standard, double lever, Grason Stadler rat stations (Model E3125-100) placed in Grason Stadler sound-attenuating animal chests (Model E3125AA-3). Two levers were available in all chambers regardless of schedule requirements, but only one lever was functional. Each lever could be displaced by a weight of 23 g (0.22N). The food pellets were P. J. Noyes Co. 45 mg standard lab pellets. Mounted on the door of each chamber was a calibrated water bottle with a glass spout projecting 1.5 cm into the chamber at a height of 2 cm from the floor and 12 cm from both sides of the door. Contact with the water at the tip of the spout activated a Grason Stadler drinkometer circuit (Model E4690A) which activated Sodeco printout counters. Lever-pressing was recorded for both FI and FT subjects on standard Sodeco counters. The equipment was isolated in a cubicle into which was broadcast a 60 dB SPL white masking noise (General Radio Sound Level Meter, Model 1551-b; scales B & C). The recording and scheduling equipment was isolated in another cubicle.

Procedure. In each phase of the research, water intake was measured until a stability criterion was met. The stability criterion required that the difference between the mean of the first three and the second three of six consecutive sessions differ by no more than 10% from the mean for all six. This criterion was a modification of one suggested by Cumming and Schoenfeld (1960). First, a 24-hour home cage water intake was established with the animals at 80% of free-feeding weight. Next, for the four chinchillas; G1, G2, G3, and W3, a baseline of water intake in the apparatus was obtained in conjunction with the availability of 100 45 mg Noyes pellets placed in the food tray before the animal was put into the chamber for 100 minutes. For four of the animals in the present study a modification of the in-apparatus baseline was used. The usual in-apparatus baseline is water intake following mass presentation of all the pellets ordinarily distributed throughout the experimental session. The baseline is determined over a period of time equal to the typical session length. This procedure was used for chinchillas G1, G2, G3, and W3. However, since in the present experiment interpellet intervals from 15s to 240s were employed, the session length in which 100 pellets are delivered (or earned) per session, ranged from 1500s (25 min) to 24000s (6.67h). Accordingly, in-apparatus baselines were measured to stability in successive 6.67h sessions. Water intake was read from a calibrated tube at intervals of 1500s, 3000s, 6000s, 12000s and 24000s.

This procedure was used for animals C1, C2, R1, and R2, and will be referred to as the cumulative apparatus baseline.

Following these two baseline determinations, two chinchillas (G3 and W3) were conditioned on FI 15 and two (G1 and G2) on FT 15. When the stability criterion was satisfied the schedule size was increased by another 15s (i.e., to FT 30 or FI 30). They were continued in this manner at 15s increments of their respective schedules through 180s for the FT subjects and one FI subject. The second FI subject progressed to FI 150s. During subsequent sessions lever-pressing was unstable. Water intake was measured to the nearest ml by weighing the water bottles before and after each session. Spillage was found to be negligible.

The two other chinchillas, (C1, C2) and the two rats, (R1, R2) were also started on FT 15 but when the stability criterion for water intake was satisfied the interval length was successively doubled and the stability criterion again established until FT 240 was attained for all four subjects. Water intakes for these animals was measured from calibrated drinking tubes and compared to the cumulative in-apparatus baseline described above. The rats served to test the SIP generating conditions in the two operant chambers and for comparison with the chinchillas.

Printing counters recorded licks after a pellet was presented and printed the number of accumulated licks at 15 s intervals. Each schedule was thus divided into 15-s bins. For example, FT 60 was divided into four 15-s bins wherein the subject could distribute its licking. For the FI subjects the last interval could be longer than 15-s if the subject was not responding when the reinforcer became available. All sessions in all FI and FT schedules were run until 100 pellets had been dispensed.

Results

Water intake

Evidence of SIP. Figures 3 to 10 show the water intake during each of the six criterion sessions for all subjects for home cage (BHC) and apparatus (BA) baselines, and for all schedule values. Figures 11 and 12 show mean magnitude of water intake during the criterion sessions under each schedule (means were derived from the six criterion sessions for each schedule). These means also appear in Tables 3 and 4. In virtually every case the apparatus baseline (BA) was exceeded at every schedule value. Thus, for these chinchillas and rats, food pellets arriving periodically rather than simultaneously, either on a FT or an FI schedule, were associated with drinking in excess of the apparatus baseline. Mean water intake in

Figure Caption

Figure 3. Water intake for chinchilla G3 as a function of each of six criterion sessions for all conditions of experiment 1 (BHC= homecage baseline; BA= apparatus baseline). Tick Marks on the X-axis mark the end of a set of criterion sessions. The points show data for individual sessions.

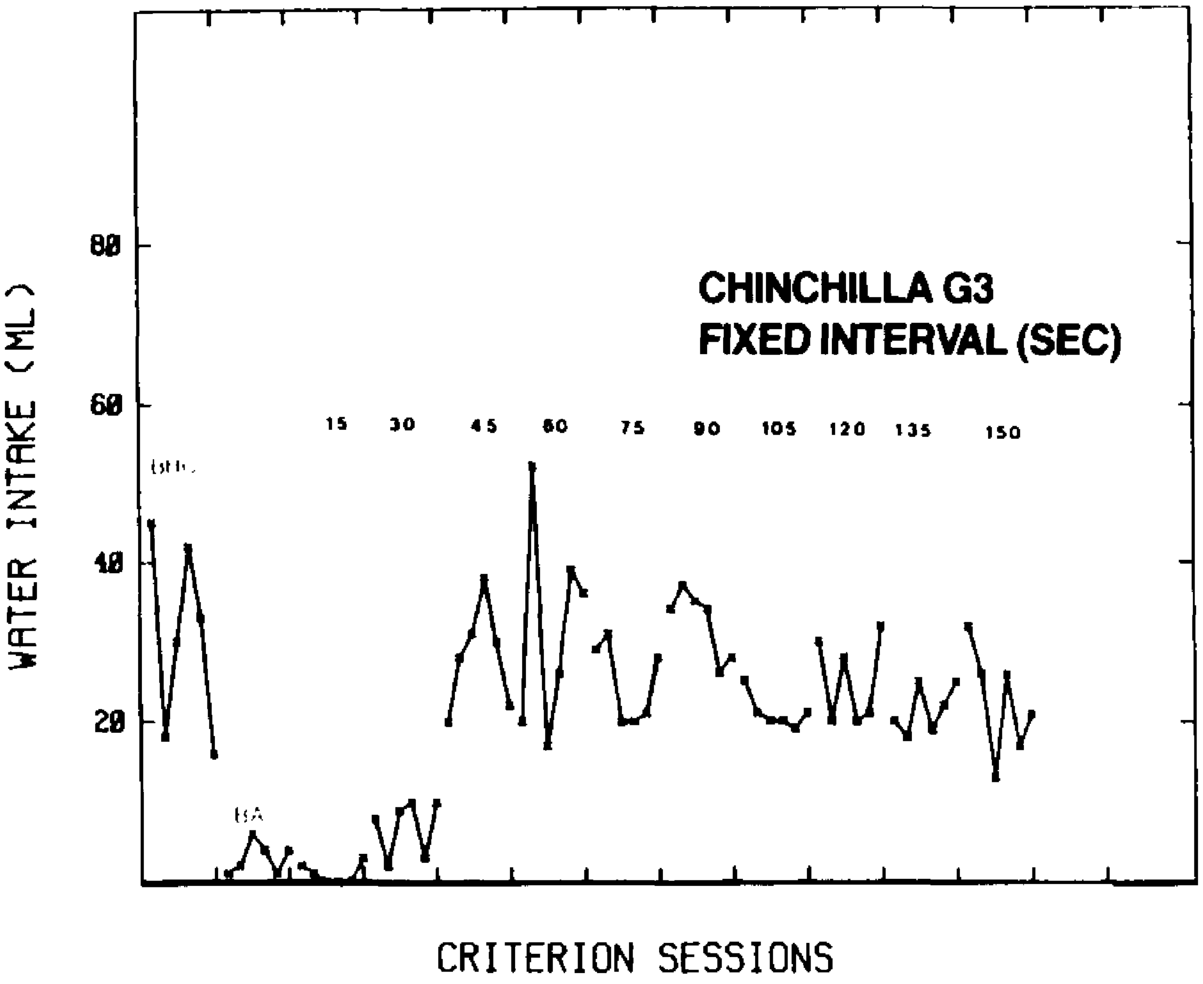

CHINCHILLA G3
FIXED INTERVAL (SEC)
WATER INTAKE (ML)
80
60
40
20
15
30
45
60
75
90
105
120
135
150
BA
CRITERION SESSIONS

Figure Caption

Figure 4. Water intake for chinchilla W3 as a function of each of six criterion sessions for all conditions of experiment 1 (BHC= homecage baseline; BA= apparatus baseline). Tick Marks on the X-axis mark the end of a set of criterion sessions. The points show data for individual sessions.

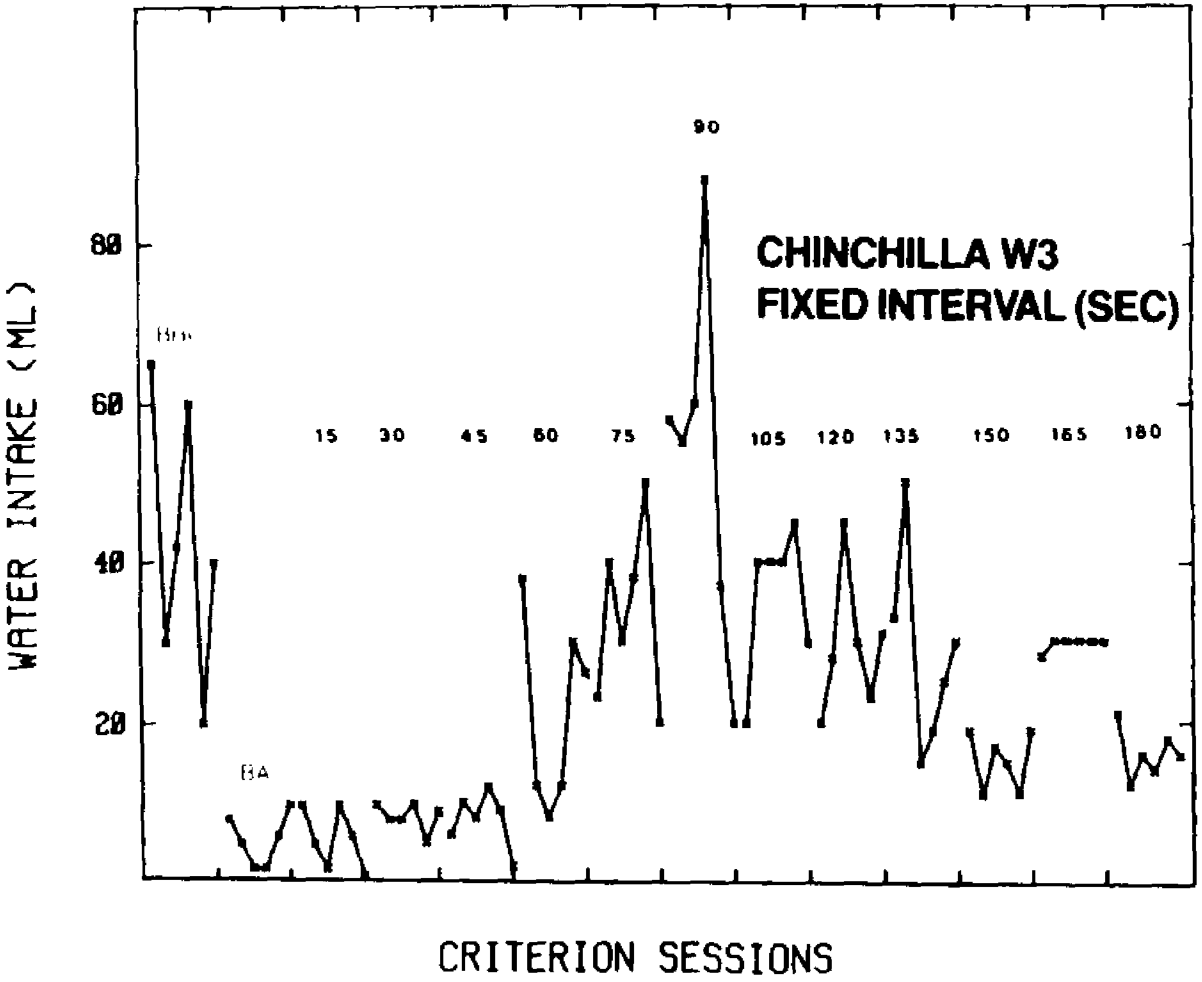

CHINCHILLA W3
FIXED INTERVAL (SEC)
WATER INTAKE (ML)
CRITERION SESSIONS
80
60
40
20
BM
BA
15
30
45
60
75
90
105
120
135
150
165
180

Figure Caption

Figure 5. Water intake for chinchilla G1 as a function of each of six criterion sessions for all conditions of experiment 1 (BHC= homecage baseline; BA= apparatus baseline). Tick Marks on the X-axis mark the end of a set of criterion sessions. The points show data for individual sessions.

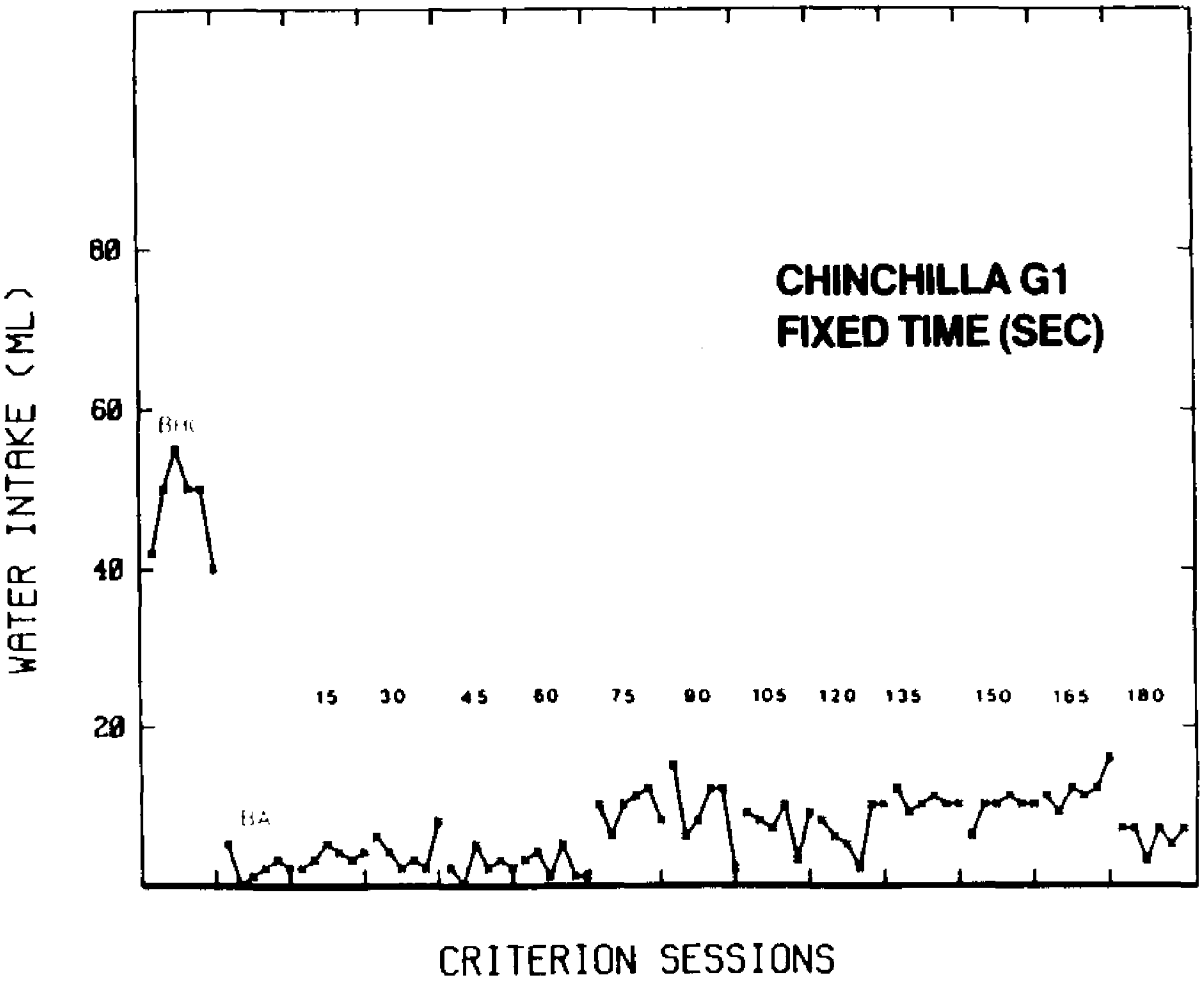

CHINCHILLA G1
FIXED TIME (SEC)
WATER INTAKE (ML)
80
60
40
20
BHC
BA
15
30
45
60
75
90
105
120
135
150
165
180
CRITERION SESSIONS

Figure Caption

Figure 6. Water intake for chinchilla G2 as a function of each of six criterion sessions for all conditions of experiment 1 (BHC= homecage baseline; BA= apparatus baseline). Tick Marks on the X-axis mark the end of a set of criterion sessions. The points show data for individual sessions.

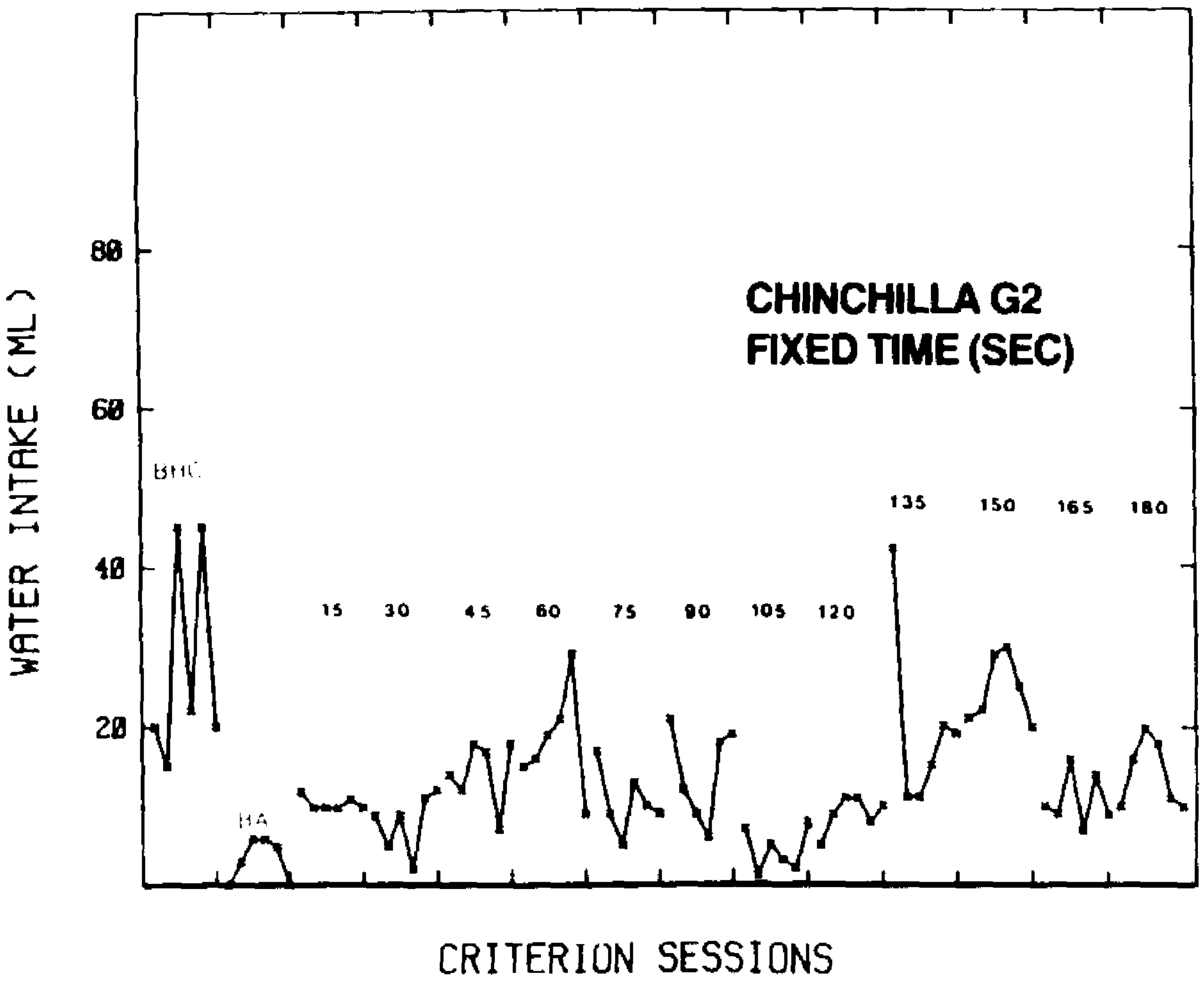

CHINCHILLA G2
FIXED TIME (SEC)
WATER INTAKE (ML)
80
60
40
20
BHC
BA
15
30
45
60
75
90
105
120
135
150
165
180
CRITERION SESSIONS

Figure Caption

Figure 7. Water intake for chinchilla C1 as a function of each of six criterion sessions for all conditions of experiment 1 including cumulative apparatus baseline intake (BA) which was determined at each schedule value (lower trace). (BHC= home-cage baseline.)

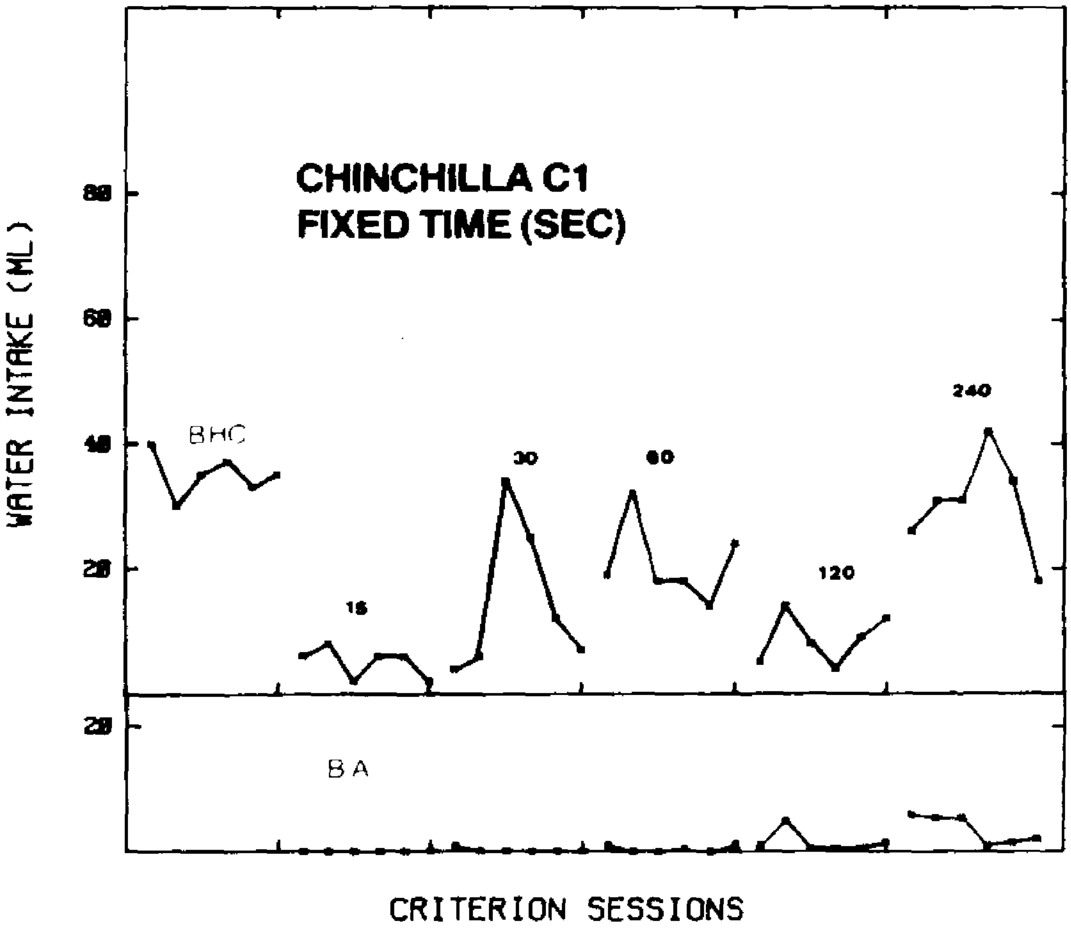

CHINCHILLA C1
FIXED TIME (SEC)
WATER INTAKE (ML)
80
60
40
20
20
BHC
15
30
60
120
240
BA
CRITERION SESSIONS

Figure Caption

Figure 8. Water intake for chinchilla C2 as a function of each of six criterion sessions for all conditions of experiment 1 including cumulative apparatus baseline intake (BA) which was determined at each schedule value (lower trace). (BHC= home-cage baseline.)

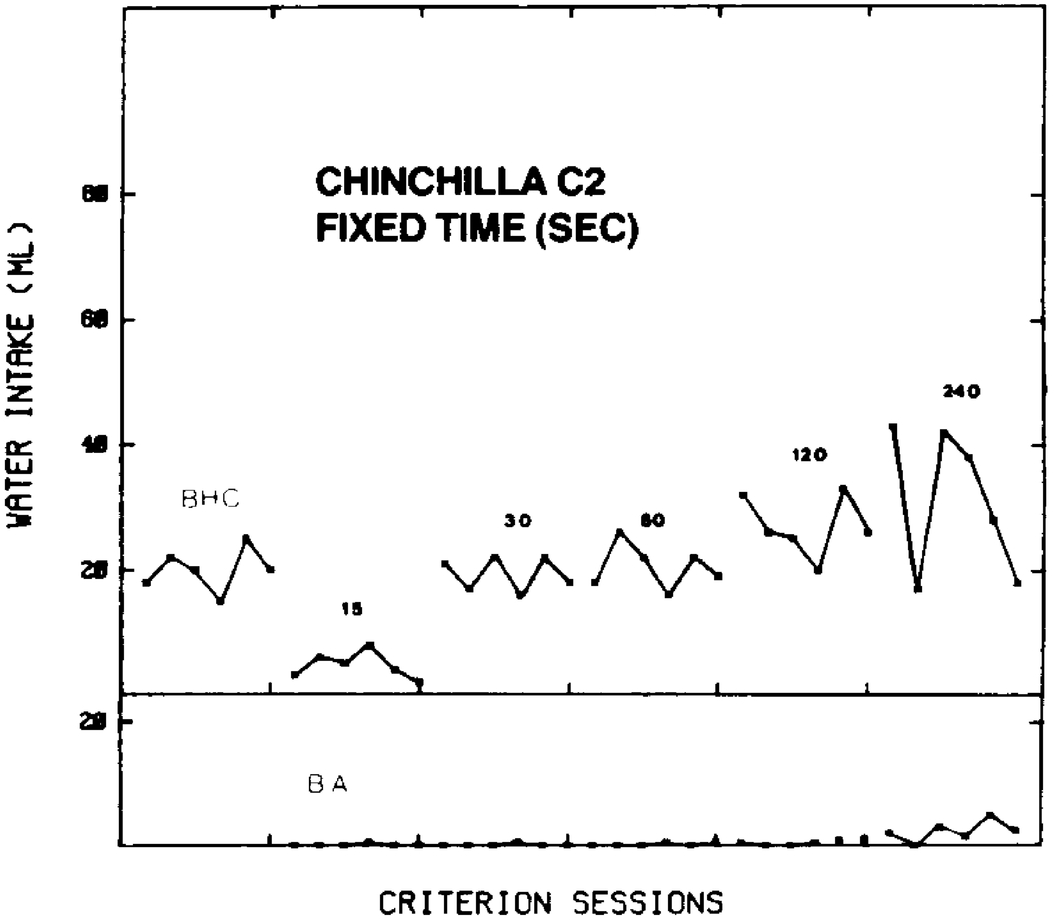

CHINCHILLA C2
FIXED TIME (SEC)
WATER INTAKE (ML)
80
60
40
20
20
BHC
15
30
60
120
240
BA
CRITERION SESSIONS

Figure Caption

Figure 9. Water intake for rat R1 as a function of each of six criterion sessions for all conditions of experiment 1 including cumulative apparatus baseline intake (BA) which was determined at each schedule value (lower trace). (BHC= home-cage baseline.)

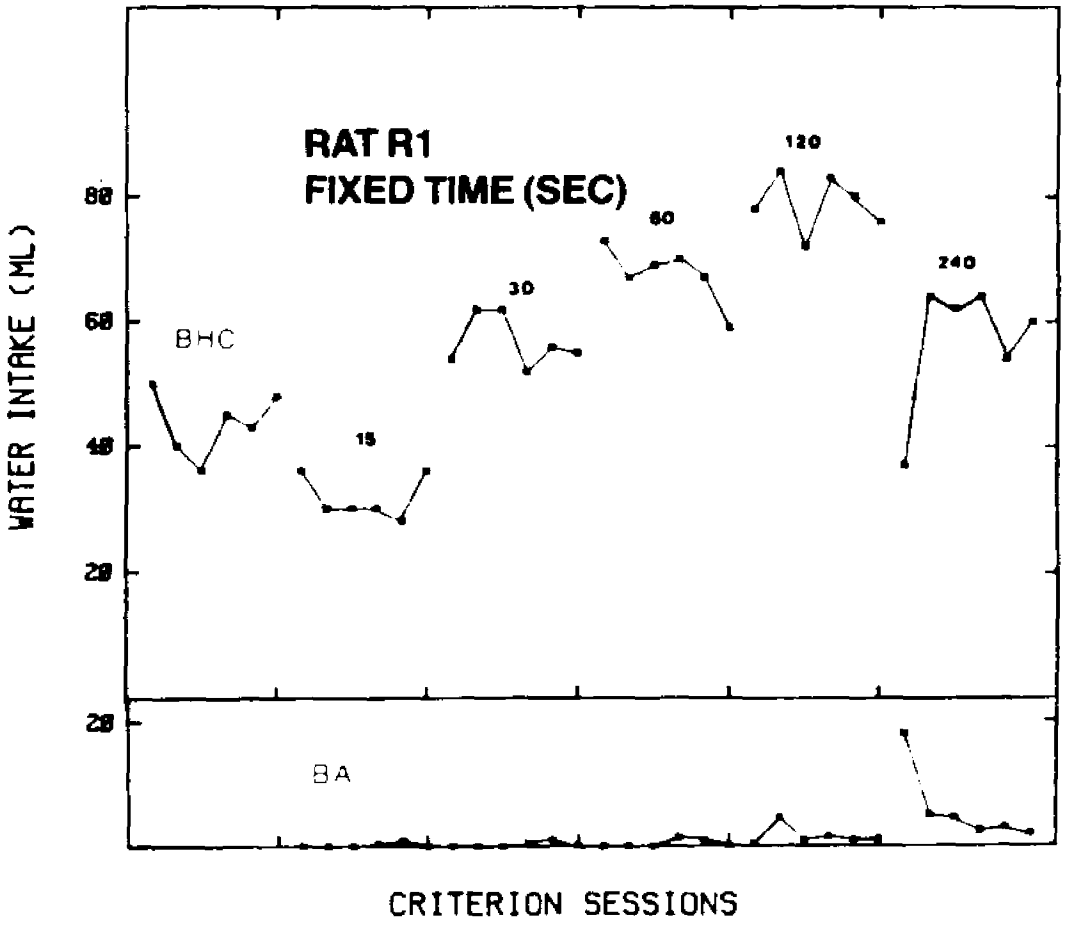
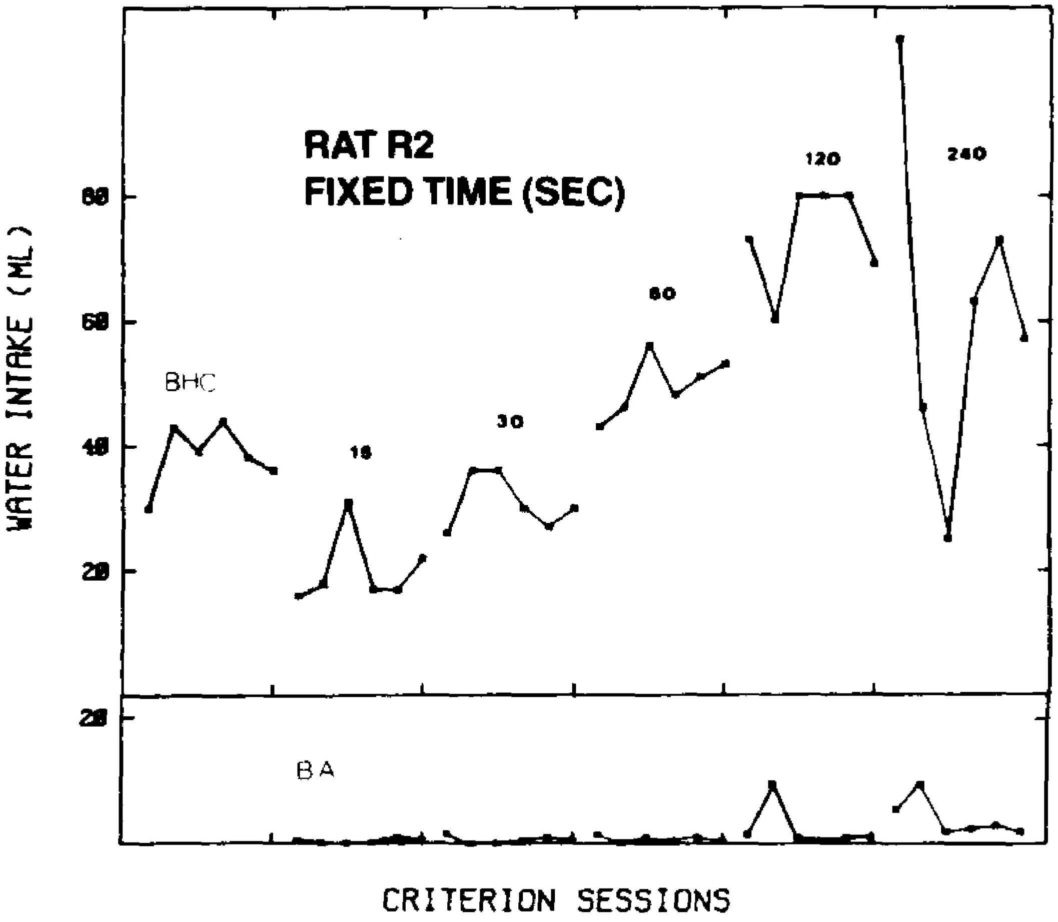

RAT R1
FIXED TIME (SEC)
BHC
15
30
60
120
240
BA
80
60
40
20
20
WATER INTAKE (ML)
CRITERION SESSIONS

Figure Caption

Figure 10. Water intake for rat R2 as a function of each of six criterion sessions for all conditions of experiment 1 including cumulative apparatus baseline intake (BA) which was determined at each schedule value (lower trace). (BHC= home-cage baseline.)


RAT R2
FIXED TIME (SEC)
WATER INTAKE (ML)
80
60
40
20
20
BHC
15
30
60
120
240
BA
CRITERION SESSIONS

excess of the 24-hour home cage baseline (BHC) occured for at least one schedule value in three chinchillas (G3, W3, and C2) and both rats. However, in the case of these chinchillas it is clear from the variance of the distribution of the six criterion session data points that the differences are not statistically reliable (Figures 3, 4, and 8). In the remaining three chinchillas, G1, G2, and C1, the home cage baseline was never exceeded.

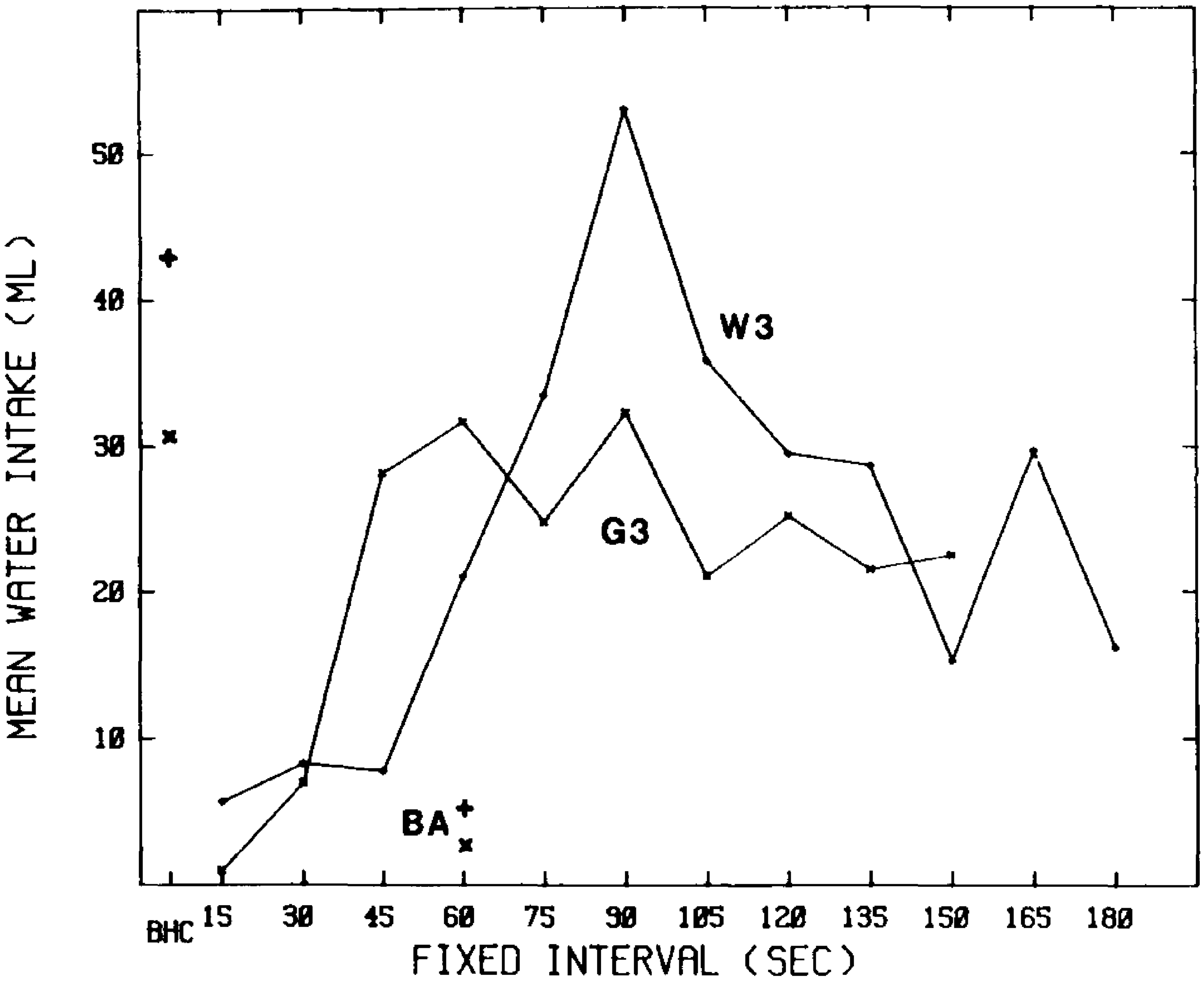
SIP defined by exceeding the apparatus baseline was seen in all chinchillas and rat subjects. However, SIP defined by exceeding the homecage baseline was not reliably observed in three of the six chinchillas. In contrast, both rats clearly met these two criteria.

Effect of schedule type. Water intake by the chinchilla subjects reached higher levels in the FI condition than in the FT. Chinchilla G3 showed a maximum mean intake of 32.3 ml at FI 90. Chinchilla W3 showed its maximum mean intake of 53.0 ml also at FI 90. No chinchilla on the FT schedules exceeded these intakes at FT 90. At FT 240, chinchillas C1 and C2 with intakes of 30.3 and 31.0 ml, respectively, approached the intake of G3.

Effect of schedule size (interpellet interval). Only the data for chinchilla G3 (Figure 11) clearly show an inverted-U relationship between water intake

Figure Caption

Figure 11. Mean water intake as a function of fixed-interval size for chinchillas G3 and W3, obtained from averaging the six criterion sessions (BHC= home-cage baseline, BA= apparatus baseline.)

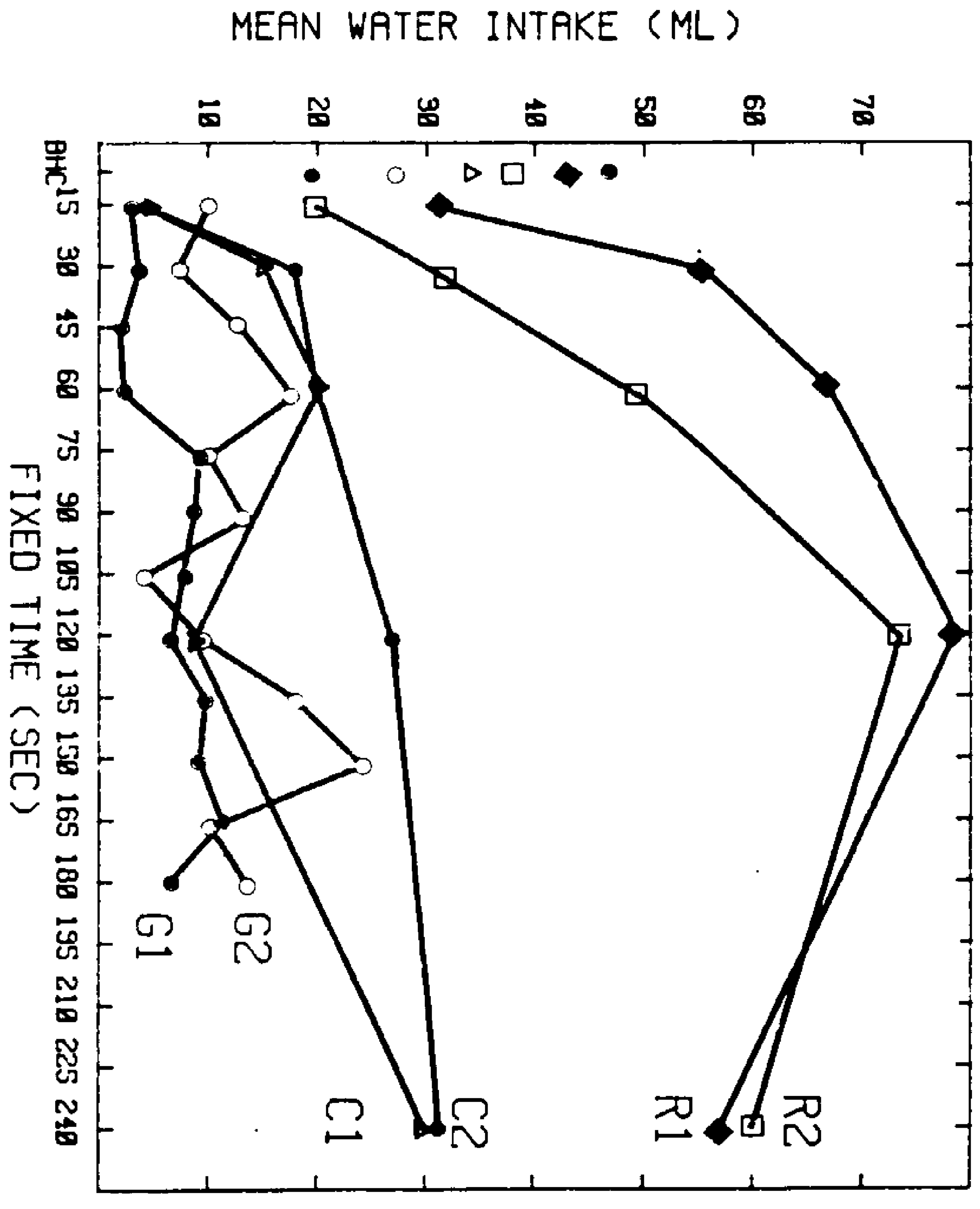

MEAN WATER INTAKE (ML)
50
40
30
20
10
W3
G3
BA
BHC
15
30
45
60
75
90
105
120
135
150
165
180
FIXED INTERVAL (SEC)

and schedule size (interpellet interval). A maximum is suggested in the data for W3 somewhere between 45 and 90 s. For G3 the maximum within the range of intervals investigated was shown at FI 90. It is not clear whether the important factor was the schedule, for these were the two animals run on fixed interval schedules. In Figure 12 it is apparent that the two rats show a maximum, but only the data of chinchilla C2 encourages speculation that a maximum might be forthcoming beyond FT 240.

