THE UNIVERSITY OF MANITOBA

THE EFFECT OF SCHEDULES OF REINFORCEMENT ON

THE DEGREE OF DOMINANCE-SUBORDINATION

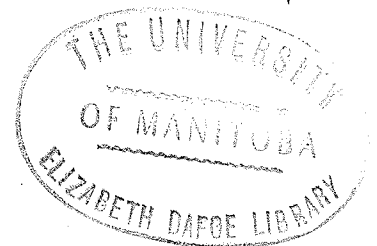BEHAVIOR IN THE RAT

by

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A THESIS

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ABSTRACT

Various schedules or reinforcement were studied in terms of their effect on the degree of dominance-subordination behavior exhibited by pairs of male albino rats competing to lever press for food. These schedules were: continuous reinforcement (CRF); gradually increasing fixed-ratio (FR); fixed-ratio of 40 (FR 40); gradually increasing fixed-interval (FI); fixed-interval of 50 seconds (FI 50 sec.). In a series of 4 experiments it was found that the degree of dominance-subordination behavior between two animals was maximized and most ridgidly maintained on FR schedules approaching or equal to FR 40, the highest FR schedule used, was minimized on a CRF schedule, and failed to emerge on FI schedules. Of the 4 dependent measures employed, the number of lever presses emitted per session, the percentage of the total session time spent controlling the aperture, and the number of reinforcements obtained per session, all were consistent in designating the dominance or subordination of an animal. The fourth measure, the number of submissive postures exhibited by each animal in a competition pair, did not appear to be correlated with the other three. This discrepancy was discussed in terms of territoriality.

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CHAPTER I

THE PROBLEM, INTRODUCTION, AND HISTORICAL BACKGROUND.

I. Statement of the Problem.

This thesis was conducted to determine the effect of various schedules of reinforcement on the degree of social dominance-subordination behavior exhibited by pairs of rats, competing to lever press for food. It was hypothesized that food competition under conditions where the probability of reinforcement is decreased (increased schedule demands) would increase and more ridgidly maintain dominance-subordination behavior between two animals. An enhancement of dominance-subordination behavior might be expected since the bar press behavior of an animal changes characteristically as the schedule of reinforcement which controls its behavior is changed. Schedule demands may be increased from continuous reinforcement (CRF), either in terms of the number of responses required per reinforcement as in a fixed-ratio (FR) schedule, or in terms of the time interval between reinforcements as in a fixed-interval (FI) schedule. Such partial reinforcement schedules generate behavior which is highly stereotypic and which is more resistant to disruption and extinction than CRF schedules, the schedules typically employed in food competition testing social dominance.

II. Introduction.

Schelderup-Ebbe's (1922) observation of the pecking order in domestic chickens was one of the first descriptions of the hierarchial organization that exists in many species of animals. In chickens

the organization is such that the animals peck all animals below and none above in the order, the order being fairly stable in time with all members of the flock behaving in accordance with their "pecking rights". These pecking rights are positively correlated with "priority rights" at a common food source, with priority rights to females in the case of males, and with the right to be the first to leave in an avoidance situation. These mutually respected rights one group member has over another constitute the dominance one animal has over the other.

In a review of dominance-subordination behavior van Kreveld (1970) has pointed out that "...Dominance is a relational concept: the priority an animal has holds for its relations to specific other animals; it is not a characteristic of the animal as such. Also, dominance is not an absolute priority of one animal over another. It can be seen as a probabilistic concept: the dominant animal is more likely to have priority." (p. 146). In an experiment by Becker and Ezinga (1969), pairs of rats competed for food at a food cup which could accommodate only one animal at a time. The animal which controlled the food source for the greater portion of a fixed time period was defined as dominant.

In addition to being superior or inferior in food competition, dominance encounters between conspecifics reveal a number of behaviors that are indicative of each animal's station, these behaviors varying across species. Crawford (1942) observed that the dominance of a chimpanzee could be predicted if the animal enters another animals cage, is groomed first by the other animal, and attacks or bluffs the other animal. Subordination could be predicted from retreating, vocalization, and grooming the other animal first.

Similarly Seward (1945 a) found that the dominance of a rat was con-
comitant with the animal attacking or threatening its opponent, with
having extreme piloerection, with grooming its opponent until it
squealed, with repeated forcing down of its opponent, and with chat-
tering its teeth over a prostrate foe. Subordination was concomitant
with the animal's breathing becoming spasmodic and labored, with it
being immobilized against a corner or the floor and fending off an
attack with all four feet, and with having bulging eyes and retracted
ears.

Dominance relations in many species are characterized by a
certain stability. After an initial period during which the relations
are settled, usually by means of aggressive display or real attack,
reversals are relatively rare. However, dominance structures which
tend toward a fixed linear hierarchy are not universally found in all
species. Other social systems may be distinguished and are roughly
classified into three categories (Baerends, 1952). The first of these
is the shoal, typically found most clearly in such fish as the herring,
but existing as well in some mammals and birds. The members in the
shoal all have the same rank and can approach each other closely with-
out displaying aggressive behavior towards one another. The second
type is the territorial society, and is found in fish, birds, and mam-
mals. Each individual has its own territory which is defended against
others. The different territories can touch to form a colony, but the
distance between individuals is fixed. Dominance ranks are not easily
distinguished in such a system, and even though some territories may
be better than others, each occupant is respected as master in his
area. The third type of social system is the hierarchized society as
typified by chickens, the swordtail, and the rhesus monkey. It is

characterized by inequality in rank among the group members with the dominant individuals having to defend their position against the subordinates.

The failure to establish hierarchial dominance relationships in some species in a laboratory setting may have its etiology in the nature of the social system that these animals exhibit in a natural setting. Masure and Allee (1934) were able to observe the emergence of a stable dominance hierarchy in chickens, but failed to find very definite peck rights in pigeons. "In only a few of the relationships observed was there a definite peck-right in which the contacting individual does all the pecking and the other does all the retreating. The more usual relationship with these pigeons was to have the pecking frequently shifting from one to the other of any given contact-pair of birds. The interval between such reversals varied from a few minutes to several days," (Masure and Allee, 1934, p. 314). "Usually, after sufficient time is given for contact relations and for their observation, the order becomes fairly definitely settled, but in the majority of these cases the subservient individual at times successfully attacks the dominant member of the contact pair and forces it to retreat without, however, causing a permanent reversal of peck dominance. Under these conditions, social ranking is apparently not determined with a high degree of finality at the first social contact of two individuals, but is a matter of gradual development." (Masure and Allee, 1934, p. 324).

Territorial societies, rather than hierarchized societies, seem to be more characteristic for pigeons (Diebschlag, 1940-1941). In general, pigeons took much longer than chickens to settle dominance

relationships, and once settled, these relationships were less stable. The aggressive encounters reported by Masure and Allee (1934) may have developed from the fact that the pigeons had to live so close together that territories could not be fully settled.

For a fixed hierarchial dominance structure to form, animals may need to be able to recognize individual and rank differences (Etkin, 1967; van Kreveld, 1970). Pigeons do not seem to have this ability (van Kreveld, 1970). Similarly Seward (1945 b) was unable to experimentally establish a stable dominance hierarchy in albino rats. Rattus norvigicus, the ferile stock from which albino rats were derived (Lockard, 1968), live crowded together in colonies which may number many hundreds. It is a territorial society in that each rat will defend its territory, (a burrow) against strangers. The lack of observed dominance hierarchy has led Etkin (1967) to state: "Though dominance patterning can be brought out to a limited extent in artificial competitions, it is neither markedly expressed, nor quickly established. Such hierchy as is shown under experimental conditions seems based on individual habits of aggression, with little evidence of recognition of individuals as such." (Etkin, 1967, p. 126).

Calhoun (1962) studied the norway rat in a semi-naturalistic setting (an enclosed pen, approximately ¼ acre). During the 27 months of observation social dominance was exhibited at the common food source situated in the center of the pen. In terms of individual recognition, Calhoun states: "Can one rat detect the identity of another rat at a distance? The only sure statement that can be made is that a subordinate rat can recognize the social rank of another rat at a distance of 10 to 20 feet during the dawn and dusk hours. The avoidance may occur whether the dominant rat is facing toward or away from the

subordinate one. Even though it may be true that there is no recognit-
ion of individual rats as individuals, there are actions or postures
characteristic of extremes of social rank that identify them as such."
(Calhoun, 1962, p. 179). Several other behaviors were noted in relation
to social dominance: dominant rats could on occasion expel low-ranking
rats from their territories; dominant rats occupied the more favorable
territories (those territories that were covered and were close to the
food source); and dominant rats bore a greater number of offspring.
The dominance hierarchy exhibited by these animals seemed to be a pyr-
amid structure rather than the linear hierarchy of Schjelderup-Ebbe's
chickens. The pyramid structure was one of the two main types of dom-
inance orders that Uhrich (1938) found in albino mice. The other type
of order was a monarchical form in which dominance was the exclusive
perogative of one member of a group.

Such social behaviors as dominance-subordination fulfill certain
"functions" in the survival of a species and the behaviors may have
been selected for according to the schema put forth by Darwin's evol-
ution theory (Tinbergen, 1965). Van Kreveld (1970) postulates three
interwoven functions that social hierarchies serve, the first of which
is one of integration. It is useful for a group to defend itself against
unfavorable forces threatening it from outside the group, the group
being able to react to the threat as a unit. Carpenter (1942) observed
in the field that one group of rhesus monkeys was dominant over another.
The intergroup dominance was dependent upon the relative dominance the
autocratic males of each of the interacting groups had toward each
other, this dominance being especially relevant for group territorial-
ism. Capturing the dominant male of a group of rhesus monkeys markedly
reduced the territorial range of the group, even though the group's
six other males remained in the group. In general it has been observed

both in the field and in the laboratory that the dominant members seem to serve as "protectors" of the subordinate members in monkey groups (Bernstein, 1964; Crawford, 1942; Maslow, 1940).

The second function of the dominance order in a group is general regulation and limitation of aggression within the group. The dominance structure reduces the total amount of intra-group fighting, contains fighting to two competitors, and allows one of these fighting animals to yield by showing submissive behavior. This second function seems to integrate the group for defense against the threat of group disintegration. In times of a scarcity of food, the strongest animals are most likely to survive. Due to their priority rights, these animals do not have to fight with every other animal. Similarly, when few females are available, the strongest are most likely to reproduce themselves, thereby insuring a strong line of successors.

Social dominance structure seems to make the group better able to survive outside threats and the inside threat of disintegration. The survival of the species is promoted by both. The third function of dominance might be to promote an effective means of controlling overpopulation. The Wynne-Edward's theory claims that animal populations do not increase because they have density-dependent mechanisms which regulate the population level by means of feed-back forces. Darwin attributed population balance to four external "checks to increase": the amount of food available, the effect of predation by other animals, the effect of physical factors such as climate, and the inroads of disease. Wynne-Edwards agrees with Darwin that the food supply is the limiting factor on population growth. However, according to his interpretation, internal factors usually prevent the animals from reaching the critical threshold of overexploitation of the food

supplies. One of these intrinsic regulatory mechanisms is the territorial system. Animals such as birds do not breed if they are unsuccessful in competition for a territory of a certain minimum size. A second mechanism operates in birds that nest in colonies. Pairs which are unable to find a suitable nest site do not breed outside the colony, but form a nonbreeding reserve. The third regulatory mechanism is the social hierarchy, a system which insures that the subordinates die in times of scarcity, that they do not breed, and that their sexual development is inhibited.

"It must be quite clear already that the kind of competition we are considering, involving as it does the right to take food and the right to breed, is a matter of highest importance to the individuals who engage in it. At its keenest level, it becomes a matter of life and death. Yet, as is well known, the actual contest between individuals for real property or personal status is almost always strictly conventionalized. Fighting and bloodshed are superseded by mere threats of violence, and threats in their turn are sublimated into displays of magnificence and virtuosity. This is the world of bluff and status symbols. What takes place, in other words, is a contest for conventional prizes conducted under conventional rules. But the contest itself is no fantasy, for the losers can forfeit the chance of posterity and the right to survive." (Wynne-Edwards, 1965, p. 1545).

III. Historical Background.

The methods which have been employed to gather data concerning social dominance fall into two categories; observation in a natural setting and experimentation in the laboratory. Field observations,

mainly by ethologists, have shown social dominance to be a common mechanism among an extensive variety of species. A review of the observational literature concerning social dominance would seem valuable in that it may broaden the base from which experimentalists view dominance-subordination behavior. Therefore, this historical review will be presented in two sections: the first describing observational studies, and the second describing experimental studies.

Observational Studies.

The social behavior of a number of primate species has been studied extensively. All of these species exhibit dominance behavior, typically of a linear type. In a two-year field study of rhesus monkeys, Altman (1962) observed that male monkeys seldom change groups. The territory of such groups is not strict, but the larger group is dominant over the smaller, even though battles occur between groups. Within groups the social status of a female is controlled by the dominance of the male that is her consort. As was mentioned earlier (Carpenter, 1942), the most dominant monkey in a group controls the dominance of the entire group and consequently its territorial range. Southwick and Siddigi (1967) observed that following the injury and disability of the dominant male, the home range of a natural group of rhesus monkeys was reduced from 40 acres to less than 10 acres. Despite his injury, the dominant male maintained his status and successfully prevented a peripheral male from entering the group. Upon the death of the dominant male, group leadership was assumed by a young subdominant male within the group. The peripheral male still remained outside the group. These observations indicated a strong social tradition in the maintenance of dominance within this wild rhesus group. The strength of social tradition within monkey groups

seems to be supported by findings of a five-year study of a pigtail monkey group (Bernstein, 1969). This group exhibited a very stable dominance hierarchy, and even the natural replacement of the alpha male produced only moderate changes in the rank-order structure.

Just as the social status of a female is controlled by the dominance of her mate, the social status of young monkeys is controlled by the dominance of the mother. Koyama (1967) observed a wild Japanese monkey troop and found that status ranking existed among consanquineous-relatives, and their dominance relation had a great effect on the ranking of individual infants, the influence of which remained after they had grown. With the development of individual infants, a dominance rank was formed by the age of 1 year among males and females of the same age according to the ranking of their mothers in the troop, i.e. the ranking of consanquineous-relatives, and it remained unchanged through the age of 2 years. Although comparison in ranking between individual males and females became difficult to assess after about 3 years of age, the dominance rank based on the mother's rank still existed among both males and females of the same age and this dominance rank became very stable. Among sisters more than 4 years old, the most recent or youngest sister ranked just below the mother and thus held second rank among lineal consanquineous-relatives. Brothers of very close ages temporarely tended toward this phenomena of "youngest ascendancy" when they were 2 or 3 years old, but this relationship was soon reversed into the dominance of the elder brother over the younger. Finally, whether male or female, a younger infant of a higher-ranking mother challenged an elder infant of a lower-ranking mother and outranked it.

The dependence of an infant's status on its mother's status was corroborated in laboratory findings. Morsden (1968) changed the rank of females in the dominance hierarchy of a confined group of 10 rhesus monkeys, either by the introduction of a strange adult male when the second ranking female was in oestrus or by the romoval and reintroduction of the currently top-ranking female. The mothers and offspring ranked in a new hierarchy following each rank change. The offspring directly reflected the rise and fall of the rank of the mother.

In species like the chocma baboons, a hierarchial dominance structure also exists and shows itself mainly in feeding and mating (Bolwig, 1959). The dominant males had larger harems, mated more frequently, and were first to feed. Also, a female in oestrus rose in dominance rank in comparison to females in anoestrus. This observation of the relationship between social dominance and the menstrual cycle in female primates is borne out by laboratory research. In all cases the female becomes more dominant during the oestrus phase (Crawford, 1940; Yerkes, 1939; Yerkes, 1940). Sexual activity and social dominance are related in most species. Carpenter (1942) found the incidence of sexual behavior in males in free ranging rhesus monkeys correlated positively and very highly with the dominance status in the group. In terms of laboratory research, dominant and more aggressive C57 mice displayed significantly more sexual approaches than did submissive animals (kohn, 1961). Similarly, Winslow (1938) observed that in the settling of dominance relations in a cat colony, the dominant animal in the group submitted newcomers to aggressive and harsh treatment, in which his mounting the newcomer played an essential role.

The observational literature reveals the diversity of animal species in which social dominance structures exist. Observations of wild Elk showed that both sexes had linear dominance hierarchies

(McCullough, 1969). Ross and Berg (1956) found that the dominance hierarchy in a flock of goats was very stable over 4 years. Similarly, in studying dairy heifers, Beilharz and Mylrea (1963) found a linear dominance hierarchy which was very stable and which was not changed by the removal of even the most dominant member. In another study of dairy cattle, Schein and Farhman (1955) found dominance to be highly correlated with age and weight. Senority seemed to be the significant factor in dominance.

Cold blooded as well as warm blooded animals show dominance structures. Westby and Box (1970) found that dominance in the social grouping of electrical fish could be reliably predicted from the electrical characteristics of the interacting individuals. The dominant fish had a greater electrical pulse frequency and subsequent display of threat movements. In observing moonfish, Braddock (1945) found nipping hierarchies in both males and females. The hierarchies were more stable in females than in males. Strange fish reacted submissively at first to all members of an established society, but soon after established a position in the hierarchy. In fish like Pomencentrus jenkisi (Rosa, 1969), dominance is indicated by visual signals with very little physical contact. Dominance behavior has also been found in the lizard (Carpenter, 1960), the leopard frog (Boice and Witter, 1969), the South African clawed frog (Haubrich, 1961), and the hermit crab (Allee and Douglis, 1945).

Several alternative measures have been employed to test for social dominance in laboratory settings. These measures do not all correlate positively with each other. This problem was pointed out by Ross (1953) when he found that dogs which are dominant in situation A may or may not be dominant in situation B. The lack of positive correlation sometimes found between alternative measures of social dominance thus makes it important to state the conditions under which dominance is ascertained. The test situations used fall roughly into two categories: an approach situation such as food or water competition, or an avoidance or escape situation such as competition to avoid electric shock. To illustrate some of these alternative measures of social dominance and the opposing results they sometimes yield, several studies are reviewed.

Food and water competition seem to yield the same dominance relations. Hoyenga and Rowe (1969) found that male Sprague-Dawley rats exhibited the same dominance hierarchy competing for food as in competition for water. Similarly, Bruce (1941) found that the same rats tended to be dominant whether motivated by hunger or by thirst. Although Baenninger (1970) found dominance hierarchies in hooded rats under food and water competition to correlate positively and highly, "spontaneous" dominance in a non-competitive situation did not correlate with either food or water dominance. In all cases, food competition created a more stable dominance hierarchy than water competition.

Competition for food and competition to avoid electric shock also seem to create the same dominance hierarchies. Hamilton (1960) found that the same dominance hierarchy in monkeys was determined by food competition and competition to avoid electric shock. Plotnik,

King, and Roberts (1965) tested squirrel monkeys for dominance under four conditions: competition in a shuttle box for food; competition for food in their home cage; competition to avoid and escape electric shock in a shuttle box; home-cage behavior without competition for food. A stable and linear social dominance hierarchy identical in all four test situations was observed with quantitative changes (number of specific responses), but no qualitative changes (changes in position in the social hierarchy) occurring over a period of four months. However, Miller and Banks (1962) found the dominance hierarchies obtained by competition to avoid electric shock were more stable and less subject to variations due to momentary distraction or lack of motivation than food competition hierarchies in rhesus monkeys.

The tube test is still another technique used for measuring social dominance. In the tube test, one animal in a competition pair is trained to run through a tube wide enough to allow only one animal at a time to pass through, while the other animal is trained to run through from the opposing direction. The two animals enter the tube simultaneously, and the animal which succeeds in forcing back its opponent is considered dominant. Lindzey, Manosevitz, and Winston (1966) found the dominance relations in mice under the tube dominance test and food competition test to be negatively related. In addition, Ward and Gerall (1968) found rats which were raised in isolation to be superior in dominance tube competition to animals raised socially. This finding is not supported by studies which employ a food competition situation. A variant of the dominance tube has been used by Uyeno and White (1967, 1968). In this technique, animals must force opponents back to escape from an underwater tube. These more stringent and

demanding conditions generate dominance behavior not found with food dominance competition. Employing this technique, Uyeno and White (1967) also found rats raised in isolation to be superior in dominance to socially raised animals. In addition they found that females and males did not differ significantly in dominance behavior when competing in the underwater dominance tube, a finding which is also not supported by studies which employ a food competition situation.

This historical review of experimental studies will be restricted to studies which employ the approach situation of food or water competition. One reason for this selectivity is that the results derived from the alternative techniques of shock avoidance or the dominance tube test may be hard to compare with a real-life situation. As was mentioned earlier, the dominant member will defend the group. Alternatively, in the case of intra-group threat to rank, the dominant member will defend his position. Defense of subordinates or individual position is impossible in the electric shock situation where there is no real competitor. It may be that the mechanisms in the dominant animal, such as posturing, threat, attack, etc., are not released in this unnatural laboratory situation. No defense is possible, only flight. Perhaps dominance does not operate at all in such a situation, but only fear. Thus, despite the high positive correlation between dominance ranks formed on the basis of competition to avoid electric shock and those formed on the basis of food or water competition, this review will deal only with food or water competition dominance.

Similarly, dominance tube competition may also be an "unnatural" situation. Animals competing to push each other out of a tube have little oppertunity to exhibit the dominance-subordination behaviors that are characteristic of their species. This may account for the negative relationship found between dominance relations formed under

dominance tube competition (Lindzey, Manosevitz, & Winston, 1966). Fin-
ally, the bulk of the experiments on dominance relations have used the
approach situation of food or water competition, and thus a relatively
comprehensive oversight of this phenomenon may be gained by reviewing
these experiments.

For organizational purposes, the review of experimental studies
will be presented under seven headings. These headings roughly cor-
respond to the type of variables which were manipulated in the study
of dominance relations.

Reliability of dominance orders. As was mentioned earlier, dom-
inance relations in many species display a certain stability. This re-
liability of the dominance order seems to vary between species, the
most stable being the primates. This aspect of primate social relations
has been frequently noted during observational studies in the field.
Warren and Maroney (1958) tested 6 groups of rhesus monkeys for domin-
ance in a food-competition situation. Each group consisted of 3 males
and 3 females, every monkey competing with each of the other 5 members
of the group 4 times over a period of one month. Two additional round
robins were made after an interval of 6 months. Eventually a stable
and linear dominance hierarchy was obtained in each group. This sup-
ported the findings of an earlier study (Miller & Murphy, 1956) in
which dominance relations in a group of 15 young rhesus monkeys were
determined on 6 occasions during a period of 15 months. The dominance
hierarchy was found to be reliable throughout the repeated series of
determinations. Again supporting the observational field data,
Bernstein (1964) found that the removal of the dominant male in a
rhesus monkey group had little effect upon the reliability of the
dominance order and consequently upon this monkey's social status.
When this male monkey was reintroduced into the group one month later,

the hierarchy reverted to its original order.

Murchison, more than 30 years ago, observed the social behavior of 6 roosters and 5 pullets in terms of "Social Reflexes"; Social Reflex No. 1 being two individuals moving towards each other, Social Reflex No. 2 being two individuals fighting each other to a decision, and Social Reflex No. 3 being the sex reflex, treading. He showed linear and reliable relations between these types of behavior and social dominance relations (Murchison, 1935: a, b, c, d). More recently, Candland (1968) obtained statistically reliable dominance orders in domestic chickens using a competitive feeding technique. These orders correlated positively with orders obtained by the observation of aggressive behavior within the flocks. Among the factors which affected the reliability of the dominance order, it was found that reliability increased with increasing age or amount of social experience with other birds. Flock size did not produce differences in reliability after the first few weeks following flock formation. In an interspecies comparison of the reliability of dominance orders, Candland and Bloomquist (1965) found statistically reliable oders of food-getting dominance in cows, sheep, chickens and parakeets using the pair comparison procedure. They failed to find significant reliabilities in rats and hamsters. In ruminants, weight was a significant factor in determining dominance orders, but this factor was not significant in determining oders in fowls and aves. In still another species, the domestic cat, stable dominance hierarchies were developed in two different food-competitive dominance testing situations (Cole & Shafer, 1966). Food deprivation level did not affect dominance relations in either pair comparisons conducted in a WGTA, or in dominance relations formed in a free envircnment where all cats, 2 females and

6 males, competing for one bowl of food.

Reliable dominance orders seem to be more difficult to exper-imentally establish in rats than in the other species discussed. Seward (1945b) found that a stable dominance hierarchy failed to emerge in groups of albino rats with paired comparisons tested in a food-compet-ition situation. The rank-orders within the groups were marked by extreme fluctuations. Similarly, Candland and Bloomquist (1965) failed to obtain statistically reliable dominance orders in rodents, the rat being one of the species studied. The findings of the above two stud-ies are not supported by other investigations. In a more observation-al study, Baenninger (1966) recorded dominance encounters within 8 groups of 4 rats from the third to the seventeenth weeks of life. Statistically reliable dominance orders were obtained in 7 groups. The number of encounters declined with age, but the stability of the hierarchies was maintained. Dominance rank was found to correlate with the number of encounters and with weaning weight. These results are supported by the findings of Schumsky and Jones (1966) who obtained reliable paired comparison dominance orders in both male and female rats. Dominance rank stability was found to be an increasing function of the number of previous competition tests. Also, changes in the level of food deprivation did not affect the dominance orders. Final-ly, Becker and Flaherty (1968) made pair comparisons in 15 groups of rats, these groups being of sizes 11, 6, and 2 rats. All groups were given 30 food competition trials and all groups eventually attained stability, with the larger groups requiring more trials. In comparing the stability coefficients between adjacent and remote blocks, it was found that the stability was higher for adjacent blocks. This suggested a distinction between short-and long-term stability, with the long-term stability being more reliable.

Thus reliable dominance orders have been found in most of the species studied. This reliability seems to correlate positively with the number of trials or encounters the animals obtain, but seems unaffected by the level of food deprivation under which the animals compete and, after the first few weeks following flock or group formation, seems also not affected by the size of the flock or group in which the hierarchy is formed.

Early experience and social dominance. One form of early experience, usually in the form of tactual or electrical stimulation during the first few weeks after birth, has consistently produced more socially dominant animals. Rosen (1958) handled albino rat pups for 5 minutes daily from the age of 21 to 41 days, the period immediately following weaning. The control group consisted of littermates which received no such gentling. All animals were then tested at the ages of 58 and 69 days in a food-competition situation by the paired-comparisons of each rat in one group with each rat in the other for a 5 minute competition session once daily. The gentled animals were found to be significantly more dominant. These results were supported by another study (Mezei & Rosen, 1960), in which gentled rats were again significantly more dominant. In addition, the differences in dominance-submission behavior were found to persist into the adult life of the gentled rats. Becker (1965) extended these findings by showing that stimulation in the form of mild electric shock during a rat's early life produced not only more dominant animals, but also less timid animals, timidity being measured in terms of the latency of an animal's emergence from its home-cage into the competition arena. Finally, using fixed-comparisons (in which each experimental rat is paired permanently with a control rat), Becker and Flaherty (1966) found that animals which had been gentled for 30 days after weaning all won the first of 12 encounters in a food-

competition situation. However, in the remaining 11 competition ses-
sions, the gentled animals failed to be consistently dominant. The
authors posited two interpretations of these transitory differences
in dominance: (1) the decay of the effects of manipulation over
long periods of time, and (2) differences created when fixed-compar-
isons are used in terms of the unfamiliarity or familiarity of the
opponent on every competition trial. It was suggested that continual
"curiosity-timidity rearousal" created in control Ss when faced with
an unfamiliar opponent on every competition trial could account for
the greater permanence of differences in dominance found when rotated-
pair comparisons are used.