The effect of species. The comparison between rat and chinchilla subjects showed that the rats drank more water at all FT schedule values than any chinchilla subject on FT or FI (Table 3). As previously mentioned both chinchillas and rats exceeded apparatus baseline at every schedule value and three out of six chinchillas exceeded the home cage baseline at least once. The two rats also exceeded the home cage baseline and it is clear from the distribution of session data points that there is no overlap between baselines and points at FT 30, 60, and 90 for rat R1 and FT 120 for rat R2 (Figures 9 and 10). The rats showed maximum intakes on FT 120 seconds of 78.8 and 73.7 ml (.23 ml/gram body weight for each subject) for subjects R1 and R2, respectively (Figure 12). Chinchilla subjects G3 and W3 showed maximum intakes at

Figure Caption

Figure 12. Mean water intake as a function of fixed-time schedule for chinchillas G1, G2, C1, C2, and rats R1, and R2, obtained from averaging the six criterion sessions (BHC= home-cage) The apparatus baseline intakes for G1 and G2 were 2.2 ml and 3.3 ml, respectively. Baseline apparatus intakes for chinchillas C1 and C2, and rats R1 and R2 can be found in Table 4.


MEAN WATER INTAKE (ML)
10
20
30
40
50
60
70
BHC
15
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
FIXED TIME (SEC)
G1
G2
C1
C2
R1
R2

FI 90 of 32.3 and 53.0 ml (.07 and .11 ml/gram body weight), respectively, but FT chinchillas showed no maxima in the schedule values chosen.

Temporal distribution of licking.

Figures 13 through 16 show that chinchillas G3, W3, G1, and G2 licked most often during the first 30 seconds following the delivery of the pellet (postpellet), but they also continued to lick, at low levels, throughout the IPI. Chinchillas G3 and W3 exposed to FI schedules licked more on all schedule values than chinchillas exposed to FT schedules. Chinchilla G4 emitted the largest number of licks for any FT schedule value while on FT 75 with a mean of 19 licks in the first 15 seconds postpellet, while chinchilla G3 emitted 141 licks in the first 15 seconds postpellet while on FI 45 and Chinchilla W3 emitted 139 in the first 15 seconds during FI 90.

Tables 5 and 6 show the average number of licks in each quarter of a session for chinchillas G1, G2, G3, and W3 on all schedule values. Only subject W3 showed a tendency to increase its mean intrasession licking over successive quarters of sessions for most schedule values. During FI 15, W3 showed a fourth quarter decrease compared to the first quarter and during FI 30 the second quarter of a session had the largest number of licks. Subjects G1, G2, and G3 tended toward a

Figure Caption

Figure 13. The average number of licks per 15-second postpellet bin for FI 30 through FI 150, obtained from the average of the last six criterion sessions of subject G3.

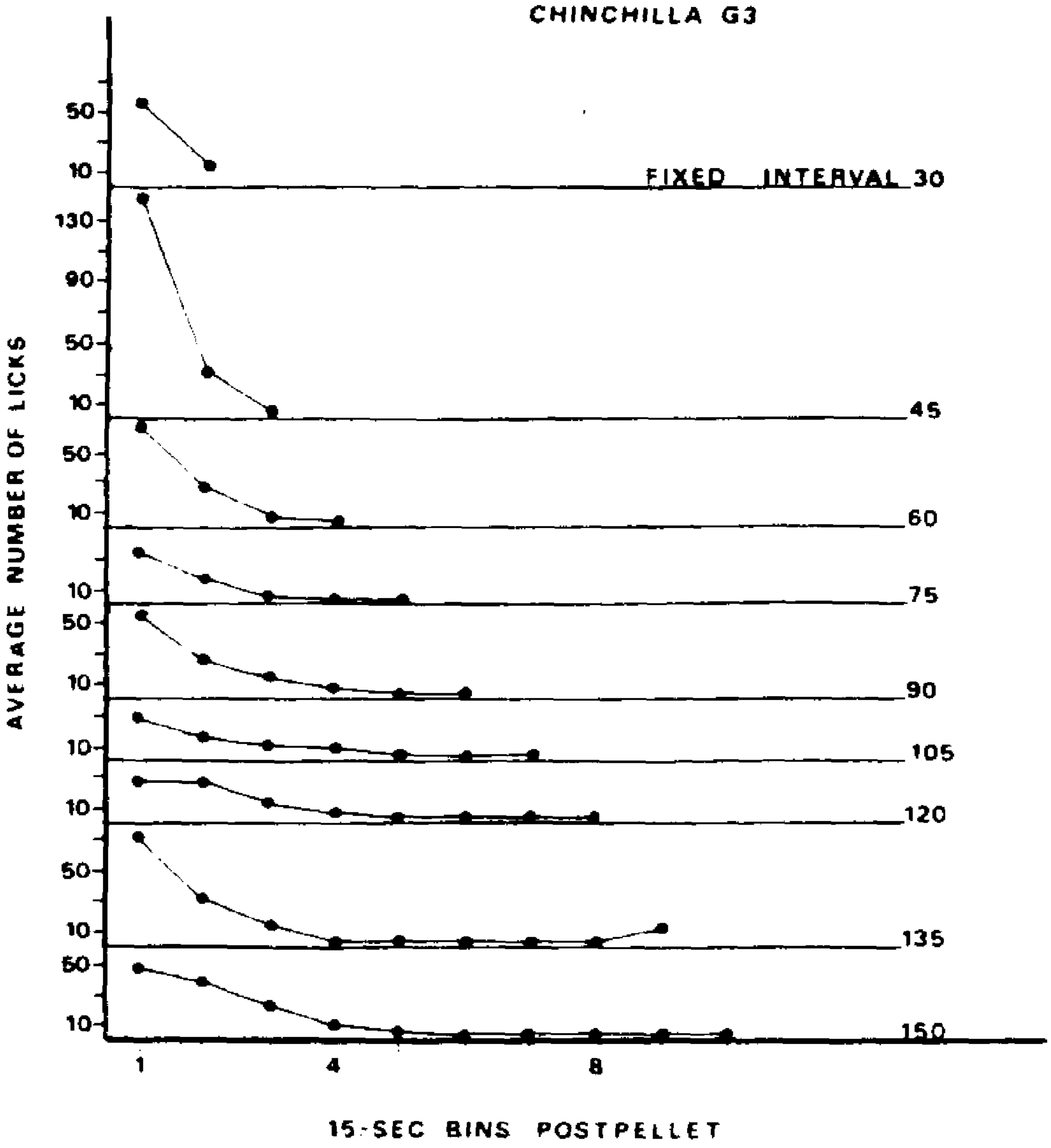

CHINCHILLA G3
FIXED INTERVAL 30
45
60
75
90
105
120
135
150
AVERAGE NUMBER OF LICKS
50
10
130
90
1
4
8
15-SEC BINS POSTPELLET

Figure Caption

Figure 14. The average number of licks per 15-second postpellet bin for FI 30 through FI 180, obtained from the average of the last six criterion sessions of subject W3.

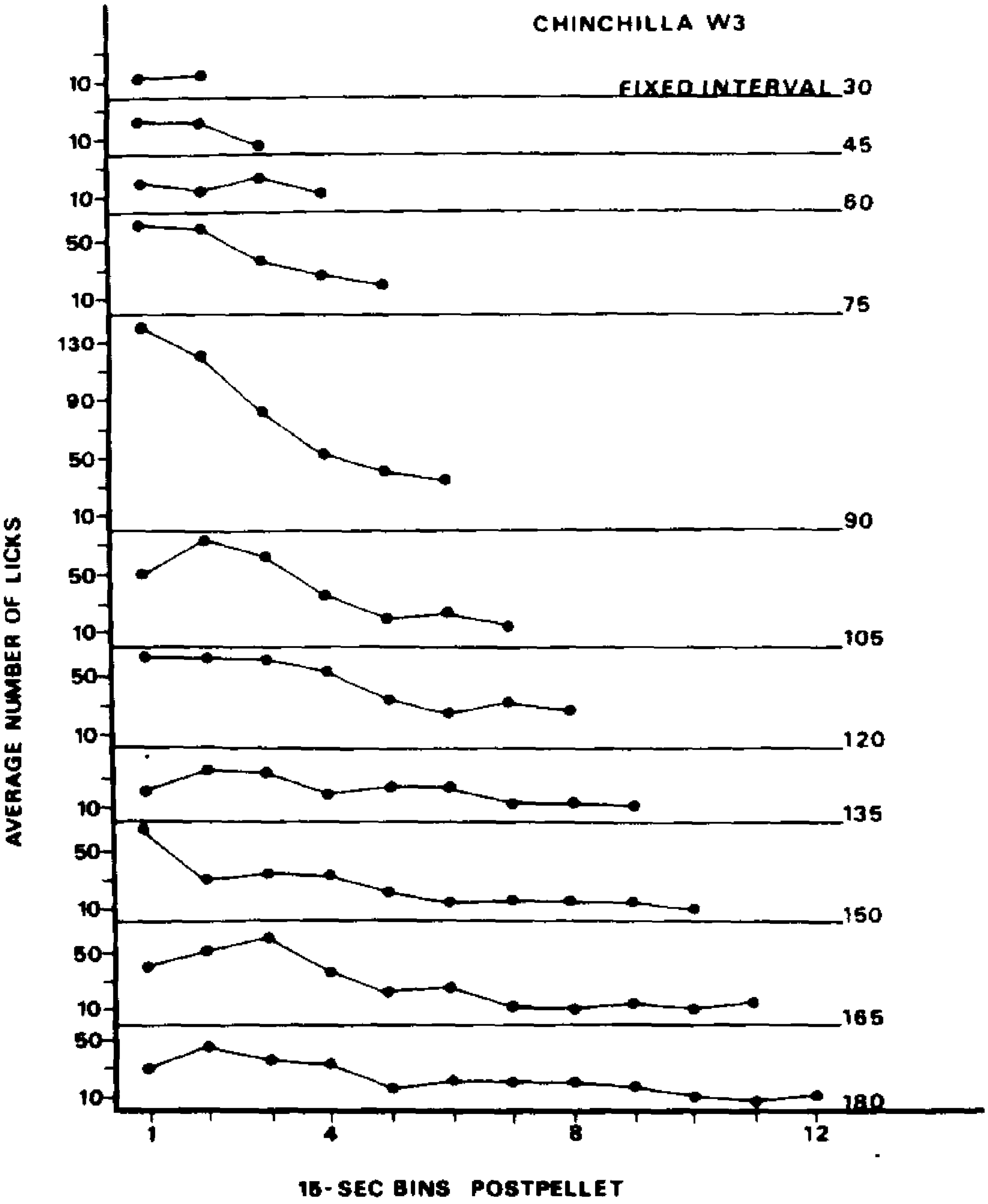

CHINCHILLA W3
FIXED INTERVAL 30
45
60
75
90
105
120
135
150
165
180
AVERAGE NUMBER OF LICKS
10
10
10
50
10
130
90
50
10
50
10
50
10
10
50
10
50
10
50
10
1
4
8
12
15-SEC BINS POSTPELLET

Figure Caption

Figure 15. The average number of licks per 15-second postpellet bin for FT 30 through FT 180, obtained from the average of the last six criterion sessions of subject G1.

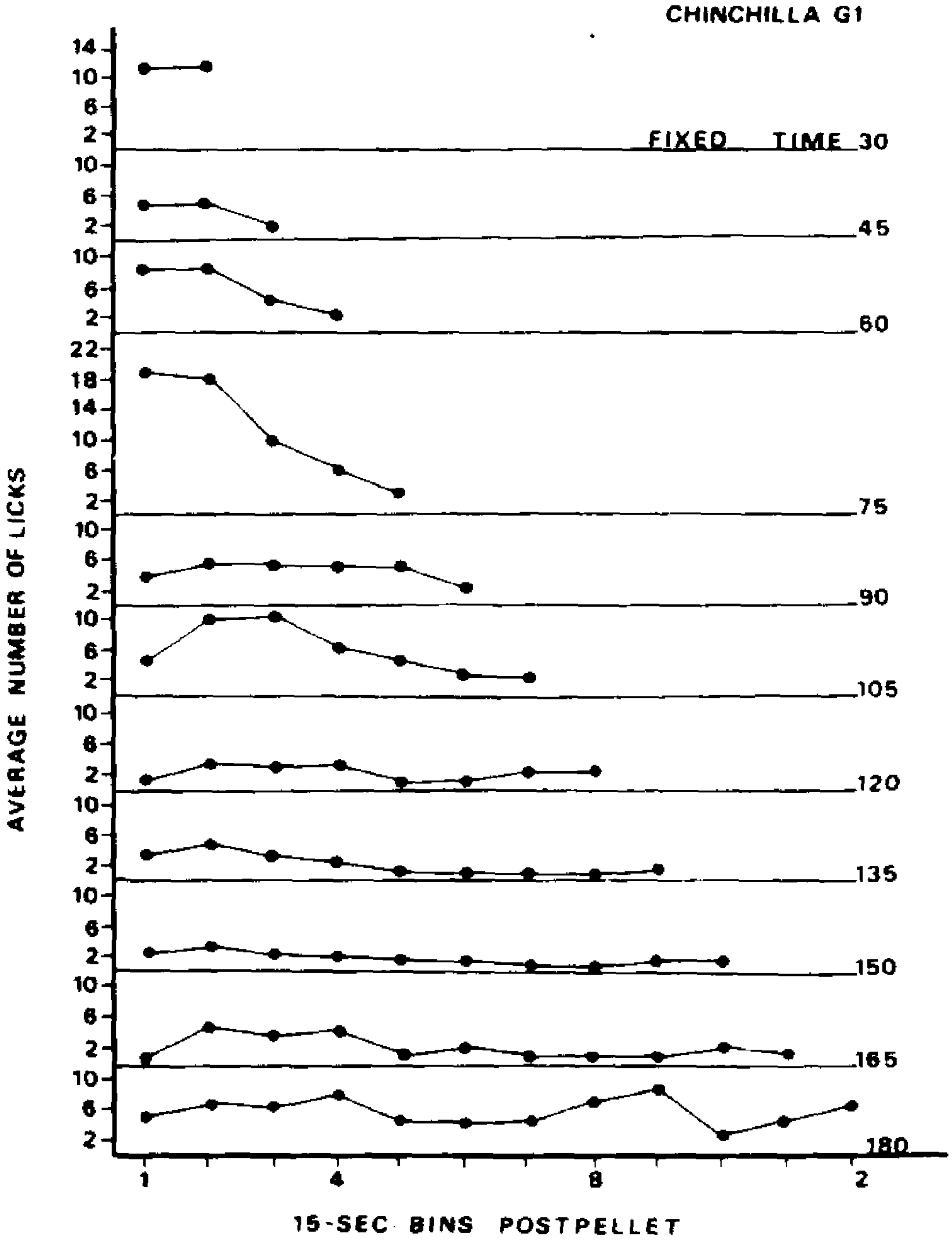
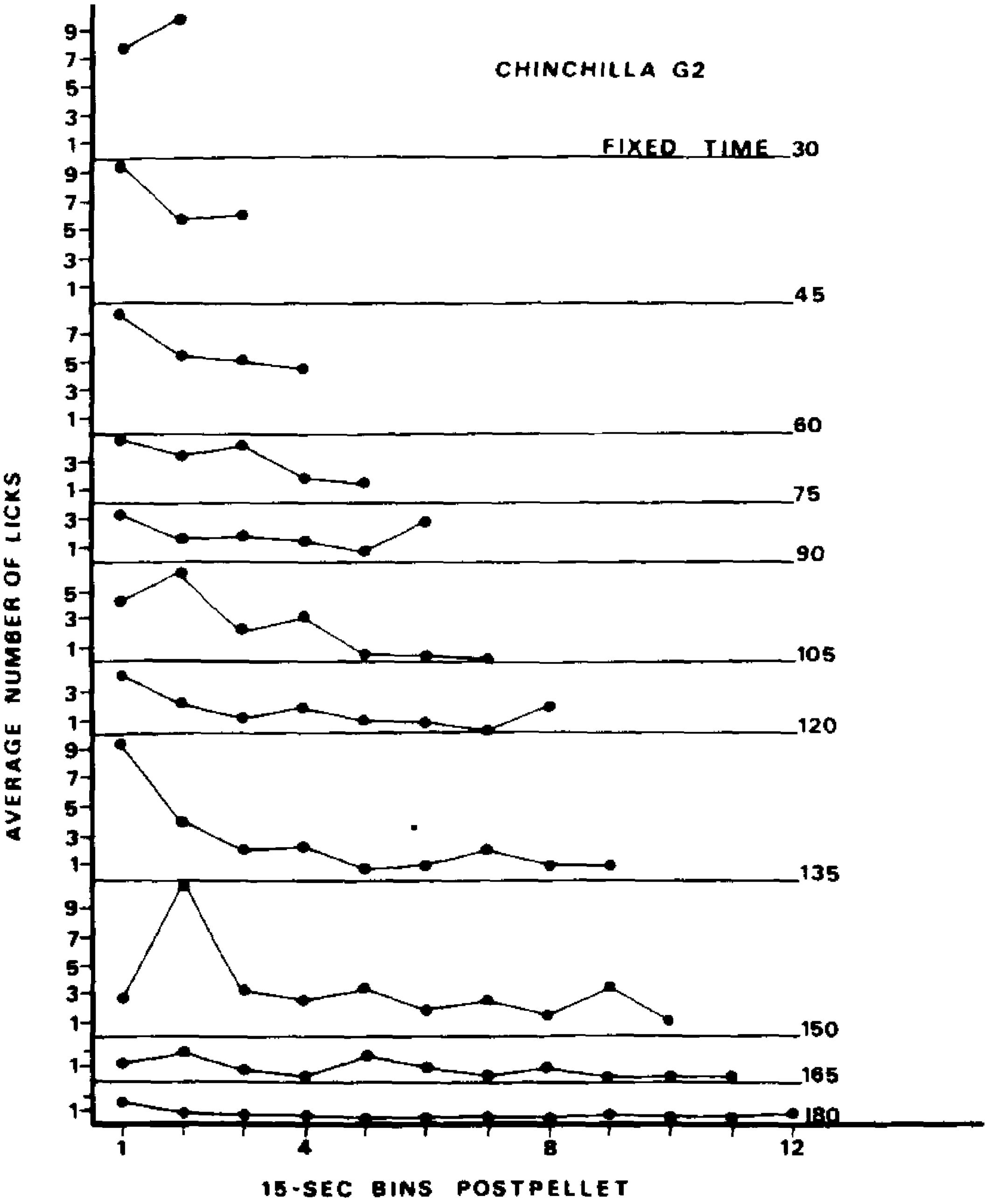

CHINCHILLA G1
AVERAGE NUMBER OF LICKS
14
10
6
2
FIXED TIME 30
10
6
2
45
10
6
2
60
22
18
14
10
6
2
75
10
6
2
90
10
6
2
105
10
6
2
120
10
6
2
135
10
6
2
150
10
6
2
165
10
6
2
180
1
4
8
2
15-SEC BINS POSTPELLET

Figure Caption

Figure 16. The average number of licks per 15-second postpellet bin for FT 30 through FT 180, obtained from the average of the last six criterion sessions of subject G2.


CHINCHILLA G2
FIXED TIME 30
45
60
75
90
105
120
135
150
165
180
AVERAGE NUMBER OF LICKS
9
7
5
3
1
1
4
8
12
15-SEC BINS POSTPELLET

decrease over successive quarters in intrasession licking. Inconsistencies occurred at a few schedule values (e.g., G1 at FT 135 and G2 at FT 165).

Temporal distribution of drinking bouts.

Figures 17 and 18 show representative cumulative records from subjects G2 and W3. These records were obtained from one of the six criterion sessions of FI 90 (W3) and FT 150 (G2) and are representative of their performances. G2, the FT subject had many fewer bouts than the FI subject W3. When W3 did drink its pattern of drinking was much like that found for rats, a bout of drinking after obtaining a pellet, but the FT subject appears to have fewer but longer drinking bouts, not necessarily post-pellet. Drinking events per IPI and bout length were not otherwise analyzed.

Drinking rate vs. reinforcement rate.

Figures 19 and 20 show the rate of drinking, in ml/min, as a function of reinforcement rate for all subjects. Drinking rates were obtained by totaling the magnitude of water intake during a session and dividing by session length. These were averaged over the six criterion sessions. Figure 18 shows that for these subjects, exposed to 15 s increments in their food schedules, low reinforcement rates produced the lowest drinking rates, but as reinforcement rates increased the two FI chinchillas (G3 and W3) increased their

Figure Caption

Figure 17. Cumulative record of subject W3 (FI 90) obtained from one of the six criterion sessions (uppertrace= lever pressing, lower trace= pellet delivery, upper trace hash marks= licking).

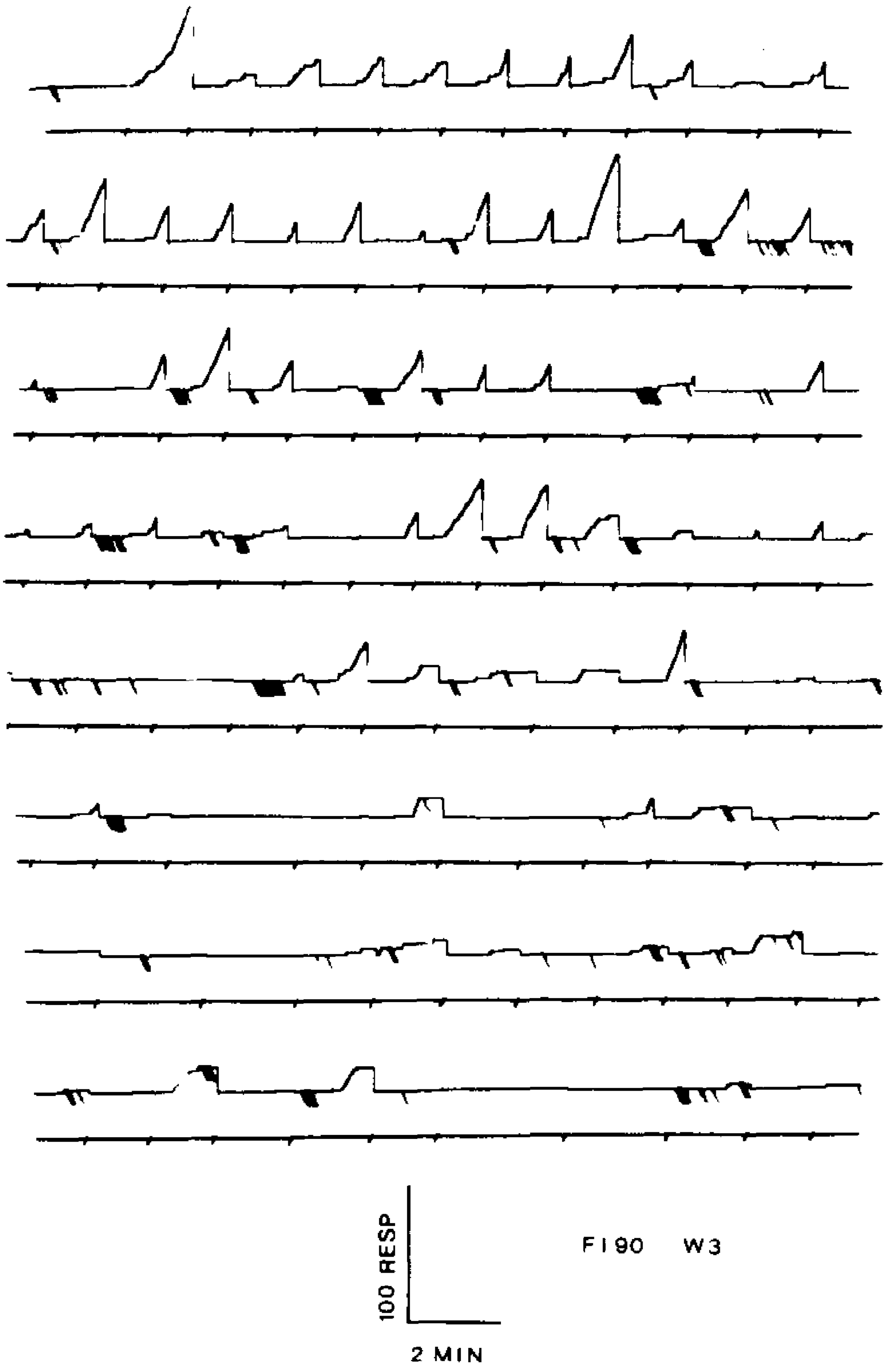

100 RESP
2 MIN
F190 W3

Figure Caption

Figure 18. Cumulative record of subject G1 (FT 150) obtained from one of the six criterion sessions (uppertrace= lever pressing, lower trace= pellet delivery, upper trace hash marks= licking).

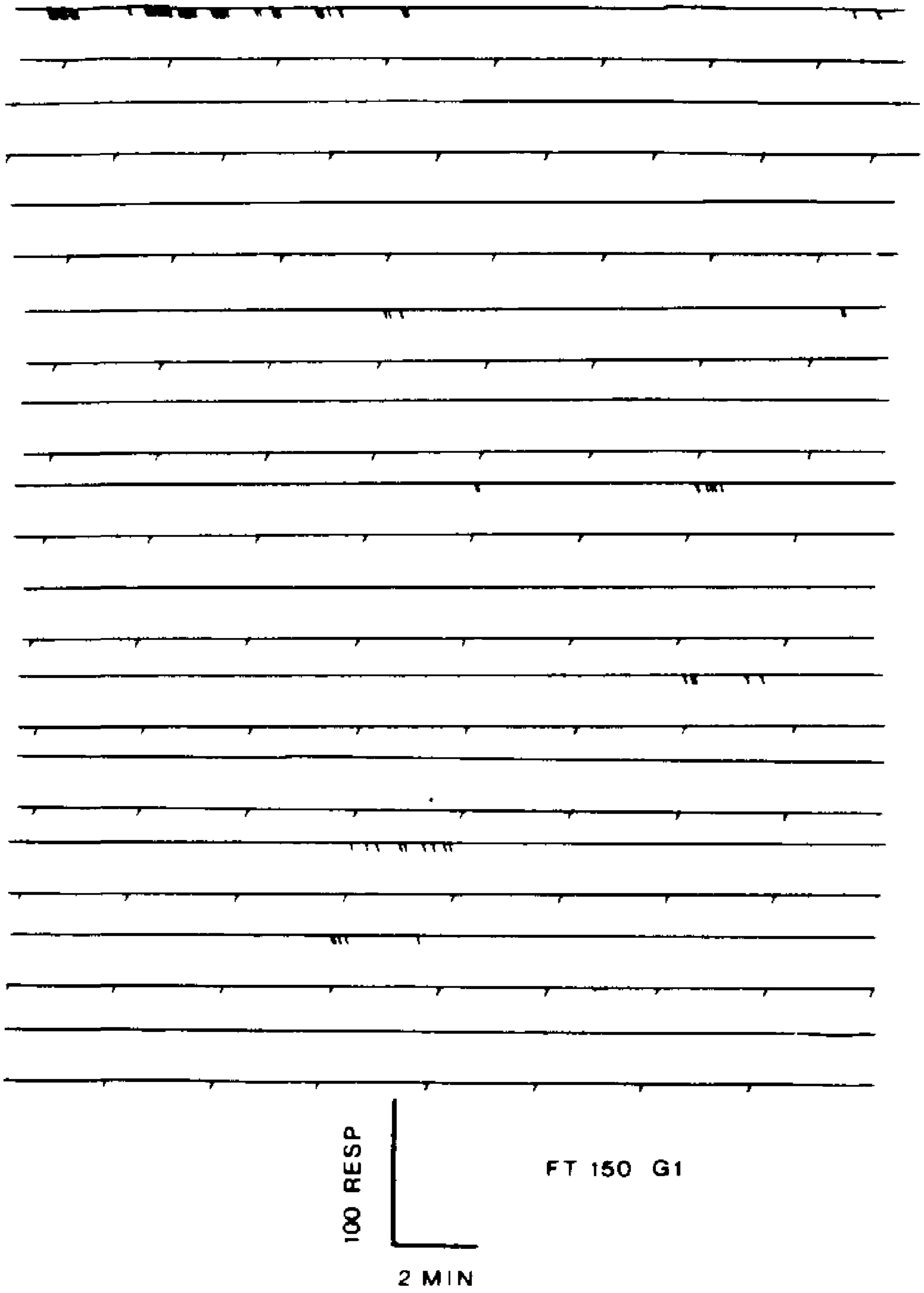

100 RESP
2 MIN
FT 150 G1

Figure Caption

Figure 19. The rate of drinking (in milliliters per minute) as a function of reinforcement rate (pellets per minute) for subjects exposed to fixed-time schedules (G1 and G2) and fixed-interval schedules (G3 and W3).

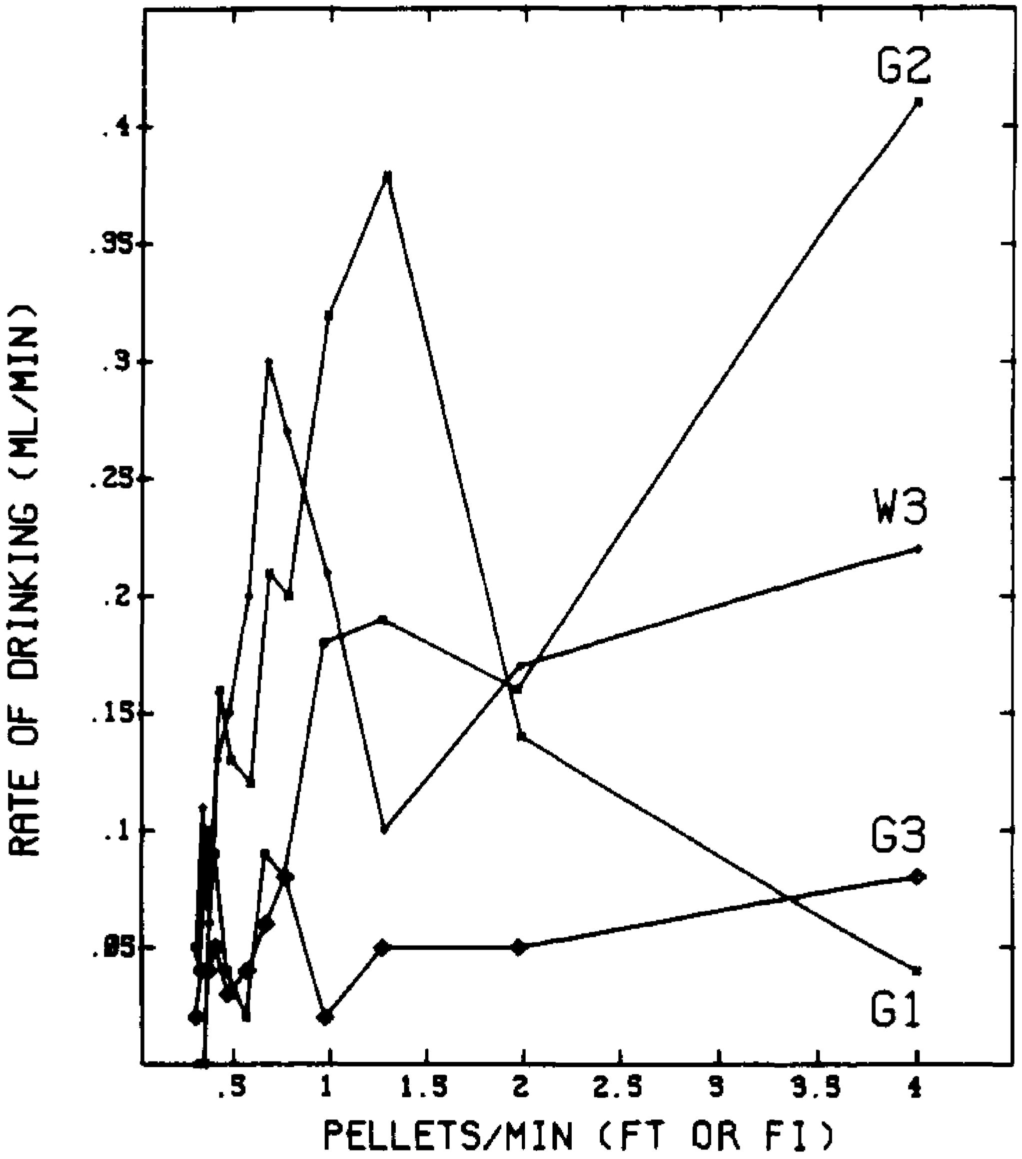
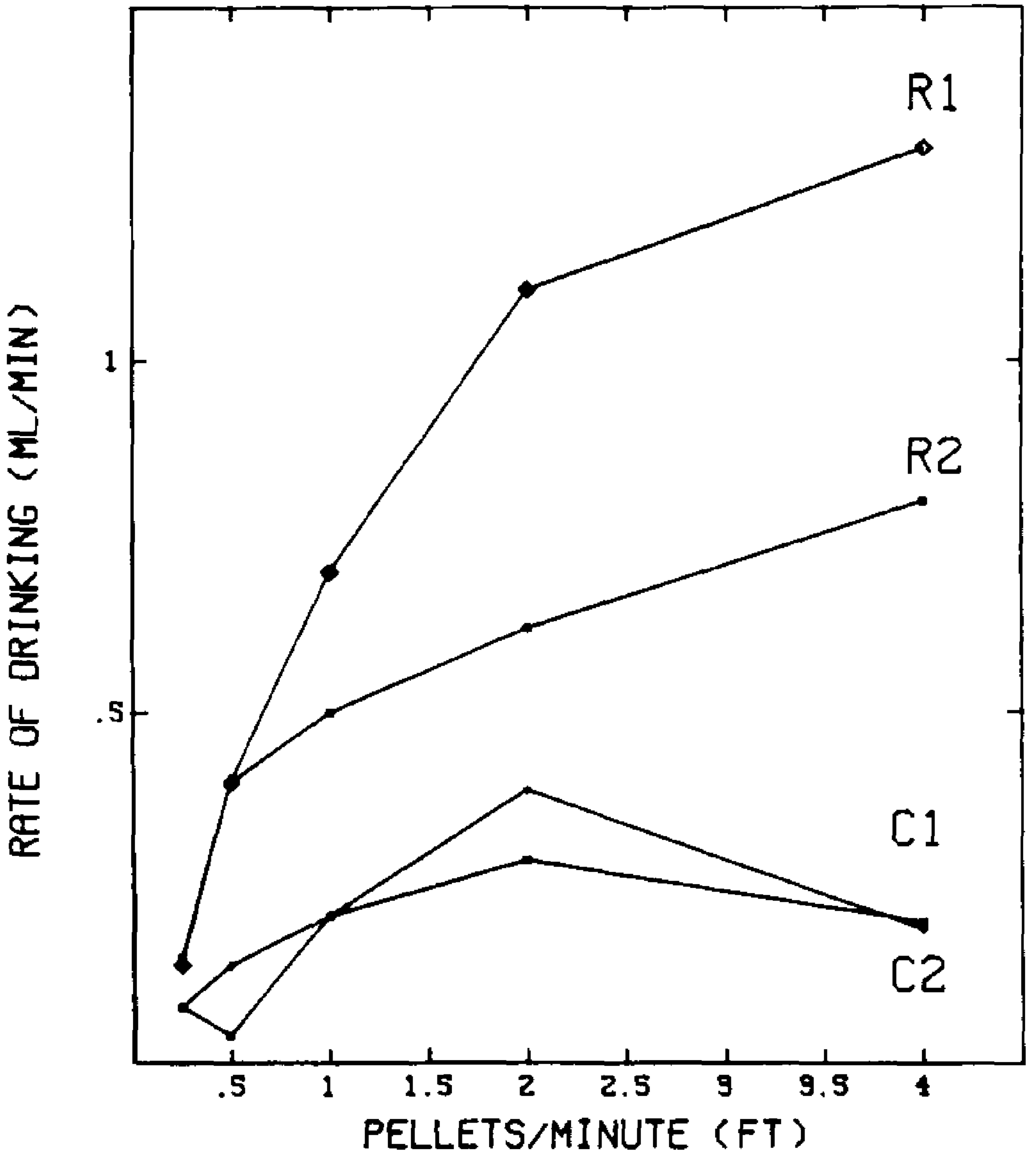

RATE OF DRINKING (ML/MIN)
.05
.1
.15
.2
.25
.3
.35
.4
PELLETS/MIN (FT OR FI)
.5
1
1.5
2
2.5
3
3.5
4
G2
W3
G3
G1

Figure Caption

Figure 20. The rate of drinking (in milliliters per minute) as a function of reinforcement rate (pellets per minute) for chinchillas C1 and C2 and for rats R1 and R2.


RATE OF DRINKING (ML/MIN)
1
.5
.5
1
1.5
2
2.5
3
3.5
4
PELLETS/MINUTE (FT)
R1
R2
C1
C2

drinking rates until FI 45 was attained then their drinking decreased and then slowly increased. The two FT chinchillas (G1 and G2) showed two different functions. Subject G1 showed a function with a maximum while G2 tended to increase its drinking rate as reinforcement rate increased. Figure 19, shows the four other FT subjects that had their schedule lengths doubled to a maximum of FT 240. These subjects all show an increase in drinking rate to two pellets per minute, then the rat subjects (R1 and R2) diverge from the chinchillas (C1 and C2) in that their drinking rates continue to increase while the chinchillas'rates decrease. Subjects C1 and C2 had maxima at two pellets per minute, while subject G3 (FI) had its maximum at one pellet per minute and subject W3 had its maximum at .67 pellets per minute. These four chinchillas (G3, W3, C1, and C2) are also similar in that their rate of drinking was similar at their respective maxima.

Correlation between licking and drinking.

Table 7 shows the Pearson product moment correlations between the average water intake (Table 3) and the average number of licks during the six criterion sessions for all subjects. The FI chinchillas (G3 and W3) show positive correlations (.54 and .80) between these two measures as do the rat subjects (.61 for R1, .72 for R2). FT subjects C1, C2, and G1 show correlations of .20, .00, and .20, respectively between these two measures. Subject G2 shows a correlation of .40.

Discussion

All six chinchillas and both rats may be considered as showing evidence of SIP as defined by an increase over the apparatus baseline in the 6-session mean water intake at at least one schedule value. Only the two rats and chinchilla G3 exceeded the 24-hour home cage baseline.

While single subject designs of this type usually include recovery of at least one data point, time limitations did not permit this. That six subjects were used somewhat offsets this criticism.

An unexpected finding was the difference between water intakes by the FI subjects compared to the FT subjects. Burks (1970) found that a fixed ratio response requirement did not affect the magnitude of water intake in rats. For this reason the more convenient FT schedules have displaced interval schedules in popularity in studies of SIP. Chinchillas G3 and W3 both showed larger water intakes and earlier peaks in intake than all other chinchillas. Chinchillas C1 and C2, showed a general increase to their maxima at FT 240, and were beginning to reach intake levels that approached the FI intake maxima but at more than twice the schedule length. Figures 17 and 18 suggested that there were differences between the FI and FT subjects with regard to the number of interpellet intervals with licks. Although this measure was not explicitly studied, inspection of the cumulative records suggested FI subjects had more IPI's with drinking bouts than FT subjects, but FT subjects had longer bouts when they occurred. Unfortunately, there are no studies that present parametric variations of schedule length to subjects of any species, using FI and FT schedules together. Thus, conclusions on the effects of a response requirement in species other than the rat would be premature.

With respect to the inverted U-shaped function found for rats on a similar range of schedule values (Falk, 1966; Flory, 1971; Wetherington, 1979), only chinchilla W3 and both rats showed this as a result of increasing IPI length. Chinchilla G3 showed a maximum water intake at FI 90 but did not consistently decrease its intake at larger schedule values. The rats showed peak water intakes at FT 120. This is generally what has been reported in the literature (Flory, 1971; Hawkins et al, 1972), although, Wetherington (1979) found maxima at FT 120 for only two of her rats and FT 240 for two other rats. The FI chinchillas, however, showed peak intakes at 90 seconds. Although chinchillas

C1 and C2 were exposed to FT up to 240, neither showed the inverted U-shaped function. Their data suggest that we did not extend our parametric exploration of IPI size far enough.

Under FI and FT schedules, chinchillas had peak water intakes on schedule values that were different from those reported for rats, and the intakes generated by the schedules were substantially less than those found for rats. Porter and Bryant (1978) found that male and female mongolian gerbils did not develop SIP on FT 30 or 60 for food. They did find that the FT 60 condition engendered three times the water intake compared to the FT 30 condition. Subsequently, Porter and Bryant (1978) placed mongolian gerbils on FT 60, 120, and 180 schedules of food. They found substantial SIP only during the FT 180 condition, suggesting that the species variable may interact with the length of the interpellet interval. Perhaps, different species in similar ecological niches should be simiarly responsive to the same IPI sizes. Our chinchillas appear to be maximally polydipsic in the vicinity of FI 90 or on FT schedules longer than 150 seconds. Gerbils have shown maximal intakes at FT 180, close to the FT value that produces maximum intake for chinchillas exposed to FT schedules (> 150). Both gerbils and chinchillas come from seasonally semi-arid biotopes (Mohlis, 1978;

Porter & Bryant, 1978). Rats, which in the wild are lowlands-wetlands animals show maximal intakes at FT and FI 120. Although, there are very few parametric studies (Porter and Bryant used only three schedule values) it may be that each species has its own sensitivity range.

Magnitude of intake is stressed by Falk (1972) and Roper (1983), while temporal pattern of food related drinking has also been emphasized (Staddon, 1977; Wetherington & Brownstein, 1983). These are not interchangeable in that magnitude of intake can be accomplished by infrequent large bouts as well as many small bouts. Be that as it may, rats (Falk, 1961; Stein, 1964; Segal, 1969; Keehn, 1970; Keehn & Colotla, 1971) and gerbils (Porter & Bryant, 1978) show a typical pattern of postpellet drinking. When a pellet is obtained the subject eats it, then proceeds to the water spout and drinks. It has been generally found in SIP studies that rats tend to drink after about 95% of a pellets deliveries. Chinchillas tended to drink after only about 65% of the pellets. The length of the bout has been found to be partly determined by interpellet interval length (Falk, 1966; 1977). In the present experiment, Figures 13-16 show postpellet licking as a function of absolute time in the interpellet interval. All subjects tended to drink the most in the first 15 seconds postpellet, although there was some drinking in the second 15 second interval. Rats are known to generally finish drinking in the first ten seconds postpellet (Keehn & Colotla, 1971).

The pattern of intrasession licking was obtained for chinchilla subjects G1, G2, G3, and W3 (Tables 5 and 6). For subjects G1, G2, and G3, intrasession licking tended to decrease as the session progressed, but this was inconsistent at larger schedule values. Subject W3, which could be said to have the strongest polydipsic response of all our chinchilla subjects, showed an intrasession increase in licking generally after FI 60. At smaller interval sizes the increase fluctuated from quarter to quarter. The intrasession licking decrease found in the other subjects was gradual across quarters suggesting an ongoing response to schedule parameters, but the results reported in Table 7 showed that there was a small or no correlation between licking and magnitude of water intake for the FT chinchillas. Therefore, the intrasession licking trends for those subjects maybe an artifact of other behavior addressed to the water spout.

The finding of greater FI intake has no precedent in the literature. In the case of differences between FT and FI lick rates, there are currently no other data. A possibly relevant study compared FR and FT in rats but was different enough proceduraly from the present study to make comparison between species inappropriate (Burks, 1970). As previously mentioned, the magnitude of intake on FT of chinchillas C1 and C2 eventually approached the intake levels of the FI subjects. Lick distributions of these two subjects were not obtained. Therefore, it is difficult to know whether the increases were due to increases in lick frequency, a larger number of licking bouts, or an increase in bout length.

The lack of positive correlations found between the mean number of licks and mean water intake does suggest that something other than SIP may be responsible for the differences between FT and FI chinchillas (Table 7). If licking was not correlated with the drinking observed than some other water bottle directed behavior must be responsible. The response could possibly have been some type of "attack" or gnawing which activated the drinkometer circuit to register "licks" but did not remove water from the drinking tube. Until more subjects are run we will not know whether this finding was a statistical perturbation or a systematic finding.

Residual licking has been identified in rats (Keehn & Colotla, 1971; Keehn, Colotla, & Beanton, 1970). This type of interpellet drinking differed from

SIP in that it was remote from the last obtained reinforcer, had fewer licks, and occurred less often than SIP. It has also been suggested that this form of drinking was maintained by the proximity to the succeeding reinforcer through superstitious pairing of licking with obtaining the reinforcer (Segal, 1969). The licking in the present study was generally within 45 seconds of obtaining a pellet, but there was licking throughout the intervals. The present data cannot differentiate between latency to the first licks postpellet and licking that occurred after an initial bout of drinking. Only the cumulative records (e.g., Figures 17 and 18) can show the distribution of licks in any particular interval in the present data. Figures 17 and 18 show that there were bouts of drinking post-pellet and that there was variable latency to the first lick post-pellet, but that there were also isolated licks after the initial bout. These licks were therefore less organized and also remote from the SIP found and was much like the drinking described by Keehn and Colotla (1970) and Keehn et al. (1971). There was no evidence that the licking was maintained by its proximity to the next reinforcer. If this were the case, the last 15 second bin postpellet, in Figures 13-16, would show an increase in the number of licks. This rarely occured for any FT or FI subject.