The other form of early experience manipulated in relation to
social dominance has been social experience. The typical design of
these studies is to rear one group of animals with conspecifics for
a period of time following weaning while the control group consists
of animals raised in isolation during this same period. Rosen (1961)
reared male albino rats in groups of 2 animals for 3 weeks immediately
following weaning. When these animals were placed in a competitive
drinking situation in adulthood with animals which had been reared
individually, the socially raised animals were not significantly
more dominant. The author suggested that the early social experience
of the group-reared animals was not of sufficient intensity or durat-
ion to produce significant differences in dominance behavior. In a
second study using two sub-species of wild deermice, Rosen and Hart
(1963) found that post-weaning social isolation had a differential
effect upon adult dominance in one of the sub-species, Peromyscus
maniculatus biardii. Ten male biardii reared together as a single
group from weaning until 91 days of age were significantly more

dominant than _biardii_ raised in isolation. In the second sub-species,
Peromyscus maniculatus gracilis, this difference in adult dominance
failed to emerge. Dominance was measured by pairing each socially-
reared mouse once with every isolate-reared mouse of the same sub-
species in a series of 5 minute competitive drinking sessions. The
authors concluded that the results further illustrated that the same
form of early social experience can have a differential effect upon
organisms of differing genotypes.

Becker and Ezinga (1969), using the fixed-pair comparison
method, compared rats raised under four early experiential conditions
in a food-competitive situation. These conditions were: (1) rats
which had been handled and were raised in groups of four, (2) rats
which had not been handled but were raised socially, (3) handled
rats raised in isolation, and (4) non-handled rats raised in isolat-
ion. It was found that handled rats in competition with non-handled
controls were dominant, especially where both competitors were raised
in isolation. Socially-raised rats, in competition with isolation-
raised rats, were dominant, but only where both competitors were
early handled. Finally, Hoyenga and Lekan (1970) found that 12 group-
reared Sprague-Dawley rats were dominant over 12 isolation-reared
rats in the early trials of a food-competition situation, but these
differences in dominance between the groups faded over the 12 days
of testing.

It thus seems that early experience in the form of tactual or
electrical stimulation reliably produces more dominant animals. Early
experience in the form of social experience seems to be a less power-
ful or reliable variable. In only two of the studies reviewed did ear-
ly social experience significantly affect dominance-submission behavior

in adulthood. In the first (Rosen & Hart, 1961) the effect was found
in only one of two closely related subspecies of mice. In the second
(Becker & Ezinga, 1969) early social experience was effective in cre-
ating more dominant animals, but only where these animals had also
experienced early tactual stimulation.

Conditioning and social dominance. From the point of view of
psychology, the question of whether social dominance can be modified
by conditioning is of great interest. Studies exploring the effect of
conditioning, particularly those which use primates as Ss, have pro-
duced conflicting results. In general two main procedure are used in
these experiments. In the first of these, the social dominance hier-
archy is determined by a food-competitive test. A member of this
hierarchy, usually an animal which occupies a low rank, is then used
as a conditioned stimulus for shock avoidance for the other animals
in the hierarchy. Post-conditioning dominance determinations, using
the food-competitive test, evaluate whether the animal used as the
conditioned stimulus has risen in rank. The second method similarly
determines an original dominance hierarchy by means of a food-compet-
ition test. Members occupying intermediate ranks in the hierarchy are
then subjected to a series of defeats or wins by matching them against
more or less dominant animals. Post-conditioning dominance determinat-
ions are used to evaluate changes in the previously found hierarchy.

Miller, Murphy, and Mirsky (1955) repeatedly determined the
social dominance hierarchy in a group of 10 rhesus monkeys over a 20
month period, using a food-competition test. The monkey which ranked
8th in the dominance order then served as a conditioned stimulus for
shock avoidance by 8 of the other monkeys. In later dominance determ-
inations, this monkey rose to third or fourth postition in the hierarchy.

However, the authors used only one group of animals, as well as employing no control group. Changes in rank can appear in any group and these facts thus prevent one from clearly drawing the conclusion that it is possible to induce changes in settled relationships. In another study, Murphy and Miller (1956) conducted two group dominance tests on 10 rhesus monkeys. On the basis of these tests, 5 pairs of monkeys which were adjacent or nearly adjacent in the hierarchy were given an additional 5 dominance determinations using a food-competition test. The dominant animal in each pair was then subjected to shock-avoidance conditioning with the subordinate partner as the conditioned stimulus. The dominance status was found to be significantly reversed following the completion of the conditioning.

Using the second method desribed earlier, Maroney, Warren, and Sinha (1959) used a food-competition situation in determining the dominance hierarchy in 17 prepubescent rhesus monkeys, 8 males and 9 females. Several low or intermediate dominant animals received "conditioning" in the form of repeated success or failure in competition by pairing them, respectively, with animals who were extremely low or high in dominance rank. Altogether, each animal received the success or failure treatment 750 times. After finishing these treatments, each conditioned animal was tested against the animals from the group of which he had been part, prior to the experiment: he was first tested against those who had been next to him in rank, and after that, against all animals in that group. There were only a few changes in dominance relations after the experimental treatments, and some of them were even contrary to the expectation; there were also reversals in unconditioned monkeys. The authors concluded that "At best, the conditioning was apparently successful in one case." So, the

dominance relations were not significantly altered by the experimental operations. These results supported the findings of an earlier study by Maroney and Leary (1957). These authors attempted to alter the dominance relations among rhesus monkeys by forcing failure experience on 4 monkeys through pairing them with very dominant animals in their home cage as well as in a food-competition situation in the WGTA. Only two pairings out of 16 revealed a reversal of the dominance relations previously found. The authors concluded that social conditioning in the WGTA, as well as home-cage conditioning, failed to change previously established dominance hierarchies.

The above findings conflict with a very similar study on mice, reported 15 years earlier by Ginsberg and Allee (1942), whose findings were quite different; conditioning, by means of repeated success or failure treatments, was generalized rather widely by the conditioned mice in accordance with the sort of conditioning, success or failure, to which they had been exposed. In a study employing another rodent, the albino rat, as Ss, Tsai and Napier (1968) established the dominance hierarchy in 4 groups, each consisting of 9 male rats. The rat ranking second in each group was then subjected to a series of defeats by the more dominant rat which ranked first, while the rat ranking third was exposed to the more submissive fourth-ranking rat. Eight of the 9 groups showed a significant decrease in the number of wins by the second-ranking rat over the third-ranking rat as a result of social conditioning. However, the hierarchy reverted to its original order shortly after conditioning, thus suggesting the effect of extinction.

The social dominance order in birds also seems ammenable to modification by conditioning procedures. In a study by Radlaw, Hale,

and Smith (1958), the bird having the highest status in a flock of 5
New Hampshire cocks was shocked each time it attacked one of its flock-
mates. After two or three 20-minute training sessions, two of the four
pair relations were reversed with the formerly subordinate bird dom-
inating the previously high status bird. In the two other pair relat-
ions, the original high status bird tolerated the subordinates, re-
sulting in mutual avoidance. These results were supported by the find-
ings of Ratner (1961). The peck order in four groups, each of 14
White Leghorns, was determined. Eight birds were then selected from
these groups, and were exposed to defeats by matching them with a
foreign despotic bird. Upon their return to their respective groups,
redetermination of the peck order showed that seven of the experim-
ental birds had lost rank and the eighth had gained rank. Thus dom-
inance relations seemed significantly altered by the experimental
operations.

There thus seems to be conflicting evidence for the possibil-
ity of inducing changes in settled dominance relationships by means
of conditioning procedured. Two of the studies reviewed which use
primates as Ss show conditioning to be effective in modifying an
established social hierarchy, one of these (Miller, Murphy & Mirsky,
1955) being inconclusive due to lack of controls. The other (Murphy &
Miller, 1956) suffers from very similar problems. As was described
earlier, these authors matched animals which were adjacent or nearly
adjacent in an established dominance hierarchy and determined which
was dominant. The dominant animal in each pair was then subjected to
shock-avoidance with the subordinate animal as a conditioned stim-
ulus. However, the significant reversals they obtained are open to
challenge. In comparing adjacent animals in a dominance hierarchy,

the probability of reversals in dominance occurring spontaneously over time is greater for such pairings than for any other pairings in the hierarchy. The study had no controls for the possible occurrence of such spontaneous reversals.

Another possible problem becomes evident when one attempts to compare the results of studies which use the shock-avoidance conditioning technique, with those obtained by studies which use forced wins or losses as a conditioning procedure. These latter studies, which also use primates as $\underline{S}$s, fail to replicate the positive results obtained by studies using shock-avoidance conditioning (Maroney & Leary, 1957; Maroney, Warren & Sinha, 1959). This brings up the question as to which is the more "natural" conditioning technique in modifying social dominance behavior. The procedure in which one animal is subjected to forced wins or losses by pairing it with more subordinate or more dominant animals respectively, conforms more closely to what typically occurs in a "natural setting", in that the animals are capable of displaying species-specific challenging and fighting behavior. In the shock-avoidance situation such behaviors are not possible. It may then be tenable to suggest that what occurs in the shock-avoidance situation is behavioral suppression in the form of conditional emotional response (CER) rather than true dominance behavior. One check on this alternative is to see if the dominance reversal following shock-avoidance conditioning is stable over time, that is, whether the possible CER will extinguish. Both of the studies reviewed which use this technique fail to do this.

What of the studies on mice and chickens which show that social conditioning is effective in modifying existing social relations? In their discussion of the negative results in the first part of their study, Maroney, Warren, and Sinha (1959) point out that inbred mice,

the $\underline{S}$s in Ginsberg and Allee's (1942) study, do not recognize dif-
ferences between individual competitors, but respond to the charact-
eristic patterns of aggressive or submissive behavior exhibited by
their opponents. Monkeys, however, differentiate more accurately
between individual opponents. This is important in that many social
relations are tied to the personal recognition of the individuals
by each other. This notion is supported by the observations of
Bernstein (1964a). The dominant male in a group of rhesus monkeys,
after being removed for a month, immediately reassumed his former
position, only showing more sexual and aggressive activity. This
contrasts with the observations of Masure and Allee (1934). A high
ranking cockerel was removed from his group for two weeks. When rein-
troduced into the group, it was observed that he had lost his posit-
ion completely.

Thus it seems that in animals which recognize individual comp-
etitors, the degree of dominance or submission behavior is rather
stable: it is not readily changed by frequently repeated success or
failure treatments. This notion is supported by the second part of
the study by Maroney, Warren, and Sinha (1959). They found that the
nature of the dominance relation which could be observed between
monkeys which had never previously competed with one another for
food could be predicted with an accuracy of around 95% from the rel-
ative success of the monkey in competitive social interactions in
the past.

Motivation and social dominance. Motivation, in terms of the
level of food-deprivation, has seemed ineffective in altering dom-
inance relations. Nowlis (1941) varied, in turn, the levels of food
deprivation of the dominant, the subordinate, or both members of

competition pairs of chimpanzees. Eighteen animals were used to form 20 competition pairs. It was found when the deprivation level of the dominant animal was decreased to satiation while that of the subordinate was increased by food deprivation for 25 - 45 hours, the latter became dominant in terms of getting more than half the test food. When both animals in a competition pair were highly motivated by long food deprivation, the relative dominance status of each animal remained the same as when both were fed in a regular fashion. Changes in the degree of food deprivation of the dominant animals had more effect on the success of food-competition of the subordinate animals than did great variations in the deprivation level of the latter. Thus, it was only when the deprivation level of the dominant animal was eliminated by satiation while that of the subordinate animal was greatly increased by long food deprivation, that a change occurred in the dominance relations. It is to be questioned whether this can be considered a valid change in that a satiated animal is unlikely to be motivated to compete for food. Therefore, the competition situation as such no longer exists.

The inability of food deprivation to affect existing dominance relations has been supported by several studies which have manipulated food deprivation levels in relation to the stability of the dominance order (Schumsky & Jones, 1966; Cole & Shafer, 1966; Candland & Matthews, 1968). In all cases, the reliability of the dominance order was not affected by the level of deprivation under which the Ss were observed, nor by changes during testing.

Physiological correlates of social dominance. A number of studies have attempted to relate endocrine structures such as the thyroids, pituitary, adrenals, and gonads to social dominance. In these studies, the typical procedure is to determine the dominance

hierarchy in the group of animals under study, then sacrifice them and attempt to relate the weight of the endocrine structure(s) to the animal's rank in the dominance hierarchy. Siegel and Siegel (1961), in studying the relationship of social competition with endocrine weights in male chickens, determined the relative aggressiveness in 28 birds from 8 paired encounters, this aggressiveness ranging from 0 to 100% wins. There was no significant correlation with this score and weight of endocrine per unit bodyweight. However, in a review of the psycho-physiological interrelations in the social behavior of chickens, Guhl (1964) points out that physiological adaptation to social stress at low levels in the dominance order is brought about by the stimulation of the pituitary-adrenal cortex axis as shown by the hypertrophy of the adrenals. This latter observation seems to be supported by a study on male and female crab-eating monkeys. Hayama (1966) divided 74 of these monkeys into 5 groups and determined the dominance ranking in each group by the order in which animals took food or water for 7 days previous to the day of meas- uring their adrenal glands. It was found that high-ranking monkeys generally had larger adrenal glands than low-ranking ones, regard- less of their weight, age, or sex.

Similarly, researchers have also attempted to relate several areas of the brain to social dominance. The typical procedure in these studies is to determine the social dominance status of an an- imal prior to lesioning an area of its brain, then lesioning the anim- al, following which its social dominance status is redetermined. Chang- es in the animal's status are then attributed to the effects of the lesion. One of the brain areas so lesioned has been the amygdala.

Bunnell (1966) determined the social dominance rank and aggressive-
ness of hooded rats in a semi-natural environment. He then lesioned
the amygdala and observed in post-operative dominance redeterminat-
ions that there was a significant reduction in the number of inter-S
interactions and in the percentage of bouts won. The social rank
decreased in some animals, but was maintained by others. The author
suggested that the effects of the lesions were the result of a
raised threshold to social stimuli. In a study involving the lesion-
ing of the orbital frontal cortex, Snyder (1970) seperately intro-
duced rhesus monkeys into a stable colony before and after orbital
frontal ablation and sham surgery in order to establish their hier-
archial position. All animals which had orbital frontal ablation or
sham surgery achieved pre-operative dominance status. Following orb-
ital frontal ablation, 3 out of 4 Ss retained their dominant posit-
ion for 1, 4, and 6 months respective, at which time they abruptly
ceased all aggressive behavior and fell to the bottom of the domin-
ance hierarchy. Sham surgery appeared to have no observable effect
on social behavior or status. The author suggested that incomplete
removal of the limbic portion of the orbital frontal cortex may have
been responsible for the 4th monkey's unimpaired social behavior.

One study which involved brain stimulation by remote control
rather than lesioning is of interest in terms of its relation to soc-
ial dominance. Robinson, Alexander, and Browne (1966) found that tele-
stimulation of the lateral and anterior hypothalamic sites in male
rhesus monkeys resulted in aggressive attacks directed against other
members in a group of these animals. The authors subsequently stim-
ulated the subordinate Ss in several other groups. It was found

that aggressive attacks by these subordinate animals against the dominant members of their respective groups was readily evoked upon stimulation, and these attacks were sufficient to cause permanent reversal of dominance, the stimulated Ss now being dominant.

There seems to be sufficient evidence to suggest that there is a correlation between one endocrine gland, the adrenal, and social dominance (Guhl, 1964; Hayama, 1966). The correlation of social dominance with any other endocrine structure is weak. The studies attempting to correlate brain areas and dominance are sporadic and without logical sequence. Consequently, few conclusions can be drawn from the studies which have been done.

Drugs, hormones, and social dominance. The effects of sex hormones such as estrogen and androgen have been studied in relation to social dominance. The procedure typically used is to castrate the animals, and then observe changes produced in social dominance behavior as the result of injections with a sex hormone. In the first of a series of studies, Birch and Clark (1945) paired a male prepuberty castrate chimpanzee with an intact male in a food-competitive situation. It was observed that male sex hormone (androgen) therapy enhanced the castrate's social dominance while female sex hormone (estrogen) therapy resulted in subordination behavior. In addition, androgen therapy induced well-established habits of social response such as aggressiveness which persisted after hormone administration had ceased. These response habits could be reversed by the administration of estrogen. These findings are supported by Shinoda (1964) who observed that a 12-day androgen administration of 300 mg/kg bodyweight per day resulted in the dominance of 3 castrate male and 4 ovariectomized female white rats in an intra-pair conflicting situation.

In a somewhat different experiment, Stewart and Palfai (1967)

determined the dominance hierarchy in 22 male rats by the method of paired competitive encounters. The animals were then castrated, and it was subsequently observed that the existing dominance hierarchy became disrupted. This hierarchy was reinstated by daily doses of 1 microgram of testosterone proprionate (an androgen compound); a higher daily dose of 50 micrograms increased further the correlation between the initial hierarchy and the hierarchy formed after androgen replacement. Work, Grossen, and Rogers (1966) found that social behavior habits played a role in masking the effect of manipulated androgen levels. In their first experiment, a highly stable and linear food-competitive dominance hierarchy emerged from daily pairings of all combinations among a group of 6 male albino Sprague-Dawley rats. Subsequent injections on testosterone to selected Ss failed to alter this hierarchy. In two subsequent experiments, the wins and losses of each rat in the hierarchy were equalized by interspersing trials against confederate rats (one very dominant and one very subordinate rat which were not members of the original hierarchy) among the initial pre-injection pairings. Of the two confederate rats, one confederate lost against all rats in the hierarchy, while the other always won. With the reinforcement history of all Ss kept identical a stable hierarchy developed, but now the subsequent effects of androgen level manipulation were readily observed as the injected Ss rose to the top of the hierarchy. These results point to the necessity for controlling habit factors in hierarchies where motivational variables such as sex hormone levels are to be assessed. This same point was made by Guhl (1968) who noted that in an established flock of hens, social stability is accompanied by "social inertia". Early studies had shown androgen to increase social dominance and the levels of aggressiveness in hens (Allee, Collias &

Lutherman, 1939), and that estrogen administration reduced aggressiveness and increased submissiveness (Allee & Collias, 1940). Guhl tested this social inertia by injections of androgen. The treatment increased social tension (an increase in aggressive encounters), but few reversals of dominance occurred. Injections of estrogen also did not alter aggressiveness or submissiveness. It was suggested that degrees of stability within a group may introduce variables in experiments on social dominance, and that these variables could mask the effects of hormonal treatment.

As was already mentioned, estrogen also seems to reliably affect social dominance (Allee & Collias, 1940; Birch & Clark, 1945), but only in castrate animals or in hierarchies where the dominance order has not yet become stabilized. Where the dominance hierarchy has become stabilized, the effect of estrogen administration may be masked by "social inertia" (Guhl, 1968). Birch and Clark (1946) tested the effects of methyl-testosterone and alpha-estriadol on the dominance-subordination relationships between 3 adult post-pubertally ovariectomized chimpanzees in a food-competitive situation. It was found that the dominance status of female chimpanzees, unlike the decrease in dominance observed in castrate chimpanzee males or hens upon injection of estrogen, was reliably enhanced by raising the estrogen level as well as by the administration of androgen. The administration of estrogen resulted in a rise in dominance status paralleling the course of sexual swelling and disappearing with detumescence. Finally, androgen therapy produced more persistent changes with the improvement of dominance status than did results from the administration of estrogen. Another study by these authors (Birch & Clark, 1946)

supported the observations that sexual swelling induced in female-castrate chimpanzees by artificial estrogen (.25 mg of diethyl stilbistrol daily) paralleled a rise in dominance, a rise which disappeared with detumescence. If progesterone is given along with estrogen, the progesterone will inhibit sexual swelling. Birch and Clark (1950) found that estrogen administrations to a subordinate female-castrate chimpanzee caused a rapid rise in dominance. However, when progesterone was administered along with the estrogen and sexual swelling was consequently inhibited, this rise in dominance did not appear. Control observations showed no effect from the progesterone alone. When estrogen was given to the dominant animal, its dominance was enhanced if sexual swelling was not inhibited.

So it seems that androgen therapy increases aggressiveness and dominance in both male and female castrates. Also, additional androgen injected into intact males will increase their dominance status. Estrogen injected into male or female castrates will decrease aggressiveness and dominance status with the exception of female primates like the chimpanzee. The swelling of the sexual skin results when estrogen is injected and when this swelling is not inhibited, estrogen will temporarely cause a rise in dominance which parallels the sexual swelling. This rise in dominance disappears with detumescence. Finally, when assessing the effect of sex hormones on animals in an already formed and stable dominance hierarchy, the variable of "social behavior habits" or "social inertia" must be controlled if it is not to mask the effects of the hormone.

Several drugs have been tested to assess their effect on social dominance. Leary and Slye (1959) injected 2 monkeys, ranking 1st

and 3rd in a dominance hierarchy among 8 rhesus monkeys, with 1.0 mg per kg of chlorpromazine prior to pairing them with the remaining Ss in the hierarchy. The animals competed for food in a modified WGTA. In the drug phase, the drugged animals generally failed to get the food and the normally submissive animals became dominant. However, these results were transitory in that comparisons of before and after the drug phase yielded no significant differences in dominance or aggression. This decrease in dominance in animals drugged with chlorpromazine is not supported by the observations of Heimstra (1961). In this study, dominance-submissive relationships were established in 20 pairs of rats. Either the dominant or submissive animal in a pair was administered chlorpromazine, the other receiving injections of saline solution. The drugged animals, whether submissive or dominant in the normal state, tended to control the food source for longer periods of time than did the non-drugged animals, thereby becoming dominant. During the drug phase of the study, fighting behavior was significantly reduced.

Assuming that chlorpromazine affects both monkeys and rats similarly, the conflicting results of the above two studies may have been due to the differing test situations used. In the Leary and Slye (1959) study, animals competed for food in a modified WGTA. The speed of an animal's response is important in this test in that the animal must grab the food before his opponent does. Chlorpromazine is a depressant which has the effect of slowing an animal's motor responses after an early and transitory excitatory phase has passed. Consequently, in such a situation the drugged animal is handicapped.

In Heimstra's (1961) study, the test situation involved a common food source which only one animal could control at a time. Once a drugged animal has control over the food source, his opponent must force him away. In this situation the animal's lowered motor responses and his probably heightened threshold to social stimuli would not hinder him, and could possibly aid him in retaining control over the food source.

In another study Heimstra and Sallee (1965) administered either 2.0 mg/kg of amphetamine or 6.0 mg/kg of chlorpromazine to two groups of 11 rats each for 25 days during the early life of the animals. Twenty-two other rats were administered daily injections of saline solution during this same period. When all rats were 160 days old, the drug groups were paired with the saline group and were tested for 5 minutes daily for 15 consecutive days. Dominance was defined as the amount of time a rat in the pair controlled a food container during the trial. It was found that 10 of the 11 rats which had received amphetamines were dominant. However, only 6 of the 11 rats in the chlorpromazine group were dominant, the result one would expect were only chance operating.

Thus it seems that the administration of chlorpromazine during the early life of an animal does not enhance its dominance behavior in later food competition if the animal is then not under the influence of the drug (Heimstra & Sallee, 1965). However, drugging an animal by means of chlorpromazine during food competition does seem to enhance its dominance behavior (Heimstra, 1961). Perhaps the effect of early experience in terms of chlorpromazine administrations does not carry over into later non-drugged food competition sessions.

Two studies explore the effect of four psycholytic drugs on social dominance. Uyeno (1966) showed that d-lysergic acid diethylamide (LSD-25) and 2-brom-lysergic acid diethylamide (BOL-148) inhibited dominance behavior of rats in a food competition situation. The peak effects of LSD-25 and BOL-148 occurred 15 minutes and 45 minutes respectively, after interperitoneal injection. The dose-response curve for each drug showed that per cent inhibition of dominance behavior is an increasing monotonic function of dose. A much lower median effective dose (ED_{50}) shown by the LSD-25 curve as compared with that of BOL-148 suggested that LSD-25 is a significantly more potent dominance inhibitor than BOL-148. The other study (Uyeno, 1967) showed that mescaline and psilocybin also inhibited the dominance behavior of rats competing for food. The time of peak inhibitory effect of both drugs was 30 minutes following interperitoneal injection. The dose-response curves for both drugs showed that the per cent inhibition of dominance behavior is an increasing function of dose. The ED_{50} of the mescaline curve was much higher than that of the psilocybin curve, suggesting psilocybin as the more potent dominance inhibitor. Thus all four psycholytic drugs were found to be effective dominance inhibitors in food competition between rats.

Genetic basis of docial dominance. Genetic selection has been able to modify behavioral characteristics in many species of animals. Several investigators have attempted to determine whether the behaviors involved in social dominance can be changed by selective breeding. Uyeno (1960) studied the behavior of 24 young male rats as a function of the dominance of the true parents and the dominance of the foster mother. The Ss were bred from rats which had been selected

for social dominance or submissiveness on the basis of food competit-
ions. All animals were subsequently raised by foster mothers, thus
yielding four foster parent-genetic background combinations. It was
found that rats born of dominant parents were more dominant when
raised by dominant mothers, but in either case were more dominant
than rats born of submissive parents. Although there was an inter-
action between genetic background and rearing environment, the gen-
etic background seemed to be the predominant factor in determining
later social dominance.

Craig, Ortman, and Guhl (1965) found that 5 generations of
bidirectional selection of mature male chickens for social dominance
scores in initial pair contests produced large strain differences
within each of two breeds. The selected strains differentiated for
frequency of contests with aggressive behavior, the ability to win
decisions, and the physical severity of interactions. Thus it seems
that genetic selection can increase the social dominance ability of
chickens, a finding that has been supported by several similar stud-
ies (Craig & Baruth, 1965; Ortman & Craig, 1968; Bennett & Anderson,
1962).

Objectives of this thesis.

This thesis attempted to ascertain the effect of various sched-
ules of reinforcement on the degree of social dominance-subordination
behavior exhibited by pairs of rats, competing to lever press for
food. The schedules employed were CRF, FR, and FI schedules. This
thesis also attempted to study and relate different measures of social

dominance behavior, these measures being: the number of lever pres-
ses emitted by each rat in a competition pair, the number of rein-
forcements each animal obtained, the percentage of the total session
time each animal spent controlling the food source, and the ability
of each animal to win decisions in aggressive interactions with its
opponent.

A search of the literature concerning social dominance relat-
ions has failed to reveal any studies which have dealt with the ef-
fect of various schedules of reinforcement on social dominance behav-
ior. CRF, the schedule typically used in dominance determinations
employing a food competition situation, may be the exception rather
than the rule in the world outside the laboratory. Animals may thus
have to deal with much more demanding schedules, FR and FI schedules
being arbitrary examples of these.

Assuming that schedules of reinforcement did differentially af-
fect the degree of dominance-subordination behavior in rats, a sec-
ond objective of this thesis was to find the schedule or schedules
which maximized this behavior. In most of the experiments on social
dominance, the researcher hopes that one or the other of the animals
in a competition pair will become either consistently and significant-
ly dominant or subordinate. A reinforcement schedule which maximized
the degree of dominance-subordination behavior would provide a more
sensitive procedure by which to assess the effect on social dominance
of variables such as early experience or sex hormone administrations.

CHAPTER II

SUBJECTS, APPARATUS, AND GENERAL EXPERIMENTAL METHOD

I. Subjects

Sixteen Holtzman male albino rats (from competition pair G1 and R1 to competition pair G8 and R8) served as subjects. The rats were experimentally naive and were 95 days of age at the start of the experiment. They were part of a group of 48 animals which were received at 70 days of age, all of which were placed in single cages and given free access to food and water. At 76 days of age, the 16 experimental animals were selected on the basis of matching body weights for each of the 8 competition pairs comprising the subjects in these experiments. The weights of the subjects ranged from 306 gms. to 335 gms. with a difference in weight between pair members of plus or minus 2 gms. In addition, a group of 8 rats which were matched to the weights of the subjects, was kept on ad lib food and water throughout the duration of the experiments. This provided a natural body weight growth curve by which to estimate the deprivation level of the experimental animals, a control measure recommended by Ezinga and Becker (1970).