The traditional dependent variable in operant research is the rate of a response. Herrnstein's (1970, 1974) equation relates the rate of a response to the rate of reinforcement. Wetherington (1979) assessed this equation with data on SIP. She found that lick rate, ingestion rate, and time spent drinking were generally negatively accelerating functions (for rats) of food rate (pellets/hour). This is what would be expected if the causal factors underlying operant and adjunctive behavior were the same.

In the present experiment only the rats produced functions of similar shape to the above. Wetherington (1982) pointed out that, at least for rats, there are many similarities between adjunctive and operant responding, Currently their are no studies that attempt to fit Herrnstein's equation to lick rates produced by SIP in other species. The possibility that something other than SIP might have accounted for our FT findings for chinchillas makes it impossible to generalize.

The stability criterion used in this study deserves some mention. The criterion was a modification of one of three described by Cumming and Schoenfeld (1960). In our case a difference not in excess of 10% was chosen after pilot work, as opposed to their recommended 5%. The criterion was chosen because it would make managable the number of sessions that a study such as this would need. The criterion satisfied this but, unfortunately, as Figures 3 to 10 show, the criterion was sensitive to problems associated with means. For example, chinchilla C1 at FT 15 had criterion intakes of 4, 6, 34, 25, 12, and 7ml. This met the stability criterion, but did not suggest a steady state. On the other hand, C2 at FT 15 showed 21, 17, 22, 16, 22, and 18ml criterion intakes and would be generally accepted as indicating a steady state.

Finally, another source of variability that may account for some of the differences between chinchillas and rats lies in the adequacy of schedule control under the deprivation and reinforcement parameters used. Chinchillas have not been studied extensively in positive reinforcement paradigms so that we cannot be confident that the values of pellet size and type, and other experimental conditions would yield comparable characteristic lever-pressing performances within and between subjects as are found in laboratory rats.

Experiment 2

Experiment 2 was a partial replication and expansion of the work of Staddon and Ayres (1975) who presented rats with an environment (Figure 1) where the selection, temporal patterning, and interactions among responses could be quantified. The present apparatus (see Figure 21) incorporated features of their's and provided opportunities for additional behavior. Chinchillas were again the subjects and were presented with both FT 30 and FI 30 schedules of food presentation. These interval lengths were chosen in order to compare the present data to those of Staddon and Ayres (1975).

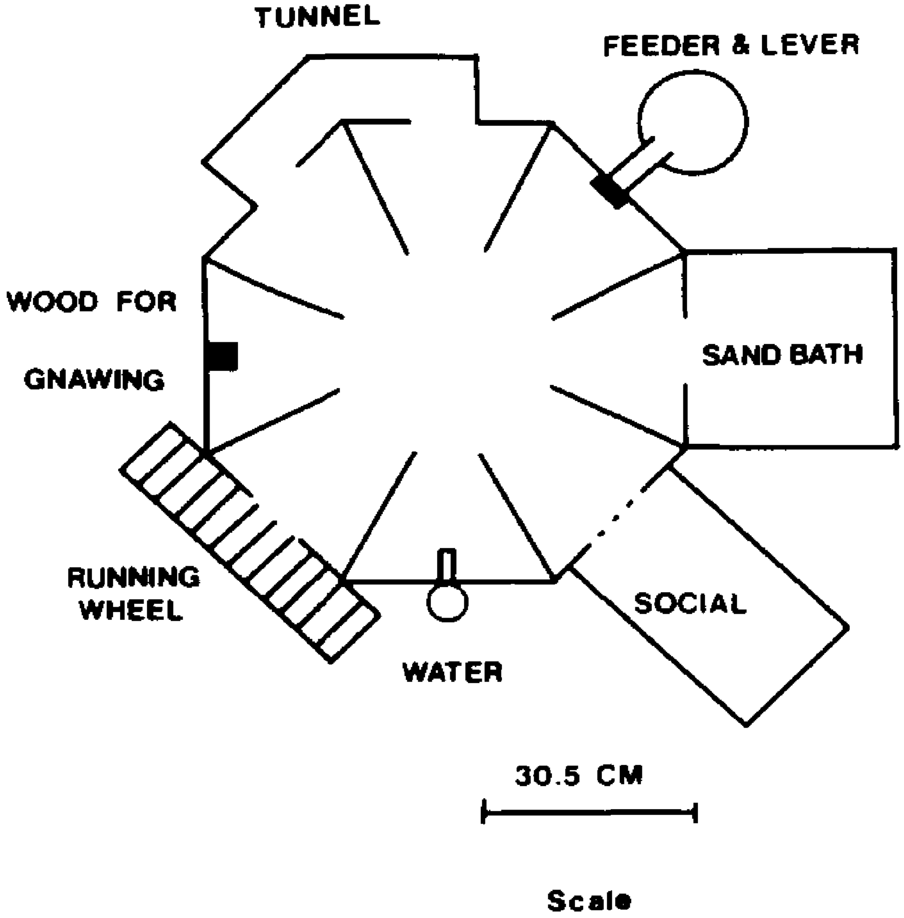
In this experiment the dependent measures examined were the time spent engaged in any particular activity, the temporal distribution of responding during the interpellet interval, and the sequencing of the response categories during the interpellet interval. The response categories were: feeding, sand bathing, socializing, drinking, running, gnawing, tunneling, and lever-pressing. A ninth category, other, included all other activities whose occurrences were not directly recorded by the apparatus.

Method

Subjects. The subjects were four experimentally naive male chinchillas (G4, G5, G7, G8), approximately

Figure Caption

Figure 21. Plan view of the apparatus based on the apparatus of Staddon and Ayres (1975) (see Figure 1).


TUNNEL
FEEDER & LEVER
WOOD FOR
GNAWING
SAND BATH
RUNNING
WHEEL
WATER
SOCIAL
30.5 CM
Scale

3 years of age, obtained from Kline Chinchilla Research Foundation, Utica, IL. The subjects weighed an average of 410 gms as determined over the last six days prior to deprivation. They were deprived to 80% of free feeding weight and maintained at that weight (±5%) for the duration of the experiment. The subjects were housed individually. Water, small white pine gnawing blocks, and salt rings were available at all times in the home cage. The subjects were maintained on a 12 hour light/dark cycle (light, 7:00 a.m.-7:00 p.m.). The animal facility was maintained at a temperature of 24 °C (±4 °C) for the duration of the experiment.

Apparatus. The apparatus was an octagonal Plexiglas-walled chamber divided into eight compartments and one common area by Plexiglas dividers which extend from the eight corners of the chamber toward the center. The sections contained access to (1) a dispenser of 45 mg standard Noyes pellets and a standard Grason Stadler rat lever (requiring a minimum of 25 gm to displace), (2) a sand bath area filled to a depth of one inch with fuller's earth, (3) a wire mesh-enclosed observation area where a subject could view and touch noses with a male conspecific, (4) a calibrated water bottle with a metal spout extending into the chamber, (5) a standard running wheel, (6) a 7-gm block of white pine mounted on an omnidirectional lever, and, (7) and (8), a tunnel that linked two sections together (see Figure 21). The entrances to the tunnel, sand bath, running wheel, and the social area were 10.2 cm in diameter and centered in each 30.5 cm square panel. The floor of the apparatus was a grid of stainless steel rods .31 cm in diameter and each separated by a space of 1.27 cm. They were supported 12.7 cm from the floor on aluminum pipe and rubber shock absorbers. The height of the apparatus was 30.5 cm and the compartment areas were all approximately 162.6 cm^2. The covering of the apparatus was also a stainless steel removable grid that was supported by the top of the apparatus. Responses were monitored electromechanically: feeding, drinking, and socializing were sensed by Grason Stadler contact relays; bathing by a Lafayette activity monitor (jiggle platform); tunneling by a microswitch placed under the tunnel floor and activated by the weight of the animal (at least 250 gm); running by photocells interrupted by the animal when it entered the wheel and for every revolution of the wheel; and wood gnawing by displacement of the omnidirectional lever. When the 45 mg Noyes food pellet was dispensed by either lever pressing on FI or freely when on FT, a compound cue was provided. This cue consisted of feeder operation, 1 s activation of a 12 W light bulb, and the operation of a

Grason Stadler pulse former set on multi-vibrator, producing a one second buzz.

House lights were two fluorescent lamps (Westinghouse 40 W) mounted in the ceiling of the room. Masking noise was 69 dB SPL supplied by a Grason Stadler white noise generator. The apparatus was monitored by a video camera mounted above and viewed on a monitor by the experimenter in another room. Contingencies were programmed by standard relay equipment located in another room. Responses were recorded on a 20-channel event recorder and a TRS 80 model III computer. A program was written that would record the amount of time spent in an activity and the sequencing of activities (see Appendix B).

Procedure. Table 8 shows the different conditions of the experiment, their order, and the number of sessions under each condition.

Baselines. When all four chinchillas reached 80% of their free feeding weights their daily water intake was monitored until the difference between the mean of the first three and second three of six consecutive days was no more than 10% of the mean for all six days. After this home cage baseline was satisfied the subjects were placed in the apparatus for 25 minute sessions with 50 free food pellets available in the feeder (baseline 1). These sessions were run seven days a week between the hours of 10:30 a.m.-12:30 p.m. When the frequency of switching between response opportunities for the entire session satisfied the stability criterion (regardless of what responses the subjects engaged in), the subjects were continued in baseline 1 until all subjects satisfied the criterion (this took 17 sessions). After baseline 1 was satisfied by all the subjects were placed in the apparatus with no pellets available. This was baseline two and has been suggested by Roper (1981) as being necessary for determining the presence of a schedule-induced behavior.

Schedules. After stability was obtained on the above two baselines, subjects were placed on FT 30 for 100 sessions of 50 pellets each. Ten 25-min. sessions of extinction (no food, no cues) followed. The subjects were then trained to lever press in the apparatus. At this time all other compartments were closed off. Once the subjects met the stability criterion on FI 30, the compartments were then reopened and 100 sessions of FI 30 were run; followed by another 10 sessions of extinction.

Operational definitions.

The arena apparatus provided for nine response categories: lever pressing, contacting the feeder, any activity in the sandbox, visiting the conspecific (social activity), contacting the water spout, running in the activity wheel, operating the omnidirectional lever on which the wood for gnawing was mounted, and entering the tunnel a sufficient distance to close the microswitch mounted under the center part of the floor, or doing none of the above. These categories are identified in the figures and tables as, respectively, lever (L), feeder (F), bath (B), water (W), socializing (S), running (R), tunnel (T), wood gnawing (Wd), and other (O). The principal dependent variables are: 1) the proportion of succesive 6-sec segments (bins) of the interpellet interval in which the response category occurs at least once, 2) the duration of involvement in each category as a proportion of the total session time, 3) the probability that response category x will be followed by response category y within each IPI, 4) the weight of water ingested during each session, and 5) the number of wheel revolutions, water contacts, feeder contacts, lever presses, and tunnel entries.

The method by which the duration data for the activities was obtained needs some clarifying. The data for the duration of any activity were obtained from the record of the Esterline Angus chart recorder. This was read by eye with the help of a ruler. Feeding, drinking, and tunneling durations were recorded as continuous recorder pen displacements. Running, socializing, and bathing were more difficult to measure since the subject could enter these areas without actually performing the consummatory response. The measurement of these three activities included not only a detector for the entry into and out of the compartment but detectors for the actual response. Thus, distinguishing between being in the running wheel and sitting (for example) compared to running, which was being in the wheel with the wheel revolving. The same is true for bathing and socializing. The subject had to be in the appropriate compartment and activating the jiggle platform (bathing), or in the social area and contacting the conspecifics cage. This solved the problem of determining sucsessive bouts of a response in that time spent in an activity compartment can be differentiated from actually engaging in the activity. Being in a compartment without engaging in the consummatory response was considered to fall into the "other" category.

The lever press response and the omnidirectional lever produced pulses which were recorded on the chart recorder. A bout of lever pressing was defined as lever pressing with no interresponse times (IRTs) greater than 2 s. Isolated lever presses (those with IRTs greater than 2 s were considered to have a duration of 1 s. Other behavior was determined as the session time left after all the other opportunities were summed.

Results

Baselines.

Figures 22-29 show the mean percentage of session time engaged by the nine response categories for the two baseline conditions. Baseline 1 had 50 food pellets placed in the food magazine at the start of the session. All subjects ran and visited the sand box. As expected there was feeder-directed behavior for all animals but this never exceeded 10%, and all other response opportunities (except "other") remained below 5%. Drinking occured only in G7. In baseline 2 (no pellets) all subjects continued to engage in bathing and running. G5 spent 78% of its session running while G7 spent 25% of the session time active in the sand box. No available response category except "other" occurred above 5%. Table 9 summarizes Figures 22-29. It shows the percentage involvement in each category for both baselines. Involvement times of less than 1% are not shown but are represented as a dash.

In the multiresponse arena the frequencies of switching from some current response to the next response was recorded. The frequency of these switches was converted into conditional probabilities of switching to one response given a prior response. For example, a subject receives a food pellet and then has

Figure Caption

<u>Figure 22</u>. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G4, derived from the last six sessions of baseline 1.

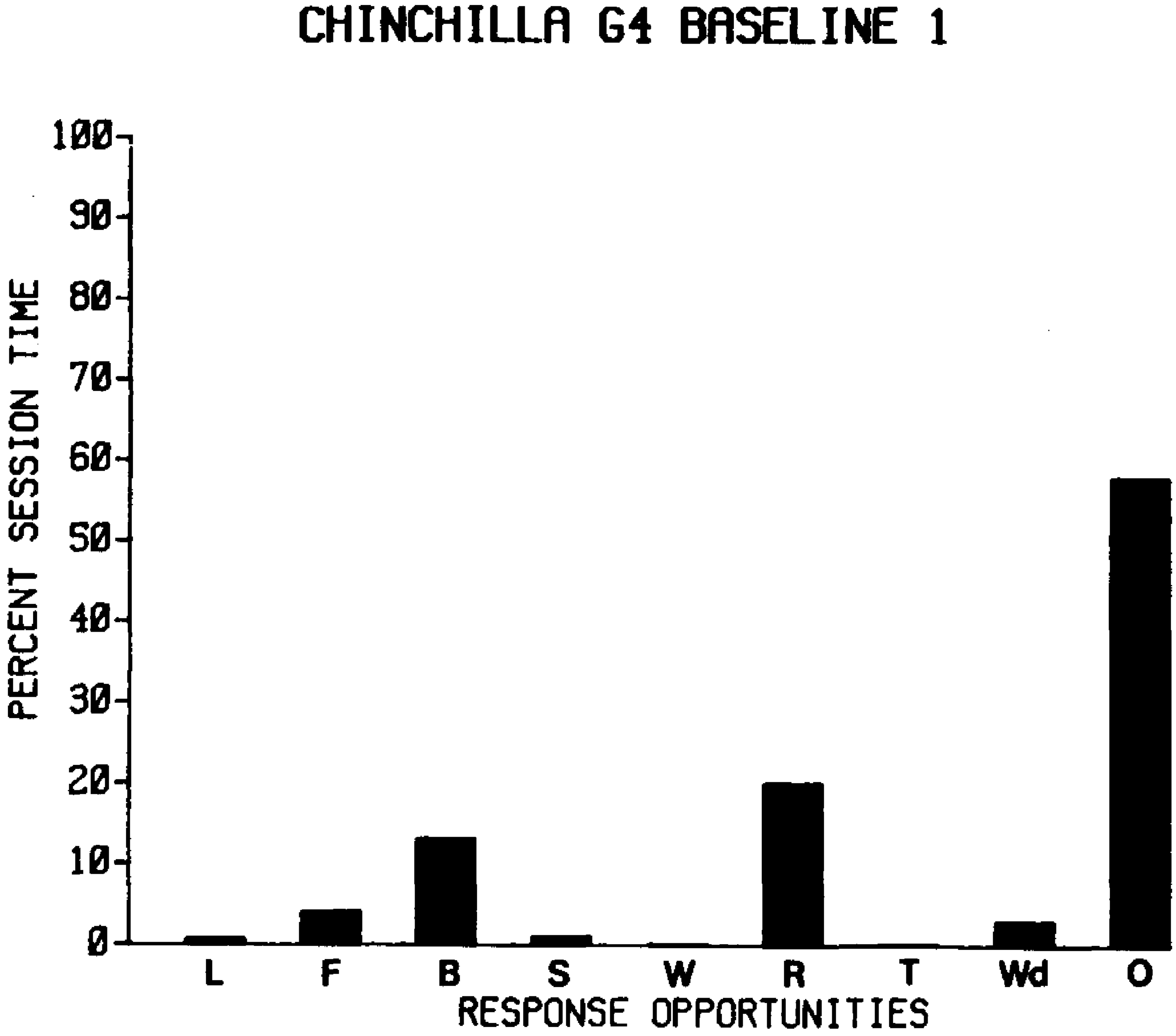

CHINCHILLA G4 BASELINE 1
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

Figure Caption

Figure 23. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G5, derived from the last six sessions of baseline 1.

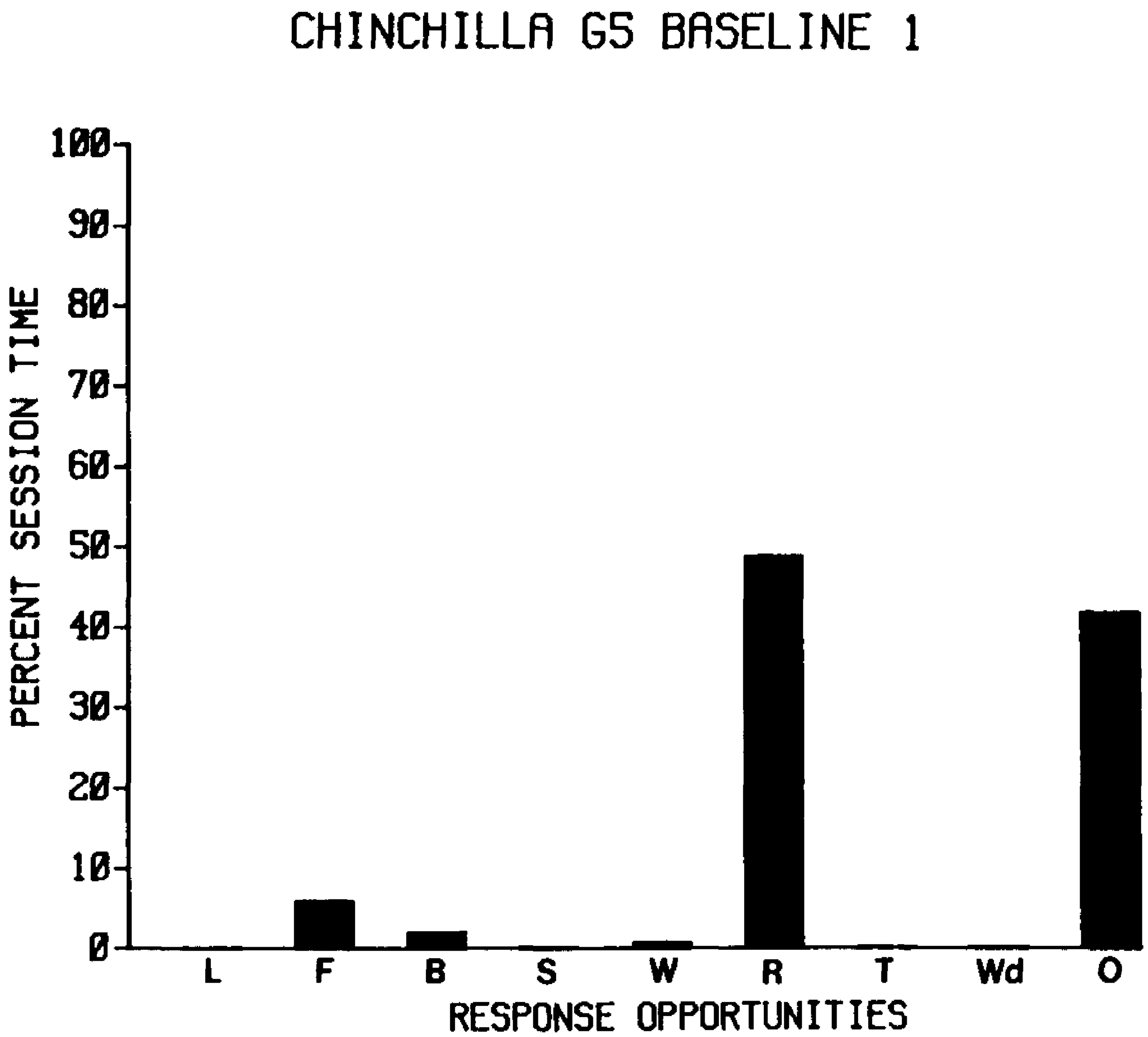
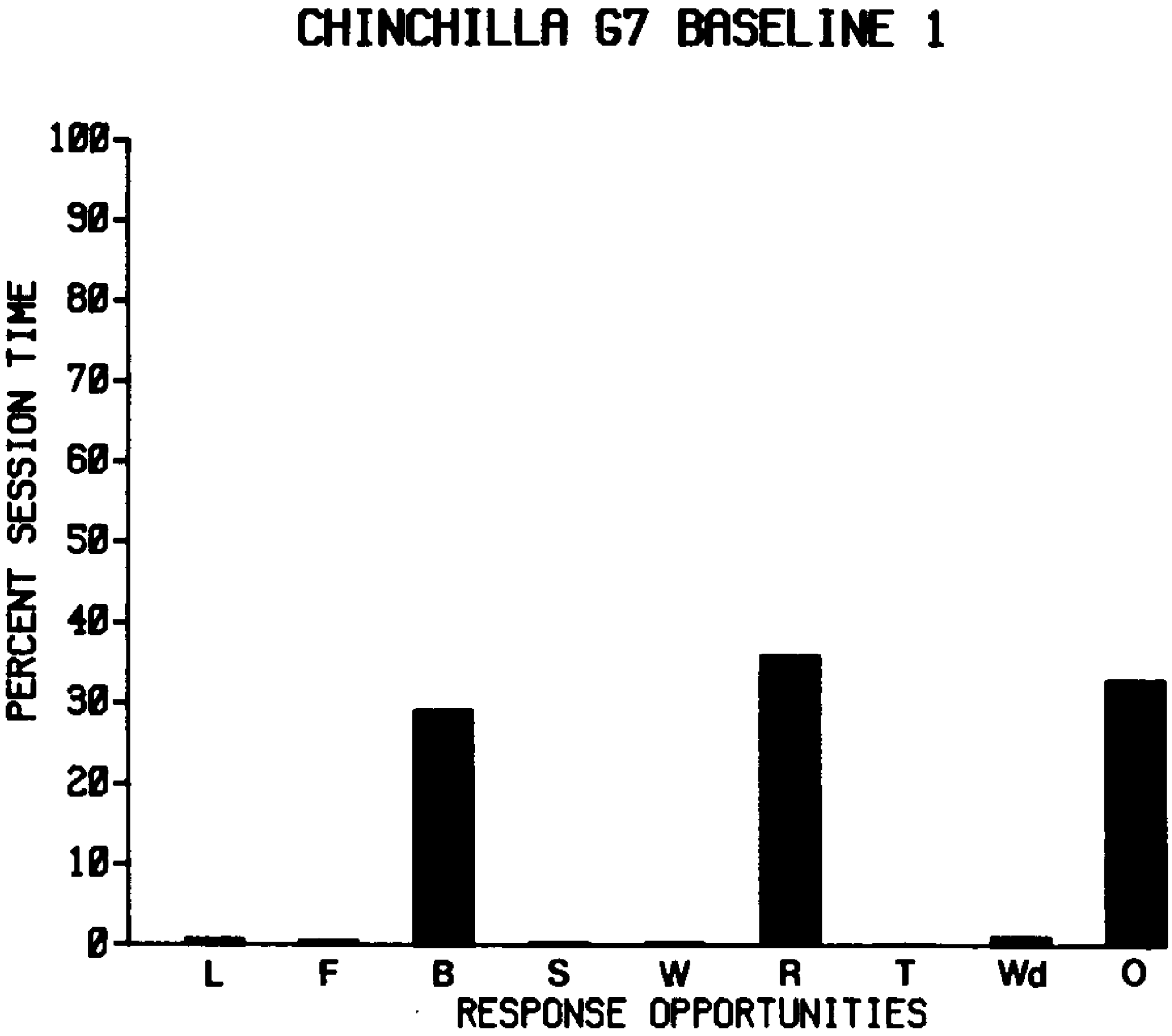

CHINCHILLA G5 BASELINE 1
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

Figure Caption

Figure 24. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G7, derived from the last six sessions of baseline 1.



CHINCHILLA G7 BASELINE 1
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

Figure Caption

Figure 25. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G8, derived from the last six sessions of baseline 1.

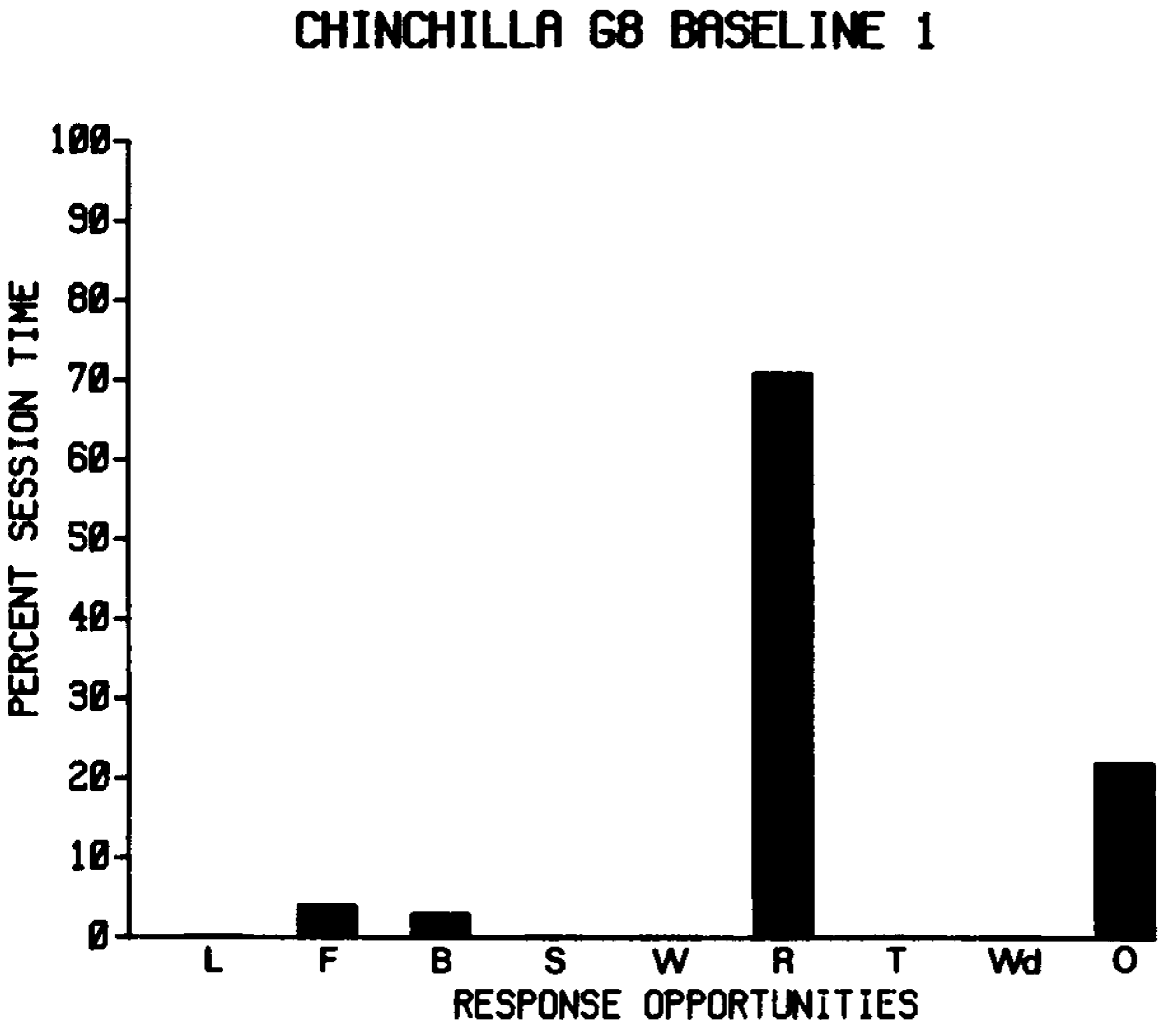

CHINCHILLA G8 BASELINE 1
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

Figure Caption

Figure 26. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G4, derived from the last six sessions of baseline 2.

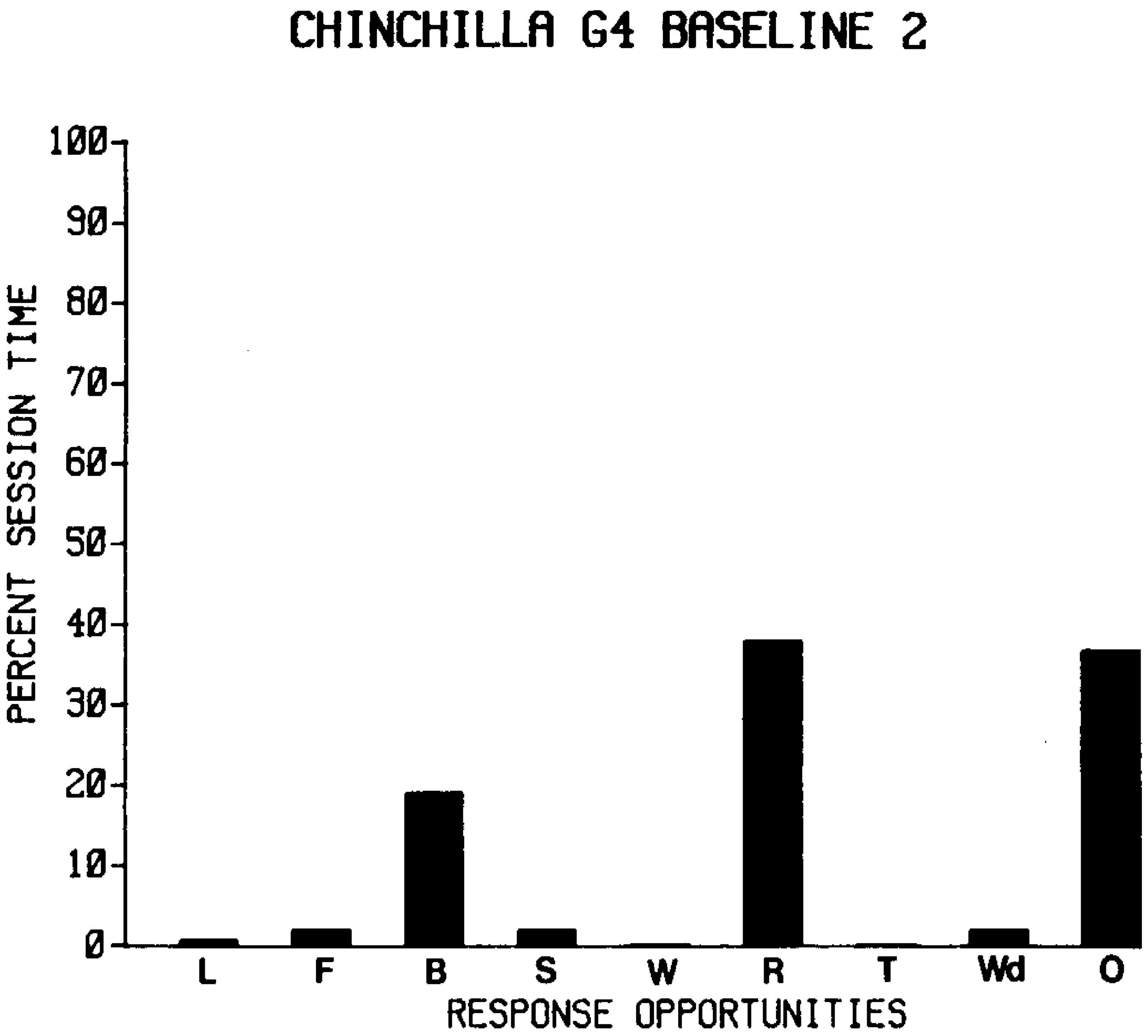

CHINCHILLA G4 BASELINE 2
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

Figure Caption

Figure 27. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G5, derived from the last six sessions of baseline 2.

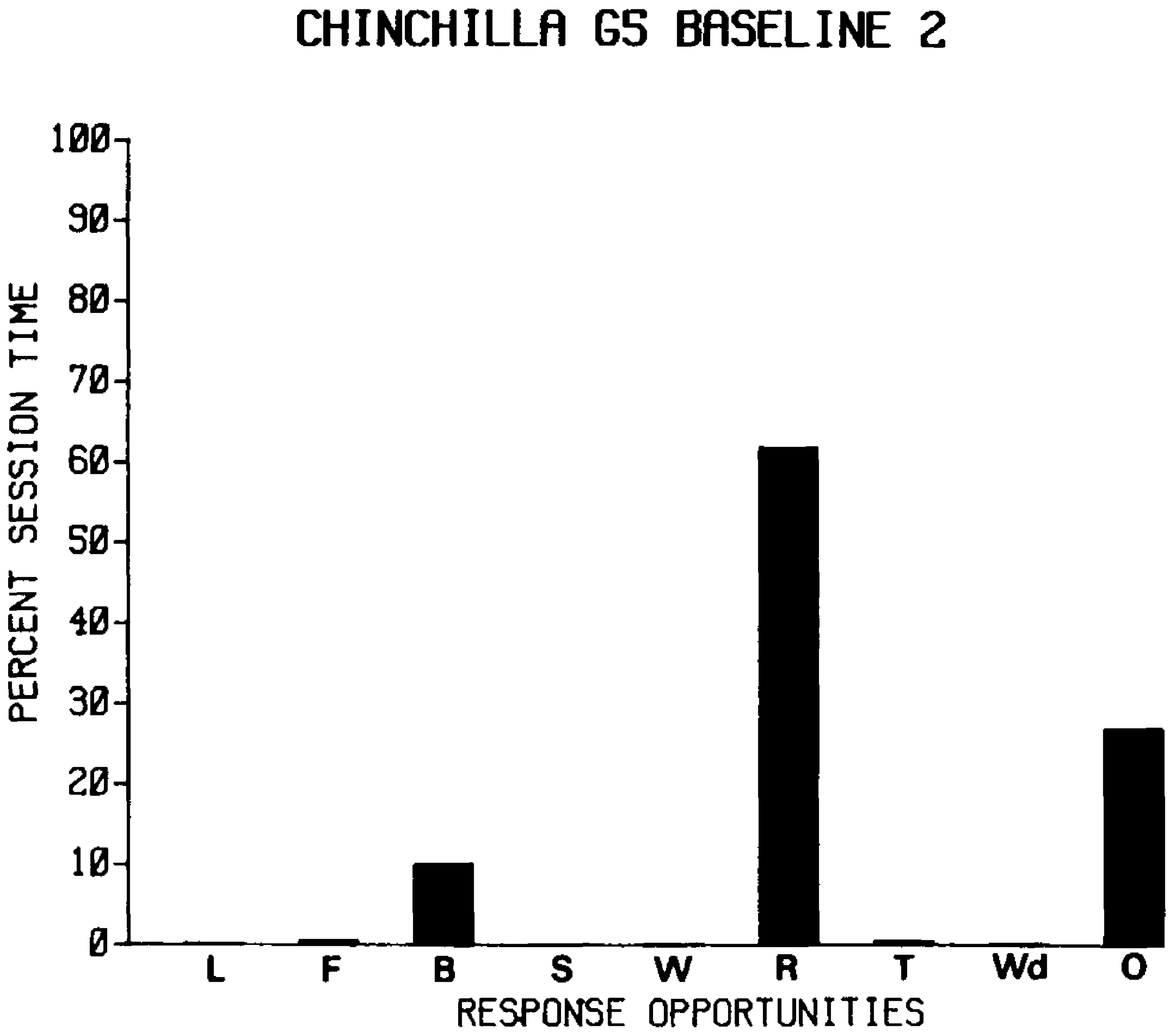

CHINCHILLA G5 BASELINE 2
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

Figure Caption

Figure 28. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G7, derived from the last six sessions of baseline 2.

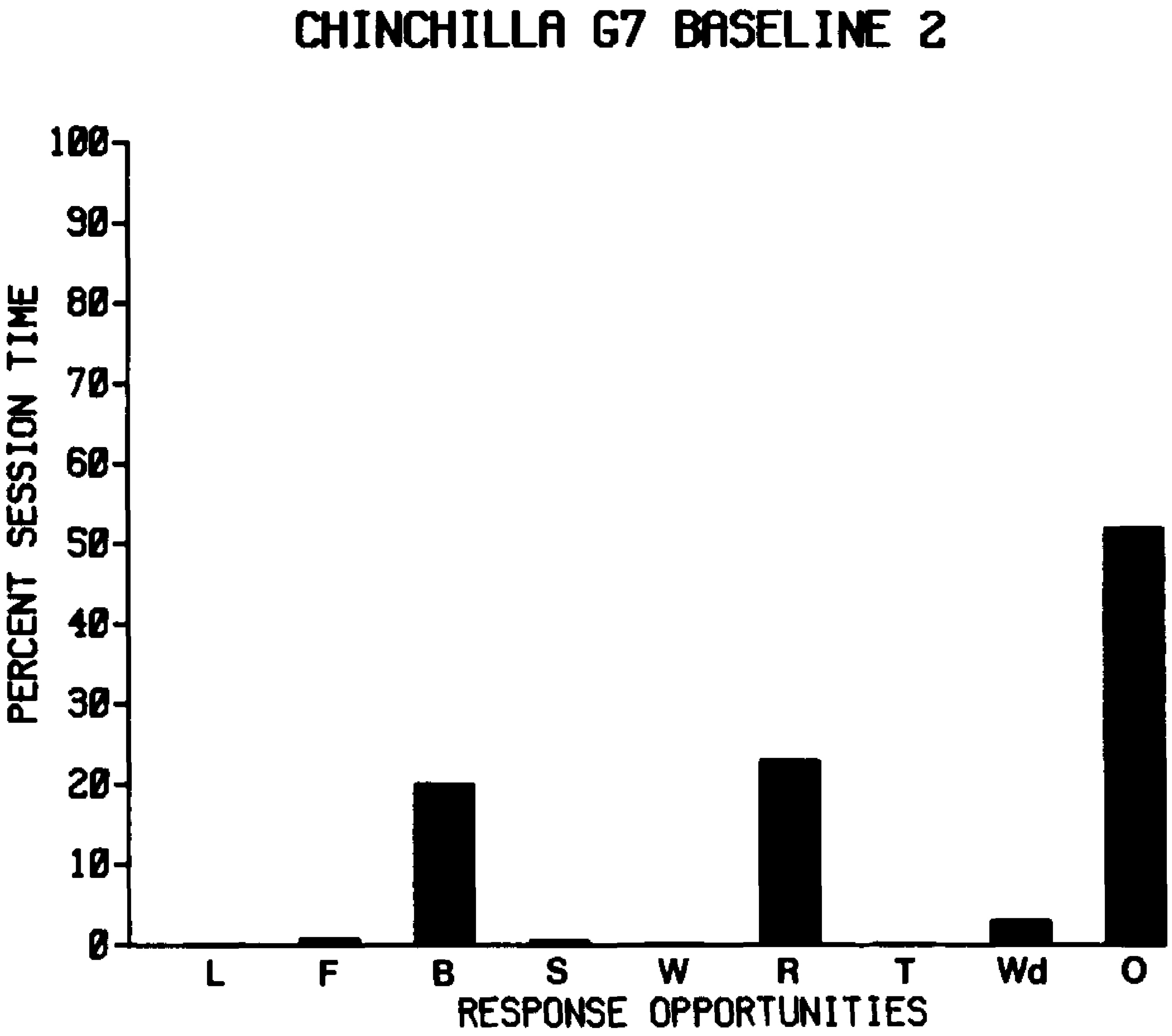
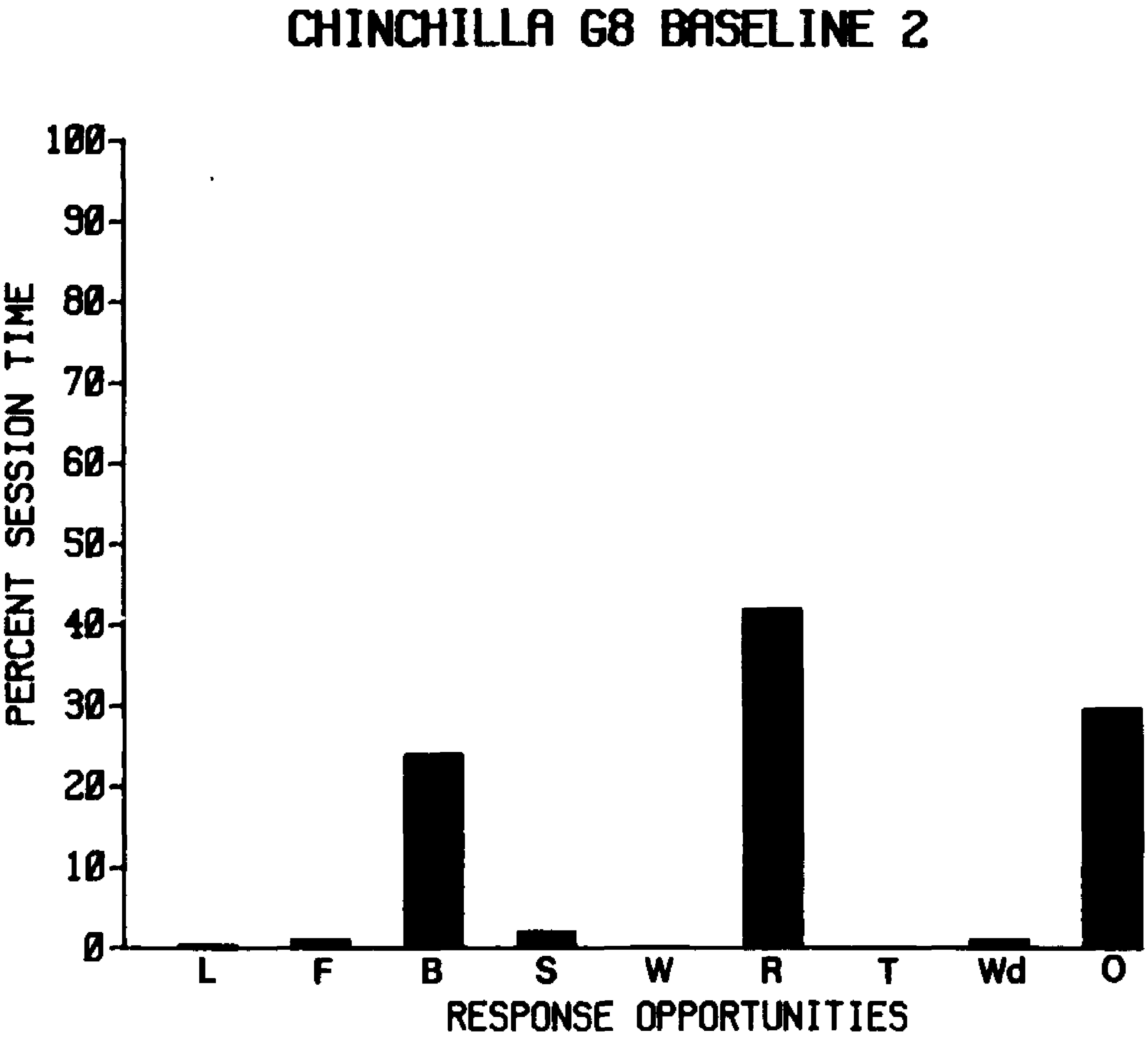

CHINCHILLA G7 BASELINE 2
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

Figure Caption

Figure 29. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G8, derived from the last six sessions of baseline 2.


CHINCHILLA G8 BASELINE 2
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

a choice of engaging in any of the eight monitored responses or some "other" (unrecorded) response. If after obtaining a pellet the subject always went to the water bottle and drank, we would say that drinking occurred with a probability of 1.00 given feeding. Once the subject finished drinking, it again had the choice of eight opportunities and so on. For the purpose of tracking a sequence, an activity was considered over when the next recordable activity began.