All subjects were continued on ad lib food and water until they were 87 days of age, at which time weights had stabilized at plus or minus 5 gms. per day. A food deprivation schedule was then initiated and continued until the subjects reached 80% normal weight as defined as the mean body weight over the last three days of ad lib

food and water. Water was continuously available in the home cage throughout the experiment. The rats were maintained at 80% body weight of the ad lib animals for the remainder of the investigation by food reinforcement received during the experimental session and supplements of Purina rat food.

II. Apparatus

The apparatus (see Figs. 1 & 2), situated in a soundproof and dark room, consisted of an experimental chamber constructed of clear .25 inch thick fibreglass with a .5 inch by .5 inch wire mesh floor, mounted 1 inch above an aluminum drop pan. The chamber was 14 inches in length, 15 inches in width, and 11 inches in height. A 28 volt (G. E. No. 1819) miniature lamp situated in the center of a perforated, hinged, clear fibreglass lid served as a houselight.

One wall of the chamber was covered by aluminum sheeting, against which were mounted two aluminum sheet boxes, one 5.5 inches wide, the other 1.75 inches wide. Both boxes were 3.25 inches long and 11 inches high, that is, the height of the chamber. The boxes were mounted so as to provide a 2 inches wide, 3.25 inches deep, and 11 inches high aperture. In more standard apparatus the manipulandum and the food trough are seperated. However, this apparatus employed a manipulandum which served the function of both a lever and a food trough simultaneously. A plastic tube, leading from a Davis (Model No. PD-109A) pellet dispenser, mounted behind the chamber, dropped food pellets directly from the dispenser into the trough part of the lever. This pellet lever, which was 1.125 inches wide, 1.125 inches

ALUMINUM SHEET BACKING ON INSIDE OF BOX.

LIGHT SOURCE BOX AND PHOTOCELL BOX OF ALUMINUM SHEET CONSTRUCTION WITH CLEAR PLEXIGLAS IN FRONT OF LIGHT SOURCE AND PHOTOCELL AREAS

"DAVIS" PELLET DISPENSER MODEL NO. PD-109-A

TRANSFORMER

3/4" PLYWOOD VERTICALS

STIMULUS LIGHT

LEVER

28 VOLT HOUSE LIGHT

1/4" CLEAR PLEXIGLAS BOX ALL WALLS AND LID

1/2"x1/2" WELDED WIRE MESH

DROP PAN FROM ALUMINUM SHEET

MICRO SWITCH

PERFORATED 1/4" THICK HINGED CLEAR "PLEXIGLAS" LID

PHOTOCELL RELAY

LIGHT SOURCE PHOTOCELLS

NOTE: CLEAR PLEXIGLAS IN FRONT OF LIGHT SOURCE AND PHOTOCELLS

3/4" PLYWOOD BASE

MANUAL SWITCH PANEL:
-DOUBLE POLE - DOUBLE THROW BAR- MICRO SWITCHES

-28V INDICATOR LIGHT

-MOMENTARY SPRUNG LOADED BUTTON SWITCHES
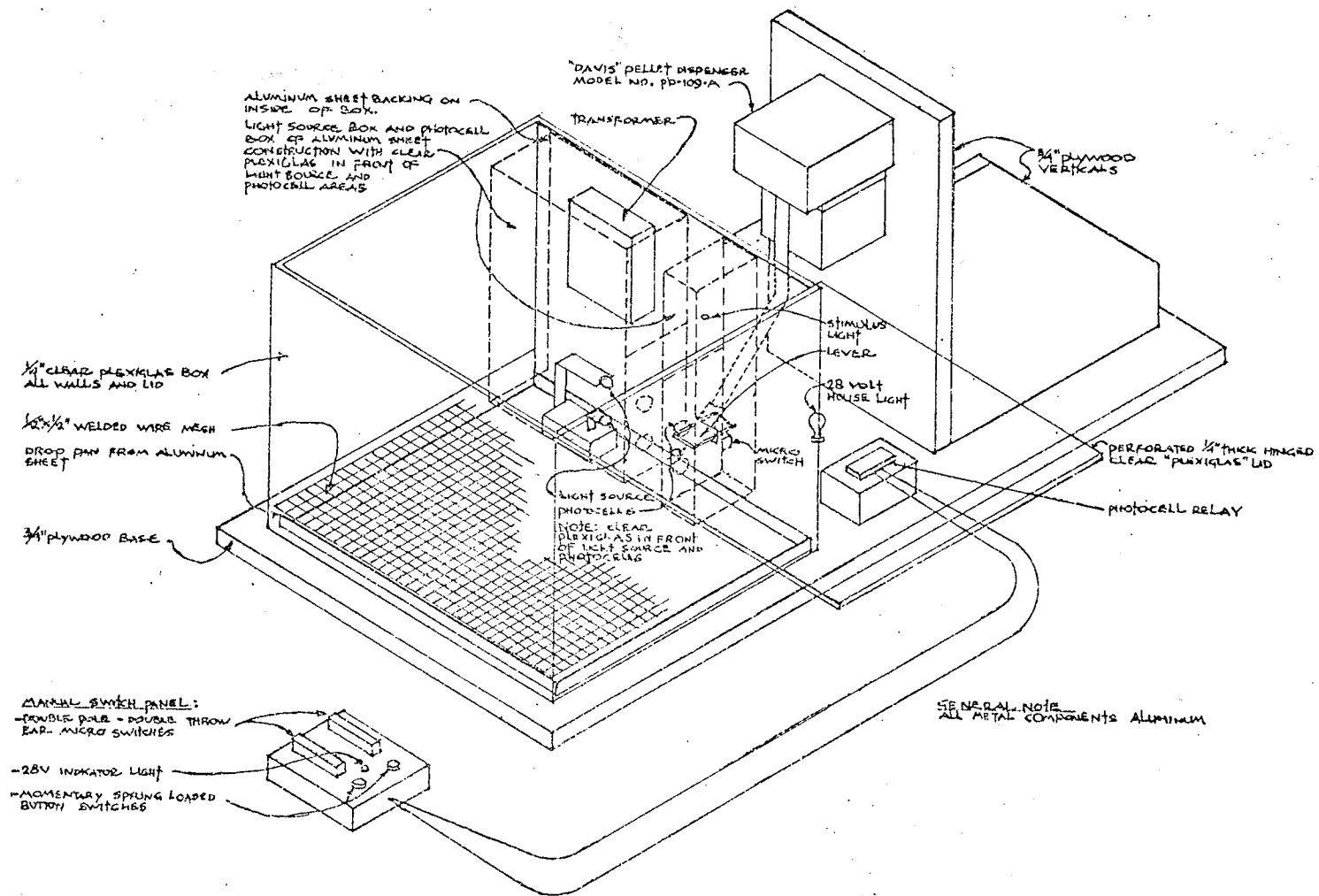
GENERAL NOTE
ALL METAL COMPONENTS ALUMINUM

Fig. 1. Isometric view of the dominance-subordination testing apparatus.
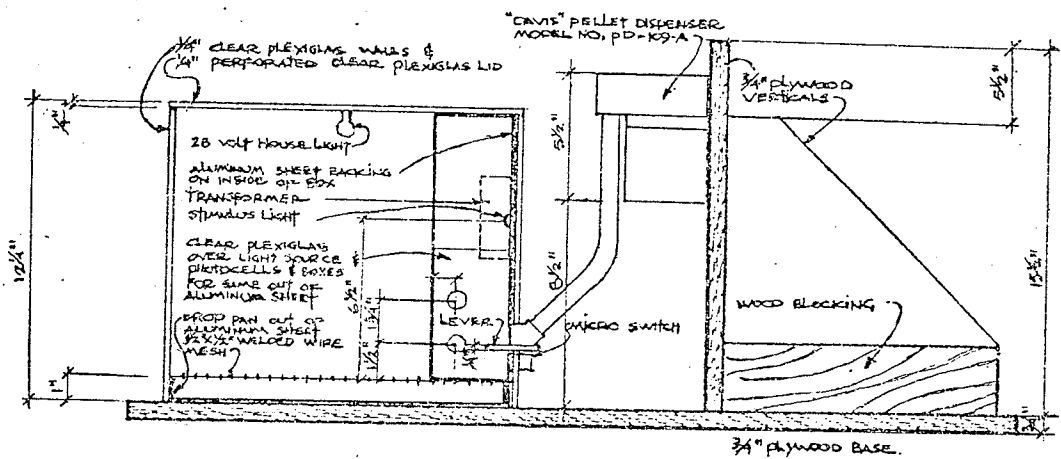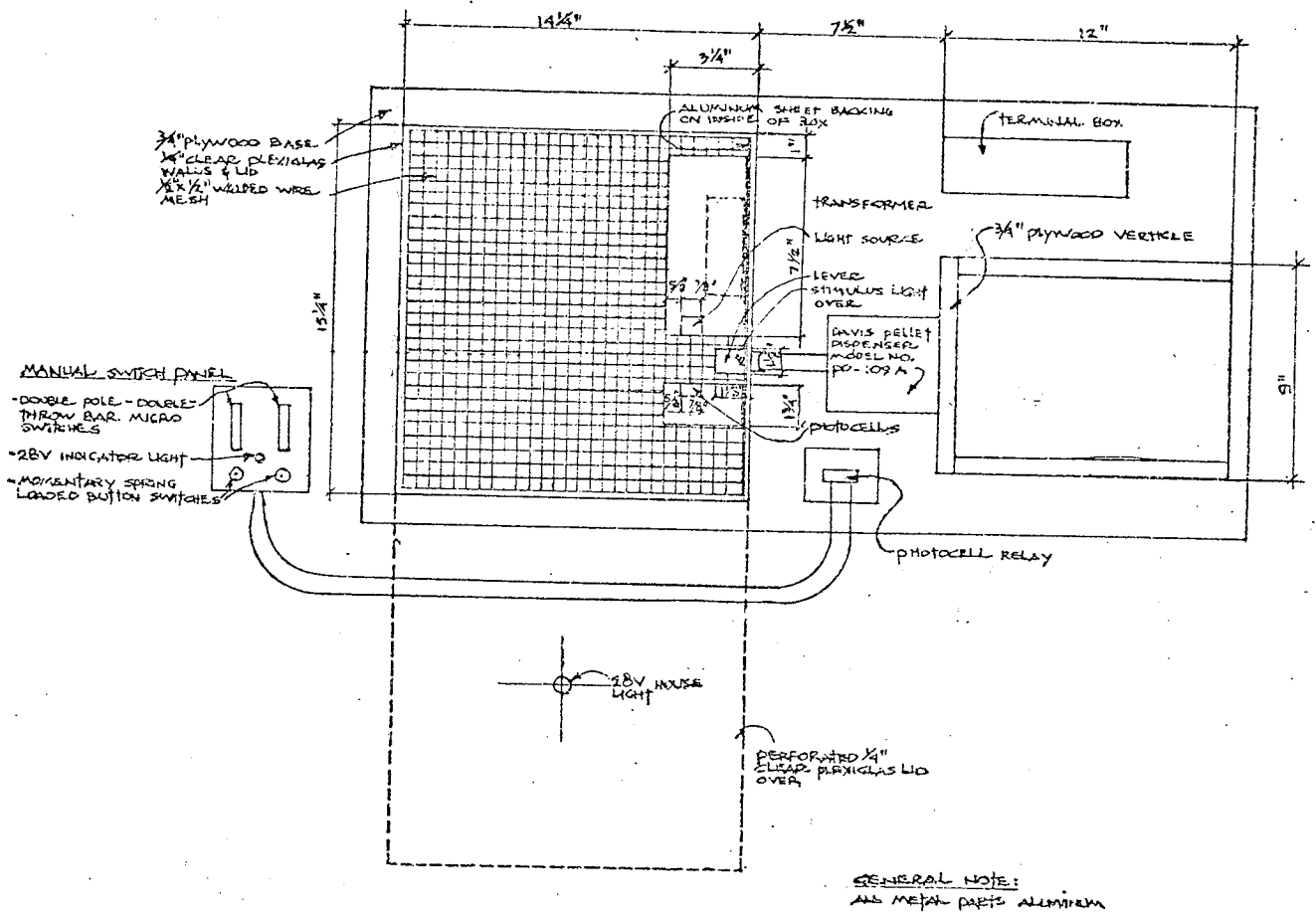
Fig. 2. Plan view of the dominance-subordination testing apparatus.

long, with sides .25 inches high, protruded centrally into the aperture formed by the boxes. It was mounted 2.5 inches above the floor of the aperture, and was slanted downward slightly to allow the food pellets to roll toward the animal. A minimum force of 11 grams was required to operate the lever.

The walls on the inside of the aperture were constructed of clear .25 inch thick plexiglass for the first 6.5 inches from the floor, the remaining 4.5 inches being of aluminum sheeting. This combination of plexiglass and aluminum sheeting comprised the walls of the aluminum sheet boxes forming the aperture. Behind the plexiglass wall of the wider box were mounted two focusing lenses, one whose center was 1.5 inches from the floor of the aperture, the other whose center was 3.25 inches above the floor. The center of both lenses was .625 inches from the outside edge of the aperture. Behind the plexiglass of the opposite wall of the aperture, the wall of the narrower box, were mounted two light-dependent resistors (LDR), whose centers were directly opposite those of the focusing lenses.

The wider of the two boxes contained a transformer which reduced regular 115 volt house current to a 2 volt current. This current powered two 2.25 volt (No. 222 Spectro) prefocused miniature lamps which were mounted directly opposite and behind the focusing lenses. Light beams produced by these lamps were thus focused through the lenses and the two layers of plexiglass onto the LDR in the opposing wall of the aperture. These LDR in turn controlled a 110 volt relay in such a way that if either or both light beams were broken by an animal entering the aperture, a current was sent to a running time meter which then recorded the length of time that animal spent

in the aperture.

Identification as to which animal of a competition pair was in the aperture was controlled manually by the experimenter (E). Depressing a momentary, double-throw, double-pole bar microswitch, one for each animal, activated the recording equipment for one animal or the other. As an animal (e.g. R1) approached the aperture, E would depress the switch color coded to the band of color on R1's tail. Should R1 not enter the aperture, releasing the switch would record an "approach" response for R1. Should the animal enter the aperture, its running time meter would be activated and any subsequent lever press responses and reinforcements would be recorded on its counters. Releasing the switch after R1 had left the aperture would record both an "approach" and an "entry" response. Two additional momentary switches, again one for each animal, recorded the number and duration of "submissive" postures exhibited by each animal during aggressive encounters in competition sessions. Interobserver reliability measures were made possible by the construction of a similar set of switches using identical circuitry.

Dependent measures were recorded for each animal of a competition pair by counters, running time meters, a six channel event pen recorder, and a cumulative recorder. These various measures consisted of lever press responses, reinforcements, "approaches", "entries", total time spent in the aperture per session, the sequence and length of periods of time spent in the aperture, and the number and duration of "submissive" postures. This standard relay-operated programming and recording equipment was located in a nearby room.

The food reinforcement used were 45 mg. Noyes precision food pellets.

III. General Procedure

Experimental sessions of 15 and 30 minutes duration were scheduled daily. Immediately prior to each experimental session the animal, or in the case of competition sessions two animals, were weighed. Each rat received its daily ration of food necessary to maintain its weight at 80% of the ad lib body weight control group following the session at approximately the same time each day.

The animals were housed in a common colony room and were taken each day to the testing room for their experimental session. With schedules calling for a single subject, the subject was placed in a corner of the chamber facing the aperture. With schedules calling for a competition session, two animals were placed simultaneously in the chamber, each in a seperate corner facing the aperture. The equipment, including the houselight of the experimental chamber, was turned on by setting a session timer at the appropriate session length. Immediately following this the room lights of the testing room were turned off, with the houselight in the experimental chamber remaining the sole source of illumination. E was situated directly in front of the chamber facing the aperture and manipulated the control panel which recorded which animal had control of the pellet lever.

An animal was considered dominant if it was in command of the pellet lever. The 2 inches wide aperture could accommodate the width of only one animal at a time. The most frequent method by which an

animal removed its opponent from the aperture was by leaping or climb-
ing over the back of the animal in the aperture, pressing the animal
to the floor while at the same time kicking the animal out of the
aperture with its back feet. This behavior is illustrated in photo-
graphs of typical instances of competitive behavior at the aperture
(see Figs. 3(A) & (B)). Another behavior frequently observed was
"displacement" activities such as grooming, engaged in by the subord-
inate rat while the dominant rat of a competition pair was engaged
at the aperture (see Figs. 3(C) & (D)). The pellet lever was situat-
ed 2.5 inches above the floor, enabling the animal on top to be in
command of the food lever. $\underline{E}$ switched the recording equipment to
show that the animal on top was dominant, even though two animals
may have been present in the aperture at the time.

An animal was considered to show submission if it lay on its
side or back, immobile, with its opponent on top. These postures
were highly stereotypic and have been described by Seward (1945a).
Typical examples of these behaviors are illustrated in photographs
of submissive postures exhibited in fighting between competition
pairs (see Fig. 4).

Interobserver reliability measures were obtained by having an
independent observer judge dominance behavior during 10 arbitrarely
selected competition sessions, using a set of switches similar in
design and circuitry to those used by $\underline{E}$. After having had some pract-
ice making judgements, the observer differed less than 2% from $\underline{E}$ in
terms of the time each animal was in control of the pellet lever.
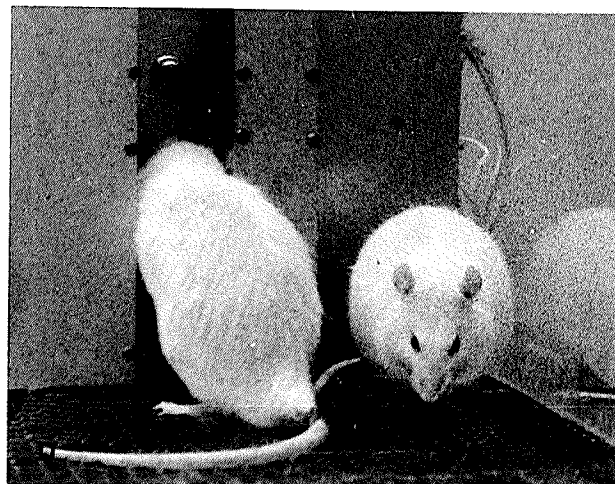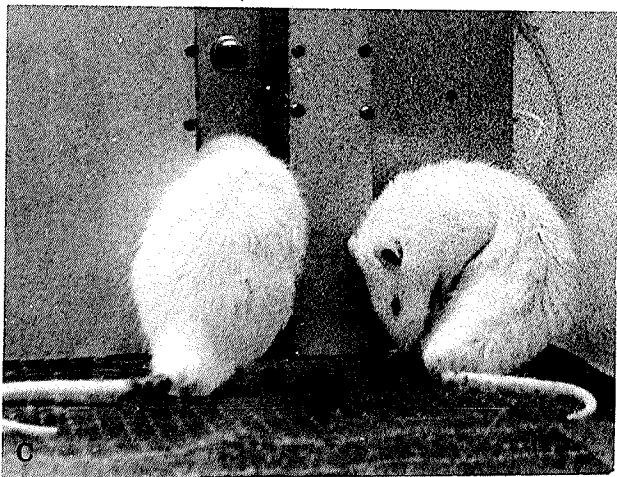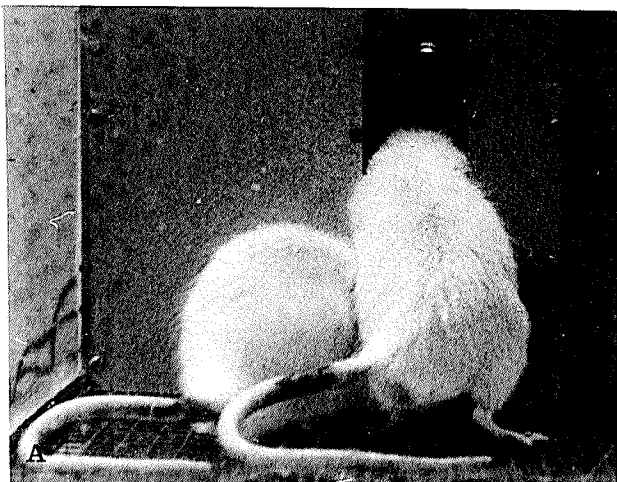Over several additional sessions, the observer and $\underline{E}$ were in complete

Fig. 3. Photographs of representative instances during competition sessions: competitive behavior at the aperture (A) and (B); displacement activity of subordinate rat (C) and (D).
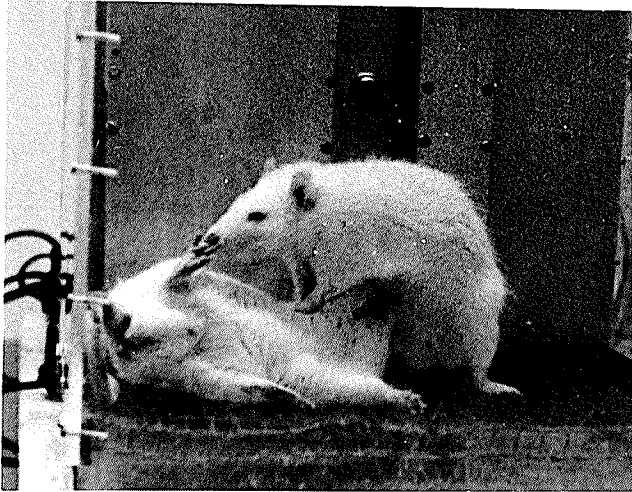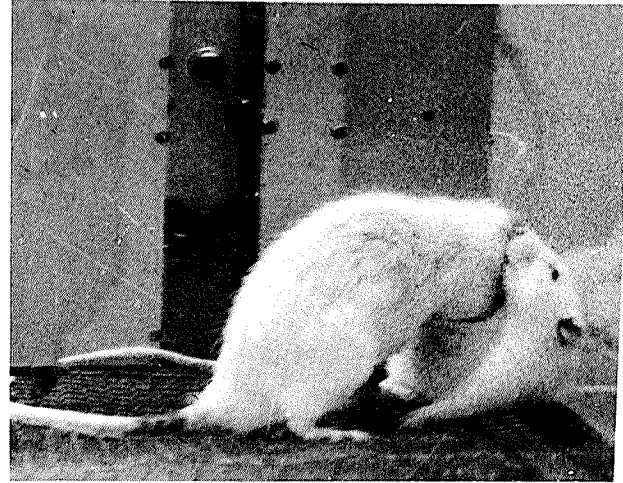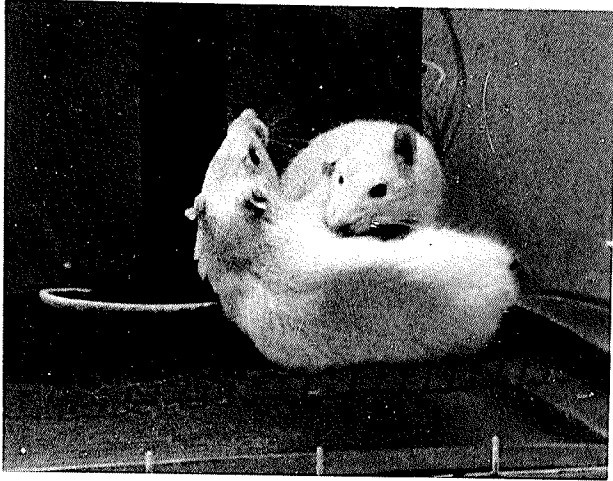
Fig.**4**. Photographs of representative instances of submissive postures in fighting within competition pairs.

agreement on the number of submissive postures exhibited by each animal.

Subjects received thirteen, 15 minute sessions of individual lever training in the apparatus and were then assigned to their respective experimental conditions. The duration of all subsequent sessions was 30 minutes. The present investigation consisted of four experiments, each of which contained three main phases: a baseline condition; an experimental manipulation; a return to baseline condition.

In phase A of Experiment I, subjects were placed together in pairs and competed to lever press for food on CRF. In phase B this was changed to food competition on gradually increasing FR schedules, to a terminal value of FR 40. The final phase (C) was a return to food competition on CRF.

In phase A of Experiment II, subjects were individually trained on FR 40. They were then placed together in pairs, phase B, and competed to lever press for food on FR 40. Phase C consisted of returning the animals to individual training on FR 40.

Unlike competition on CRF or FI schedules, the responses made by one rat in a competition pair could count towards its opponent's ratio during FR schedule competition sessions. For example, during competition sessions on FR 40, rat A could enter the aperture and emit the initial 35 lever presses. Its opponent rat B could then displace rat A from the aperture, emit the last 5 lever presses and consequently obtain the reinforcement. A dominant rat could thus adopt the "strategy" of allowing its subordinate opponent to emit most of the initial lever presses on higher FR ratios, displacing the

subordinate animal prior to the last few lever presses needed to fulfill a ratio requirement, emit these last few lever presses and thus obtain the reinforcement with a minimum of work.

In phase A of Experiment III, subjects were placed together in pairs and competed for food on CRF. In phase B this was changed to food competition on gradually increasing FI schedules, to a terminal value of FI 50 seconds. The final phase (C) was a return to food competition on CRF.

In phase A of Experiment IV, subjects were individually trained on FI 50 seconds. They were then placed together in pairs, phase B, and competed for food on FI 50 seconds. Phase C consisted of returning the animals to individual training on FI 50 seconds.

CHAPTER III

EXPERIMENT I

I. Introduction

The object of this experiment was to observe changes in the degree of dominance-subordination behavior exhibited by pairs of rats as the schedule demands under which each pair competed to lever press for food was gradually changed from CRF to FR 40 by increments of two FR steps per session.

II. Procedure

Four rats served as $\underline{S}$s, forming two competition pairs (G1 & R1, G2 & R2). The training and testing sequence began with 13 individual 15 minute sessions of lever training on CRF. Animals were then placed in competition pairs and competed to lever press for food on CRF, this phase constituting the baseline condition. All subsequent sessions were of 30 minutes duration. Competition pair G1 and R1 received 14 competition sessions and pair G2 and R2 received 13 competition sessions under the baseline condition. The schedule under which each pair was competing was then changed from CRF to an increasing FR schedule, beginning with FR 4 and increasing by two FR steps each succeeding session until the terminal schedule of FR 40 was reached. Each pair then competed on FR 40 for 6 sessions. Finally, in a return to the baseline condition, each pair competed for 6 sessions on CRF. As was described earlier, during competition sessions

on FR schedules, the responses made by one rat could count towards
its opponent's ratio.

Four dependent measures of the degree of dominance-subordinat-
ion behavior were employed. The first of these was the number of lev-
er press responses made by each animal in a competition pair. Since
at any time only one animal in a pair could control the aperture con-
taining the manipulandum, the percentage of the total session time
spent in the aperture by each animal comprised the second dependent
measure. The third measure was the number of reinforcements obtained
during a session by each animal in a competition pair and, finally,
the number of submissive postures exhibited each session by each
animal in a pair constituted the fourth measure.

One or the other animal in a competition pair was defined as
dominant if it emitted a higher number of lever press responses, if
it spent the larger percentage of time in the aperture, if it ob-
tained the greater number of reinforcements, of if it exhibited few-
er submissive postures than its opponent.