Figures 30-37 show the mean percentages of switching between responses during the six criterion sessions of baselines 1 and 2. Only percentages based on switches that occurred with a frequency of 10 or more per session were included in the figures. Appendix C shows the complete tables of probabilities that the figures are based on regardless of absolute frequency.

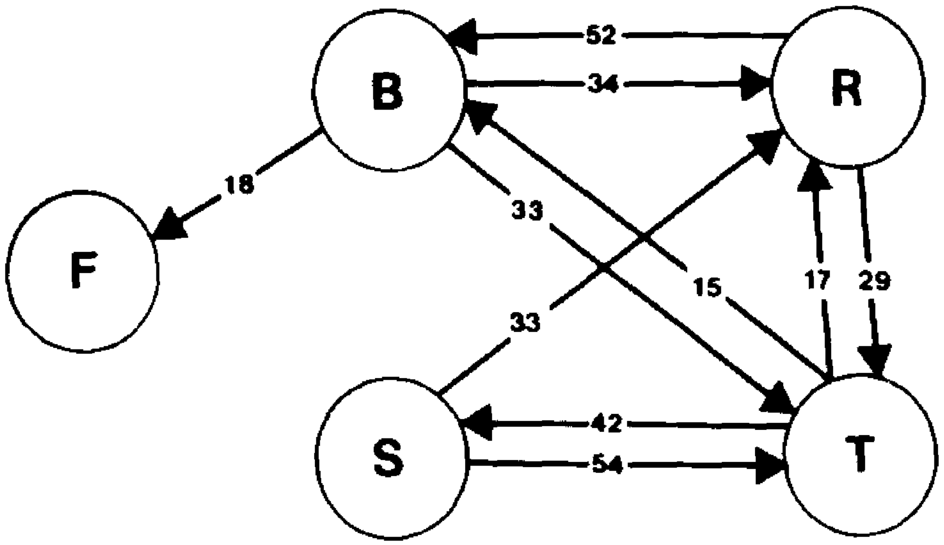
During baseline 1 the subjects were allowed free access to the arena with 50 food pellets available. During these sessions subjects switched primarily between running and sand bathing. In a second baseline, with no food pellets, subjects continued to switch between running and bathing (see Figures 30-37).

Fixed time.

After the two baseline conditions FT 30 was begun.

Figure Caption

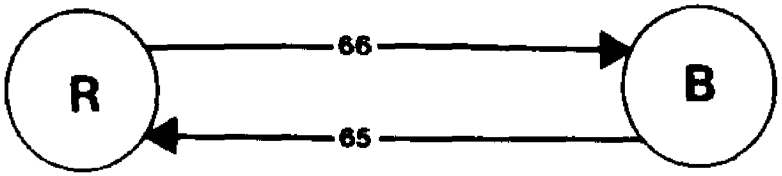
Figure 30. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G4 during baseline 1 (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G4 BASELINE 1

Figure Caption

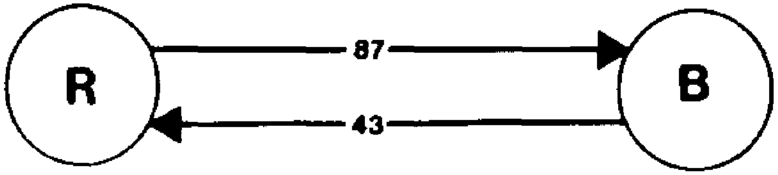
Figure 31. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G5 during baseline 1 (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G5 BASELINE 1

Figure Caption

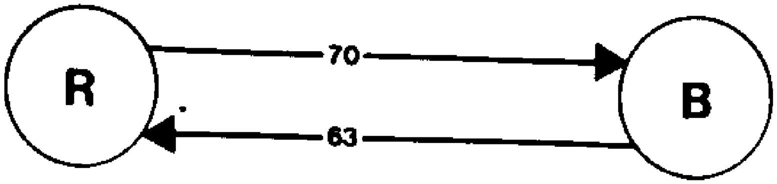
Figure 32. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G7 during baseline 1 (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G7 BASELINE 1

Figure Caption

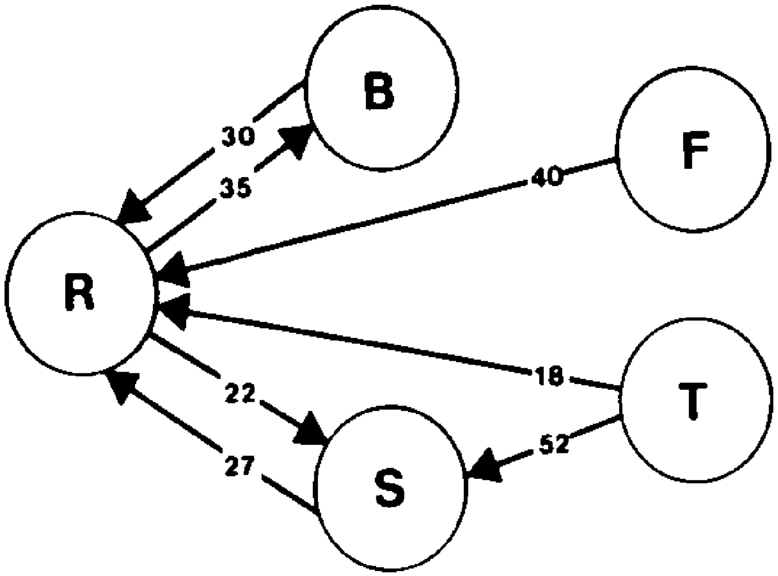
Figure 33. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G8 during baseline 1 (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G8 BASELINE 1

Figure Caption

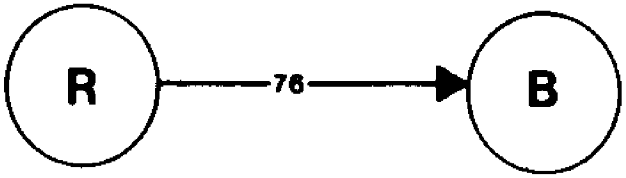
Figure 34. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G4 during baseline 2 (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G4 BASELINE 2

Figure Caption

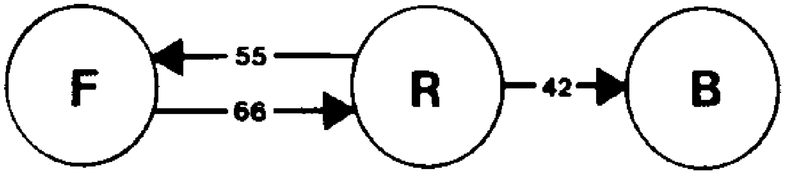
Figure 35. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G5 during baseline 2 (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G5 BASELINE 2

Figure Caption

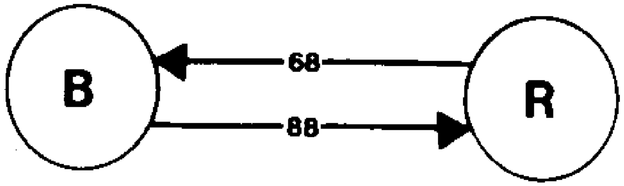
Figure 36. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G7 during baseline 2 (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G7 BASELINE 2

Figure Caption

Figure 37. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G8 during baseline 2 (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G8 BASELINE 2

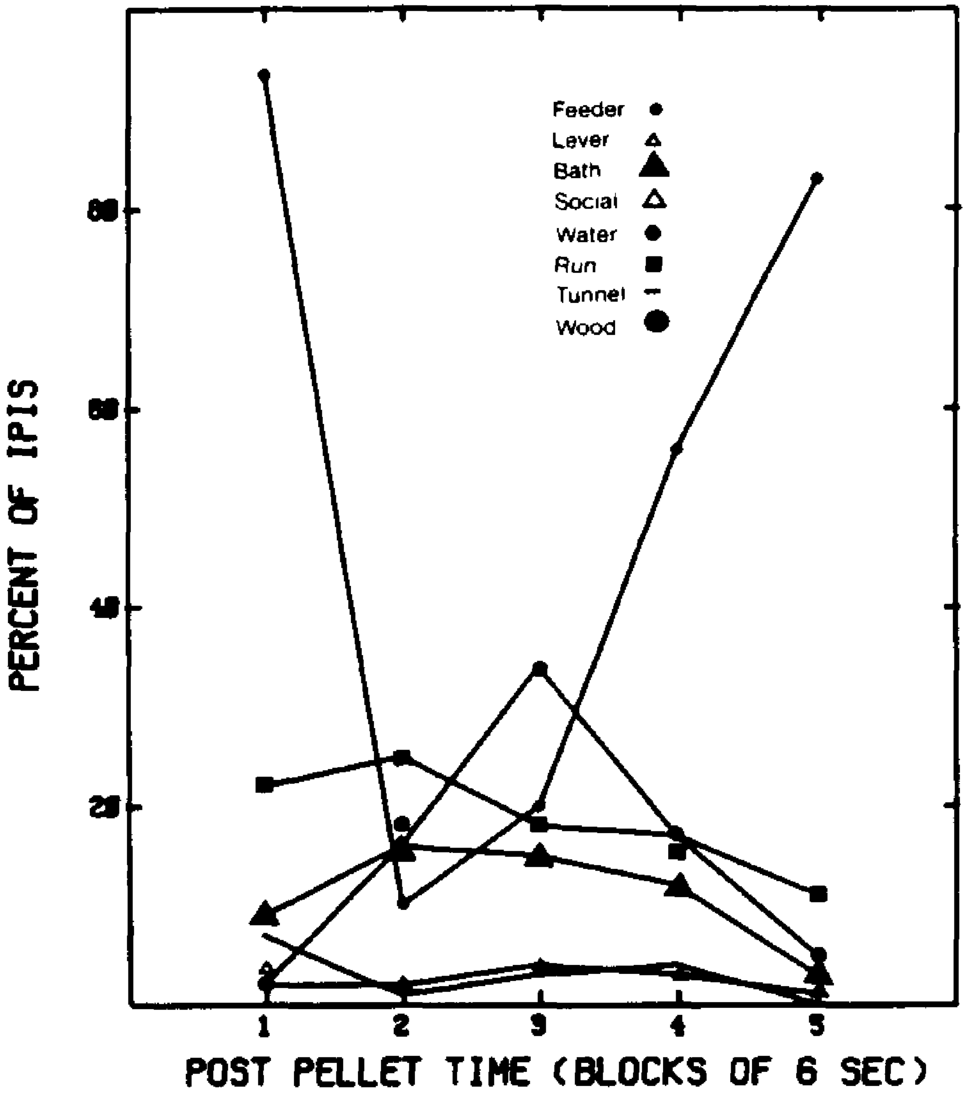
Figures 38-41 show the percentage of interpellet intervals containing any of the eight responses as a function of postpellet time during FT 30 (It can be seen that the sum of percentages within a bin can exceed 100% because the subject can visit more than one compartment in each 6-sinterval.). All subjects were found in the feeder area shortly after and just before pellet delivery. G5 was in the feeder area in 99% of the intervals regardless of postpellet time. G8 was in the feeder area at the end of the intervals, but instead of feeder directed responses it would lever-press which had no programmed consequences.

With respect to running and drinking, G7 ran in one quarter of the intervals in the first 6 s postpellet and this declined to 18% in the last 6 s postpellet. Drinking increased to a maximum in the middle of the interval and then declined. G4 and G8 also showed this same general pattern of running in greater than 20% of the intervals in the first 6 s with a general decline toward the end of the interval. Drinking also followed a increase to the middle of the interval and then decreased. Bathing fluctuated between 8% and 17% of the IPIs. All remaining response categories never exceeded 10%.

With respect to the duration of activities on FT 30, Figures 42-45 show the percent session time engaged

Figure Caption

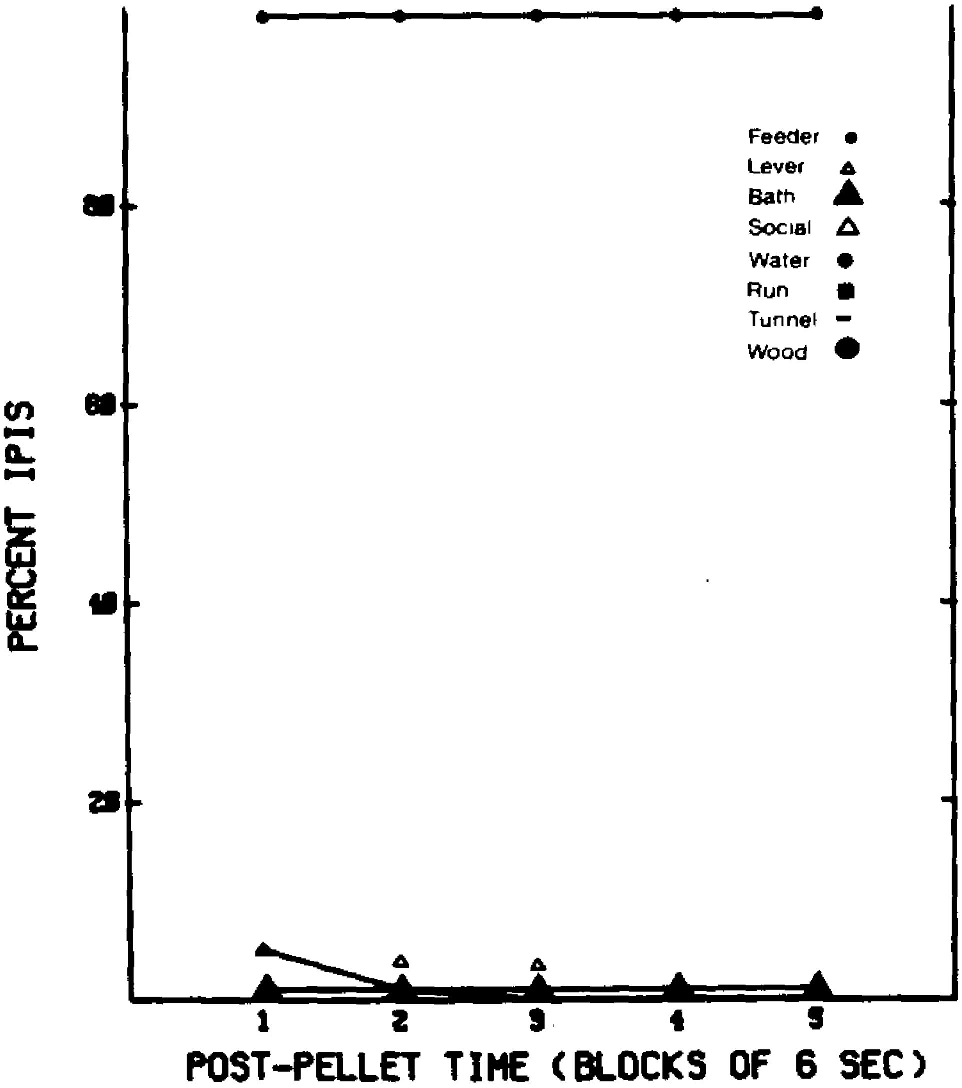
Figure 38. Percent of interpellet intervals (IPIs) containing at least one occurrence of any of eight responses as a function of six-second blocks of post-pellet time for subject G4 on FT 30. Overlapping points were offset to increase the clarity of the figure.



CHINCHILLA G4 FT 30 SEC

Figure Caption

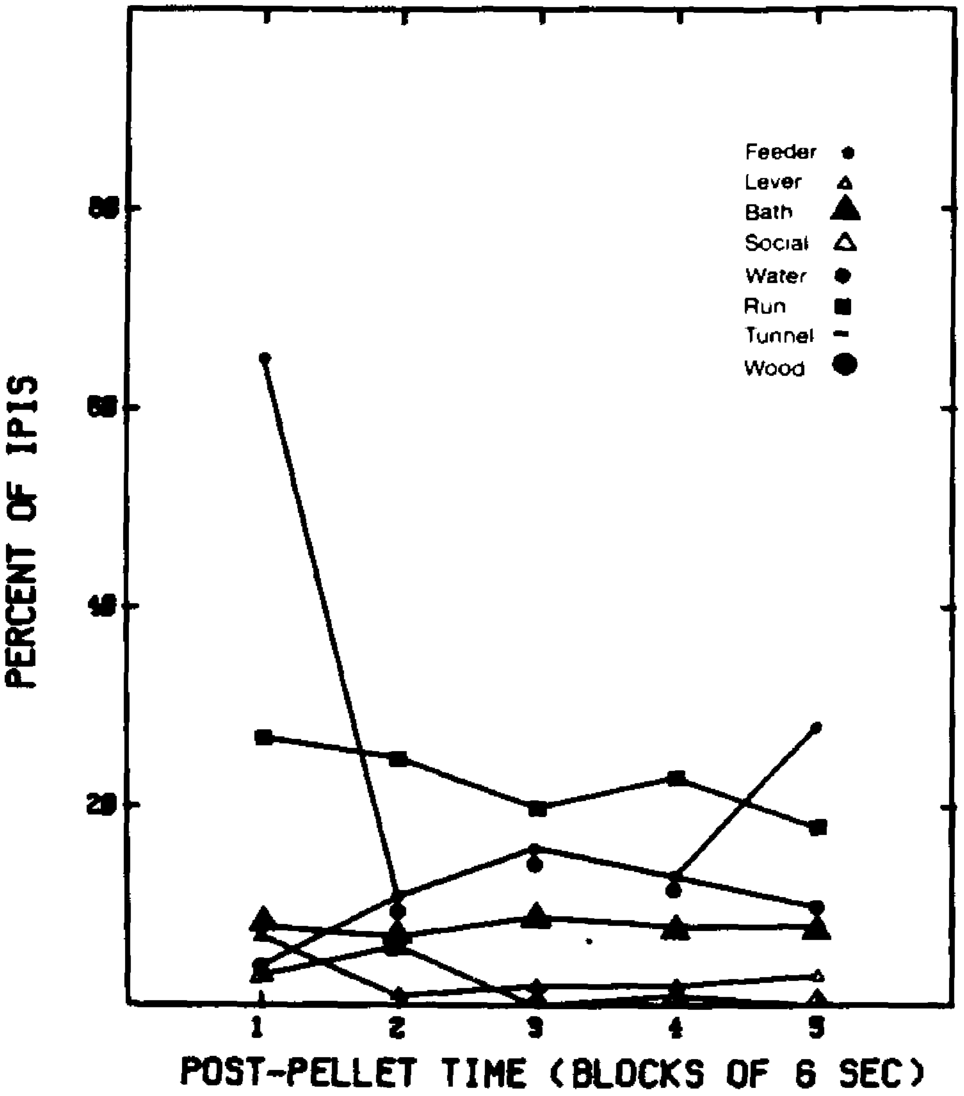
Figure 39. Percent of interpellet intervals (IPIs) containing at least one occurrence of any of eight responses as a function of six-second blocks of post-pellet time for subject G5 on FT 30. Overlapping points offset to increase the clarity of the figure.



CHINCHILLA G5 FT 30 SEC

Figure Caption

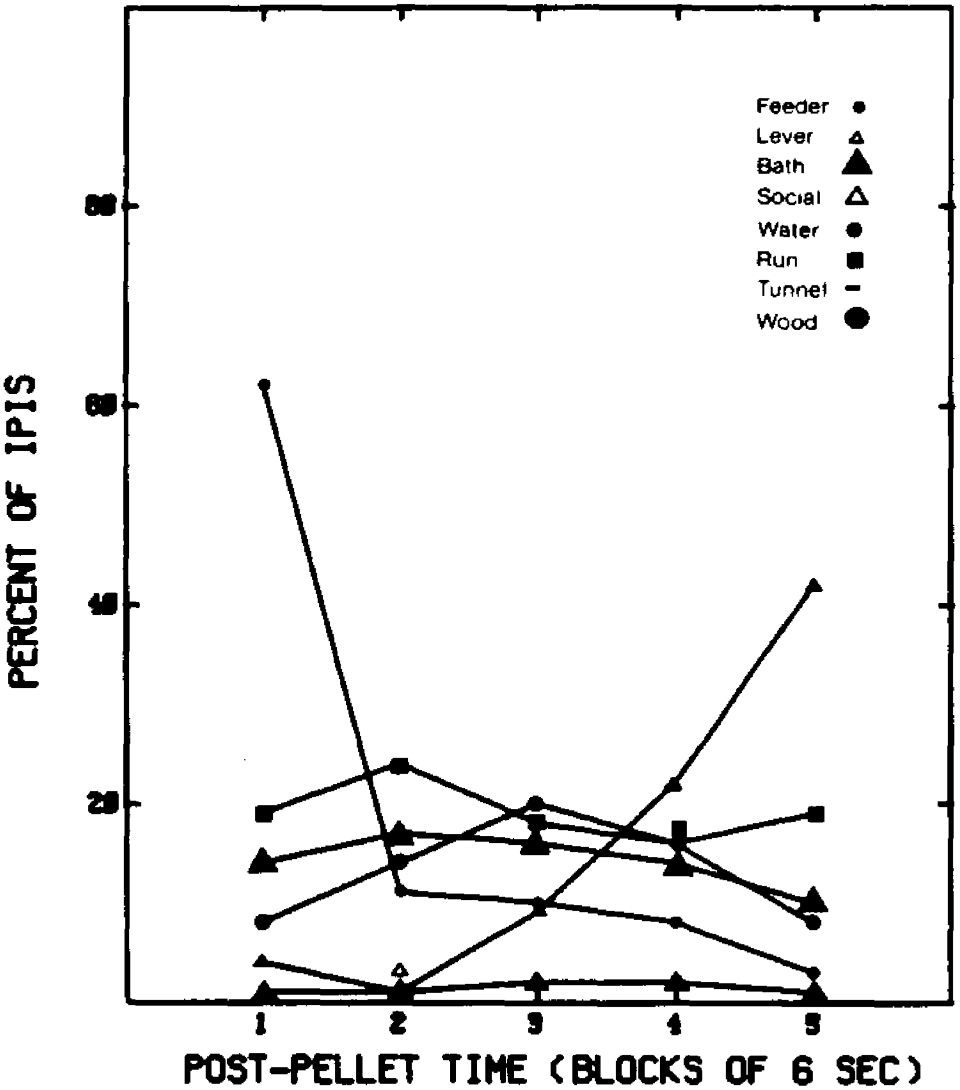
Figure 40. Percent of interpellet intervals (IPIs) containing at least one occurrence of any of eight responses as a function of six-second blocks of post-pellet time for subject G7 on FT 30. Overlapping points were offset to increase the clarity of the figure.



CHINCHILLA G7 FT 30 SEC

Figure Caption

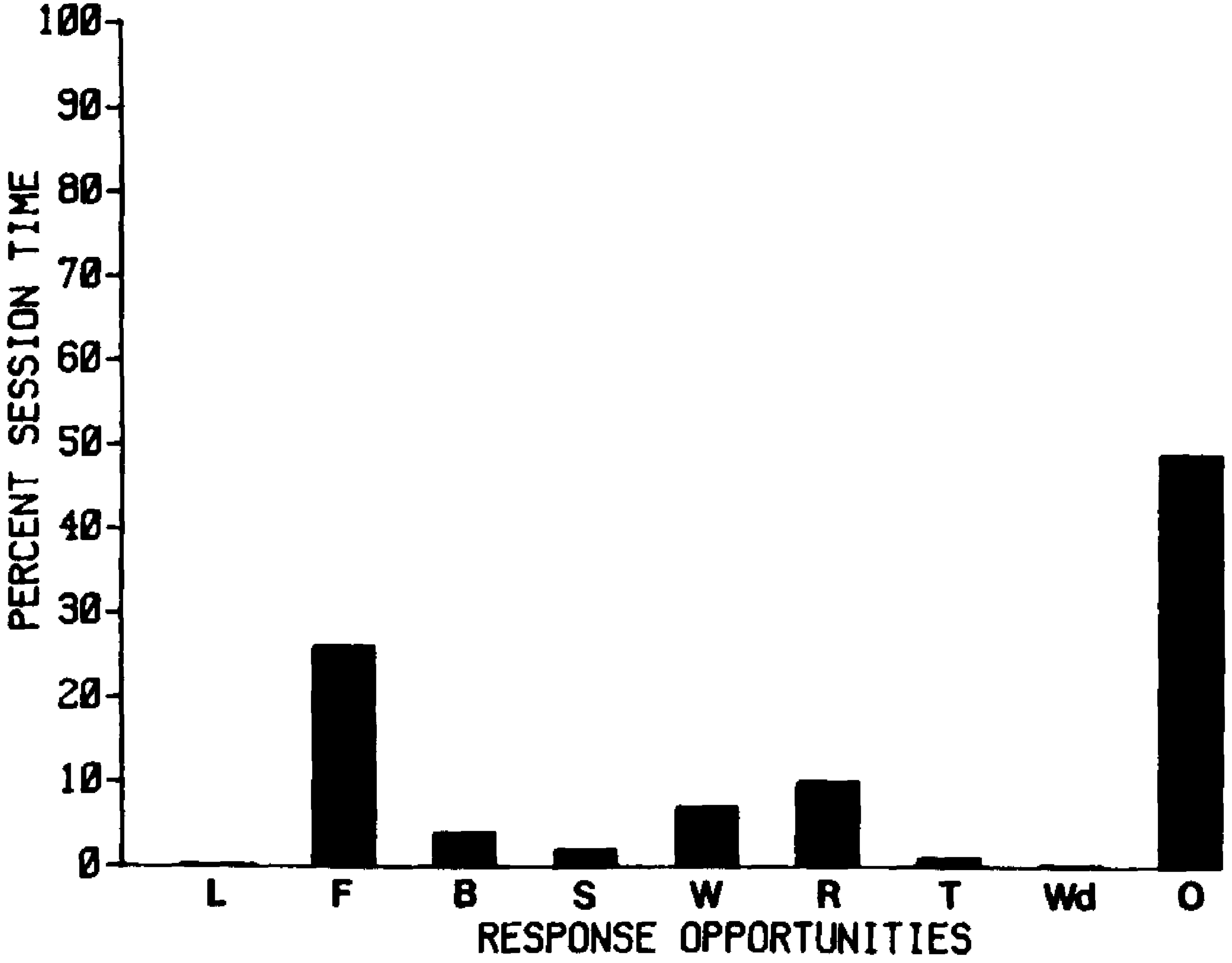
Figure 41. Percent of interpellet intervals (IPIs) containing at least one occurrence of any of eight responses as a function of six-second blocks of post-pellet time for subject G8 on FT 30. Overlapping points were offset to increase the clarity of the figure.



CHINCHILLA G8 FT 30 SEC

Figure Caption

Figure _42_. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G4, derived from the last six sessions of FT 30.



CHINCHILLA G4 FIXED TIME 30 SEC

Figure Caption

Figure _43_. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G5, derived from the last six sessions of FT 30.

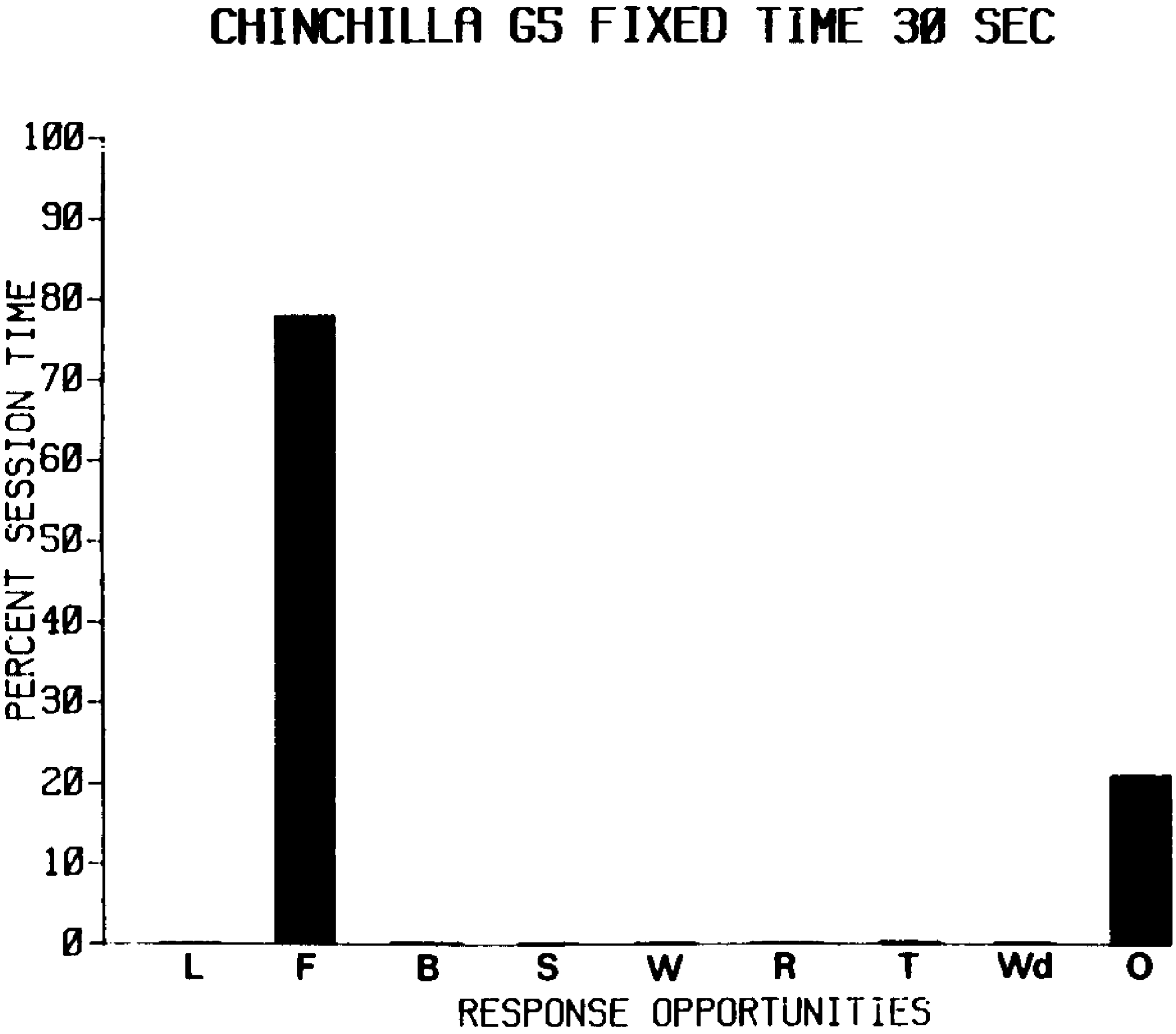

CHINCHILLA G5 FIXED TIME 30 SEC
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

Figure Caption

Figure 44. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G7, derived from the last six sessions of FT 30.

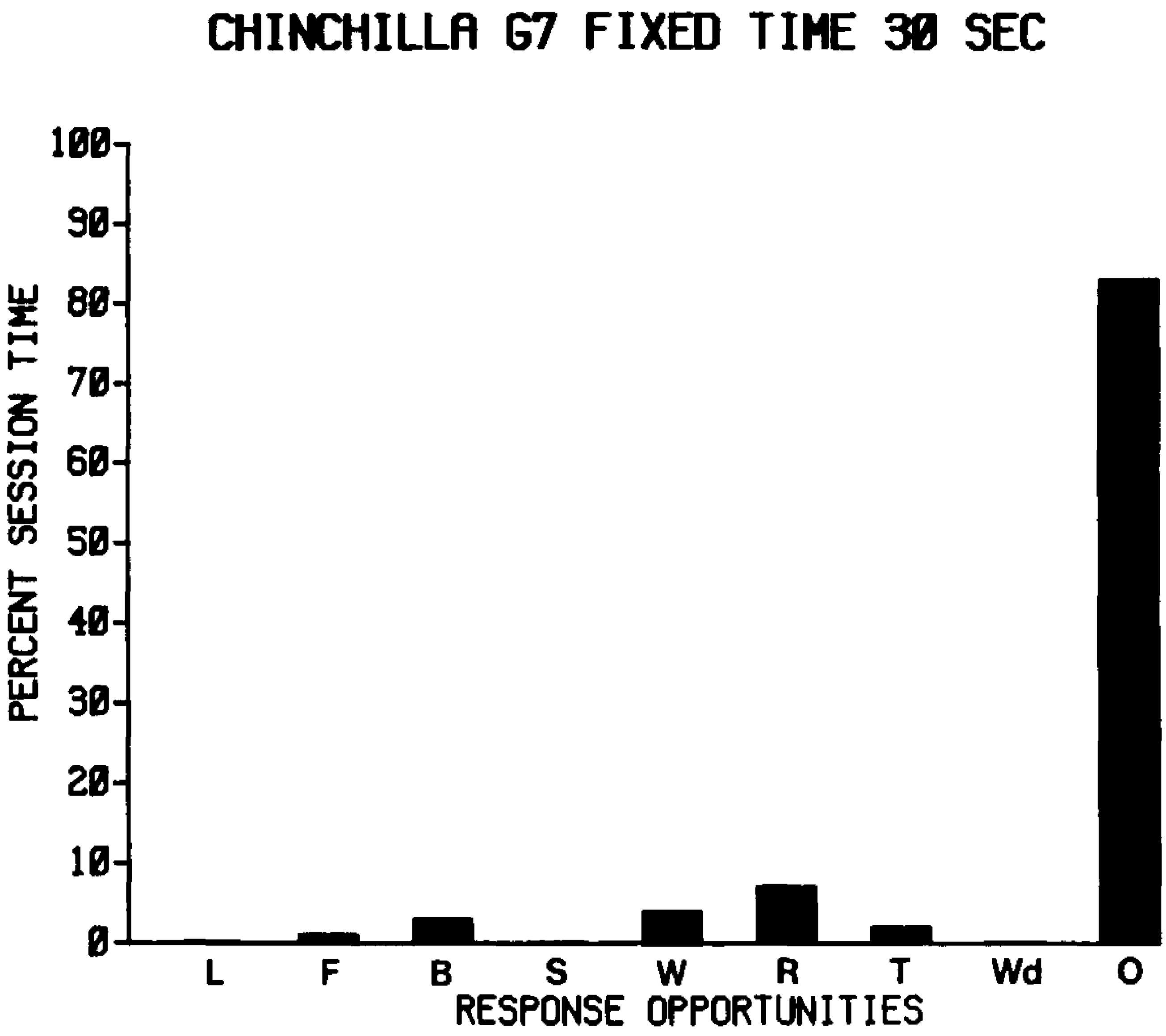
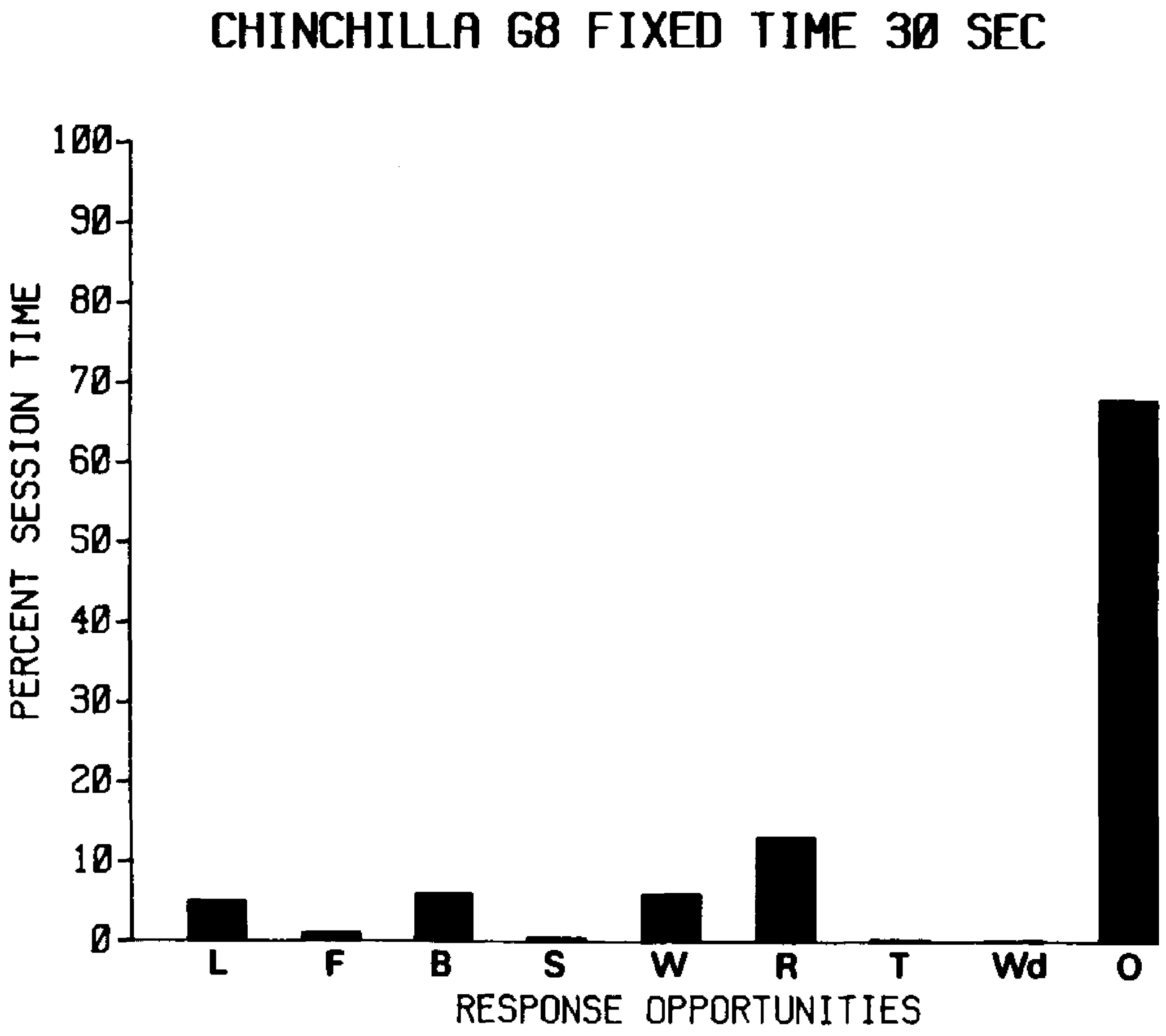

CHINCHILLA G7 FIXED TIME 30 SEC
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

Figure Caption

Figure 45. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G8, derived from the last six sessions of FT 30.


CHINCHILLA G8 FIXED TIME 30 SEC
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

in the nine response categories. G5 spent 78% of its session time in feeder-directed responding. For the other three subjects the variety of responses engaged in increased but the amount of time spent in the previously most common responses (running and bathing) decreased. In fact, only feeding in G4 and G5, and running in G8 occurred above 10%. Drinking was present in G7, G4 and G8, and was polydipsic in nature when compared to the two baseline levels.

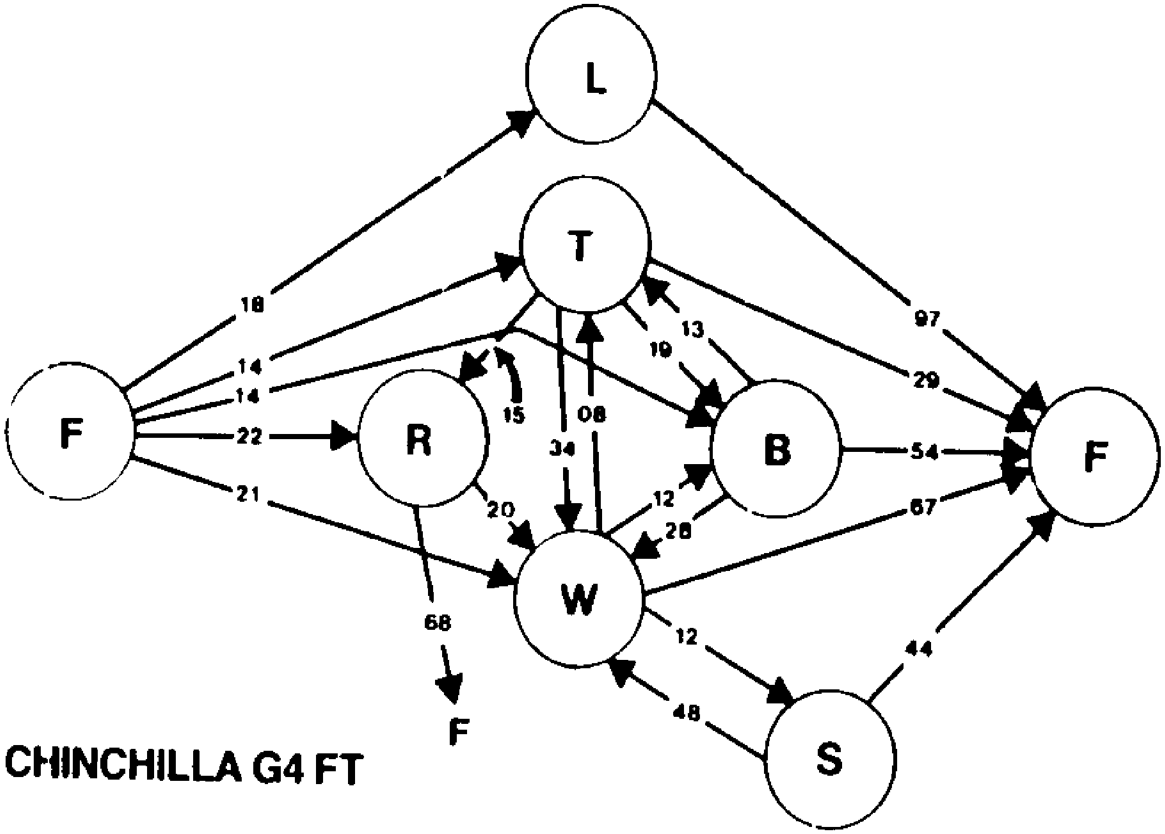
When the FT schedule was instituted, subjects began to show feeder-directed behavior ("food anticipation"). Figures 46-49 show that subjects would leave the feeder area after obtaining a pellet and engage in one other response before returning to the feeder (G4 was an exception). The probability of switching from the feeder to the second activity was always smaller than the probability of switching from that activity back to the feeder. The high probability responses were bathing, drinking, and running for G7, G4 and G8 plus tunneling for G7 and G4. G5 only alternated between the feeder and the lever.

Fixed interval.

Figures 50-53 show the percentage of IPIs with any of eight response categories for the FI 30 condition. For G7, G4 and G8 the first response postpellet was feeding. Lever-pressing replaced feeder-directed

Figure Caption

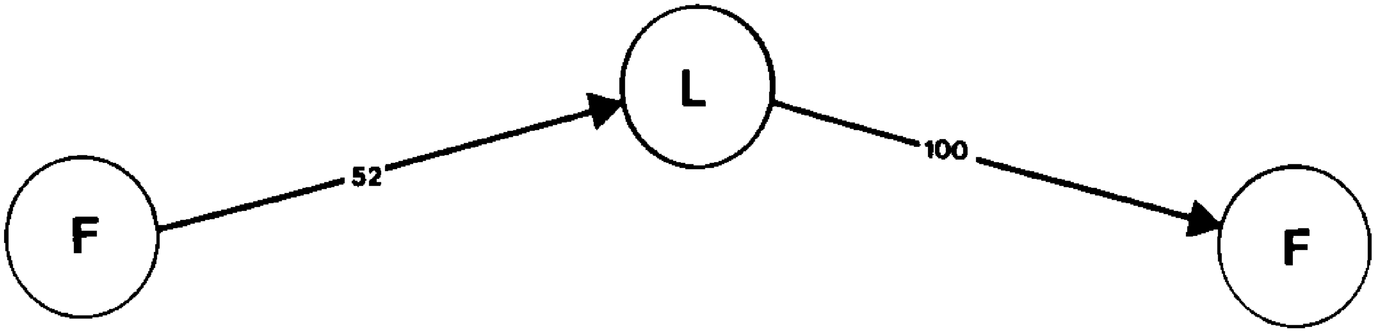
Figure 46. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G4 during FT 30 (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G4 FT

Figure Caption

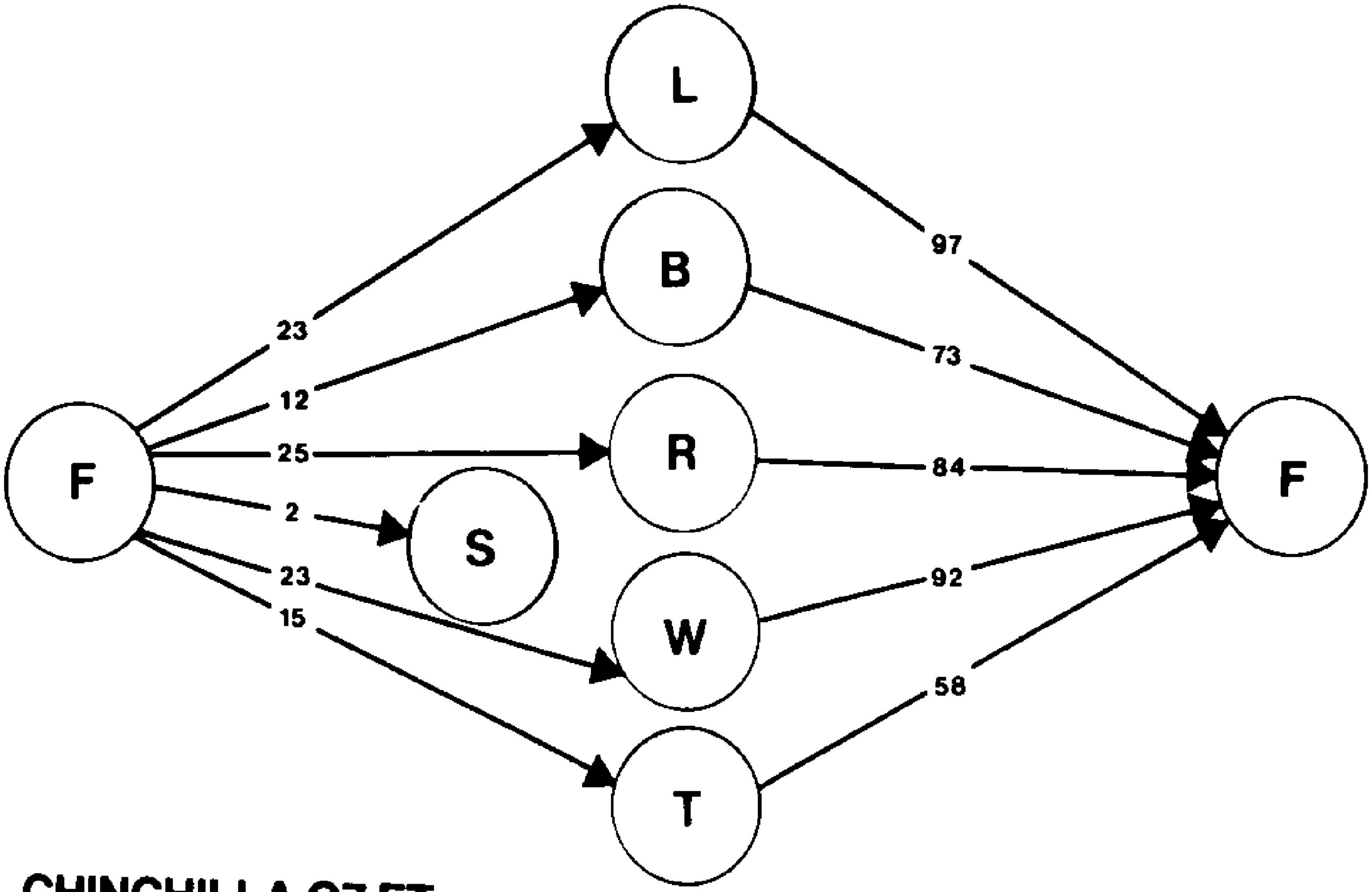
Figure 47. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G5 during FT 30 (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G5 FT

Figure Caption

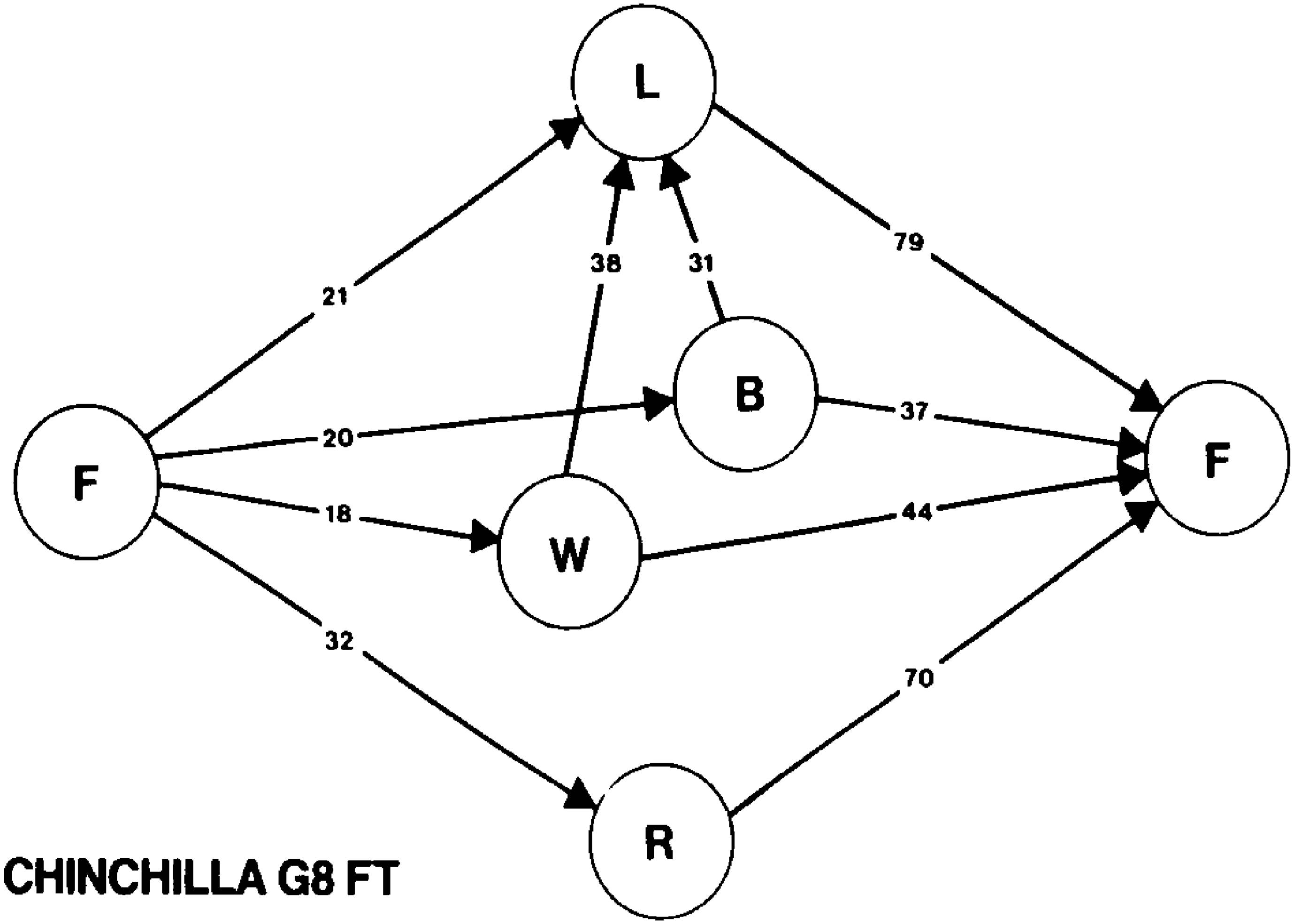
Figure 48. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G7 during FT 30 (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G7 FT

Figure Caption

Figure 49. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G8 during FT 30 (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G8 FT

Figure Caption

Figure 50. Percent of interpellet intervals (IPIs) containing at least one occurrence of any of eight responses as a function of six-second blocks of post-pellet time for subject G4 on FI 30. Overlapping points were offset to increase the clarity of the figure.

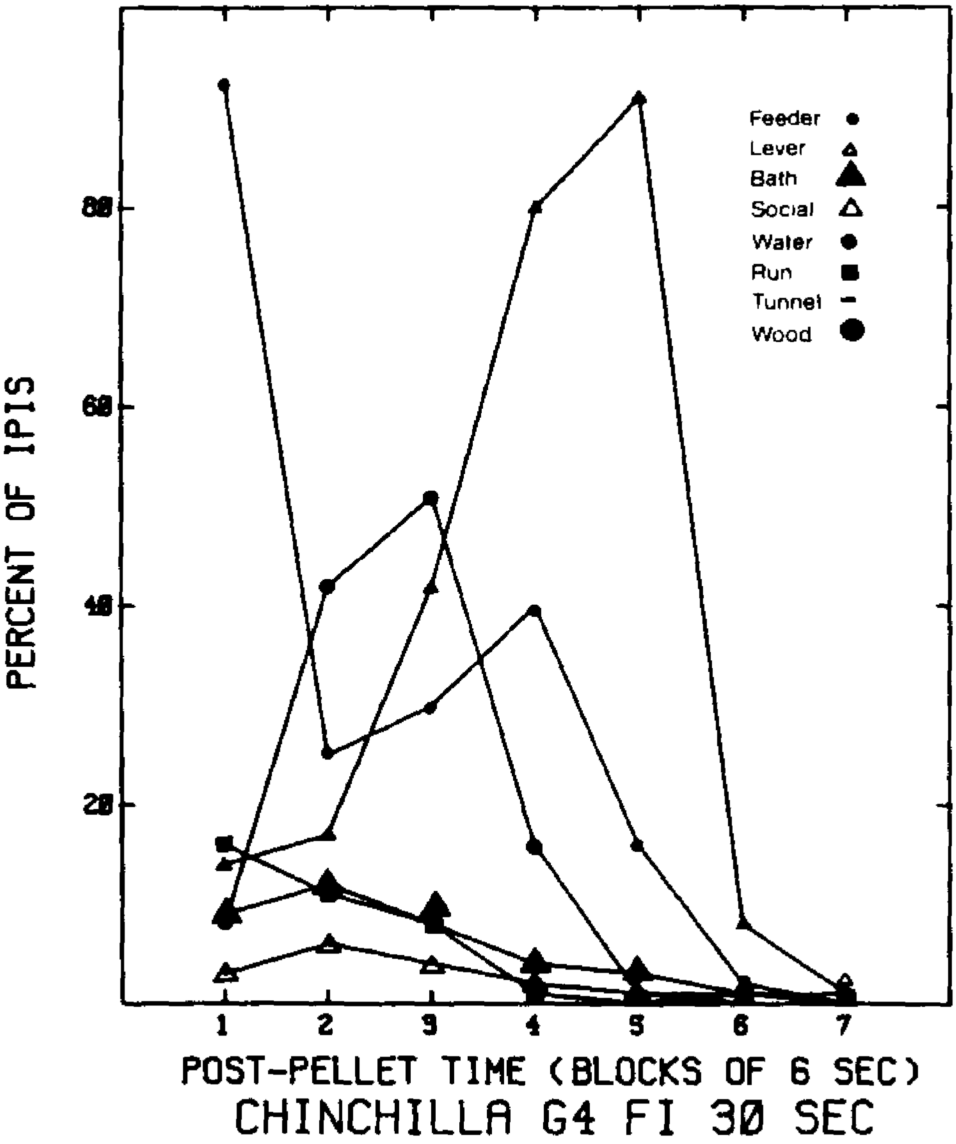
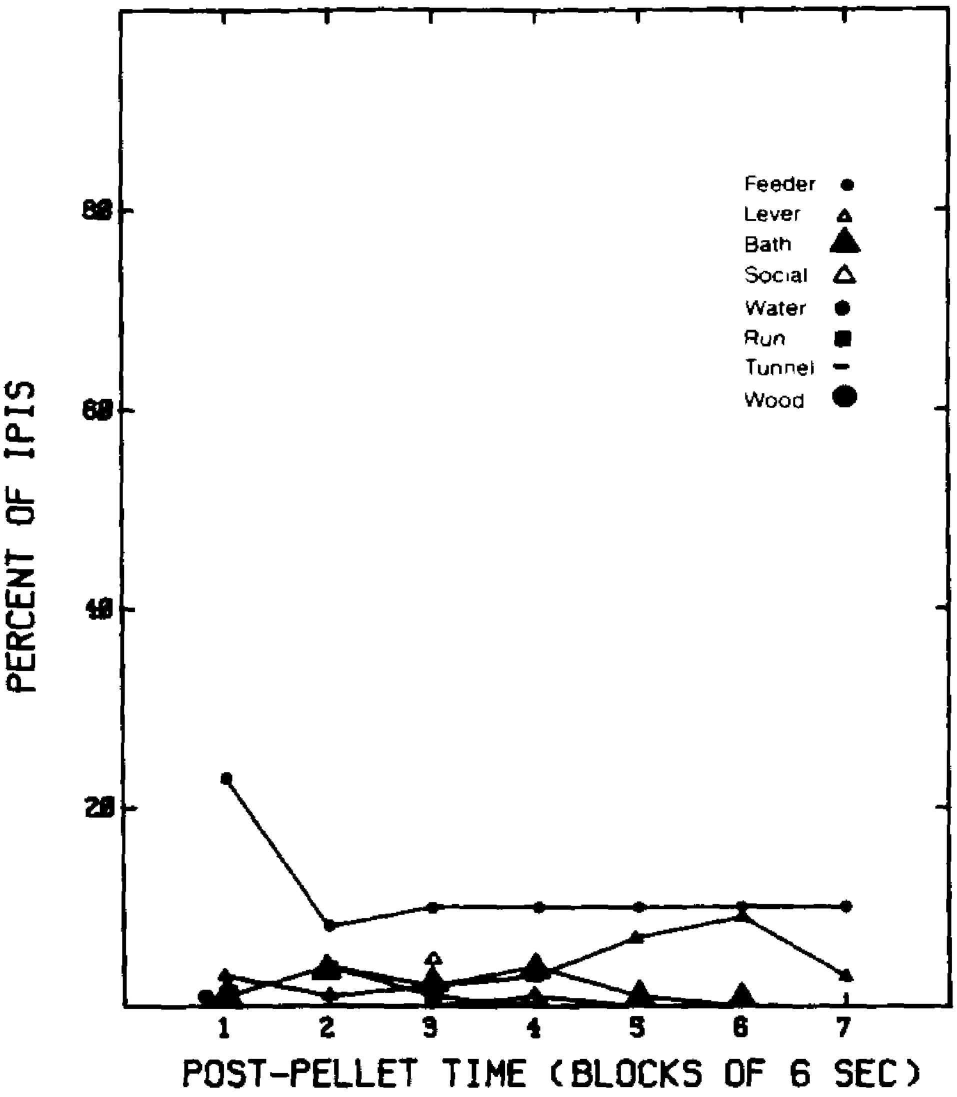

PERCENT OF IPIS
80
60
40
20
1
2
3
4
5
6
7
POST-PELLET TIME (BLOCKS OF 6 SEC)
CHINCHILLA G4 FI 30 SEC
Feeder ●
Lever ▲
Bath ▲
Social △
Water ●
Run ■
Tunnel -
Wood ●

Figure Caption

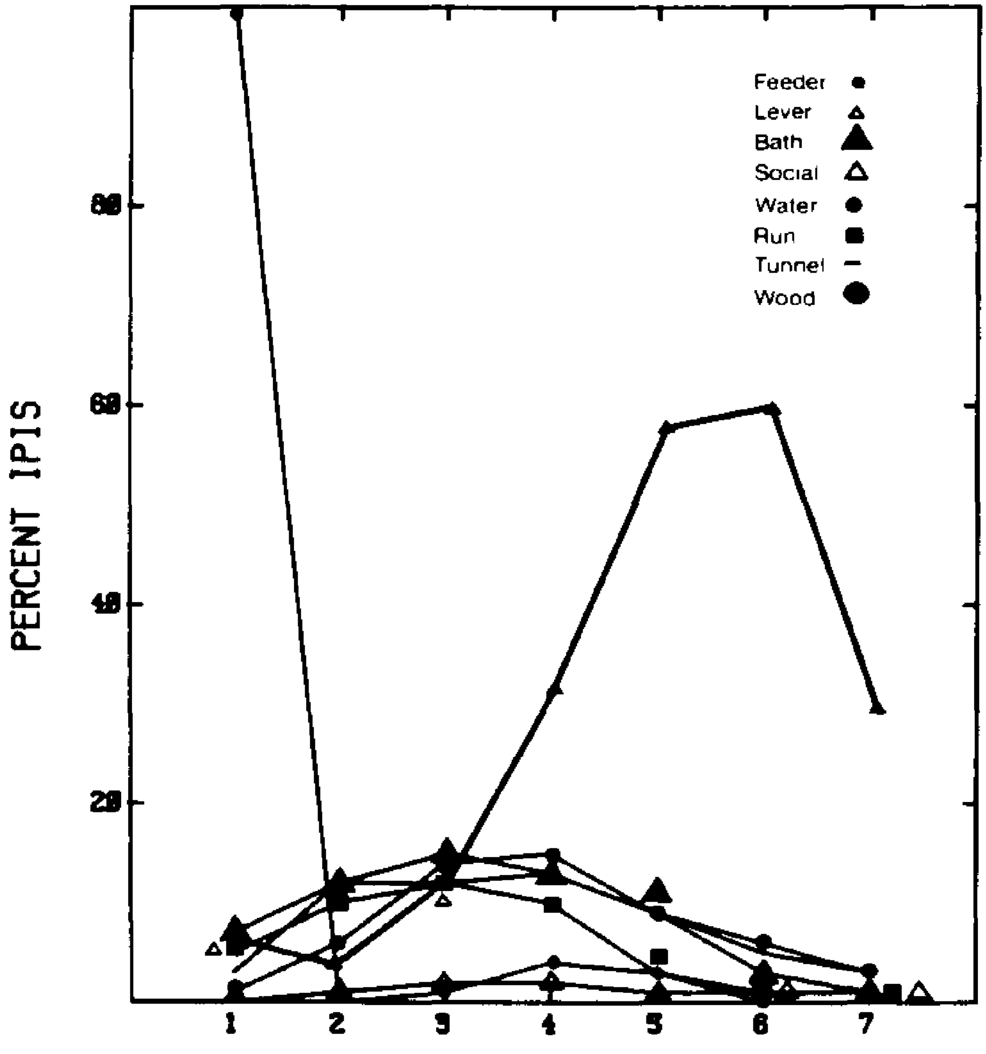
Figure 51. Percent of interpellet intervals (IPIs) containing at least one occurrence of any of eight responses as a function of six-second blocks of post-pellet time for subject G5 on FI 30. Overlapping points were offset to increase the clarity of the figure.



CHINCHILLA G5 FI 30 SEC

Figure Caption

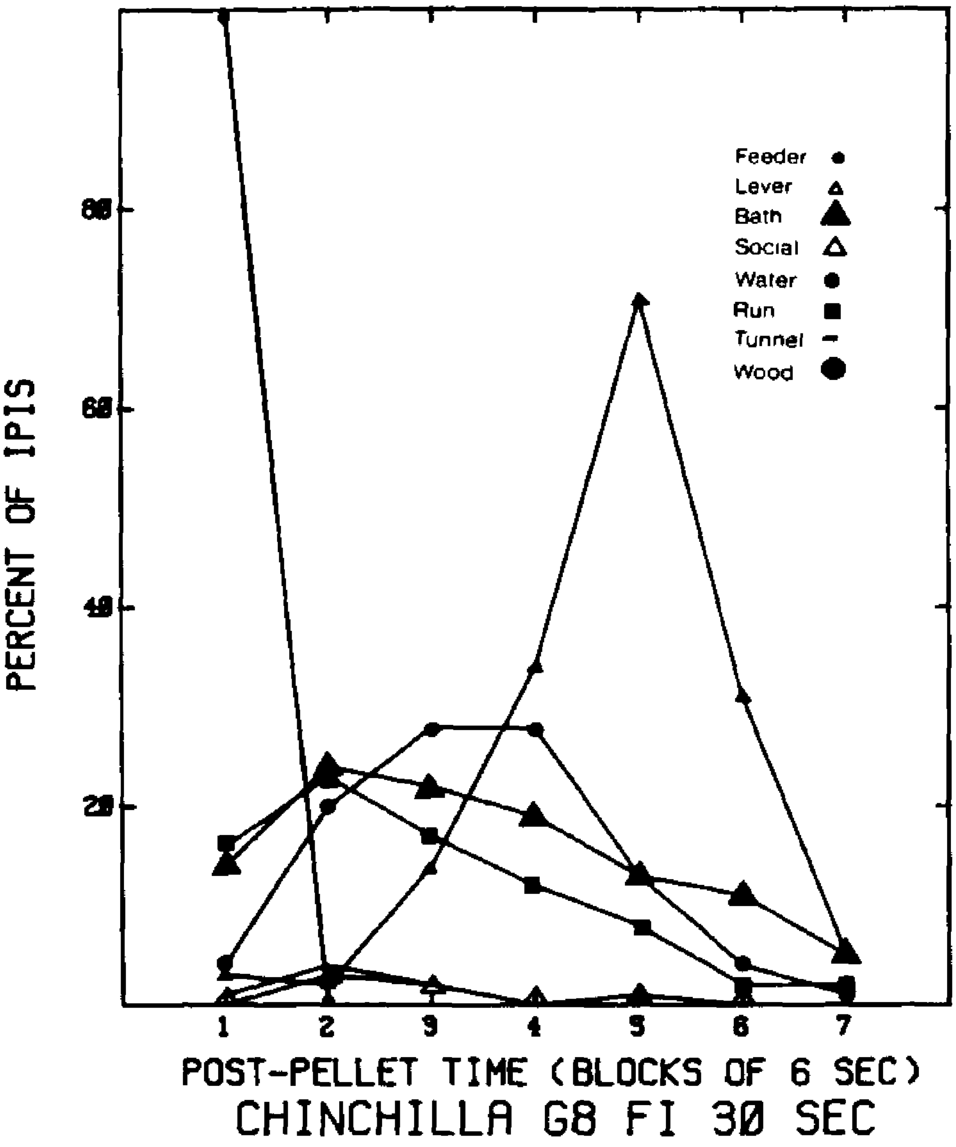
Figure 52. Percent of interpellet intervals (IPIs) containing at least one occurrence of any of eight responses as a function of six-second blocks of post-pellet time for subject G7 on FI 30. Overlapping points were offset to increase the clarity of the figure.



CHINCHILLA G7 FI 30 SEC

Figure Caption

Figure 53. Percent of interpellet intervals (IPIs) containing at least one occurrence of any of eight responses as a function of six-second blocks of post-pellet time for subject G8 on FI 30. Overlapping points were offset to increase the clarity of the figure.


Feeder ●
Lever △
Bath ▲
Social △
Water ●
Run ■
Tunnel -
Wood ●
PERCENT OF IPIS
20
40
60
80
1
2
3
4
5
6
7
POST-PELLET TIME (BLOCKS OF 6 SEC)
CHINCHILLA G8 FI 30 SEC

responding as the terminal response found on FT. G4 maintained its feeder directed responding (found on FT) to the point where it greatly reduced its number of IPIs, i.e., it did not acquire the usual pattern of FI responding on the lever. In the case of drinking, G7 shifted its peak to the fourth block of postpellet time while G4 and G8 maintained their peaks at the third block. G7 drank in a maximum of 15% of the IPIs while G4 and G8 increased their drinking to 51% and 28% of the IPIs, respectively.

Following the shift to FI 30 the expected increase in lever pressing occured, ranging from 2% to 24% of session time (Figures 54-57). Water contacts also increased. Most other responses did not occur above 10%.

The most probable response following feeding during FI was lever-pressing. All FI subjects engaged in more diverse responses than during the FT condition. Subjects would most often move from drinking, bathing, running, or feeder to lever in descending order (Figures 58-61).

<u>FT</u> <u>and</u> <u>FI</u>.

Comparison of the FT and FI data shows that feeding occurred with the longest duration of any activity (except other) for both conditions. The other responses of long duration were running for FT subjects

Figure Caption

Figure 54. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G4, derived from the last six sessions of FI 30.

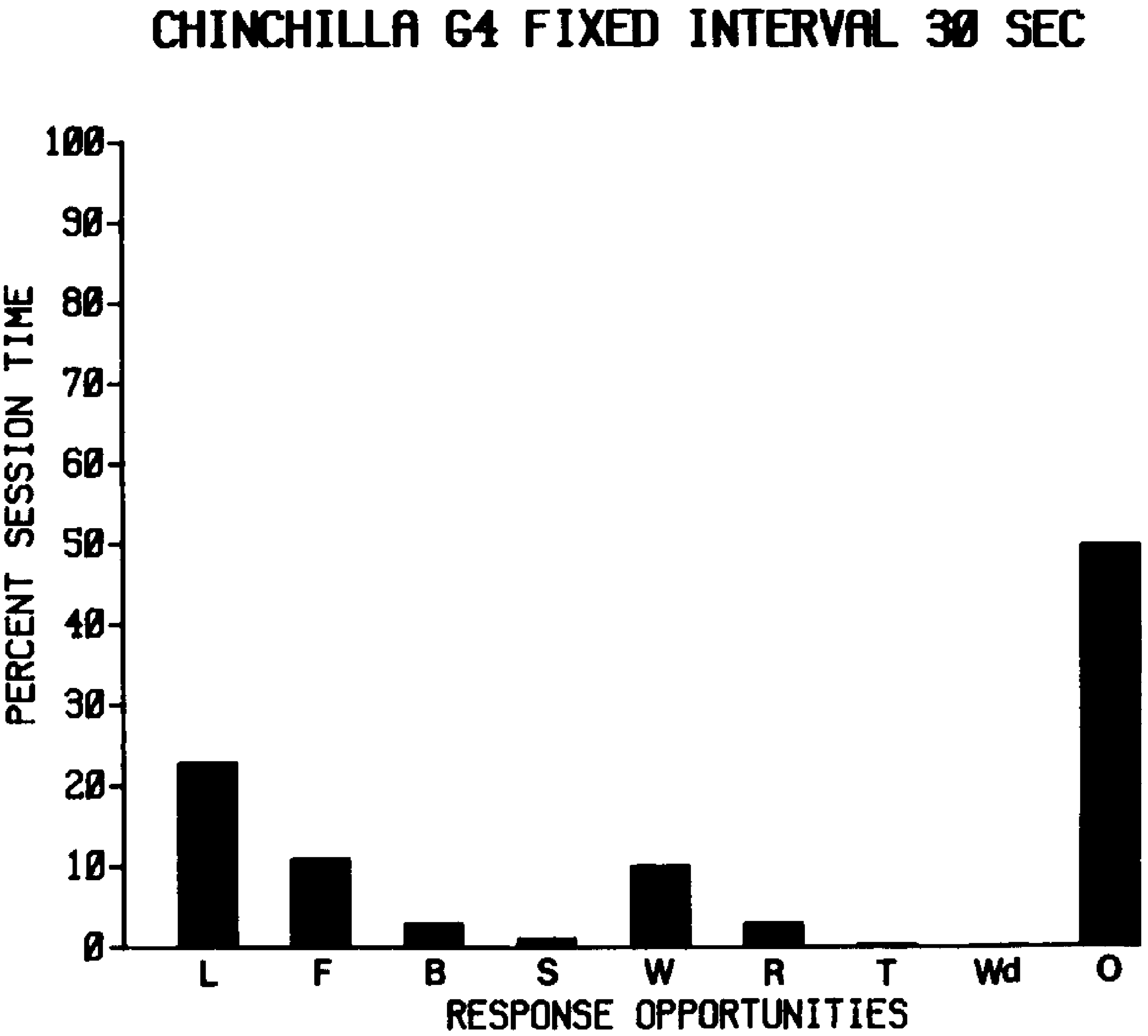

CHINCHILLA G4 FIXED INTERVAL 30 SEC
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

Figure Caption

Figure 55. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G5, derived from the last six sessions of FI 30.

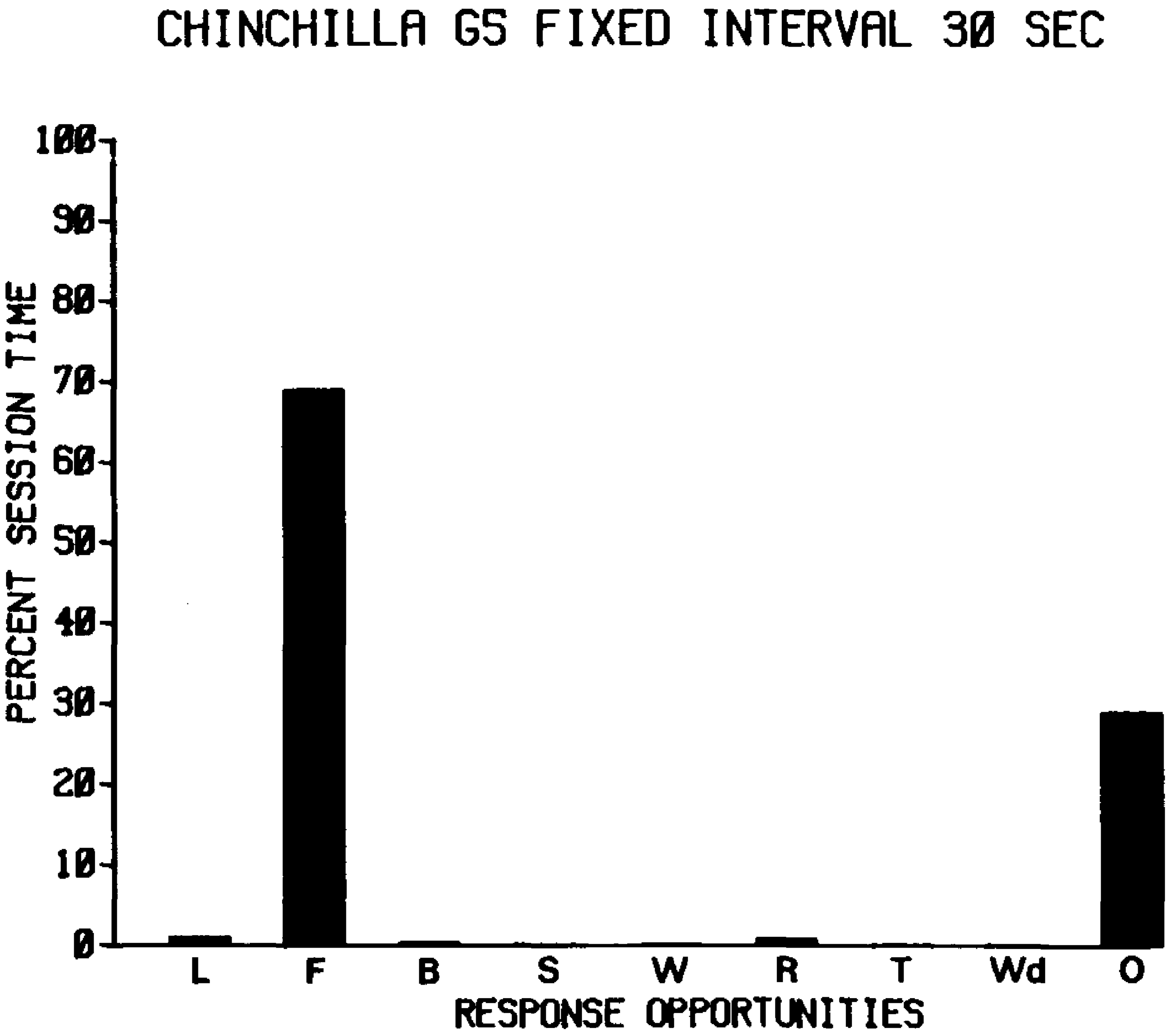

CHINCHILLA G5 FIXED INTERVAL 30 SEC
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

Figure Caption

Figure 56. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G7, derived from the last six sessions of FI 30.

CHINCHILLA G7 FIXED INTERVAL 30 SEC

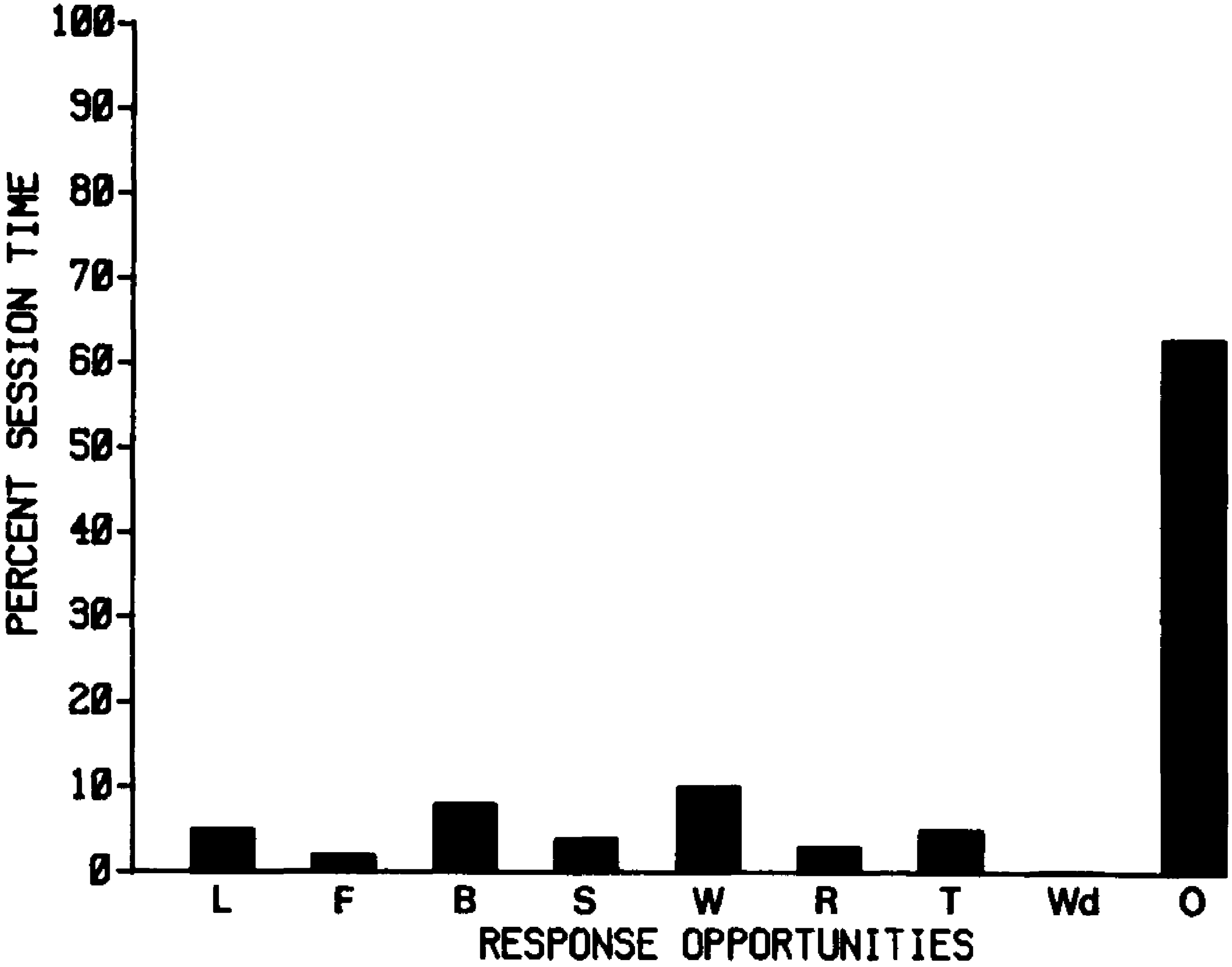
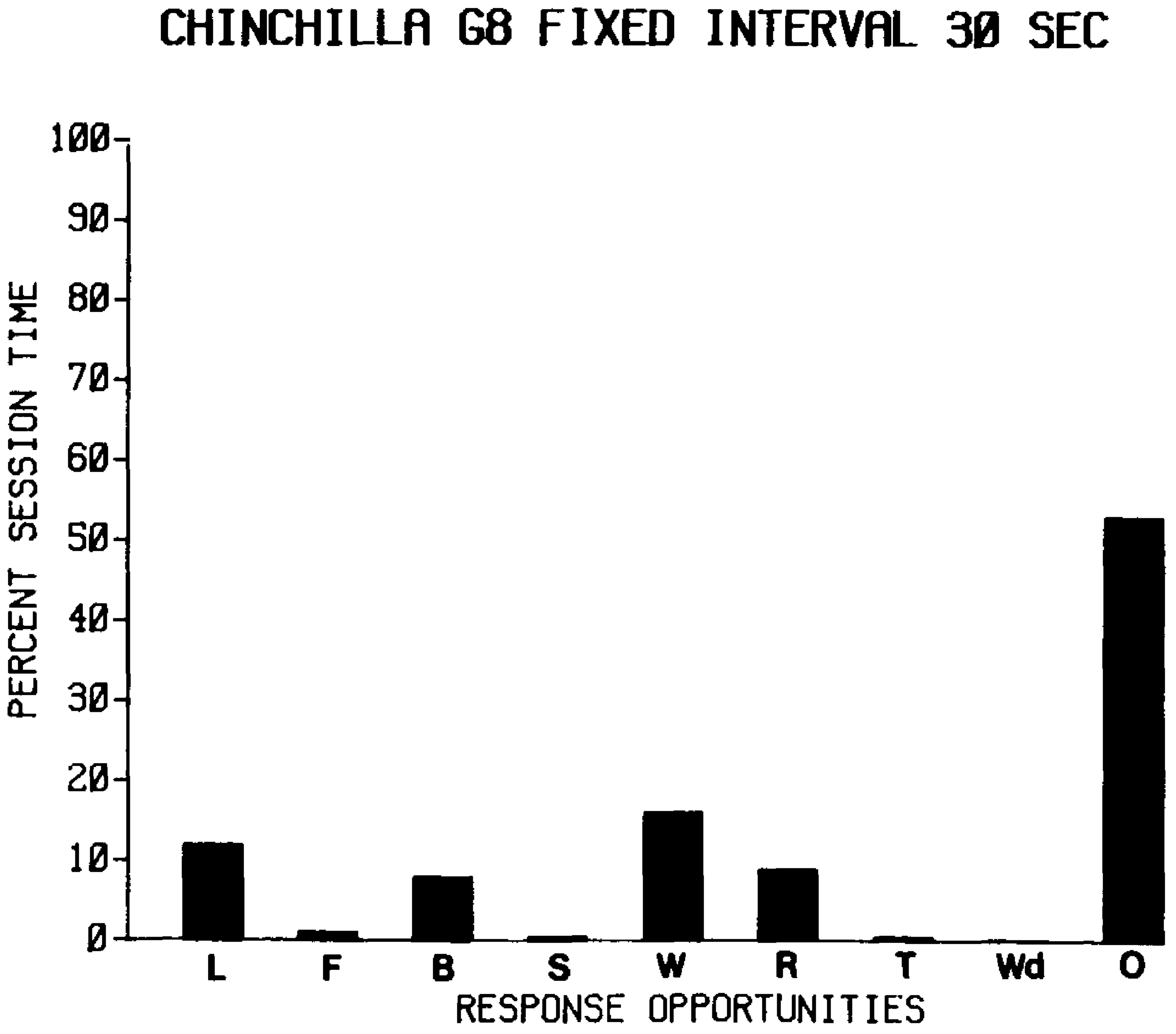


Figure Caption

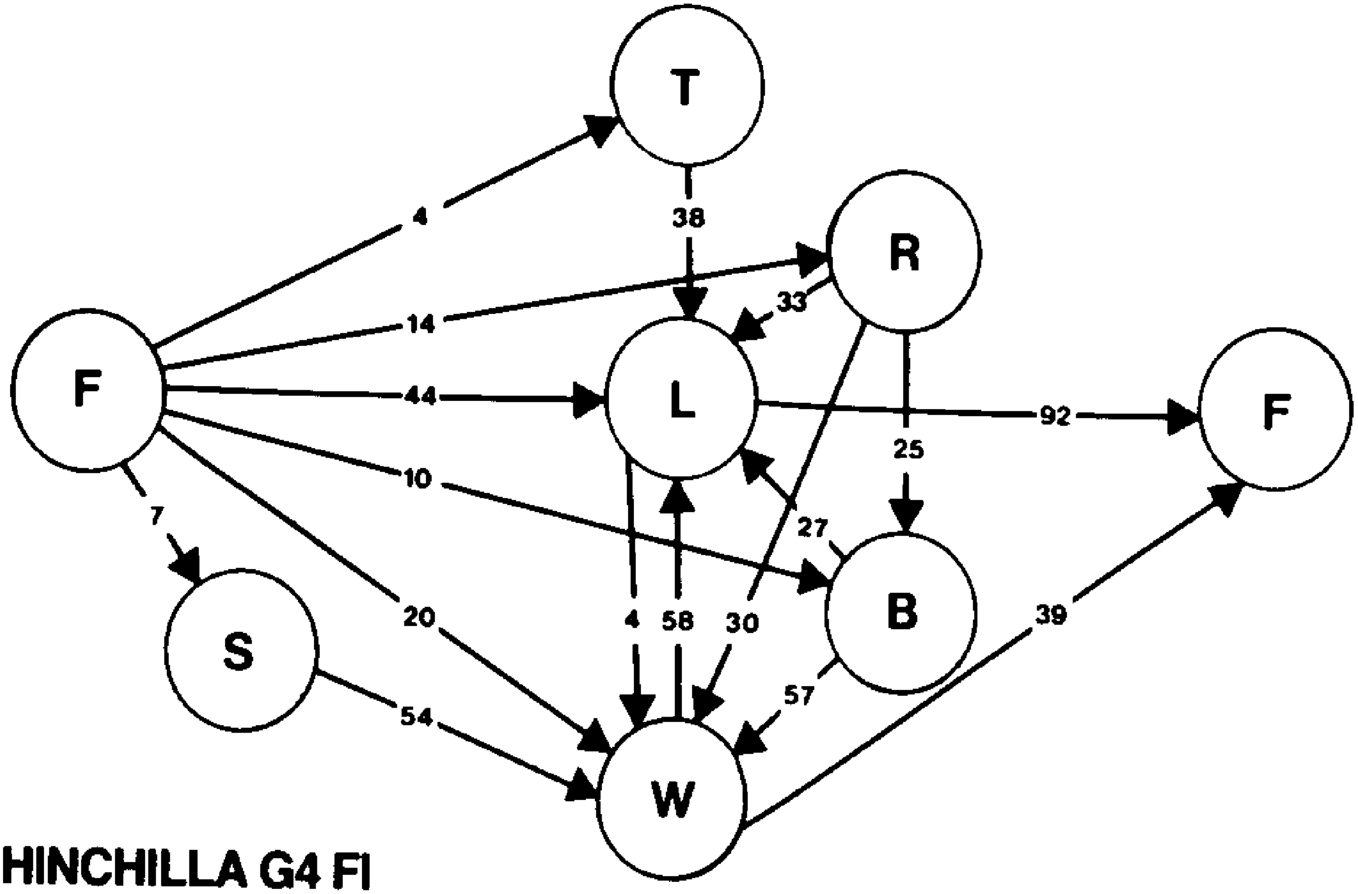
Figure 57. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G8, derived from the last six sessions of FI 30.