III. Results

Number of lever press responses. The degree of dominance-sub-
ordination behavior in terms of the number of lever press responses
made by each rat in competition pairs R1 and Gi and R2 and G2 (see
Figs. 5 & 6) under the CRF baseline condition was small and became
inconsequential as the sessions under this condition progressed. With
the schedule changing from CRF to an increasing FR schedule, rat R1
in competition pair R1 and G1 and rat G2 in pair R2 and G2 became

Fig. 5. Number of lever press responses emitted each session by each animal in competition pair G1 and R1, competing on CRF, increasing FR, and FR 40 schedules.
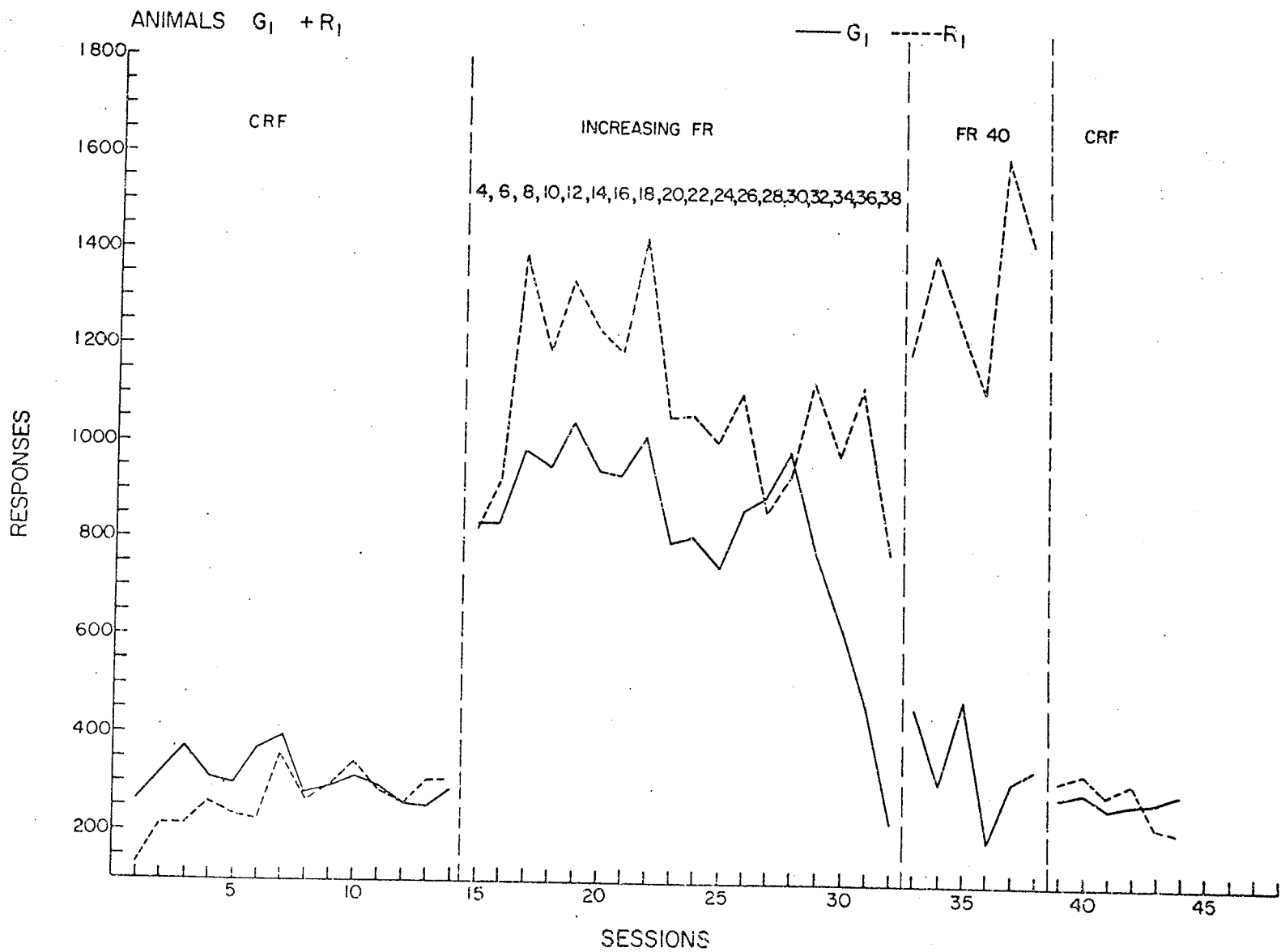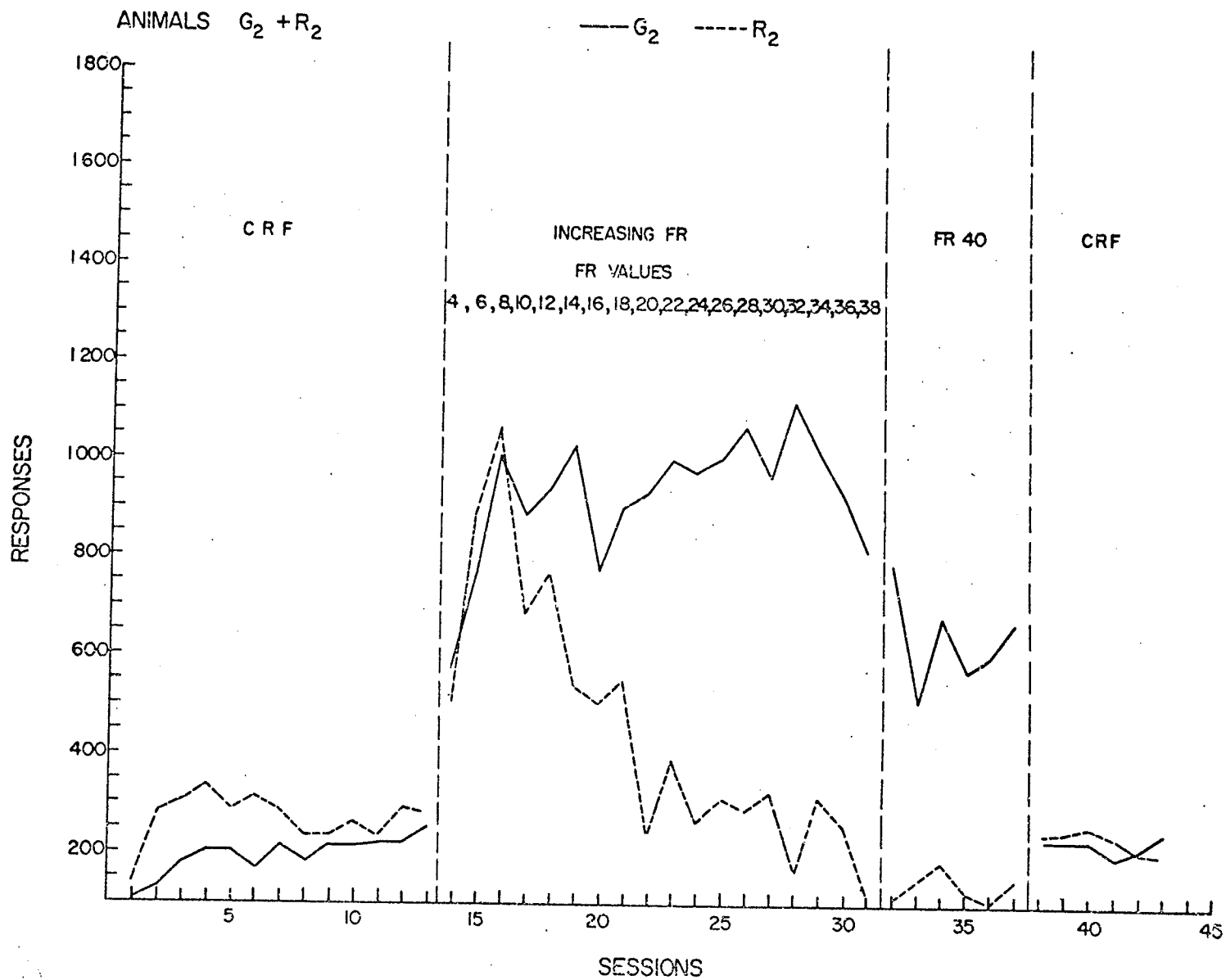
Fig. 6. Number of lever press responses emitted each session by each animal in competition pair G2 and R2, competing on CRF, increasing FR, and FR 40 schedules.

dominant. With the exception of sessions 27 and 28 (see Fig. 5) in which the number of lever presses of the dominant rat R1 decreased to that of his competitor G1, this degree of dominance-subordination behavior was maintained throughout the increasing FR schedules in each competition pair. In the 6 subsequent sessions under the terminal FR 40 schedule, the degree of dominance-subordination behavior observed under increasing FR schedules was maintained in pair R2 and G2 and was increased in pair R1 and G1. Typical cumulative recordings of lever press behavior under the terminal FR 40 schedule (see Figs. 7 & 8) reveal that rat R1 in pair R1 and G1 and rat G2 in pair R2 and G2 maintained a higher lever press rate and exhibited stronger FR behavior relative to the low lever press rate and weak FR behavior of their opponent G1 and R2 respectively. Due to a shortage of instrumentation, the cumulative recordings of each animal in each competition pair were taken from different but representative sessions during FR 40 competition. A return to the CRF baseline condition resulted in the reduction of dominance-subordination behavior in each competition pair to the level observed during the pre-experimental CRF baseline.

Percentage of time spent in the aperture. The degree of dominance-subordination behavior in terms of the percentage of the total session time spent in the aperture by each animal in a competition pair became small and inconsequential as the sessions under the CRF baseline condition progressed (see Fig. 9). With the schedule changing from CRF to an increasing FR, no clear degree of dominance-subordination behavior emerged in competition pair G1 and R1