CHINCHILLA G8 FIXED INTERVAL 30 SEC

Figure Caption

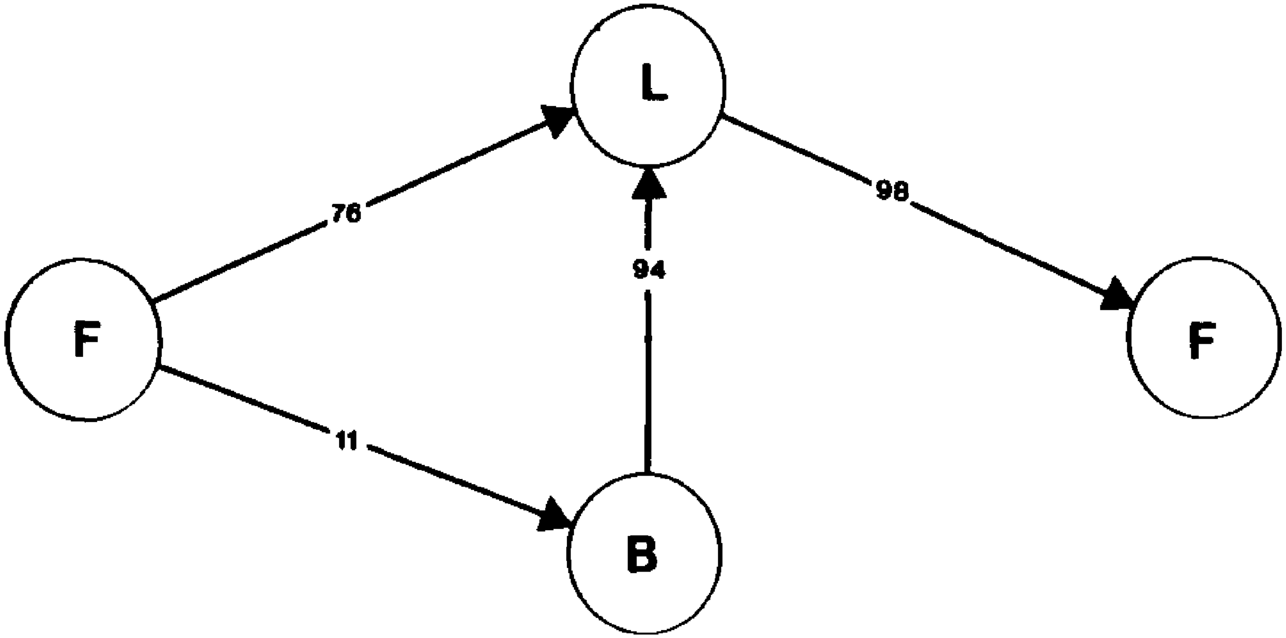
Figure 58. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G4 during FI 30 (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G4 FI

Figure Caption

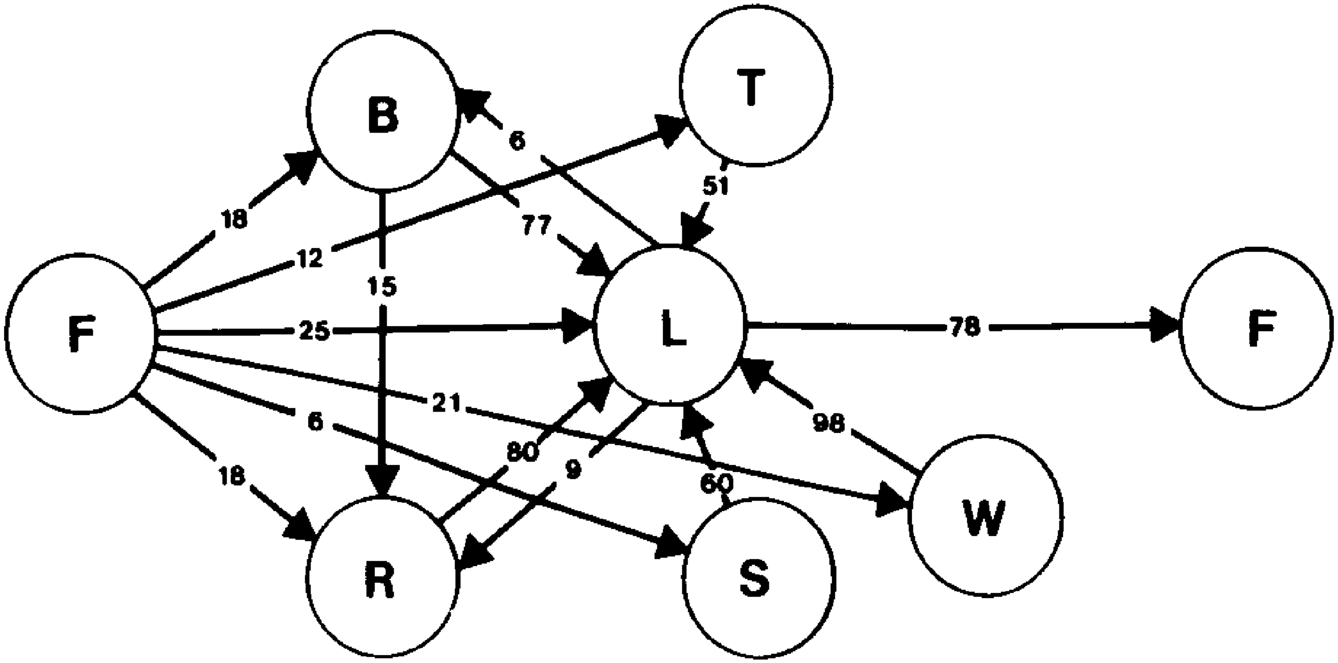
Figure 59. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G5 during FI 30 (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G5 FI

Figure Caption

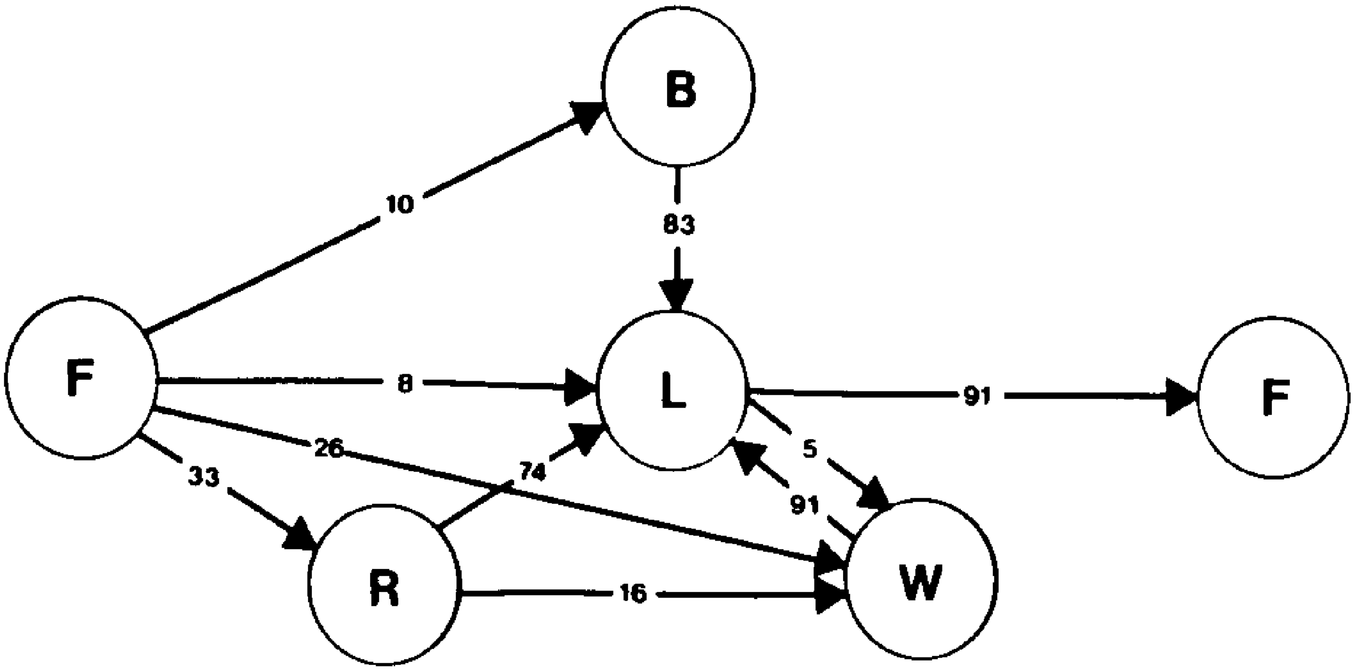
Figure 60. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G7 during FI 30 (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G7 FI

Figure Caption

Figure 61. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G8 during FI 30 (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G8 FI

and lever-pressing for FI subjects. If we ignore the necessity of lever pressing for the FI group then drinking occupied the second longest amount of session time. FT subjects ran and fed for longer session times than FI subjects, but FI subjects spent more session time in all other activities excluding wood gnawing, which no one engaged in.

Running was greatly altered on FI compared to FT. G7 and G8 reduced their overall percentage of running while G5 increased its running to a maximum of 38% of the intervals. After peaking, running declined to approximately zero by the sixth block postpellet. All other responses remained below 10% of the IPIs over all postpellet bins.

The rank ordering of the eight response categories (other than other) for FT and FI for the last 20 sessions are shown in Table 10. The order was different between and within groups. Feeding, running and drinking were most often first or second on FT. During FI lever pressing was in the first or second rank for all subjects. Bathing and running were most often third or fourth and tunneling, socializing and gnawing occurred in ranks 6, 7 and 8. These ranking were based on the response durations shown in Figures 42-45 (FT) and 54-57 (FI).

During extinction sessions, bathing and running were again the most frequent responses (Figures 62-69). Bathing returned to baseline levels but running did not. Tunneling returned to baseline 2 levels and drinking decreasd. Subjects also spent more time socializing than during the FT condition.

Table 11 shows the transition probabilities for switching from feeding to three of the primary responses engaged in by the subjects. Running had the highest probability of occurrence after feeding, then drinking, and bathing. Transition probabilities tended to be larger during FI 30 then FT 30. Subsequently, extinction produced reductions in lever pressing, feeder responses, and drinking. Running and tunneling increased in duration over both FT and FI levels (Figures 62-69).

Figure Caption

Figure 62. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G4, derived from the last six sessions of FT extinction.

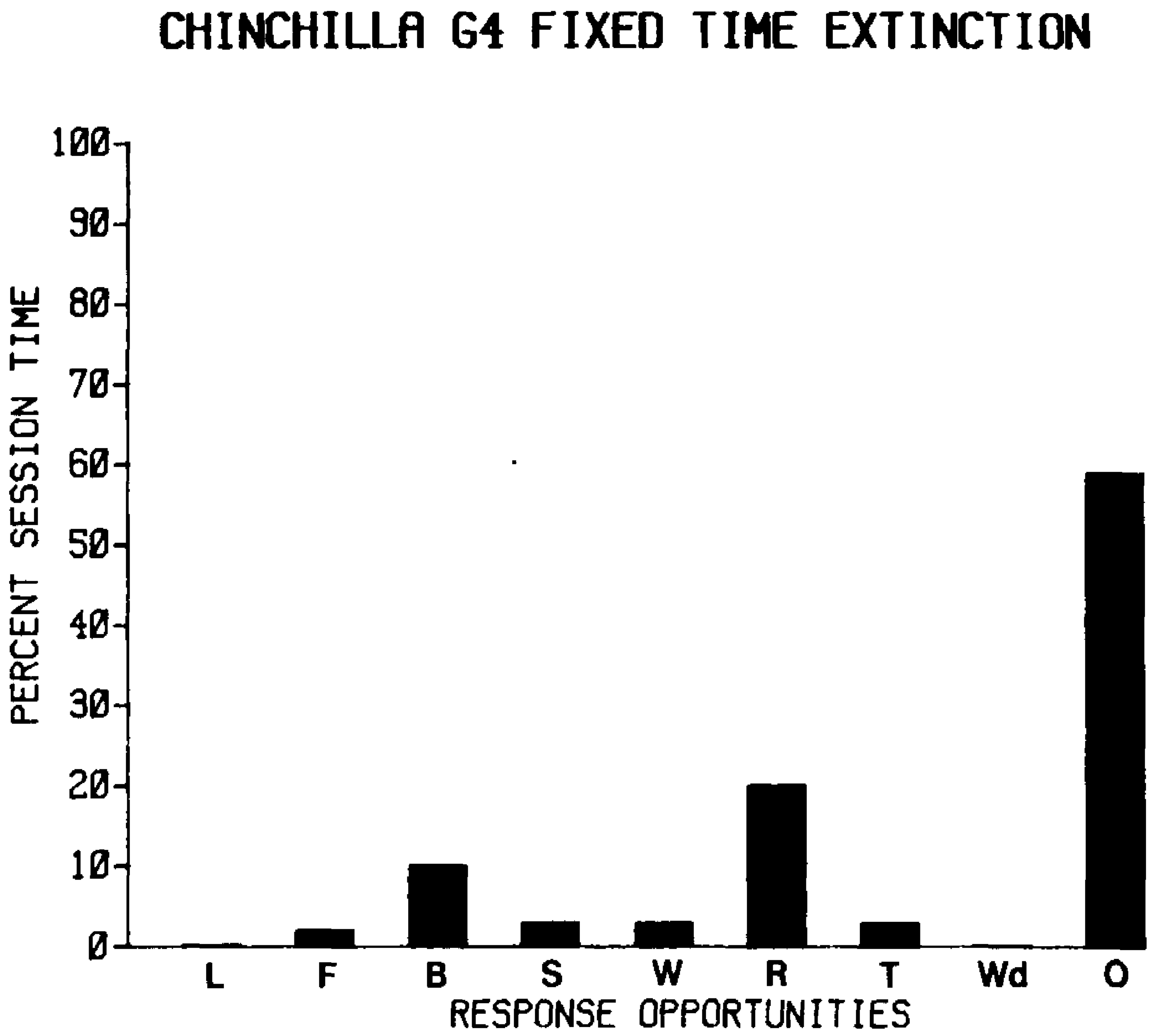

CHINCHILLA G4 FIXED TIME EXTINCTION
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

Figure Caption

Figure 63. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G5, derived from the last six sessions of FT extinction.

CHINCHILLA GS FIXED TIME EXTINCTION

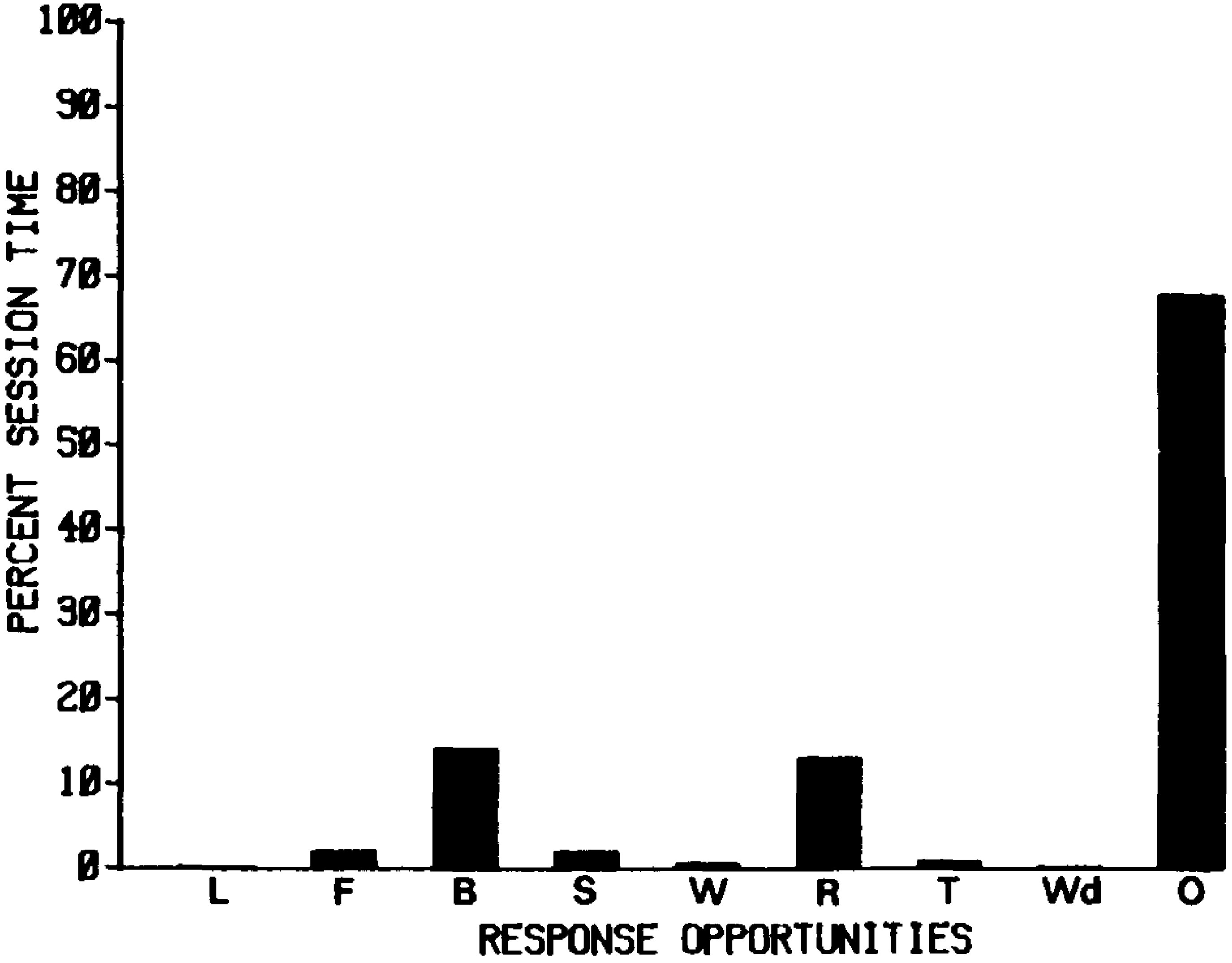


Figure Caption

Figure 64. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G7, derived from the last six sessions of FT extinction.

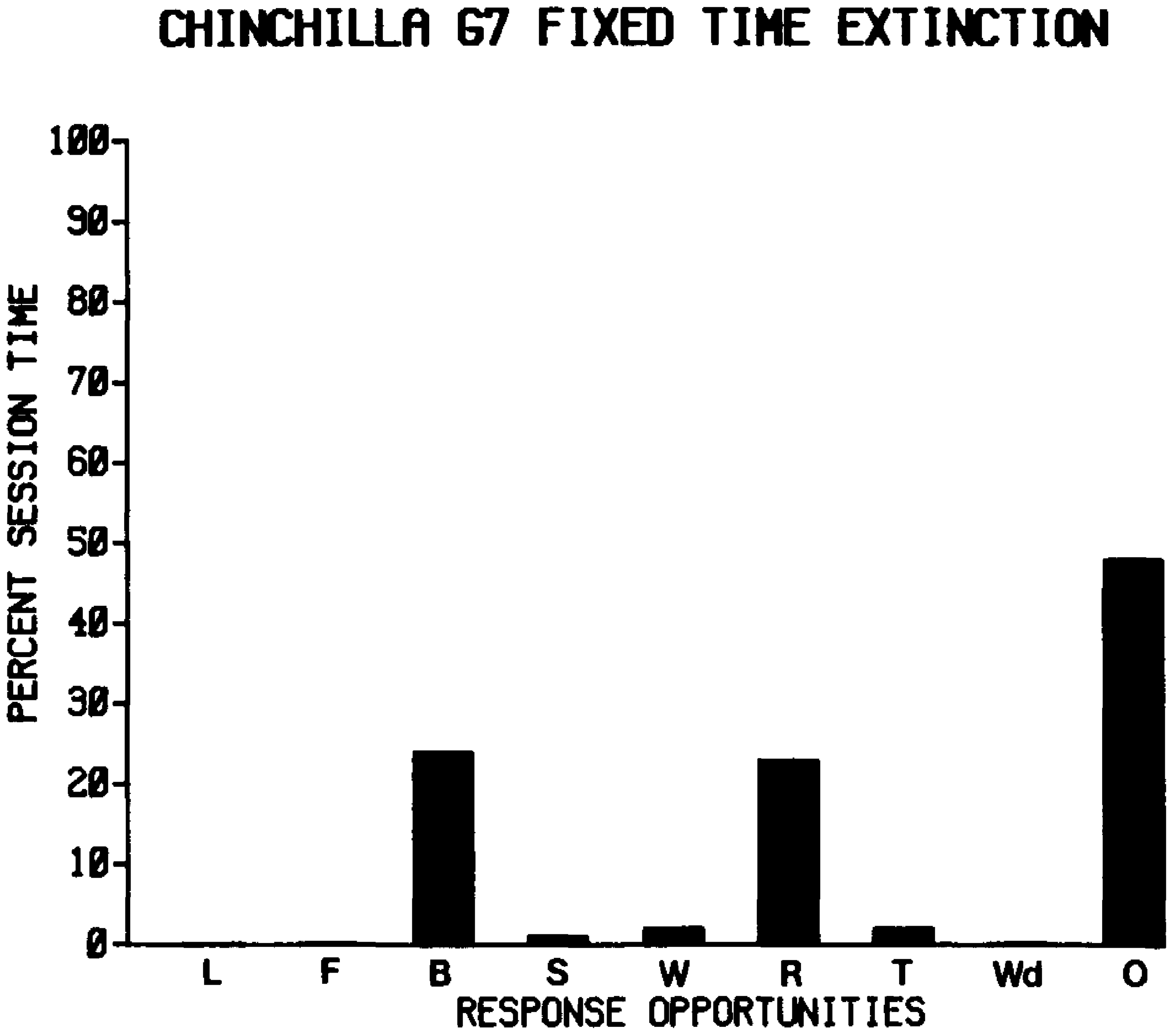
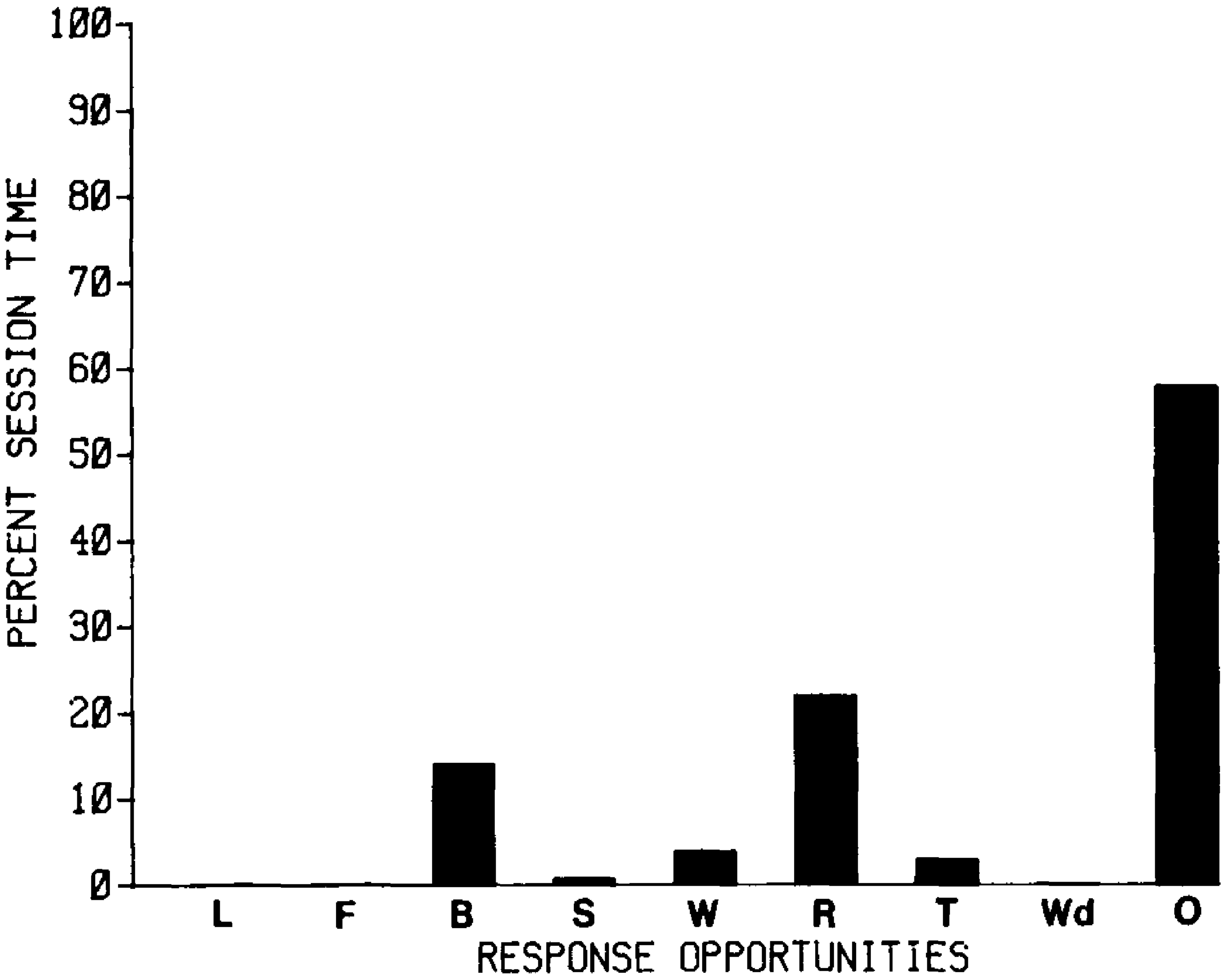

CHINCHILLA G7 FIXED TIME EXTINCTION
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

Figure Caption

Figure 65. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G8, derived from the last six sessions of FT extinction.



CHINCHILLA G8 FIXED TIME EXTINCTION

Extinction.

After the last session of FT and FI subjects were placed on extinction for 10 sessions (Figures 62-77). Subjects responded as on baseline 2, alternating between sand box visits and running. When again placed on extinction, after FI 30, the familiar run<->sand bathe sequence appeared (Figures 62-77).

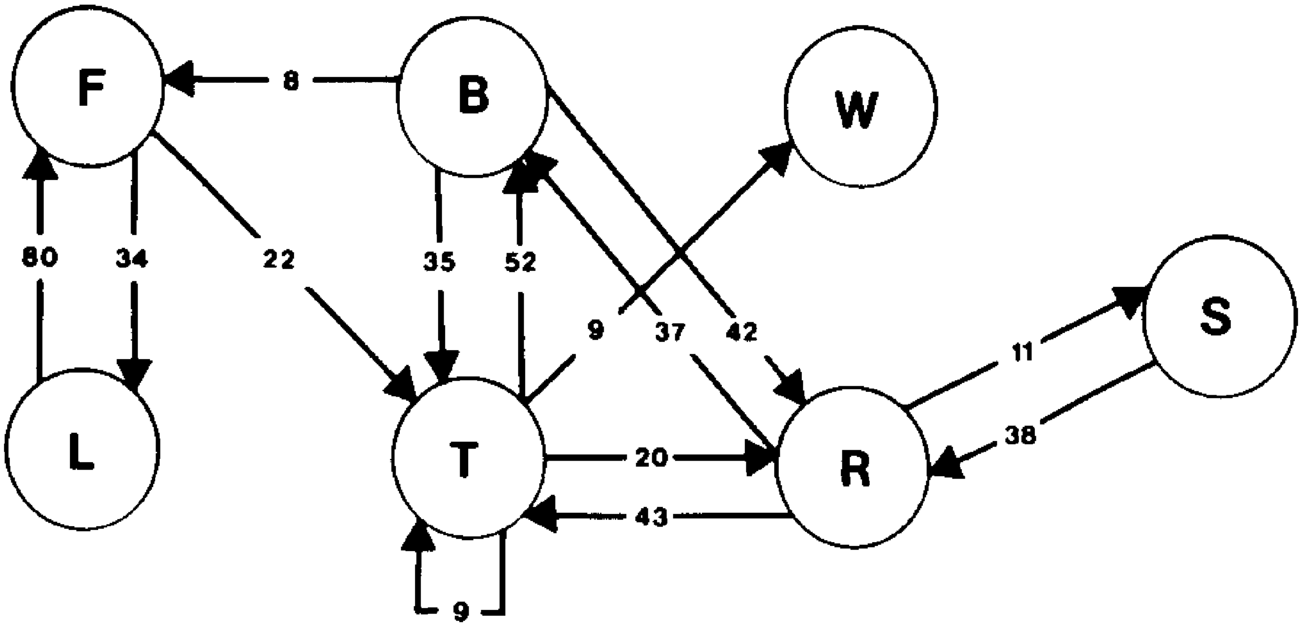
It appears that when not under the constraints of a spaced feeding schedule, the most probable sequence of responding was to switch from the sand box to the running wheel and from the running wheel to the sand box. In baseline 1 the probability of switching from running to sand box ranged from .35 to .76. In baseline 2 it ranged from .52 to .87 and switching from bathing to running ranged from .34 to .65. During FT run<->bathe did not occur frequently enough to be reliable, and on FI only G4 switched between running and bathing (probability .25) and G7 switched between bathing and running (probability .15). During extinction all subjects alternated between running and bathing. Probabilities ranged from .25 to .80 run->bathe and .37 to .68 bathe->run, respectively.

Water Intake.

Table 12 shows the water ingestion for all subjects in all phases for the last six sessions of Experiment 2. Baseline 1 with food available generated

Figure Caption

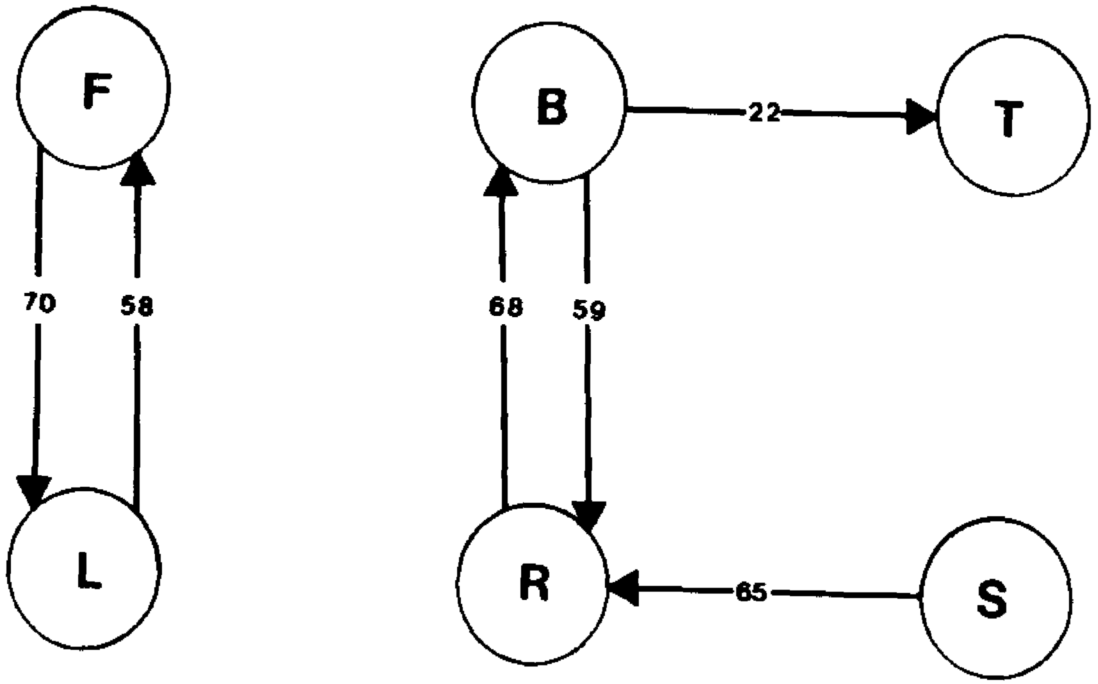
Figure 66. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G4 during FT extinction (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G4 FT EXTINCTION

Figure Caption

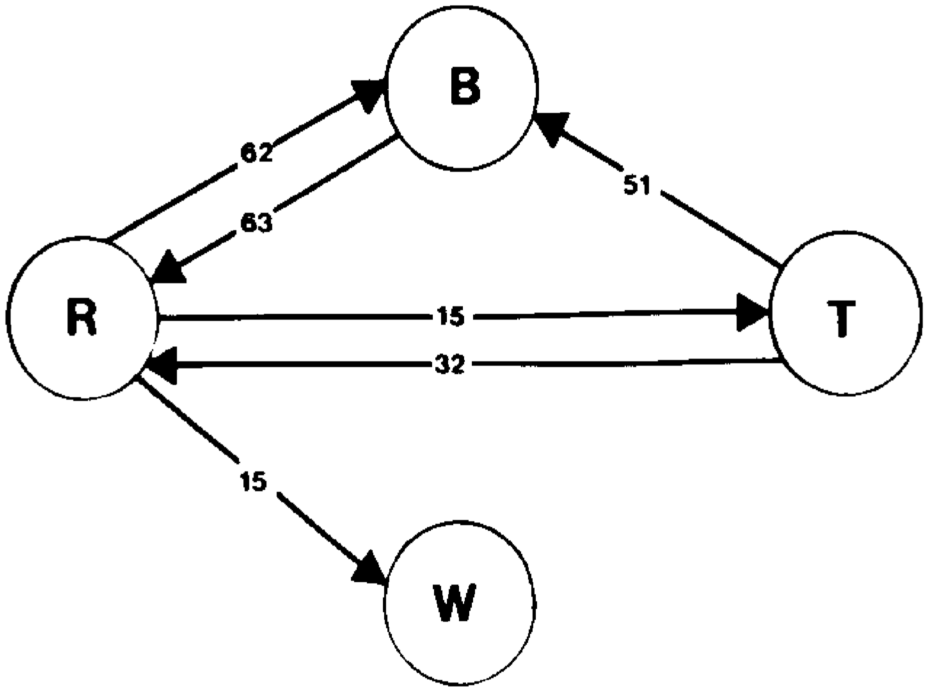
Figure 67. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G5 during FT extinction (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G5 FT EXTINCTION

Figure Caption

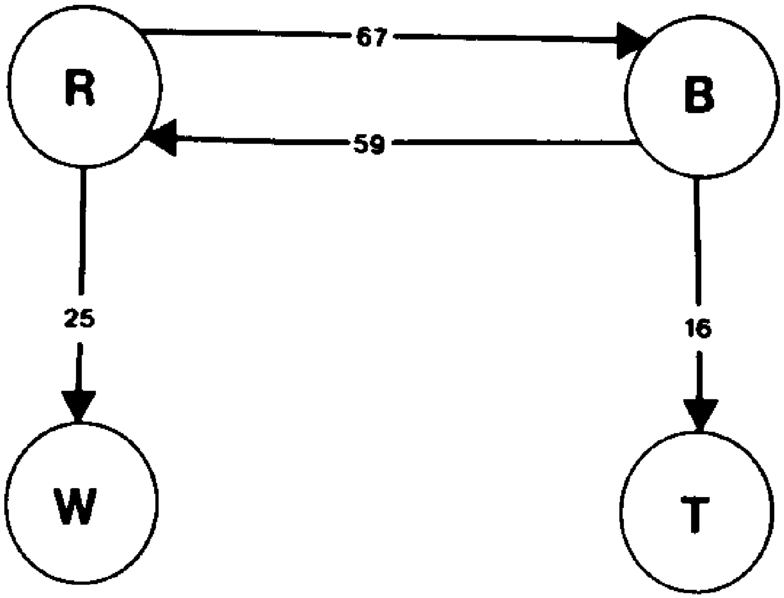
Figure 68. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G7 during FT extinction (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G7 FT EXTINCTION

Figure Caption

Figure 69. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G8 during FT extinction (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G8 FT EXTINCTION

Figure Caption

Figure 70. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G4, derived from the last six sessions of FI extinction.

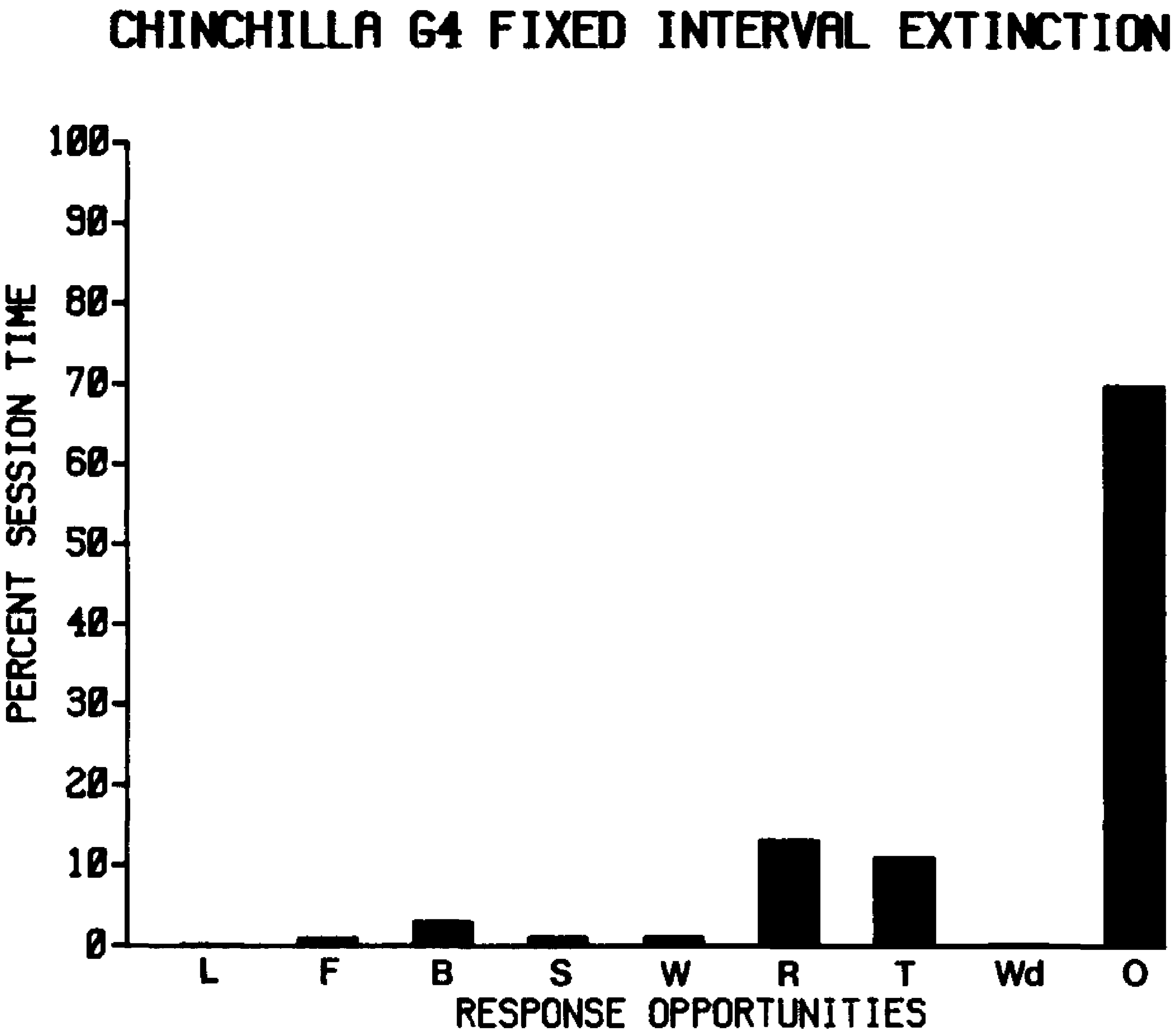

CHINCHILLA G4 FIXED INTERVAL EXTINCTION
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

Figure Caption

Figure 71. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G5, derived from the last six sessions of FI extinction.

CHINCHILLA G5 FIXED INTERVAL EXTINCTION

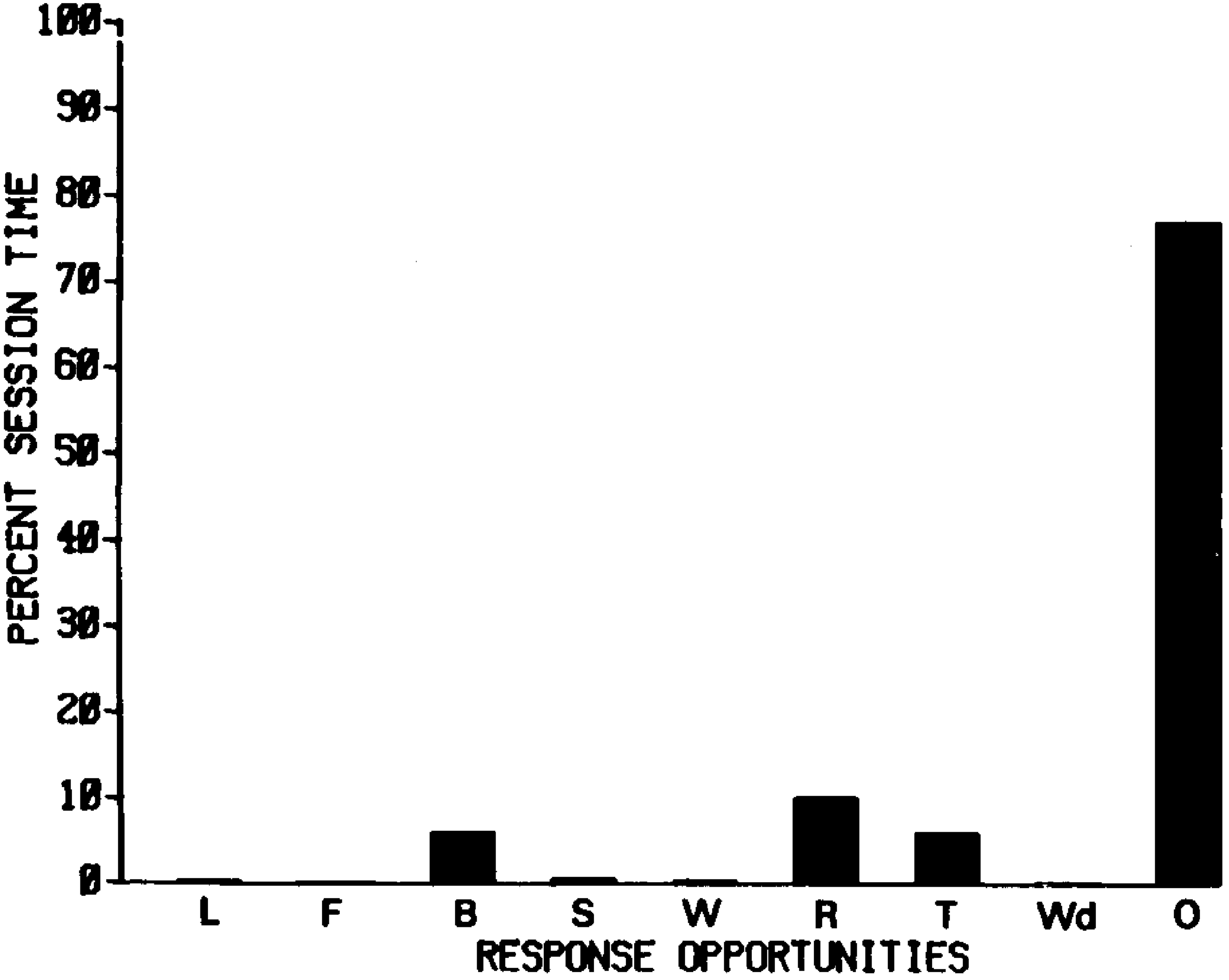


Figure Caption

Figure 72. Bargraph showing the percent of session time spent in each of eight response categories (plus "other") for subject G7, derived from the last six sessions of FI extinction.

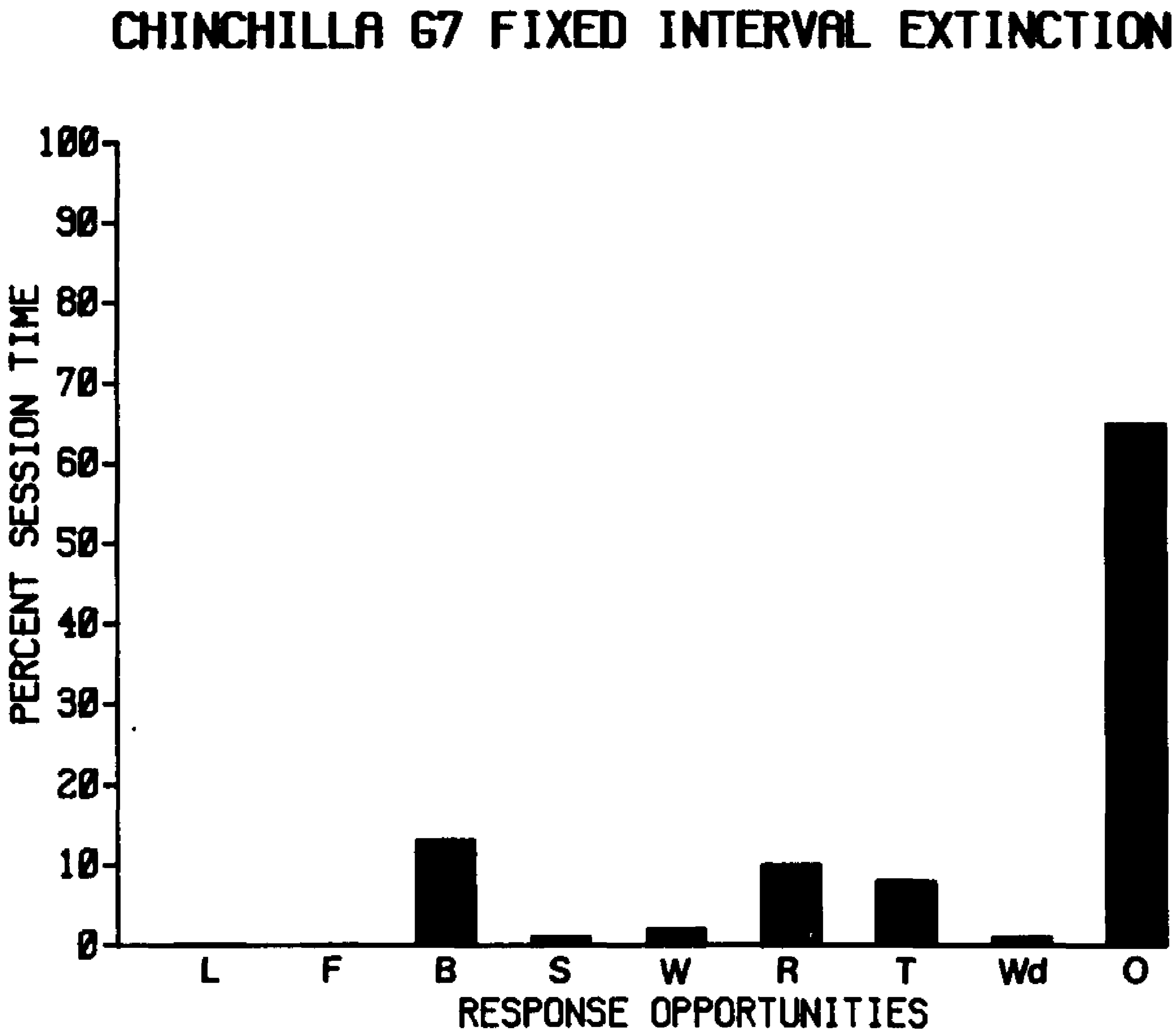

CHINCHILLA G7 FIXED INTERVAL EXTINCTION
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

Figure Caption

Figure 73. Bargraph showing the percent of session time spent in each eight response categories (plus "other") for subject G8, derived from the last six sessions of FI extinction.

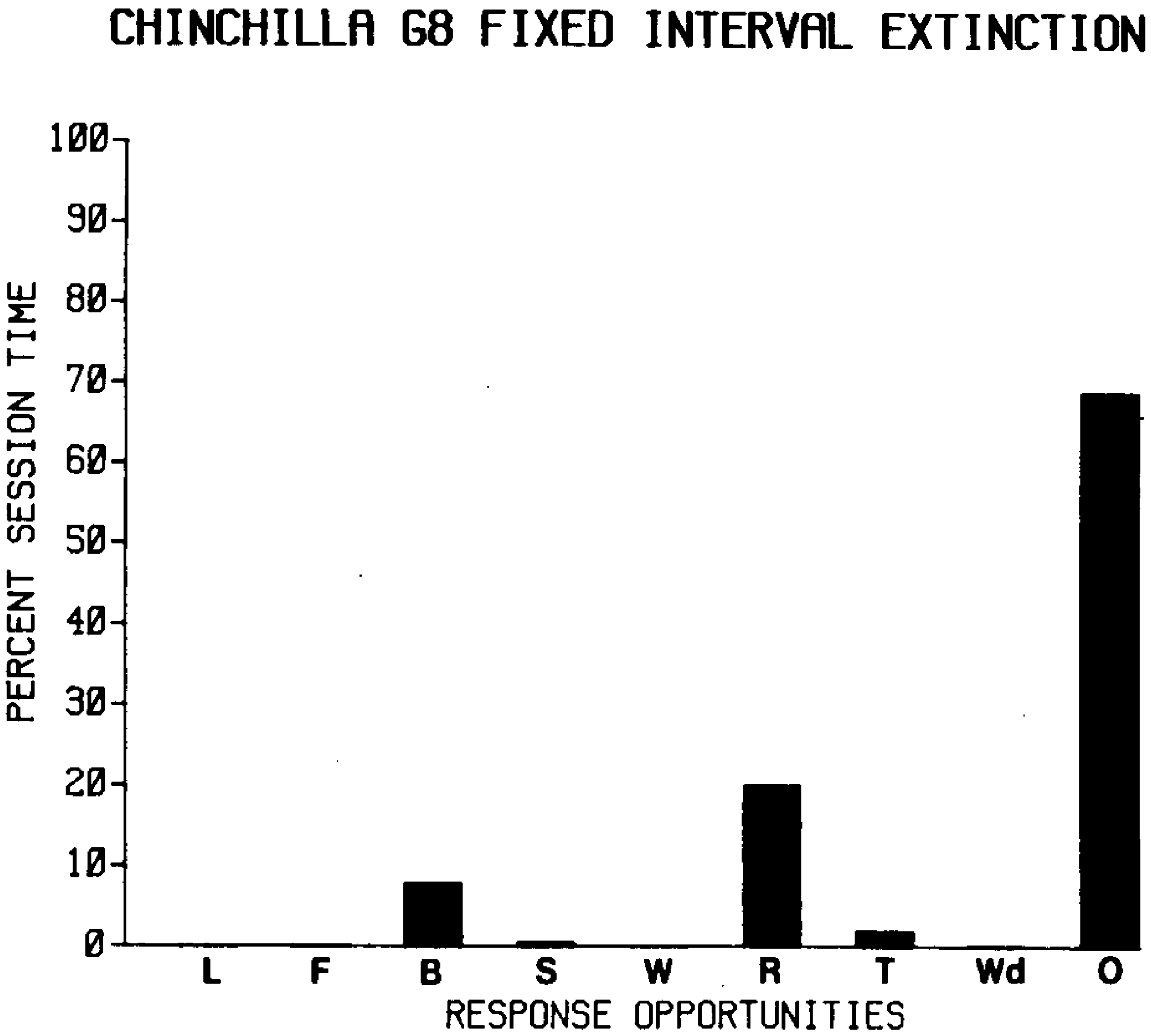
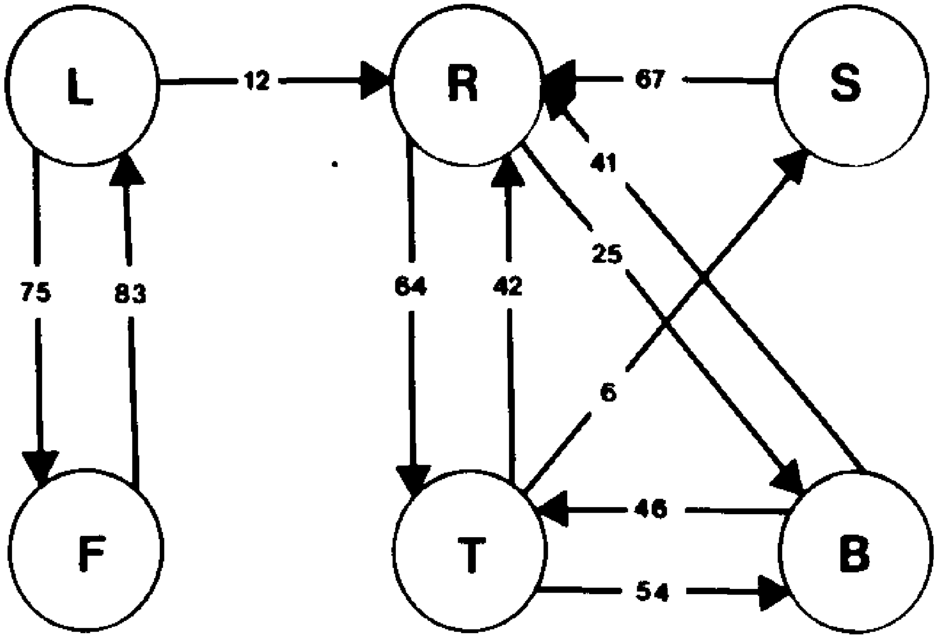

CHINCHILLA G8 FIXED INTERVAL EXTINCTION
PERCENT SESSION TIME
100
90
80
70
60
50
40
30
20
10
0
L
F
B
S
W
R
T
Wd
O
RESPONSE OPPORTUNITIES

Figure Caption

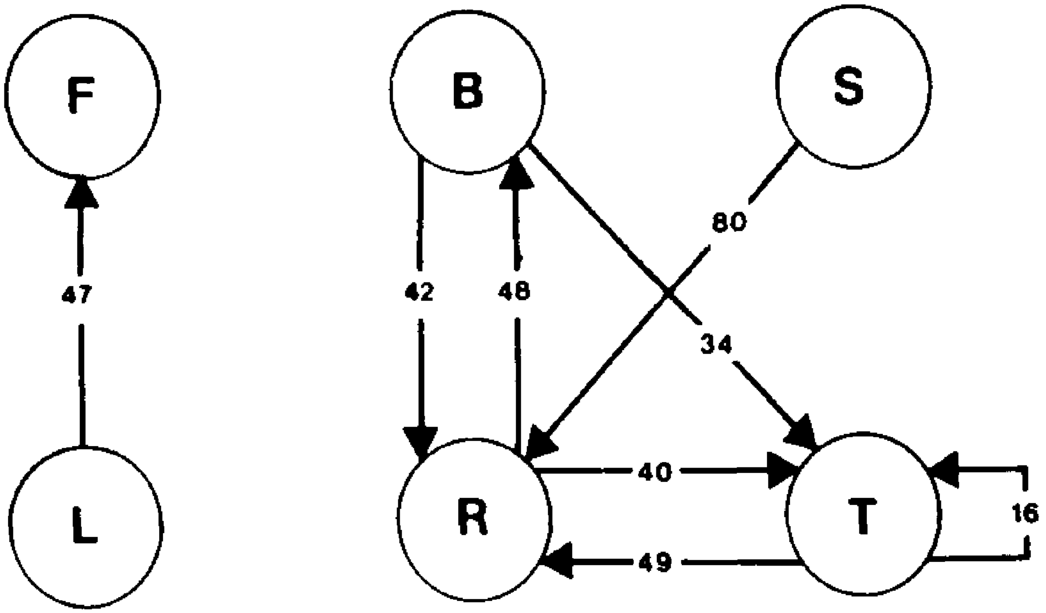
Figure 74. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G4 during FI extinction (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G4 FI EXTINCTION

Figure Caption

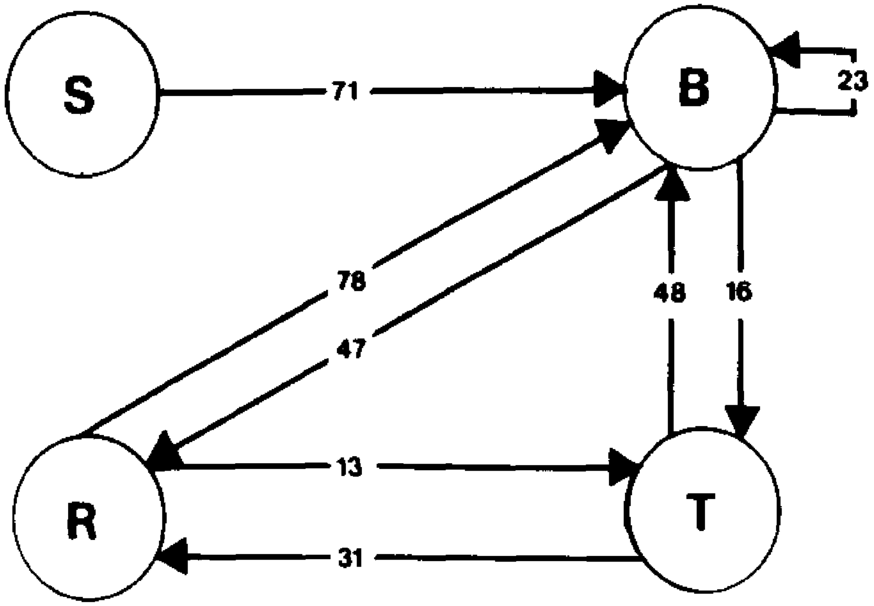
Figure 75. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G5 during FI extinction (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G5 FI EXTINCTION

Figure Caption

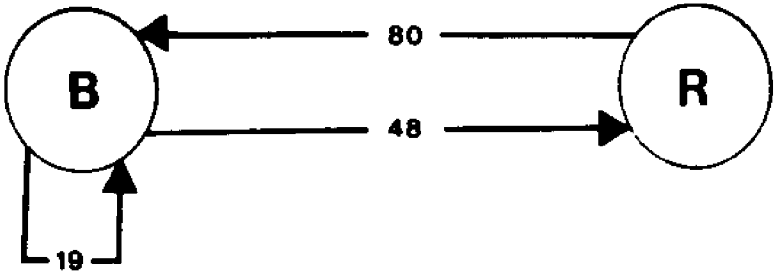
Figure 76. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G7 during FI extinction (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G7 FI EXTINCTION

Figure Caption

Figure 77. Sequential dependencies expressed as percentage of switching between responses, based on a minimum frequency of 10 switches between responses for subject G8 during FI extinction (F= feeder, L= lever, B= bath, S= social, R= running wheel, T= tunnel, Wd= wood block, and W= water bottle).



CHINCHILLA G8 FI EXTINCTION

more drinking than baseline 2, and FT subjects tended to drink more than when on FI 30, but this was found to be insignificant *t* (df 6) = .67, *p*>.05 (correlated means). Extinction reduced drinking in subjects G4, G7 and G8 after FT. After FI 30, extinction reduced drinking for all subjects.

When placed on FT or FI 30 in a standard two-lever free operant chamber, chinchillas drank an average of 7.6 ml on FT and 8.8 ml on FT in a 100 pellet 50 minute session (Experiment 1, Table 13). When exposed to the same interval length with a 25-minute, 50-pellet session and seven other competing responses available in a free operant "arena"; FI subjects drank an average of 10.9 ml and in FT these same subjects drank an average of 14.7 ml in sessions comparable to the above. In the last six sessions in the arena, FI subjects drank slightly less than in the earlier sessions. Comparisons of independent means with a *t*-test showed no significant differences between the arena and operant chamber or between FI and FT groups within either environment (see Table 14). If we then equate for session length by doubling the means found for the arena, we find that having seven competing responses enhances drinking.

Discussion

When exposed to FT or FI 30 schedules of food reinforcement all chinchillas developed reliable patterns of responding in the interpellet interval. These patterns varied from chinchilla to chinchilla and also between schedule types. As expected, food delivery appeared to be the pivotal event whereby the distribution of responding was determined. All subjects regardless of schedule were in the vicinity of the feeder shortly before and after pellet delivery. Subjects G7, G4 and G8 were found to develop similar patterns of responding in the interpellet interval with regard to non-food related activities. Running occurred throughout the IPI but generally decreased as postpellet time increased, drinking showed an increase within the IPI with a maximum at 13 to 18 seconds postpellet and sand bathing peaked at the same point as drinking but was always in fewer IPIs then running.

When placed on FI 30, the most obvious change in the animals' behavior was the replacement of feeder directed behavior at the end of the IPI with lever-pressing. Lever-pressing occurred in a larger number of IPIs but followed the same general pattern as feeder directed behavior found on FT. Non-food related activities were also affected by the response requirement. Drinking tended to occur in more IPIs for FI and running was reduced for two of the three active subjects. The pattern of running was more closely an inverted U-shaped function and bathing followed a similar temporal distribution and occasionally exceeded running.

These findings support and extend those found by Anderson and Shettleworth (1977), Staddon and Ayres (1975) and Staddon and Simmelhag (1971) in that subjects exposed to schedules of food presentation that have no response requirement, or to schedules that do have a response requirement produce reliable interpellet patterns of responding. The effect of the response requirement was to generally replace or compete with food anticipation found on free food schedules by replacing it with lever-pressing. In the case of G7 and G8 this competition was virtually complete, while G4 maintained some feeder directed behavior (Figures 50-53).

Whether any of the observed reponses during FT or FI sessions are schedule-induced can be determined by the amount of session time spent engaged in each activity compared to the time engaged in each activity during the two baseline conditions (Roper, 1978; 1982). During baseline sessions running and bathing where the primary activities for all subjects. When the FT or FI contingency was introduced, these responses were generally reduced. In the case of running, when water is not avaiable, it has been found that rats tend to distribute their running throughout the IPI and that it was also not excessive compared to appropriate baseline controls (Levitsky and Collier, 1968; Staddon, 1977; Wetherington, Brownstein, & Schull, 1977). Recently, Bryant and Porter (1983) have shown that this finding depends on the species tested. In the present case, chinchillas show the same pattern of running in the IPI as do rats. This pattern of running appears to be schedule-reduced as opposed to induced or schedule-independent (facultative). The FI condition also produced more supression than the FT condition. Sand bathing, the other prominent baseline response, was also reduced by the reinforcement contingencies but did appear in some cases to approach an inverted U-shaped function of IPI time. An inverted U-shaped function within an IPI is thought typical of schedule-induced responses but is not a defining feature of that group (Roper, 1983).

With respect to SIP, it was found that the contingencies produced enhanced drinking over both baselines for all subjects, that the FT and FI intakes were not significantly different and that the pattern of drinking in the IPI was an inverted U-shaped function of IPI time. This describes classic SIP. Furthermore, when the animals were placed on extinction, running and bathing increased (compared to

FT or FI sessions), but not always to baseline levels, while drinking always decreased to approximately baseline level.

Finally, gnawing was negligible in all subjects, and tunneling or socializing were erratic in their response to the different contingencies. They are thus, most likely facultative responses for these subjects.

As previously mentioned, following the pattern of a particular response throughout the IPI does not reveal the changes between that response and other available responses. The present work has used state diagrams to illustrate these interactions (Figures 30-37, 46-49, 58-61, and 70-77). It was found that during both baselines most subjects alternated between the running wheel and the sand box, and that running was the most probable response given sand bathing and sand bathing the most probable response given running. When FT 30 was introduced the most probable response given these two responses was feeding and when FI 30 was introduced the most probable response after sand bathing or running was lever-pressing (except for G8 which drank). Thus, the net effect of the food schedules was to direct responding away from the previously most probable response and direct it toward the terminal response (feeder contact on FT and lever-pressing on FI). In fact, this was what generally occurred for all responses.

Another effect of the FT and FI schedules was a general increase in the number of responses engaged in and that the subjects exposed to the FI schedule engaged in more activities than those subjects exposed to the FT condition. It was interesting to note that the schedule with a response requirement produced more alternative response variation and that this was not due to just the addition of lever pressing. If the later was the case, then the number of response transitions during FI should be the same as during FT plus one for the switch from lever-pressing to feeding because the lever must be pressed to obtain the pellet.

With respect to responding during extinction, it was found that the number of response transitions decreased compared to the food delivery conditions but increased compared to original baseline levels. Staddon and Ayres (1975) found that the number of response changes during extinction also decreased when compared to their FT 30 condition. Unfortunately, they had no baseline or FI conditions to allow for a full comparison of these two studies. In this study, one effect of the food schedules was to increase the number of area changes for each subject compared to baseline. This experience of switching among more responses appears to have carried over into the extinction conditions accounting for the increase above baseline, while the decrease below food schedule levels may be attributed to the reduction of terminal and induced responses.

When the directing effects of the food schedules are removed, the primary sequence of running<-> sand bathing found during baseline conditions reemerges with the above mentioned increase in response transitions. Thus, sequencing of responding during FT and FI was determined by food delivery, while on baseline or extinction it was determined by response preference.

In the next section, the results from Experiments 1 and 2 were integrated, in an attempt to better understand the induction phenomenon.

General Discussion

When food deprived chinchillas were placed on schedules of food reinforcement they developed, patterns that could be described, following Staddon (1977), as interim, facultative, and terminal responses. When the environment offered only the opportunity to obtain food and water, SIP was the only measurable interim response, while activity at the feeder or lever-pressing were the terminal responses depending on the schedule (FT or FI, respectively). When the environment was "enriched" with eight other response opportunities, SIP was also obtained as a primary interim response (see figures 38-41 and 50-53). These results are similar to those described in the literature on schedule-induced behavior for rats (Falk, 1961; 1966; 1975; Roper, 1978; Staddon & Ayres, 1975). The drinking found in the two experimental environments had two important similarities to the SIP found in other species: it was both excessive when compared to apparatus baseline conditions and there was a particular temporal pattern of postpellet drinking. No other available recorded response appeared to be consistently induced for all subjects.

Staddon (1977) and Wetherington, Brownstein, and Schull (1977) have identified running as a facultative response in rats. Experiment 2 found evidence that running was facultative and that sand bathing was also facultative for chinchillas. Both running and bathing were the primary responses for all subjects during baseline and extinction conditions. During both the FT and FI conditions these activities were reduced. This reduction is a characteristic of facultative responses when a schedule is imposed over some previous baseline (Staddon, 1977).

One unexpected finding was the large amount of water ingested on FT and FI 30 in the arena compared to that ingested in an operant chamber (Table 13). The arena both increases the number of responses available to the subject and the size of the chamber. These two factors may contribute to the observed difference. Both Staddon and Ayres (1975) and Roper (1979) found that removal of opportunities enhanced SIP. Data on operant responses while the subjects are restrained have shown mixed results tending toward increased response rate (Frank & Staddon, 1974; Skubar & Richardson, 1975; Richardson & Loughead, 1974). Wetherington, Brownstein, and Schull (1977) found that increasing chamber size produced a decrease in running, a facultative response, in rats. As of yet, there have been no reports of chamber size effects on schedule-induced responses. If increased chamber size does not increase operant response rates, although this is currently unclear, then the suppression of running found by Wetherington, et al (1977) was probably due to an increase in interim responding. Therefore, the enhanced drinking found in the larger operant arena may be due to chamber size and not the number of opportunities made available.

The current discussion in the literature on the attributes of schedule-induced responding may be characterized as qualitative temporal control hypotheses (Anderson & Shettleworth, 1977; Reberg et al; 1978; Staddon, 1977; Staddon & Ayres, 1975; Staddon

& Simmelhag, 1971; Wetherington, 1983; Wetherington & Brownstien, 1982) and quantitative response magnitude hypotheses, originally described by Falk (1961b; 1966; 1971) and currently championed by Roper (1979; 1982; 1983). The drawbacks of a qualitative description of schedule-induced responding have been ameliorated somewhat by the work of Killeen (1975; 1977), Gibbon (1982), and Cohen and Campagnoni (1983). These investigators have attempted to quantify how time controls the pattern of responding on schedules of reinforcement.

There is a third way of analyzing responding on schedules of reinforcement and that is by describing the interactions among different responses. Staddon and Simmelhag (1971) and Staddon and Ayres (1975) attempted to quantify the temporal relations found between and within responses on schedules of food reinforcement, therebye focusing on the sequencing of responding. Dunham and Grantmyre (1982) have also focused on the sequencing of responding, but on schedules of punishment. Staddon and Simmelhag (1971) and Dunham and Grantmyre (1982) have used transition probabilities to describe the sequences they have found. Staddon and Ayres (1975) used correlations between bout lengths and activity start times to describe theirs.

The possibility that a transition probability analysis of responding may help in the defining of schedule-induced, interim, facultative, or terminal responses can be seen in the state diagrams. The definition of SIP, as an adjunct, includes a description of the pattern of the responses involved, a bout of drinking closely follows the obtaining of a pellet. Therefore, the transiton probabilities should be large between feeding and drinking. Table 11 showed that the transition probabilities to drinking after eating were geneally no larger then those for running or bathing. It appears then that it was not how often the subjects switched to the water bottle but how long they drank that gave the best indication of the special properties of water. Yet, there were other properties of drinking in this environment. Drinking tended not to interact with other responses, but most other available responses interacted with drinking. Subjects switched from other responses to drinking and when finished drinking, subjects would most often move to the appropriate terminal response (food anticipation on FT; lever pressing on FI). Therefore, a definition of SIP that includes transition probability information sould be as concerned with what occurs after drinking as before.

The terminal response also had obvious transition interactions. The primary one was that the probability of moving to the terminal response was always larger than moving from the feeder to the intervening response. This would be expected if a temporal control model were correct. It's more important to leave an ongoing response because time may be running out. After beginning the terminal response, there was a small probability of returning to one of the three primary responses (water, sand bath, run). This was probably due to the early start of the terminal response.

Thus, the application of a transition probability analysis to schedule-induced phenomena may be effective in quantifying Staddon's triad of interim-facultative-terminal responses and might also be effective in quantifying the relationship between induced responses and their inducers.

Table 1

Substances tested for their SIP-inducing properties.

Formula	Findings	Source
Sucrose		
4, 16, & 32%	SIP on FT Schedule	Christian and Schaeffer (1973)
4% with 7.5 Glucose	"	Burks, Hitzing, and Schaeffer (1967)
92.4%	No SIP on VI schedule	Falk (1967)
Glucose		
7.5% (standard Noyes)	SIP under proper deprivation and scheduling.	Most SIP studies.
Dextrose		
90%	No SIP on FI schedule	Christian (1976)
91.3%	No SIP on VI schedule	Falk (1967)
Sugarless	SIP on FI schedule	Christian and Schaeffer (1973)
Salt (NaCl)		
7.5%	SIP on FI schedule	Christian and Mc'Coy
15%	No SIP on FI schedule	(Cited in Christian, Schaeffer, & King, 1979)
Other Variations		
Pellets of Varying nutritive content	SIP decreased when nutritive value switched from 100% to 50%	Freed (1971)
250mg SKF pellets	SIP on FI schedule	Rosenblith (1970)

Table 1 continued

D & G whole diet monkey pellets	Sip in Rhesus monkeys	Schuster and Woods (1966)
Ciba banana pellets	SIP in monkeys	Mello and Mendelson (1971)
Noyes 150mg banana pellets	SIP in monkeys	Porter and Kenshalo (1974)
Mixture of 33% water and standard monkey diet	SIP in rats on VI schedule	Falk (1967)
Vegtable oil	No SIP in rats on VI schedule	Stricker and Adair (1966)
33% milk-67% water solutions in .15ml portions	No SIP	Stein (1964)

Table 2

Species tested for for SIP.

Species (Common Name)	N	Number Exhibiting SIP	
Laboratory rat	large	generally all	
Cotton rat	3	2 of 3	Porter, Merrill, Hastings, and Pagels (1980)
Wild caught Norways	5	1 of 5	Hoppman and Allen (1979)
Mice			
c57bl/6j	4	0 of 4	Palfai, Kutscher, and Symons (1971)
DBA/2J	3	3 of 3	
B6D2FL	3	3 of 3	
DBA/2JF1	11	10 of 11	
c57bl/6JF1	11	6 of 11	
F2	27	18 of 27	
Monkeys			
Rhesus	11	11 of 11	Schuster and Woods (1966)
Java	3	3 of 3	Allen and Kenshalo (1978)
Squirrel	2	2 of 2	Barrett, Stanley, and Weinberg (1978)
Other Rodents			
Guinea Pig	14	2 of 14	Porter, Sozer, and Moeschl (1977)
Mongolian Gerbil	8	4 of 8	Porter and Bryant (1978)

Table 2 Continued

Degu	2	0 of 2	Fischer and Porter (1979)
Golden Hamster	5	0 of 5	Wilson and Spencer (1975)
Pigeons			
White Carneaux	1	1 of 1	Shanab and Peterson (1969)
White King	5	0 of 5	Miller and Gollub (1974)
Other Primates			
Human	24	13 of 24	Kachanoff, Leveille, Mclelland, and Wayner (1973)

Table 3

Mean water intake (ml) in last six sessions for chinchillas and rats (R1, R2) at each schedule value.

	Fixed Interval (sec)				Fixed Time (sec)			
	Subjects							
Condition	G3	W3	G1	G2	C1	C2	R1	R2
Home cage baseline (24-hour)	30.7	42.8	47.8	27.8	35.0	20.0	43.7	38.3
Apparatus baseline (100 min) session, 100 free pellets)	3.0	5.5	2.2	3.3	*	*	*	*
FT or FI								
15	1.0	5.7	3.5	10.5	5.0	4.7	31.7	20.2
30	7.0	8.3	4.2	8.0	14.7	19.3	56.8	30.8
45	28.2	7.8	2.3	14.3				
60	31.7	21.0	2.5	18.2	20.8	20.5	67.5	49.5
75	24.8	33.5	9.5	10.5				
90	32.3	53.0	9.2	14.2				
105	21.0	35.8	7.7	4.3				
120	25.2	29.5	6.8	9.0	8.7	27.0	78.8	73.7
135	21.5	28.7	10.3	19.7				
150	22.5	15.3	9.5	24.5				
165		29.7	11.8	10.8				
180		16.2	6.0	14.2				
240					30.3	31.0	56.8	61.5

*These data were determined at all FT values and can be found on Table 4.

Table 4

Mean water intake (ml) in last six sessions for chinchillas (C1, C2) and rats (R1, R2) at each FT schedule compared with cumulative apparatus baselines (BA).

		Subjects			
Condition	Schedule	C1	C2	R1	R2
25 min		.00	.08	.25	.33
	FT 15	5.00	4.70	31.70	20.20
50 min		.17	.08	.22	.58
	FT 30	14.70	19.30	56.80	30.80
100 min		.42	.17	.42	.75
	FT 60	20.80	20.20	67.50	49.50
200 min		1.50	.50	1.60	2.50
	FT 120	8.70	27.00	78.80	73.70
400 min		3.60	2.30	5.80	4.10
	FT 240	30.30	31.00	56.80	61.50

Table 5

Average number of licks from each quarter of a session for subjects G3 and W3 on all schedule values from the six criterion sessions.

Quarters of sessions

Schedule	Subjects G3				W3			
FI sec	1	2	3	4	1	2	3	4
15	.2	.2	3.7	0.0	10.5	8.8	10.0	8.8
30	47.5	42.5	15.5	13.0	6.0	15.3	11.5	11.0
45	100.3	44.8	28.0	9.3	7.7	14.0	4.7	27.3
60	69.5	11.0	21.0	8.0	14.2	17.8	19.0	23.8
75	37.2	5.7	11.5	12.8	39.5	36.7	29.7	72.8
90	56.0	12.2	16.7	25.2	56.3	85.5	159.7	166.0
105	32.5	15.7	11.7	8.5	42.8	66.3	85.8	99.2
120	53.2	26.2	13.2	18.5	14.5	45.7	116.5	192.8
135	70.5	35.3	10.5	22.7	19.5	53.0	63.3	81.2
150	65.8	39.3	24.2	14.2	15.5	16.3	81.0	162.7
165					35.3	85.0	90.3	102.2
180					29.3	69.8	74.7	103.0
Mean	53.2	23.3	15.6	13.2	24.3	42.8	62.2	87.6
SD	26.8	16.4	7.2	7.5	16.1	29.8	48.5	62.9

Table 6

Average number of licks from each quarter of a session for subjects G1 and G2 on all schedule values from the six criterion sessions.

Quarters of sessions

Schedule	Subjects G1				G2			
FT sec	1	2	3	4	1	2	3	4
15	9.0	8.5	4.0	3.2	25.8	1.8	2.2	1.0
30	10.5	22.6	16.2	1.2	17.8	4.2	1.3	.2
45	6.3	4.2	0.0	1.7	20.8	0.8	0.0	0.0
60	15.0	12.3	8.8	5.9	12.7	3.8	2.2	4.0
75	22.6	15.5	9.3	1.8	10.4	1.2	.6	3.0
90	12.5	3.3	5.0	8.5	5.7	1.8	2.7	1.3
105	22.3	10.3	5.5	10.7	6.3	1.5	6.3	3.3
120	5.7	3.0	5.8	3.2	5.7	3.0	3.3	1.8
135	2.8	4.2	5.8	6.0	7.5	5.0	9.2	1.8
150	4.5	6.5	5.3	4.0	15.5	5.8	7.0	7.5
165	3.2	6.3	6.3	7.8	1.5	1.3	2.3	3.8
180	14.1	25.3	15.8	15.3	2.0	1.0	1.0	1.7
Mean	10.3	10.0	7.2	5.8	11.0	2.6	3.2	2.5
SD	7.0	7.8	4.9	4.4	7.7	1.7	2.8	2.0

Table 7

Correlation between mean water intake and mean number of licks for each subject from the six criterion session at all schedule values.

Subjects	*G3*		*W3*		*G1*		*G2*	
	Water	*Licks*	*Water*	*Licks*	*Water*	*Licks*	*Water*	*Licks*
Schedule	*FI*		*FI*		*FT*		*FT*	
15	1.0	4.0	5.7	36.5	3.5	24.8	10.5	30.8
30	7.0	119.7	8.3	47.2	4.2	44.0	8.0	25.5
45	28.2	182.5	7.8	55.3	2.3	12.6	14.3	21.7
60	31.7	108.0	21.0	74.3	2.5	16.0	18.2	22.7
75	24.8	68.8	33.5	204.7	9.5	49.3	10.5	15.2
90	32.3	109.7	53.0	451.7	9.2	29.2	14.2	11.5
105	21.0	68.3	35.8	294.2	7.7	48.2	4.3	17.7
120	25.2	111.2	29.5	369.5	6.8	17.7	9.0	12.2
135	21.5	139.0	28.7	200.3	10.3	22.7	19.7	24.5
150	22.5	143.5	15.3	275.5	9.5	20.3	24.5	34.2
165			29.7	312.8	11.8	23.7	10.8	8.2
180			16.2	276.8	6.0	70.5	14.2	5.7
Pearson's *r*	.54		.80*		.20		.40	

Subjects	*C1*		*C2*		*R1*		*R2*	
	Water	*Licks*	*Water*	*Licks*	*Water*	*Licks*	*Water*	*Licks*
Schedule	*FT*		*FT*		*FT*		*FT*	
15	5.0	95.0	4.7	34.0	31.7	1419	20.2	2913
30	14.7	32.0	19.3	19.0	56.8	2244	30.8	6100
60	20.8	72.0	20.5	57.0	67.5	4904	49.5	5530
120	8.7	106.5	27.0	41.8	78.8	4218	73.7	4683
240	30.3	119.0	31.0	26.5	56.8	5601	61.5	18582
Pearson's *r*	.20		.00		.65		.72	

*Significant at *p* <.05.

Table 8

Order of Conditions in Experiment 2

Condition	Procedure	Sessions
1	Baseline 1: 25 minutes free access to apparatus - 50 food pellets placed in food magazine, no cues	17
2	Baseline 2: 25 minutes free access to apparatus - no food, no cues	17
3	FT 30 - cued pellet delivery	100
4	Extinction - no cues	10
	Lever-press training on FI 30s to stability criterion, other compartments closed	
5	FI 30 - cued pellet delivery	100
6	Extinction - no cues	10

Table 9

Baseline data: percentage involvement.

	Chinchilla							
	G4		G5		G7		G8	
Baseline*->	1	2	1	2	1	2	1	2
Activity								
L	-	-	-	-	-	-	-	-
F	4	2	6	-	-	-	4	1
B	13	19	2	10	29	20	3	24
S	1	2	-	-	-	-	-	2
W	-	-	-	-	-	-	-	-
R	20	38	49	62	36	23	72	42
T	-	-	-	-	-	-	-	-
Wd	3	2	-	-	1	3	-	-
O	58	36	42	27	34	53	21	29

*Baseline 1 sessions began with 50 pellets present;
Baseline 2 sessions had no food available.
Blanks represent less than 1%.

Table 10

Rank Order of Eight Response Opportunities For all Subjects in Conditions FT and FI (based on the last 20 sessions in each)

Condition	Subject	Ranks							
		1	2	3	4	5	6	7	8
FT	G7	R	W	B	F	T	L	S	Wd
FT	G4	F	W	B	R	S	T	L	Wd
FT	G5	F	B	L	R	W	S	T/Wd	-
FT	G8	R	W	B	L	F	S	T	Wd
FI	G7	W	B	R	L	S	F	T	Wd
FI	G4	L	W	F	B	R	S	T	Wd
FI	G5	F	L	B	R	W	S	Wd	T
FI	G8	W	L	B	R	S	F	T	Wd

Table 11

Transition probabilities between feeding and three high duration responses: drinking, bathing, and running, for all subjects in all conditions.

	Condition					
Subject	B1	B2	FT	FTE	FI	FIE
Response-Drinking						
G7	--	--	.23	.15	.98	---
G4	--	--	.21	.09	.20	---
G5	--	--	---	---	--	---
G8	--	--	.18	.25	.26	---
Response-Bathing						
G7	--	--	.12	---	.18	---
G4	--	--	.14	---	.10	---
G5	--	--	--	---	.11	---
G8	--	--	.20	---	.28	---
Response-Running						
G7	.66	--	.25	---	.18	---
G4	.40	--	.22	---	.14	---
G5	--	--	--	---	--	---
G8	--	--	.32	---	.33	---

B=baseline; E=extinction

Table 12

Mean Water Ingestion (gm) for Chinchillas in the Last Six Sessions of each Condition. Data from Multiresponse Arena.

Condition	Subjects			
	G7	G4	G5	G8
Baseline 1	7.3	5.7	5.7	0.8
Baseline 2	1.7	0.3	1.2	0.0
FT 30	14.8	20.2	1.0	12.8
FT Extinction	9.4	6.4	4.0	6.0
FI 30	10.0	13.2	1.5	11.3
FI Extinction	5.2	3.4	1.2	0.6

Table 13

Schedule-induced polydipsia in the chinchilla: mean water intake (gm) in two experiments.

1. Operant chamber	Mean of six sessions-gm						Mean for group
Subjects	C1	C2	G1	G2	G3	W3	
Home cage	--	--	47.8	20.3	29.0	42.8	34.9
Free pellet (100)	--	0.3	2.1	3.3	3.0	5.5	2.4
FI 30 (100 pellets)	--	--	--	--	7.0	8.3	7.6
FT 30 (100 pellets)	7.4	15.8	4.1	8.0	--	--	8.8

2A. Arena study

(Sessions comparable to 1.)

Subjects	G7	G4	G5	G8	Mean for group
Baseline 1 (50 pellets)	7.3	5.7	5.7	0.8	4.9
Baseline 2 (No pellets)	1.7	0.3	1.2	0.0	.8
FI 30 (50 pellets)	17.8	17.7	8.2	15.3	14.7
FT 30 (50 pellets)	12.8	10.4	7.7	12.8	10.9

2B. Arena study

(Sessions 94-100)

	G7	G4	G5	G8	Mean for group
FI 30 (50 pellets)	10.0	13.2	1.5	11.3	12.2
FT 30 (50 pellets)	14.8	20.2	1.0	12.8	9.0

Table 14

Significance Tests of the Conditions of Experiments 1 and 2 found in Table 13.

Conditions	Test	*p* value
1. Operant Chamber		
FT 30 vs FI 30	*t*(df4)=.31	NS
2. Arena (sessions comparable to 1.)		
Bl vs FT 30	*t*(df4)=2.85	*p*<.05
Bl vs FI 30	*t*(df4)=3.81	*p*<.05
FT 30 vs FI 30	*t*(df6)=1.49	NS
3. Arena (sessions 94-100)		
FT 30 vs FI 30	*t*(df6)=.67	NS
4. Mixed Tests		
FI 30 (2) vs FI 30 (3)	*t*(df4)=6.38	*p*<.05
FT 30 (2) vs FT 30 (3)	*t*(df4)=.38	NS
FT 30 (1) vs FT 30 (3)	*t*(df6)=.76	NS
FI 30 (1) vs FI 30 (3)	*t*(df4)=2.08	NS

Numbers in parentheses indicate from what condition the means are drawn.

Appendix A

Water intake (ml) for the six criterion sessions for all phases of Experiment 1, with 95% confidence intervals.

	Subjects							
Schedule Type:	**Fixed Interval**				**Fixed Time**			
Phase or IPI Size (Sec)	O3	W3	O1	O2	C1	C2	R1	R2
	45	65	42	20	40	18	50	30
	18	30	50	15	30	22	40	43
Home Cage	30	42	55	45	35	20	36	39
24-Hour	42	60	50	22	37	15	45	44
Baseline	33	20	50	45	33	25	43	38
	16	40	40	20	35	20	48	36
Mean	30.7	42.8	47.8	27.8	35	20	43.7	38.3
SD	12	17.2	5.7	13.5	4.9	3.4	5.2	5.1
SE	4.9	7	2.3	5.5	2	1.4	2.1	2.1
CIU	43.3	60.8	53.7	41.9	40.1	23.6	49.1	43.7
CIL	18.1	24.8	41.9	13.7	29.9	16.4	38.3	32.9

	G3	W3	G1	G2	C1	C2	R1	R2
	1	3	5	0	*	*	*	*
	2	5	0	3				
"Free" Pellet	6	2	1	6				
Baseline	4	2	2	6				
	1	6	3	5				
	4	10	2	0				
MEAN	3	5.5	2.2	3.3				
SD	2	3.2	1.7	2.8				
SE	.8	1.3	.7	1.1				
CIU	5.1	8.8	4	6.4				
CIL	.9	2.2	.4	.2				

The free Pellet baseline was determined at all IPI lengths for these subjects.

	G3	W3	G1	[illegible]	C1	C2	R1	R2
	2	10	2	12	6	3	36	16
	1	5	3	10	8	6	30	18
15	0	2	5	10	2	5	30	31
	0	10	4	10	6	8	30	17
	0	6	3	11	6	4	28	17
	3	1	4	10	2	2	36	22
Mean	1	5.7	3.5	10.5	5	4.7	31.7	20.2
SD	1.3	3.8	1	.8	2.4	2.2	3.4	5.7
SE	.5	1.6	.4	.3	1	.9	1.4	2.3
CIU	2.3	9.8	4.6	11.4	7.6	7	35.3	26.1
CIL	.3	5.6	2.4	9.6	2.4	2.4	28.1	14.3

	G5	W3	G1	G2	C1	C2	R1	R2
	8	10	6	9	4	21	54	26
	2	8	4	5	6	17	62	36
30	9	8	2	9	34	22	62	36
	10	10	3	2	25	16	52	30
	3	5	2	11	12	22	56	27
	10	9	8	12	7	18	55	30
Mean	7	8.5	4.2	8	14.7	19.3	56.8	30.8
SD	3.6	1.9	2.4	3.8	12.1	2.7	17.3	18.6
SE	1.5	.8	1	1.5	5	1.1	1.7	1.8
CIU	10.8	10.4	6.7	11.8	37.5	22.1	61.2	35.4
CIL	3.2	6.2	1.7	4.2	1.9	16.5	52.4	26.2

	G3	W3	G1	G2	C1	C2	R1	R2
	20	6	2	14				
	28	10	0	12				
45	31	8	5	18				
	38	12	2	17				
	30	9	3	7				
	22	2	2	18				
Mean	28.2	7.8	2.3	14.3				
SD	6.5	3.5	1.6	4.3				
SE	2.7	1.4	.7	1.8				
CIU	35.1	11.4	4.1	18.9				
CIL	21.3	4.2	.5	9.7				

	G3	W3	G1	G2	C1	C2	R1	R2
	20	38	3	15	19	18	73	43
	52	12	4	16	32	26	67	46
60	17	8	1	19	18	22	69	56
	26	12	5	21	18	16	70	48
	39	30	1	29	14	22	67	51
	36	26	1	9	24	19	59	53
Mean	31.7	21	2.5	18.2	20.8	20.5	67.5	49.5
SD	13.2	12	1.8	6.7	6.3	3.6	4.7	4.8
SE	5.4	4.9	.7	2.7	2.6	1.5	1.9	1.9
CIU	45.6	33.7	4.3	25.1	27.5	24.3	72.8	54.5
CIL	17.8	8.3	.7	11.3	14.1	26.7	62.6	44.5

	G3	W3	G1	G2	C1	C2	R1	R2
	29	23	10	17				
	31	40	6	9				
75	20	30	10	5				
	20	38	11	13				
	21	50	12	10				
	28	20	8	9				
Mean	24.8	33.5	9.5	10.5				
SD	5	11.3	2.2	4.1				
SE	2.1	4.6	.9	1.7				
CIU	30.2	45.3	11.8	14.8				
CIL	19.4	21.7	7.2	6.2				

	G3	W3	G1	G2	C1	C2	R1	R2
	34	58	15	21				
	37	55	6	12				
90	35	60	8	9				
	34	88	12	6				
	26	37	12	18				
	28	20	2	19				
Mean	32.3	53	9.2	14.2				
SD	4.3	23	4.7	6				
SE	1.8	9.4	1.9	2.5				
CIU	36.9	77.2	14.1	20.6				
CIL	27.7	28.8	4.3	7.8				

	G3	W3	G1	G2	C1	C2	R1	R2
	25	20	9	7				
	21	40	8	1				
105	20	40	7	5				
	20	40	10	3				
	19	45	3	2				
	21	30	9	8				
Mean	21	35.8	7.7	4.3				
SD	2.1	9.2	2.5	2.8				
SE	.9	3.7	1	1.1				
CIU	23.3	45.3	10.3	7.1				
CIL	18.7	26.3	5.1	1.5				

	G3	W3	G1	G2	C1	C2	R1	R2
	30	20	8	5	5	32	78	73
	20	28	6	9	14	26	84	60
120	28	45	5	11	8	25	72	80
	20	30	2	11	4	20	83	80
	21	23	10	8	9	33	80	80
	32	31	10	10	12	26	76	69
Mean	25.2	29.5	6.8	9	8.7	27	78.8	73.7
SD	5.5	8.7	3.1	2.3	3.9	4.8	4.5	8.1
SE	2.2	3.5	1.3	.9	1.6	2	1.8	3.3
CIU	30.8	38.5	10.1	11.3	12.8	32.1	83.4	82.2
CIL	19.6	20.5	3.5	6.7	4.6	21.9	74.2	65.2

	G3	W3	G1	G2	C1	C2	R1	R2
	20	33	12	42				
	18	50	9	11				
135	25	15	10	11				
	19	19	11	15				
	22	25	10	20				
	25	30	10	19				
Mean	21.5	28.7	10.3	19.7				
SD	3	12.4	1	11.6				
SE	1.2	5.1	.4	4.7				
CIU	24.6	41.8	11.4	31.8				
CIL	18.4	15.6	9.2	7.6				

	G3	W3	G1	G2	C1	C2	R1	R2
	32	19	6	21				
	26	11	10	22				
150	13	17	10	29				
	26	15	11	30				
	17	11	10	25				
	21	19	10	20				
Mean	22.5	15.3	9.5	24.5				
SD	6.9	3.7	1.8	4.2				
SE	2.8	1.5	.7	1.7				
CIU	29.7	19.2	11.3	28.9				
CIL	15.3	11.4	7.7	20.1				

	G3	W3	G1	G2	C1	C2	R1	R2
		28	11	10				
		30	9	9				
165		30	12	16				
		30	11	7				
		30	12	14				
		30	16	9				
Mean		29.7	11.8	10.8				
SD		.8	2.3	3.4				
SE		.3	.9	1.4				
CIU		30.6	14.1	14.4				
CIL		28.8	9.5	7.2				

	G3	W3	G1	G2	C1	C2	R1	R2
		21	7	10				
		12	7	16				
180		16	3	20				
		14	7	18				
		18	5	11				
		16	7	10				
Mean		16.2	6	14.2				
SD		3.1	1.7	4.4				
SE		1.3	.7	1.8				
CIU		19.5	7.8	18.8				
CIL		12.9	4.2	9.6				

	G3	W3	G1	G2	C1	C2	R1	R2
					26	43	37	105
					31	17	64	46
240					31	42	62	25
					42	38	64	63
					34	28	54	73
					18	18	60	57
Mean					30.3	31	56.8	61.5
SD					8	11.7	10.4	26.9
SE					3.3	4.8	4.2	11
CIU					38.8	43.5	67.6	90.2
CIL					21.8	18.7	46	32.8

Appendix B

A Computer Program for Tracking the Sequencing of Responding in a Multiresponse operant arena.

This program was written in TRS 80 level three basic.

```
10 OUT 236,16
20 A$=INKEY$: IF A$="A" GOTO 170 ELSE 60
60 A=INPUT (0)
100 IF A<255: GOTO 110 ELSE 20
110 B=255-A: C=(LOG(B)/LOG(2))+1
115 PRINT "ACTIVITY= "C< "CH= " CH
120 SQ(P,C)=SQ(P,C)+1
130 IF P<>C THEN LET CH=CH+1
 140 P=C
150 For I=1 TO 20 : NEXT I
160 GOTO 20
170 FOR P=1 TO 8: PRINT: FOR C=1 TO 8: PRINT FQ(P,C);
175 NEXT C,P
```

Appendix C

Table 1

Sequential dependencies between all possible combinations of the eight responses observed during Baseline 1 (massed reinforcer). Based upon the average frequencies from the last six sessions.

Subjects	Lever	Feeder	Bath	Social	Water	Run	Tunnel	Wood
G7								
Lever	.00	1.00	.00	.00	.00	.00	.00	.00
Feeder	.14	.00	.09	.19	.00	.38	.19	.00
Bath	.04	.13	.13	.09	.00	.43	.17	.00
Social	.00	.43	.07	.00	.07	.14	.28	.00
Water	.00	.37	.37	.25	.00	.00	.00	.00
Run	.00	.08	.87	.00	.00	.00	.04	.00
Tunnel	.00	.21	.36	.00	.07	.36	.00	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00
G4								
Lever	.00	1.00	.00	.00	.00	.00	.00	.00
Feeder	.12	.00	.27	.24	.00	.18	.18	.00
Bath	.00	.18	.08	.07	.00	.34	.33	.00
Social	.00	.07	.06	.00	.00	.33	.54	.00
Water	.00	.00	.00	.00	.00	.00	.00	.00
Run	.02	.06	.52	.11	.00	.00	.29	.00
Tunnel	.00	.06	.15	.42	.00	.17	.20	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00
G5								
Lever	.00	1.00	.00	.00	.00	.00	.00	.00
Feeder	.00	.00	.17	.00	.00	.83	.00	.00
Bath	.00	.11	.00	.08	.04	.65	.11	.00
Social	.00	.00	.00	.00	.00	.00	1.00	.00
Water	.00	.00	.00	.00	.00	.00	1.00	.00
Run	.00	.03	.66	.00	.03	.09	.23	.00
Tunnel	.10	.10	.20	.00	.00	.50	.10	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00
G8								
Lever	.00	.50	.50	.00	.00	.00	.00	.00
Feeder	.25	.00	.42	.08	.00	.17	.08	.00
Bath	.05	.10	.00	.05	.00	.63	.16	.00
Social	.00	.37	.00	.00	.00	.62	.00	.00
Water	.00	.00	.00	.00	.00	.00	.00	.00
Run	.04	.09	.70	.04	.00	.00	.13	.00
Tunnel	.00	.08	.00	.33	.00	.25	.33	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00

Appendix C

Table 2

Sequential dependencies between all posible combinations of the eight responses observed during Baseline 2. Based upon the average from the last six sessions.

Subjects	Lever	Feeder	Bath	Social	Water	Run	Tunnel	Wood
G7								
Lever	.00	.00	.00	.00	.00	.00	.00	.00
Feeder	.00	.00	.12	.09	.06	.66	.06	.00
Bath	.00	.41	.00	.00	.06	.53	.00	.00
Social	.00	.00	.50	.00	.50	.00	.00	.00
Water	.00	.29	.00	.00	.00	.71	.00	.00
Run	.00	.55	.42	.00	.03	.00	.00	.00
Tunnel	.00	.33	.00	.00	.00	.33	.33	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00
G4								
Lever	.00	1.00	.00	.00	.00	.00	.00	.00
Feeder	.00	.00	.14	.26	.07	.40	.12	.00
Bath	.00	.34	.08	.12	.00	.30	.16	.00
Social	.00	.17	.08	.00	.00	.27	.48	.00
Water	.00	.50	.50	.00	.00	.00	.00	.00
Run	.02	.13	.35	.22	.00	.00	.28	.00
Tunnel	.00	.10	.14	.52	.00	.18	.06	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00
G5								
Lever	.00	.00	.00	.00	.00	.00	.00	.00
Feeder	.00	.00	.00	.00	.10	.90	.00	.00
Bath	.00	.23	.00	.00	.08	.69	.00	.00
Social	.00	.50	.00	.00	.00	.50	.00	.00
Water	.00	.00	.00	.25	.00	.75	.00	.00
Run	.00	.09	.76	.05	.09	.00	.00	.00
Tunnel	.00	.00	.00	.00	.00	.00	.00	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00
G8								
Lever	.00	.00	.00	.00	.00	.00	.00	.00
Feeder	.00	.00	.14	.00	.00	.86	.00	.00
Bath	.00	.12	.00	.00	.00	.88	.00	.00
Social	.00	.00	.50	.00	.00	.50	.00	.00
Water	.00	.00	.00	.00	.00	.00	.00	.00
Run	.00	.31	.68	.06	.00	.00	.06	.00
Tunnel	.00	.00	.00	.00	.00	1.00	.00	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00

Appendix C

Table 3

Sequential dependencies between all possible combinations of the eight responses observed during FT 30 sessions. Based upon the average from the last six sessions.

Subjects	Lever	Feeder	Bath	Social	Water	Run	Tunnel	Wood
G7								
Lever	.00	.63	.02	.00	.10	.14	.10	.00
Feeder	.23	.00	.12	.02	.23	.25	.15	.00
Bath	.07	.73	.00	.00	.00	.17	.03	.00
Social	.00	.33	.00	.00	.33	.33	.00	.00
Water	.06	.92	.02	.00	.00	.02	.00	.00
Run	.03	.84	.05	.00	.03	.00	.05	.00
Tunnel	.03	.58	.00	.00	.21	.18	.00	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00
G4								
Lever	.00	.97	.00	.00	.00	.00	.02	.00
Feeder	.10	.00	.14	.10	.21	.22	.14	.00
Bath	.00	.54	.00	.02	.28	.02	.13	.00
Social	.00	.44	.02	.00	.48	.02	.02	.00
Water	.00	.67	.12	.12	.00	.02	.08	.00
Run	.00	.68	.07	.01	.20	.00	.07	.00
Tunnel	.00	.21	.19	.04	.34	.15	.00	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00
G5								
Lever	.00	1.00	.00	.00	.00	.00	.00	.00
Feeder	.52	.07	.14	.00	.00	.10	.17	.00
Bath	.00	1.00	.00	.00	.00	.00	.00	.00
Social	.00	.00	.00	.00	.00	.00	.00	.00
Water	.00	1.00	.00	.00	.00	.00	.00	.00
Run	.00	1.00	.00	.00	.00	.00	.00	.00
Tunnel	.00	.00	.00	.00	.00	.00	.00	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00
G8								
Lever	.00	.79	.05	.02	.08	.08	.04	.00
Feeder	.21	.00	.20	.03	.18	.32	.04	.01
Bath	.31	.37	.04	.00	.09	.20	.02	.00
Social	.44	.22	.11	.00	.11	.00	.11	.00
Water	.38	.44	.11	.02	.00	.03	.00	.02
Run	.06	.70	.06	.02	.08	.00	.00	.00
Tunnel	.08	.46	.08	.00	.23	.08	.08	.00
Wood	.00	1.00	.00	.00	.00	.00	.00	.00

Appendix C

Table 4

Sequential dependencies between all possible combinations of the eight responses observed during FI 30. Based upon the average from the last six sessions.

Subjects	Lever	Feeder	Bath	Social	Water	Run	Tunnel	Wood
G7								
Lever	.00	.76	.06	.02	.02	.09	.09	.00
Feeder	.25	.00	.18	.06	.21	.18	.12	.01
Bath	.76	.00	.00	.00	.01	.15	.06	.00
Social	.60	.00	.05	.00	.35	.00	.00	.00
Water	.98	.00	.00	.02	.00	.00	.00	.00
Run	.80	.00	.07	.00	.01	.00	.11	.00
Tunnel	.51	.04	.10	.02	.15	.15	.02	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00
G4								
Lever	.00	.92	.02	.00	.04	.01	.00	.00
Feeder	.44	.00	.10	.07	.20	.14	.04	.00
Bath	.27	.03	.01	.01	.57	.04	.04	.00
Water	.58	.39	.03	.03	.00	.02	.01	.00
Run	.03	.08	.25	.00	.30	.00	.04	.00
Tunnel	.38	.00	.21	.10	.03	.24	.03	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00
G5								
Lever	.02	.98	.00	.00	.00	.00	.00	.00
Feeder	.76	.02	.11	.01	.02	.08	.00	.00
Bath	.94	.00	.00	.06	.00	.00	.00	.00
Social	.66	.00	.00	.00	.00	.33	.00	.00
Water	.66	.00	.00	.00	.00	.33	.00	.00
Run	.50	.07	.42	.00	.00	.00	.00	.00
Tunnel	.00	.00	.00	.00	.00	.00	.00	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00
G8								
Lever	.00	.91	.02	.00	.05	.01	.00	.00
Feeder	.08	.00	.28	.02	.26	.33	.02	.00
Bath	.83	.01	.00	.01	.08	.06	.00	.00
Social	.78	.00	.00	.00	.22	.00	.00	.00
Water	.91	.00	.08	.00	.00	.01	.00	.00
Run	.74	.02	.04	.03	.16	.00	.00	.00
Tunnel	.00	.00	.00	.00	.00	.00	.00	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00

Appendix C

Table 5

Sequential dependencies between all possible combinations of the eight responses observed during FT Extinction. Based upon the average from the last six sessions.

Subjects	Lever	Feeder	Bath	Social	Water	Run	Tunnel	Wood
G7								
Lever	.00	.00	.14	.00	.00	.00	.71	.00
Feeder	.27	.00	.36	.09	.09	.09	.09	.00
Bath	.02	.00	.07	.06	.04	.63	.16	.00
Social	.09	.00	.09	.00	.00	.72	.09	.00
Water	.00	.18	.25	.12	.00	.37	.06	.00
Run	.01	.02	.62	.02	.15	.00	.15	.00
Tunnel	.00	.03	.51	.03	.06	.32	.03	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00
G4								
Lever	.05	.80	.05	.10	.00	.00	.00	.00
Feeder	.34	.00	.19	.06	.15	.02	.22	.00
Bath	.00	.08	.05	.07	.03	.42	.35	.00
Social	.00	.08	.18	.00	.15	.38	.21	.00
Water	.00	.12	.27	.19	.00	.27	.15	.00
Run	.01	.09	.37	.11	.00	.00	.43	.00
Tunnel	.00	.03	.52	.08	.09	.20	.09	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00
G5								
Lever	.00	.70	.05	.15	.00	.05	.05	.00
Feeder	.58	.00	.16	.03	.00	.16	.06	.00
Bath	.02	.14	.11	.03	.08	.40	.22	.00
Social	.00	.06	.06	.00	.00	.65	.23	.00
Water	.00	.00	.20	.11	.00	.44	.22	.00
Run	.02	.09	.68	.11	.02	.00	.07	.00
Tunnel	.00	.06	.29	.19	.03	.29	.01	.03
Wood	.00	.00	.00	.00	.00	.00	1.00	.00
G8								
Lever	.33	.00	.00	.00	.33	.33	.00	.00
Feeder	1.00	.00	.00	.00	.00	.00	.00	.00
Bath	.00	.02	.08	.05	.11	.59	.16	.00
Social	.00	.00	.33	.00	.00	.40	.33	.00
Water	.00	.00	.33	.13	.00	.33	.13	.00
Run	.00	.00	.67	.04	.25	.00	.04	.00
Tunnel	.00	.06	.35	.12	.18	.23	.00	.06
Wood	.00	.00	1.00	.00	.00	.00	.00	.00

Appendix C

Table 6

Sequential dependencies between all possible combinations of the eight responses observed during FI Extinction. Based upon the average from the last six sessions.

Subject	Lever	Feeder	Bath	Social	Water	Run	Tunnel	Wood
G7								
Lever	.15	.15	.23	.13	.03	.18	.13	.00
Feeder	1.00	.00	.00	.00	.00	.00	.00	.00
Bath	.07	.00	.23	.05	.02	.47	.18	.01
Social	.05	.00	.71	.00	.09	.09	.05	.00
Water	.57	.00	.14	.29	.00	.00	.00	.00
Run	.04	.00	.78	.03	.01	.00	.13	.01
Tunnel	.10	.00	.48	.04	.00	.31	.06	.02
Wood	.00	.00	.25	.25	.00	.25	.25	.00
G4								
Lever	.01	.75	.03	.01	.00	.12	.07	.00
Feeder	.83	.00	.02	.00	.00	.07	.07	.00
Bath	.04	.02	.00	.02	.04	.41	.46	.00
Social	.04	.00	.04	.00	.00	.67	.26	.00
Water	.00	.00	.62	.13	.00	.00	.25	.00
Run	.08	.00	.25	.04	.00	.00	.64	.00
Tunnel	.04	.00	.27	.06	.00	.42	.19	.00
Wood	.00	.00	.33	.00	.00	.00	.67	.00
G5								
Lever	.23	.47	.17	.00	.00	.10	.03	.00
Feeder	.37	.00	.43	.06	.06	.00	.06	.00
Bath	.13	.00	.10	.01	.00	.42	.34	.00
Social	.00	.00	.00	.00	.00	.80	.20	.00
Water	.00	.00	.25	.00	.00	.50	.25	.00
Run	.04	.00	.48	.05	.03	.00	.40	.00
Tunnel	.05	.02	.14	.14	.02	.49	.16	.00
Wood	.00	.00	.00	.00	.00	.00	.00	.00
G8								
Lever	.12	.12	.12	.12	.00	.12	.25	.12
Feeder	.00	.00	1.00	.00	.00	.00	.00	.00
Bath	.06	.00	.19	.08	.04	.48	.13	.02
Social	.00	.00	.18	.00	.00	.82	.00	.00
Water	.00	.00	.00	.33	.00	.00	.66	.00
Run	.03	.00	.80	.11	.03	.00	.05	.00
Tunnel	.21	.00	.36	.07	.00	.29	.07	.00
Wood	.00	.00	.50	.50	.00	.00	.00	.00

Appendix D

The Chinchilla

The chinchilla is a nocturnal, South American hystricomorph rodent of the family Chinchilidae. There is currently some controversy as to whether it is monospecific with three subspecies or dispecific. Osgood (1941; 1944) described chinchilla *C. velligerae*, *C. C. chinchilla* and *C. C. Boliviana*; while Cabrera (1940) recognizes *C. lanigera* and *C. brevicaudata*. The present study used *C. lanigera* as described by Cabrera (see Figure 2).

The body of the adult male or female *C. lanigera* ranges from 260-270 mm long, and the tail is generally 150 mm long. Adults weigh from .5 kg to as much as 7 kg. Its coloration is grey on the dorsal and lateral portion of the body and creamy white ventrally. The tail has long grey, white and black hairs on the dorsal section, short white hairs on the lateral surfaces and short black hairs on the ventral surface. The fur of the chinchilla is multicolored with grey stalks with a small white band distally ending in a grey tip. There are fifty to seventy hairs per follicle. Interspersed among the fur are guard hairs that keep the fur fluffy. The forefeet are small, 20-25 mm, with four functional digits and a rudimentary fifth. The hindfoot is 50-60 mm long and has three major digits and a forth that is one half the length of the others. The head is approximately one forth of the body length. The eyes are round and brownish-black in color. The whiskers are white and black in color and are from 30-110 mm long. The chinchilla also has large, 50-55 mm long hairless ears. This later feature has brought the chinchilla to the scientific community as a subject primarily used for auditory research (Bohne, 1981; Burdick & Miller, 1973; Henderson, Hamernik, & Sitler, 1974; Henderson, Onishi, Elderidge, & Davis, 1969; Mast, 1970; Smith & Rasmussen, 1963).

Chinchillas were once found in abundance throughout the Andes of Argentina, Bolivia, Chile, and Peru. Currently, colonies have been located only in Chile and Peru. When found, the colonies dwell in large rock outcroppings and rocky slopes over 600 meters in elevation and with slopes of 18'-40'. The substrate is a combination of sandy soil, fine gravel, and talus with rockiness ranging from 30-100%. Within this environment chinchillas frequently den within the bases of large shrubs (paya berteroniana) or under rock.

The population structure appears colonial in that young males emigrate. Mother-offspring bonds are strong, and there is some evidence of monogamy (Mohlis, 1978). Intraspecific aggression between males and males, and males and females is not uncommon. Female aggression is attenuated post-partum. Life expectancy of chinchillas is estimated at 15-20 years, but in captivity 8-10 is common (Grau, 1974; Bickel, 1976). Chinchillas reach breeding age at seven to nine months and have a gestation period of 111-128 days. There is an average of two young per litter and weaning is complete at 60 days. Young are precocial in that they are born fully furred, eyes open and are on their paws within 10 minutes after birth (Fried, unpublished observations).

Finally, chinchillas are herbivores. Their food includes seeds, roots, leaves, stems and fruit of surrounding plant species. The environment is described as semi-arid. When it rains the pools of water that form quickly evaporate.

References

Allen, J. D., & Kenshalo, D. R., Jr. (1978). Schedule-induced drinking as functions of interpellet interval and draught size in the Java macaque. Journal of the Experimental Analysis of Behavior, 30, 139-151.

Anderson, M. C., & Shettleworth, S. J. (1977). Behavioral adaptation to fixed-interval and fixed-time food delivery in golden hamsters. Journal of the Experimental Analysis of Behavior, 25, 33-49.

Appel, J. B. (1963). Aversive aspects of a schedule of positive reinforcement. Journal of the Experimental Analysis of Behavior, 6, 423-428.

Azrin, N. H. (1961). Time-out from positive reinforcement. Science, 133, 382-383.

Azrin, N. H., Hutchinson, R. R., & Hake, D. F. (1966). Extinction-induced aggression. Journal of the Experimental Analysis of Behavior, 9, 191-204.

Barret, J. E., Stanley, J. A., & Weinberg, E. S. (1978). Schedule-induced water and ethanol consumption as a function of interreinforcement interval in the squirrel monkey. Physiology and Behavior, 21, 453-455.

Bellingham, W. P., Wayner, M. J., & Barone, F. C. (1979) Schedule-induced eating in water deprived rats. Physiology and Behavior, 23, 1105-1107.

Berrios, N., Carlson, N. R., Sawchencko, P. E., Gold, R. M., & Mui, A. H. (1979). Insulinogenic mediation of schedule-induced polydipsia? *Physiology and Behavior*, *23*, 237-240.

Bickel, E. (1976). *Chinchillas, wie man sie halt und zuchtet*. Minden: Albrecht Philler Verlag.

Bohne, B. A. (1981). A frequency-position map of the chinchilla cochlea. *The Journal of the Acoustical Society of America*, *69*, 1091-1095.

Bond, N. (1973). Schedule-induced polydipsia as a function of the consummatory rate. *The Psychological Record*, *23*, 277-382.

Brown, T. G., & Flory, R. K. (1972). Schedule-induced escape from fixed-interval reinforcement. *Journal of the Experimental Analysis of Behavior*, *17*, 395-403.

Brush, M. E., & Schaeffer, R. W. (1974). Effects of water deprivation on schedule-induced polydipsia. *Bulletin of the Psychonomic Society*, *4(2A)*, 69-72.

Bryant, W. E., Jr., & Porter, J. H. (1983). A comparison of schedule-induced wheel running in rats, hamsters, gerbils, and guinea pigs. *Bulletin of the Psychonomic Society*, *21*, 311-314.

Burdick, C. K. and Miller, J. D. (1973). New procedure for training chinchillas for psychoacoustic experiments. *The Journal of the Acoustical Society of America*, *54*, 789-792.

Burks, C. D. (1970). Schedule-induced polydipsia: Are response-dependent schedules a limiting condition?

Journal of the Experimental Analysis of Behavior, 13, 351-358.

Burks, C. D., Hitzing, E. W., & Schaeffer, R W. (1967). Drinking response distributions associated with a 4% sucrose FFI food schedule. Psychonomic Science, 8, 13-14.

Cabrera, A. (1940). Acerca de las chinchillas. Actas y Trabajos del Primer Congerso Sudamericano de Zoologia (La Plata), 4, 195-202.

Campagnoni, F. R., & Cohen, P. S. (1983). Scalar timing and the spatial organization of behavior between reward presentations. Poster presented at the Conference on Timing and Time Perception. New York: NY.

Carlisle, H. J. (1971). Fixed ratio polydipsia: Thermal effects of drinking, pausing, and responding. Journal of Comparative and Physiological Psychology, 75, 10-22.

Carlisle, H. J. (1973). Schedule-induced polydipsia: Effect of water temperature, ambient temperature, and hypothalamic cooling. Journal of Comparative Psychology, 83, 208-220.

Carlisle, H. J. & Laudenslager, M. L. (1976). Separation of water and ambient temperature effects on polydipsia. Physiology and Behavior, 16, 121-124.

Carlisle, H. J., Shanab, M. E., & Simpson, C. W. (1972). Schedule-induced behavior: effect of intermittent water reinforcement on food intake and body temperature.

Psychonomic Science, *26*, 35-36.

Catania, C. A. (1968). *Contemporary research in operant behavior.* Glenview, Illinois: Scott Foresman & Company.

Chapman & Richardson. (1974). The role of systemic hydration in the acquisition of schedule-induced polydipsia by rats. *Behavioral Biology*, *12*, 501-508.

Christian, W. P. (1974). Investigations of schedule-induced polydipsia as an example of displaced consummatory activity elicited by frustration. (Doctoral dissertation, Auburn University, 1974). *Dissertation Abstracts International*:, *35*, 3053A.

Christian, W. P. (1976). Control of schedule-induced polydipsia: Sugar content of the dry food reinforcer. *The Psychological Record*, *26*, 41-47.

Christian, W. P. & Schaeffer, R. W. (1973). The effects of sucrose concentrations upon schedule-induced polydipsia on a FFI-60-sec dry-food reinforcement schedule. *Psychological Reports*, *32*, 1067-1073.

Christian, W. P., & Schaeffer, R. W. (1973). A note on the advisability of using sugar-free food pellets for schedule-induced polydipsia research. *Psychological Reports*, *32*, 274.

Christian, W. P., Schaeffer, R. W., & King, G. D. (1979). *Schedule-induced behavior.* Montreal: Eden Press.

Clark, F. C. (1962). Some observations on the adventitious reinforcement of drinking under food reinforcement.

Journal of the Experimental Analysis of Behavior, 5, 61-63.

Cohen, P. S., & Campagnoni, F. R. (1981). Is time spent away from the reinforcer dispenser analogous to time out. Paper presented at the meeting of the American Psychological Association. Los Angeles, CA.

Cohen, P. S., & Looney, T. A. (1973). Schedule-induced mirror responding in the pigeon. Journal of the Experimental Analysis of Behavior, 19, 395-408.

Colotla, V. A., & Keehn, J. D. (1975). Effects of reinforcer -pellet composition on schedule-induced polydipsia with alcohol, water, and saccharin. The Psychological Record, 25, 91-98.

Cumming, W. W., & Schoenfeld, W. N. (1960). Behavior stability under extended exposure to a time-correlated reinforcement contingency. Journal of the Experimental Analysis of Behavior, 3, 71-82.

Denny, M. R., & Ratner, S. C. (1970). Comparative Psychology. Homewood, IL: Dorsey.

Deutsch, R. (1974). Conditioned hypoglycemia: a mechanism for saccharin-induced sensitivity to insulin in the rat. Journal of Comparative and Physiological Psychology, 86, 350-358.

Dunham, P. J. (1971). Punishment: method and theory. Psychological Review, 78, 58-70.

Dunham, P. J. (1972). Some effects of punishment upon unpunished responding. Journal of the Experimental Analysis of Behavior, 17, 443-450.

Dunham, P. J. (1977). The nature of reinforcing stimuli. In W. K. Honig & J. E. R. Staddon (Eds.), Handbook of operant behavior. Englewood Cliffs, NJ.: Prentice Hall.

Dunham, P. J. (1978). Changes in unpunished responding during response-contingent punishment. Animal Learning and Behavior, 6, 174-180.

Dunham, P. J., & Grantmyre, J. (1982). Changes in a multiple -response repertoire during response-contingent punishment and response restriction: sequential relationships. Journal of the Experimental Analysis of Behavior, 37, 123-133.

Ellerman, J. R. (1941). Families and genera of living rodents (Vol. 2). London: British Museum Press.

Everett, P. B., & King, R. A. (1970). Schedule-induced alcohol consumption. Psychonomic Science, 18, 278-279.

Falk, J. L. (1961a). Production of Polydipsia in normal rats by an intermitent food schedule. Science, 133, 195-196.

Falk, J. L. (1961b). The behavioral regulation of water electrolyte balance. In M. R. Jones (Ed.), Nebraska symposium on motivation 1-33. Lincoln: University of Nebraska Press.

Falk, J. L. (1964). Studies on schedule-induced polydipsia. In M. J. Wayner (Ed.), Thirst: first international symposium on thirst and the regulation of body water (pp 95-116). NY: Pergamon Press.

Falk, J. L. (1966a). The motivational properties of schedule -induced polydipsia. Journal of the Experimental Analysis of Behavior, 9, 19-25.

Falk, J. L. (1966b). Schedule-induced polydipsia as a function of fixed interval length. Journal of the Experimental Analysis of Behavior, 9, 37-39.

Falk, J. L. (1966c). Analysis of water and NaCl solution acceptance by schedule-induced polydipsia. Journal of the Experimental Analysis of Behavior, 9, 111-118.

Falk, J. L. (1967). Control of schedule-induced polydipsia: type, size, and spacing of meals. Journal of the Experimental Analysis of Behavior, 10, 199-206.

Falk, J. L. (1969). Conditions producing psychogenic polydipsia in animals. Annals of the New York Academy of Sciences, 157, 569-593.

Falk, J. L. (1971). The nature and determinants of adjunctive behavior. Physiology and Behavior, 6, 577-588.

Falk, J. L. (1972). The nature and determinants of adjunctive behavior. In R. M. Gilbert & J. D. Keehn (Eds.), Schedule effects: drugs, drinking, and aggression (pp. 148-173). Toronto: University of Toronto press.

Falk, J. L. (1977). The orgins and function of adjunctive behavior. Animal Learning and Behavior, 5, 325-335.

Fischer, R. B., & Porter, J. H. (1979). Failure to demonstrate schedule-induced polydipsia in the degus (Octodon degus). Psychological Reports, 44, 1276.

Flory, R. K. (1969). Attack behavior as a function of minimum inter-food interval. Journal of the Experimental Analysis of Behavior, 12, 825-832.

Flory, R. K. (1971). The control of schedule-induced polydipsia: frequency and magnitude of reinforcement. Learning and Motivation, 2, 215-227.

Frank, J., & Staddon, J. E. R. (1974). Effects of restraint on temporal discrimination behavior. Psychological Record, 24, 123-130.

Freed, E. X. (1971). Schedule-induced polydipsia with nutritive and non-nutritive reinforcers. Psychonomic Science, 23, 367-368.

Freed, E. X. (1974). Fluid selection by rats during schedule -induced polydipsia. Quarterly Journal of Studies on Alcohol, 35, 1035-1043.

Freed, E. X., & Hymowitz, N. (1969). A fortuitous observation regarding "psychogenic" polydipsia. Psychological Reports, 24, 224-226.

Freed, E. X., & Lester, D. (1970). Schedule-induced polydipsic consumption of ethanol: calories or chemotherapy? Physiology and Behavior, 5, 555-560.

Freed, J. W., Zec, R. F., & Mendelson, J. (1977). Schedule

-induced polydipsia: the role of orolingual factors and a new hypothesis. In Weijen, J. A. W. M., & Mendelson, J. (Eds.), Drinking behavior: oral stimulation, reinforcement, and preference (pp. 341-397). New york: Plenum Press.

Fried, A. W., & Thompson, R. L. (1982). Schedule-induced polydipsia in the chinchilla. Poster presented at the meeting of the American Psychological Association. Washington, DC.

Gibbon, J. (1977). Scalar expectancy theory and Weber's law in animal timing. Psychological Review, 84, 279-325.

Gilbert, R. M. (1973). Effects of ethanol on adjunctive drinking and bar-pressing under various schedules of reinforcement. Bulletin of the Psychonomic Society, 1, 161-164.

Githens, S. H., Hawkins, T. D., & Schrot, J. F. (1973). DRL schedule-induced alcohol ingestion. Physiology and Psychology, 1, 397-400.

Goldfine, J. D., Abraira, C., Gruenwald, D., & Goldstein, M. S. (1970). Plasma insulin levels during imaginary food ingestion under hypnosis. Proceedings of the Society for Experimental Biology and Medicine, 133, 274-276.

Grau, J. (1974). La chinchilla, su crianza extodos los climas. Buenos Aires: Ediciones Cientificas Oikos S. R. L.

Hawkins, T. D., Schrot, J. F., Githens, S. H., & Everett, P.

B. (1972). Schedule-induced polydipsia: an analysis of water and alcohol ingestion. In R. M. Gilbert and J. D. Keehn (Eds.), *Schedule effects: Drugs, drinking, and aggression* (pp. 95-128). Toronto: University of Toronto Press.

Henderson, D., Hamernick, R. P., & Sitler, R. W. (1974). Audiometric and histological correlates of exposure to 1-msec noise impulses in the chinchilla. *Journal of the Acoustical Society of America*, *56*, 1210-1221.

Henderson, D., Onishi, S., Elderidge, D. H., & Davis, H. (1969). A comparison of chinchilla auditory evoked response and behavioral response thresholds. *Perception and Psychophysics*, *5*, 41-45.

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

Herrnstein, R. J. Formal properties of the matching law. *Journal of the Experimental Analysis of Behavior*, *21*, 159-164.

Hoppman, R. A., Allen, J. D. (1979). Test of the generality of schedule-induced polydipsia to wild caught Norway rats. *Physiology and Behavior*, *22*, 195-198.

Hudson, R., & Singer, G. (1979). Polydipsia in the monkey generated by visual display schedules. *Physiology and Behavior*, *22*, 379-381.

Hutchinson, R. R., Azrin, N. H., & Hunt, G. M. (1968). Attack produced by intermittent reinforcement of a contingent operant response. Journal of the Experimental Analysis of Behavior, 11, 485-495.

Hymowitz, N. (1971). Schedule-induced polydipsia and aggression in rats. Psychonomic Science, 23, 226-228.

Innis, N. K., & Honig, W. K. (1979). Stimulus control of behavior during the postreinforcement pause of FI schedules. Animal Learning and Behavior, 7, 203-210.

Kachanoff, R., Leveille, R., Mclelland, J. P., & Wayner, M. J. (1973). Schedule-induced behavior in humans. Physiology and Behavior, 11, 395-398.

Keehn, J. D. (1970). Schedule-induced licking and polydipsia. Psychological Reports, 26, 155-161.

Keehn, J. D. (1972). Effects of trihexyphenidyl on schedule -induced alcohol drinking in rats. Psychonomic Science, 29, 20-22.

Keehn, J. D., & Colotla, V. A. (1971). Schedule-induced drinking as a function of interpellet interval. Psychonomic Science, 23, 69-71.

Keehn, J. D., Colotla, V. A., & Beaton, J. M. (1970). Palatability as a factor in the duration and pattern of schedule-induced drinking. Psychological Record, 20, 433-422.

Killeen, P. (1975). On the temporal control of behavior. Psychological Review, 83, 92-97.

Killeen, P., Hanson, S. J., & Osborne, S. R. (1978). Arousal: its genisis and manifestation as response rate. Psychological Review, 85, 571-581.

King, G. D., & Schaeffer, R. W. (1973). Developmental analysis of schedule-induced polydipsia. Psychological Reports, 32, 1087-1095.

Knutson, J. F., & Kleinknecht, R. A. (1970). Attack during differential reinforcement of low rate responding. Psychonomic Science, 19, 289-290.

Lashley, R. L., & Rosellini, R. A. (1980). Modulation of schedule-induced polydipsia by Pavlovian conditioned states. Physiology and Behavior, 24, 411-414.

Laties, V. G., Weiss, B., & Weiss, A. B. (1969). Further determination of overt "mediating" behavior and the discrimination of time. Journal of the Experimental Analysis of Behavior, 12, 43-57.

Laties, V. G., Weiss, B., Clark, R. L., & Reynolds, M. D. (1965). Overt "mediating" behavior during temporally spaced responding. Journal of the Experimental Analysis of Behavior, 8, 107-116.

Lester, D. (1961). Self-maintenance of intoxication in the rat. Quarterly Journal of Studies on Alcohol, 22, 223-231.

Lester, D. (1966). Self-selection of alcohol by animals, human variation and the etiology of alcoholism. Quarterly Journal of Studies on Alcohol, 27, 395-438.

Levitsky, D., & Collier, G. (1968). Schedule-induced wheel running. Physiology and Behavior, 3, 571-573.

Mast, T. E. (1970). Study of single units of the cochlear nucleus of the chinchilla. The Journal of the Acoustical Society of America, 48, 505-512.

Mello, N. K., & Mendelson, J. H. (1971). Evaluation of a polydipsia technique to induce alcohol consumption in monkeys. Physiology and Behavior, 7, 827-836.

Mendelson, J. H. (1977). Air licking and cold licking in rodents. In J. A. W. M. Weijnen, & J. Mendelson (Eds.), Drinking behavior: oral stimulation, reinforcement, and preference (pp.157-197). New York: Plenum Press.

Mendelson, J. H., & Chillag, D. (1968). Schedule-induced air -licking in rats. American Zoologist, 8, 744.

Mendelson, J. H., & Chillag, D. (1970). Schedule-induced air licking in rats. Physiology and Behavior, 5, 535-537.

Mendelson, J. H., & Plotsky, P. M. (1974). Cold-licking in guinea pigs as a function of temperature. Behavioral Biology, 10, 191-198.

Miller, L. K. (1968). Escape from an effortful situation. Journal of the Experimental Analysis of Behavior, 11, 619-628.

Miller, J. S., & Gollub, L. R. (1974). Adjunctive and operant bolt pecking in the pigeon. The Psychological Record, 24, 203-208.

Minor, T. R., & Coulter, X. (1982). Associative and postprandial control of schedule-induced drinking: implications for the study of interim behavior. Animal

Learning and Behavior, 10, 455-464.

Mohlis, C. (1978). Preliminary information on the conservation and management of wild chinchillas (Chinchilla lanigera) in Chile. Santiago, Corporacion Nacional Forestal.

Osgood, W. H. (1941). The technical name of the chinchilla. Journal of Mammology, 22, 407-411.

Osgood, W. H. (1944). The Mammals of Chile (Publication 542). Field Museum of Natural History Zoological Series.

Palfai, T., Kutscher, C. L., & Symons, J. P. (1971). Schedule-induced polydipsia in the mouse. Physiology and Behavior, 6, 461-462.

Penick, S. B., Prince, H., & Hinkle, L. E. (1966). Fall in plasma content of free fatty acids associated with the sight of food. New England Journal of Medicine, 275, 416-419.

Porter, J. H., & Bryant, W. E. (1978). Adjunctive behavior in the mongolian gerbil. Physiology and Behavior, 21, 151-155.

Porter, J. H., & Bryant, W. E. (1978). Acquisition of schedule-induced polydipsia in the mongolian gerbil. Physiology and Behavior, 21, 825-827.

Porter, J. H., Hastings, M. T., & Pagels, J. F. (1980) Schedule-induced polydipsia in the cotton rat (Sigmodon hispidus). Bulletin of the Psychonomic Society, 16, 15-18.

Porter, J. H., & Kenshalo, D. R. (1974). Scedule-induced drinking following omission of reinforcement in the rhesus monkey. Physiology and Behavior, 12, 1075-1077.

Porter, J. H., Sozer, N. N., & Moeschl, T. P. (1977). Schedule-induced polydipsia in the guinea pig. Physiology and Behavior, 19, 573-575.

Reberg, D., Innis, N. K., Mann, B., & Eizenga, C. (1978). "Superstitious" behavior resulting from periodic respose-independent presentations of food or water. Animal Behavior, 26, 507-519.

Richardson, W. K., & Loughead, T. E. (1974). The effect of physical restraint on behavior under the differential-reinforcement-of-low-rate schedule. Journal of the Experimental Analysis of Behavior, 21, 455-461.

Roper, T. J. (1978). Diversity and substitutability of adjunctive activities under fixed-interval schedules of food reinforcement. Journal of the Experimental Analysis of Behavior, 30, 83-96.

Roper, T. J. (1981). What is meant by the term "schedule-induced" and how general is schedule induction? Animal Learning and Behavior, 9, 433-440.

Roper, T. J. (1982). Schedule-induction: a reply to Timberlake and to Wetherington and Brownstein. Animal Learning and Behavior, 10, 540.

Roper, T. J., & Posadas-Andrews, A. (1981). Are schedule -induced and displacement activities causally related? Quarterly Journal of Experimental Psychology, 338, 181-193.

Rosenblith, J. Z. (1970). Polydipsia induced in the rat by a second-order schedule. Journal of the Experimental Analysis of Behavior, 14, 139-144.

Schuster, C. R., & Woods, J. H. (1966). Schedule-induced polydipsia

in the rhesus monkey. Psychological Reports, 19, 823-828.

Segal, E. F. (1969). Transformation of polydipsic drinking to operant drinking: a paradigm. Psychonomic Science, 16, 133-135.

Segal, E. F., Deadwyler, S. A. (1964). Amphetamine differentially effects temporally spaced barpressing and collateral water drinking. Psychonomic Science, 1, 349-350.

Segal, E. F., & Deadwyler, S. A. (1965). Determinants of polydipsia: VI. Taste of the drinking solution on DRL. Psychonomic Science, 3, 101-102.

Segal, E. F., & Hollaway, S. M. (1963). Timing behavior in rats with water drinking as a mediator. Science, 140, 888-889.

Segal, E. F., Oden, D. L., & Deadwyler, S. A. (1965). Determinants of polydipsia: IV. Free reinforcement schedules. Psychonomic Science, 3, 11-12.

Segal, E. F., Oden, D. L., & Deadwyler, S. A. (1965). Determinants of polydipsia: V. Effect of amphetamine and pentobarbitol. Psychonomic Science, 3, 33-34.

Shanab, M., & Petersen, J. L. (1969). Polydipsia in the pigeon. Psychonomic Science, 15, 51-52.

Shumake, R. A. B. (1968). Schedule-induced polydipsia: licking response patterns associated with concurrently available fluids. Unpublished master's thesis, Florida State University.

Shurtleff, D., Delamater, A. R., & Riley, A. L. (1983). A reevaluation of the CS- hypothesis for schedule-induced polydipsia under intermittent schedules of pellet delivery. Animal Learning and Behavior, 7, 247-254.

Skinner, B. F. (1948). "Superstition" in the pigeon. Journal of Experimental Psychology, 38, 168-172.

Skinner, B. F., & Morse, W. H. (1957). Concurrent activity under fixed-interval reinforcement. Journal of Comparative and Physiological Psychology, 50, 279-291.

Skuban, W. E., & Richardson, W. K. (1975) The effect of the size of the test environment on behavior under two temporally defined schedules. Journal of the Experimental Analysis of Behavior, 23, 271-275.

Smith, C. A., & Rasmussen, G. L. (1963). Recent observations on the oliviocochlear bundle. Annals of Otolaryngology, Rhinology, and Laryngology, 72, 489-506.

Staddon, J. E. R. (1977). Schedule-induced behavior. In W. K. Honig & J. E. R. Staddon (Eds.), *Handbook of operant behavior* (pp. 125-152). Englewood Cliffs, NJ: Prentice -Hall.

Staddon, J. E. R., & Ayres, S. L. (1975). Sequential and temporal properties of behavior induced by a schedule of periodic food delivery. *Behaviour*, *54*, 26-49.

Staddon, J. E. R., & Simmelhag, V. L. (1971). The "superstition" experiment: a reexamination of its implications for the principles of adaptive behavior. *Psychological Review*, *78*, 3-43.

Stein, L. (1964). Excessive drinking in the rat: superstition or thirst? *Journal of Comparative and Physiological Psychology*, *58*, 237-242.

Stricker, E. M., & Adair, E. R. (1966). Body fluid balance, taste, and postprandial factors in schedule-induced polydipsia. *Journal of Comparative and Physiological Psychology*, *62*, 449-454.

Terrace, H. S. (1966). Stimulus control. In W. K. Honig (Ed.), *Operant behavior: areas of research and application* (pp. 271-344). NY: Appelton-Century-Crofts.

Thompson, D. M. (1964). Escape from SD associated with fixed -ratio reinforcement. *Journal of the Experimental Analysis of Behavior*, *7*, 1-8.

Timberlake, W. (1982). Controls and schedule-induced behavior. *Animal Learning and Behavior*, *10*, 535-536.

Walker, E. P. (Ed.). (1964). Mammals of the world. Baltimore: Johns Hopkins Press.

Wallace, M., & Singer, G. (1976). Schedule-induced behavior: a review of its generality, determinants, and pharmacological data. Pharmacology, Biochemistry, and Behavior, 5, 483-490.

Wallace, M., Singer, G., & Cook, P. (1975). Adjunctive behavior in humans during game playing. Physiology and Behavior, 14, 651-654.

Wayner, M. J., & Greenberg, I. (1973). Schedule dependence of schedule-induced polydipsia and lever pressing. Physiology and Behavior, 10, 965-966.

Wetherington, C. L. (1979). Schedule-induced drinking: rate of food delivery and Herrnstein's equation. Journal of the Experimental Analysis of Behavior, 32, 323-333.

Wetherington, C. L., & Brownstein, A. J. (1982). Comment on Roper's discussion of the language and generality of schedule-induced behavior. Animal Learning and Behavior, 10, 537-539.

Wetherington, C. L., & Brownstein, A. J. (1979). Schedule -control of eating by fixed-time schedules of water presentation. Animal Learning and Behavior, 7, 38-40.

Wetherington, C. L. (1982). Is adjunctive behavior a third class of behavior? Neuroscience and Biobehavioral Reviews, 6, 329-350.

Wetherington, C. L., Brownstein, A. J., & Schull, R. L.

(1977). Schedule-induced running and chamber size. Psychological Record, 27, 703-713.

Wilson, S., & Spencer, W. B. (1975). Schedule-induced polydipsia: species limitations. Psychologiacl Reports, 36, 863-866.

Wuttke, W., & Innis, N. K. (1972). Drug effects upon behavior induced by second-order schedules of reinforcement: the relevance of ethanol analyses. In R. M. Gilbert and J. D. Keehn (Eds.), Schedule effects: drugs, drinking, and aggression (pp. 129-147). Toronto: University of Toronto Press.

Yoburn, B. C., & Cohen, P. S. (1979). Assessment of attack and drinking in White King pigeons on response -independent food schedules. Journal of the Experimental Analyis of Behavior, 31, 91-102.

Zimmerman, J., & Ferster, C. B. (1964). Chained VI performance of pigeons maintained with an added stimulus. Journal of the Experimental Analysis of Behavior, 7, 83-89.

Zuriff, G. E. (1969). Collateral responding during differential reinforcement of low rates. Journal of the Experimental Analysis of Behavior, 12, 971-976.