Fig. 7. Typical cumulative recordings of lever press behavior by animals G1 and R1 during competition sessions on an FR 40 schedule.
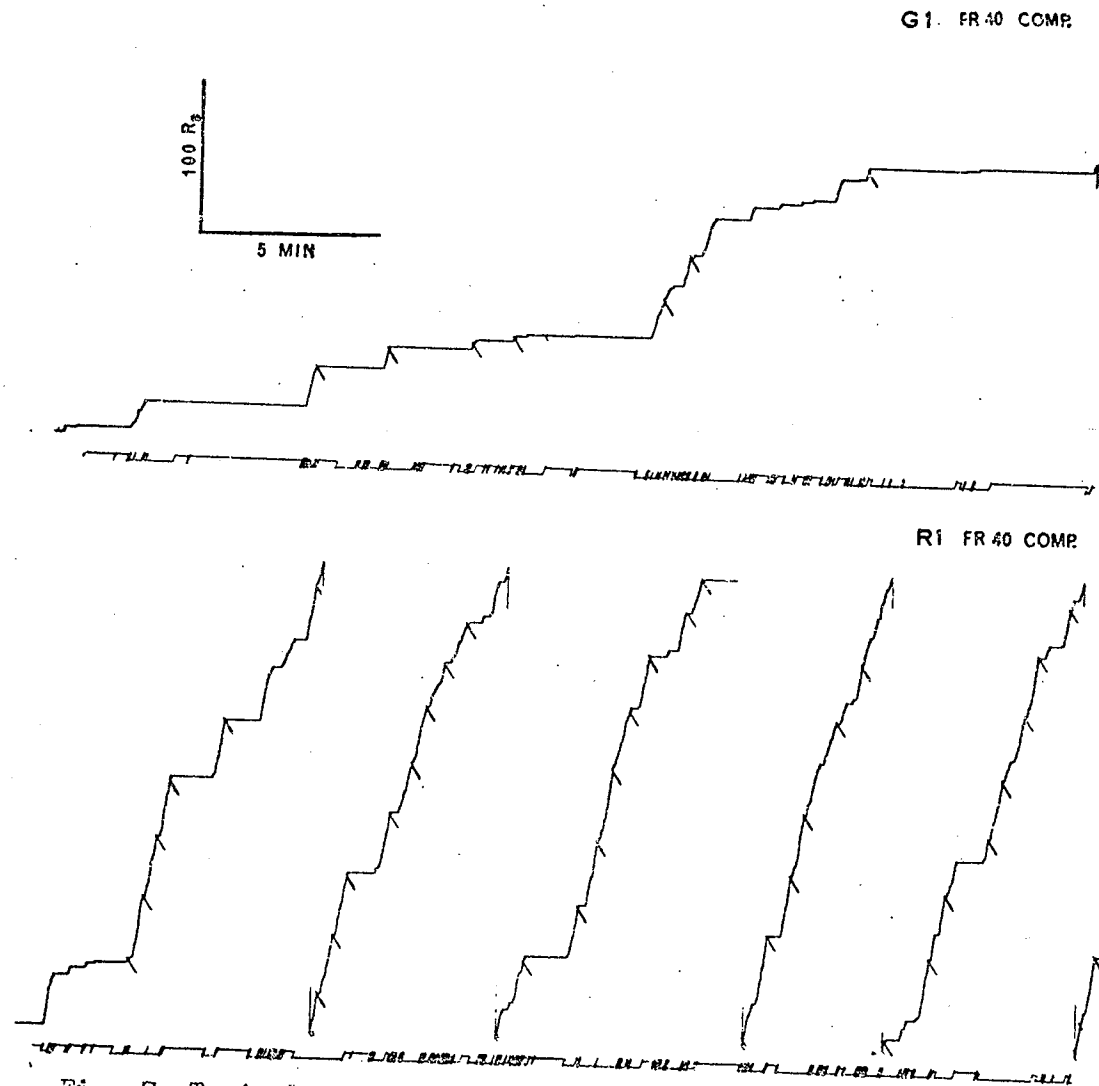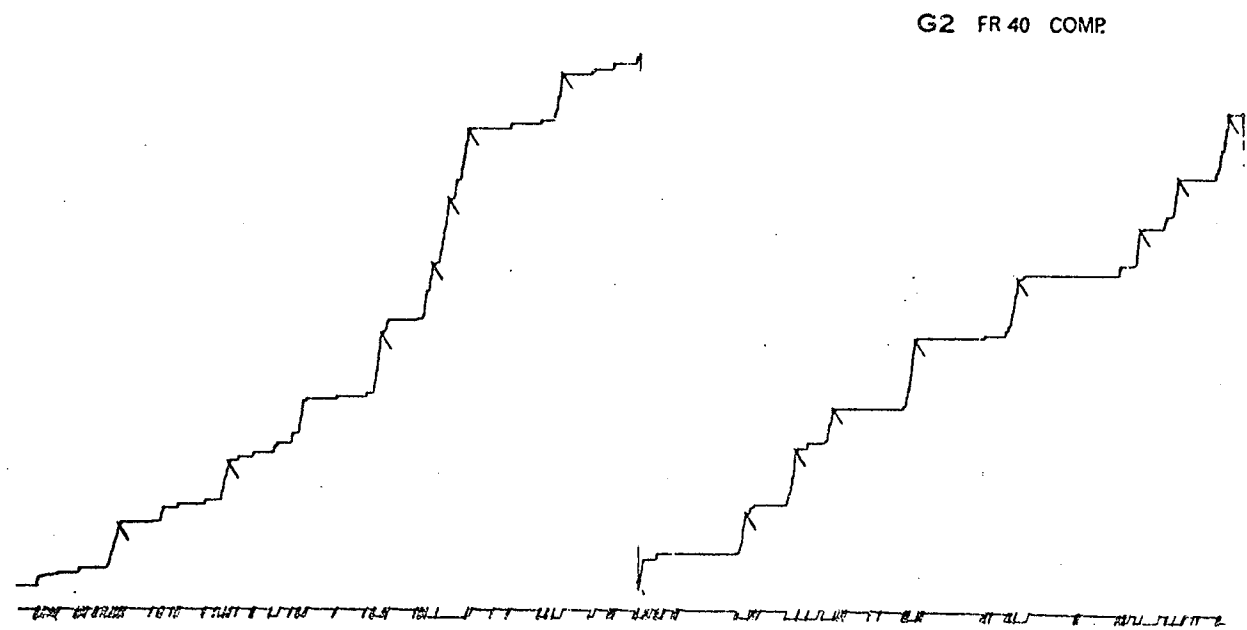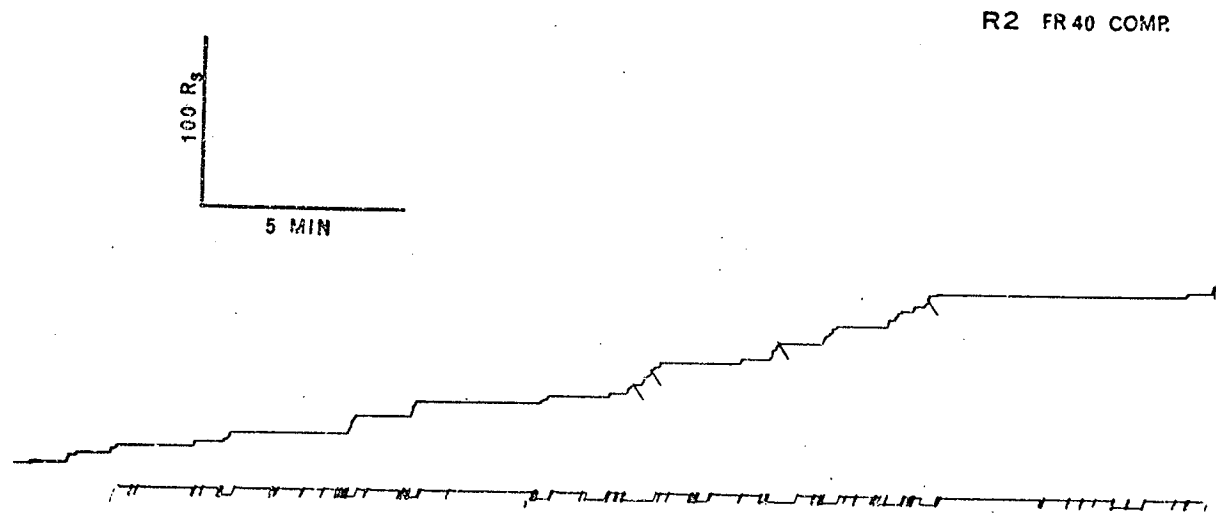
Fig. 8. Typical cumulative recordings of lever press behavior by animals R2 and G2 during competition sessions on an FR 40 schedule.
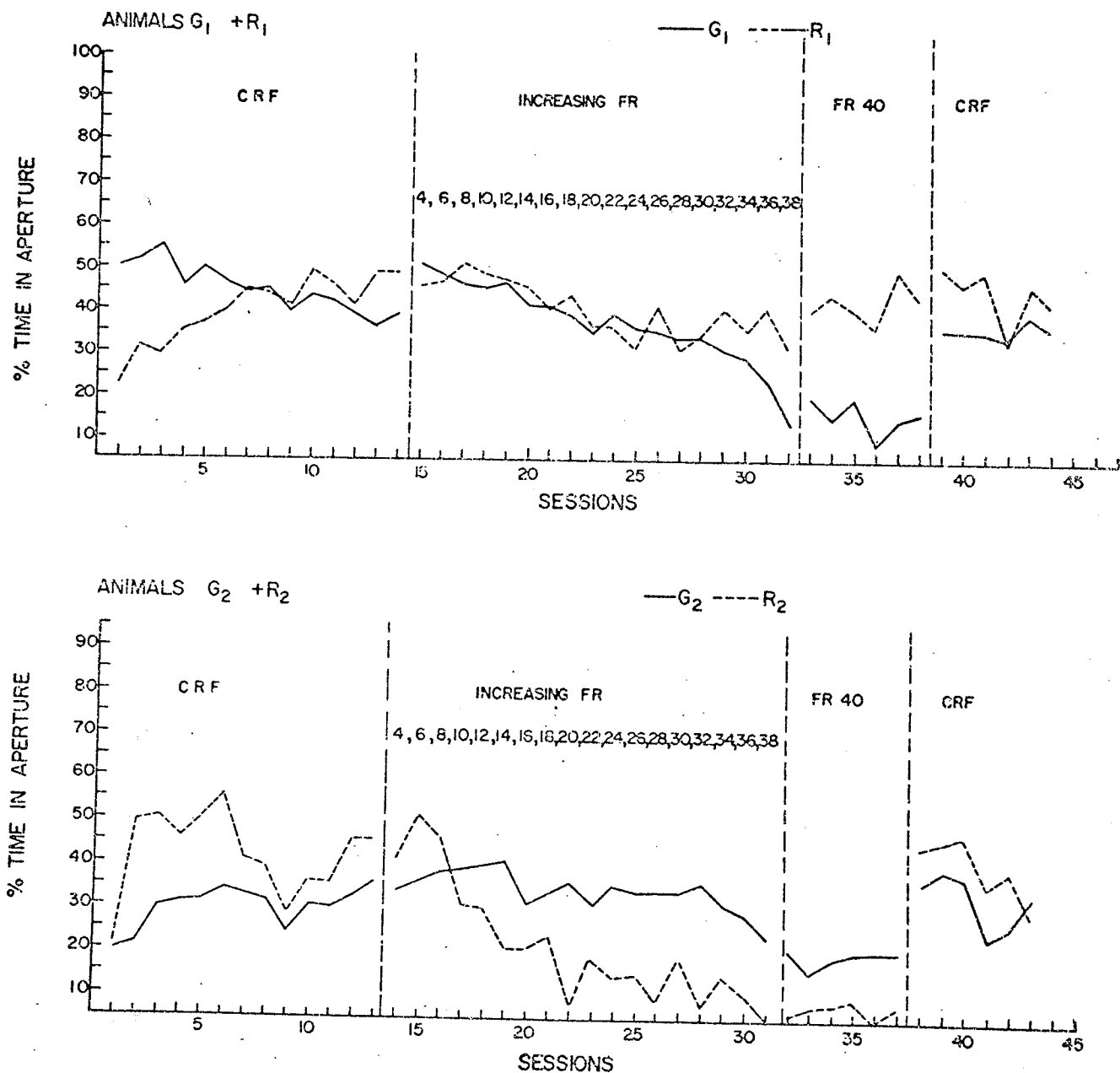
Fig. 9. Percentage of the total session time spent controlling the aperture by each animal in competition pairs G1 and R1; G2 and R2, competing under CRF, increasing FR, and FR 40 schedules.

until the FR 32 schedule was reached in session 29, at which time
rat R1 became dominant and rat G1 became subordinate. Rat R1 main-
tained its dominance and rat G1 continued to become more subordin-
ate during the remaining sessions in the increasing FR schedules
phase.

Rat G2 in competition pair R2 and G2 became dominant in ses-
sion 17 under the FR 10 schedule and maintained this dominance dur-
ing the increasing FR schedules (see Fig. 9), while its opponent
R2 spent increasingly less time in the aperture as these sessions
progressed. In the 6 subsequent sessions under the terminal FR 40
schedule, the degree of dominance-subordination behavior increased
in competition pair G1 and R1 and was maintained in competition
pair G2 and R2. A return to the CRF schedule of the baseline cond-
ition resulted in the reduction of the degree of dominance-subord-
ination behavior in each competition pair to the level observed
during the pre-experimental CRF schedule baseline.

Reinforcements obtained per session. The degree of dominance-
subordination behavior exhibited in terms of the number of reinforce-
ments obtained each session by each animal in a competition pair was
not calculated for food competition under the CRF schedule. It was
assumed that the number of reinforcements gained was approximately
equal to the number of lever press responses emitted in these ses-
sions. With the exception of session 17 under the FR 8 schedule
(see Fig. 10), rat G1 in competition pair R1 and G1 was dominant in
terms of obtaining the larger number of reinforcements. It was not
until session 31 under the FR 36 schedule that R1 became dominant in
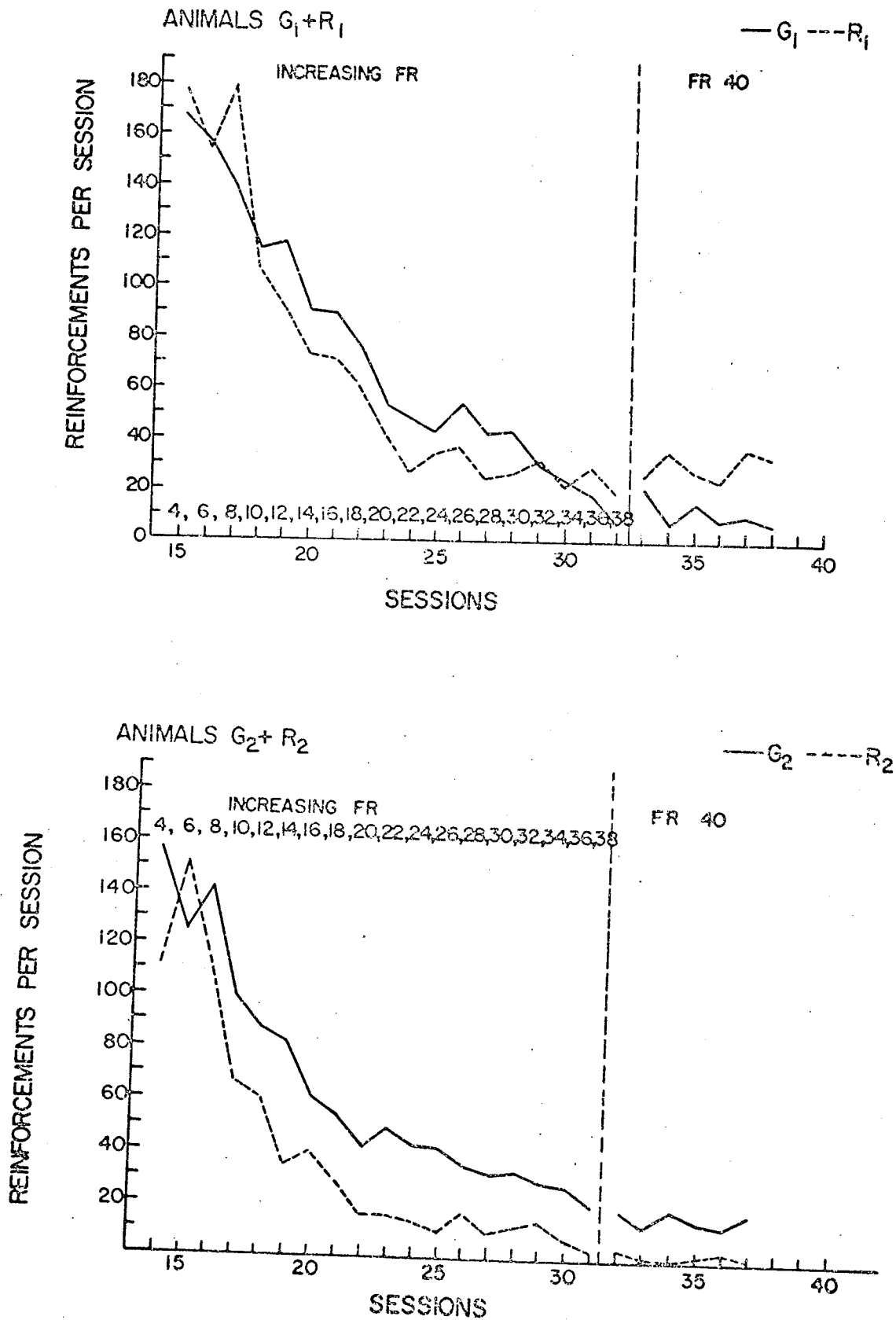
Fig. 10. Number of reinforcements obtained each session by each animal in competition pairs G1 and R1; G2 and R2, competing under increasing FR and FR 40 schedules.

terms of this measure. It should be noted that the number of rein-
forcements each animal could obtain in competition each session under
the increasing FR schedules decreased rapidly as a function of the
increasing lever press demands of these schedules.

Rat G2 in competition pair R2 and G2 became dominant in ses-
sion 17 under the FR 10 schedule and maintained this dominance dur-
ing the increasing FR schedules phase (see Fig. 10). In the 6 sub-
sequent sessions under the terminal FR 40 schedule, rat R1 increased
and rat G2 maintained its dominance in terms of this measure.

Number of submissive postures. The number of submissive
postures exhibited by each animal in each of the two competition
pairs was recorded in all phases of the experiment. The degree of
dominance-subordination behavior in terms of this measure was small
and unclear in competition pair R1 and G1 during all but the last 5
sessions of the FR 40 schedule phase. During the 14 sessions under
the initial CRF schedule baseline condition, rat R1 exhibited 15
submissive postures while its opponent exhibited 4 (see Fig. 11).
The number of submissive postures exhibited increased for both anim-
als as the lever press value of the FR schedules increased, with rat
R1 exhibiting 48 submissive postures and G1 exhibiting 39 in the 18
sessions of this phase of the experiment. In the last 5 of the 6
sessions under the terminal FR 40 schedule, this dominance-subordin-
ation relationship reversed with R1 exhibiting 14 submissive post-
ures while rat G1 exhibited 29. A return to the CRF schedule base-
line condition resulted in a return of the dominance-subordination
behavior observed under the initial baseline condition, with rat R1
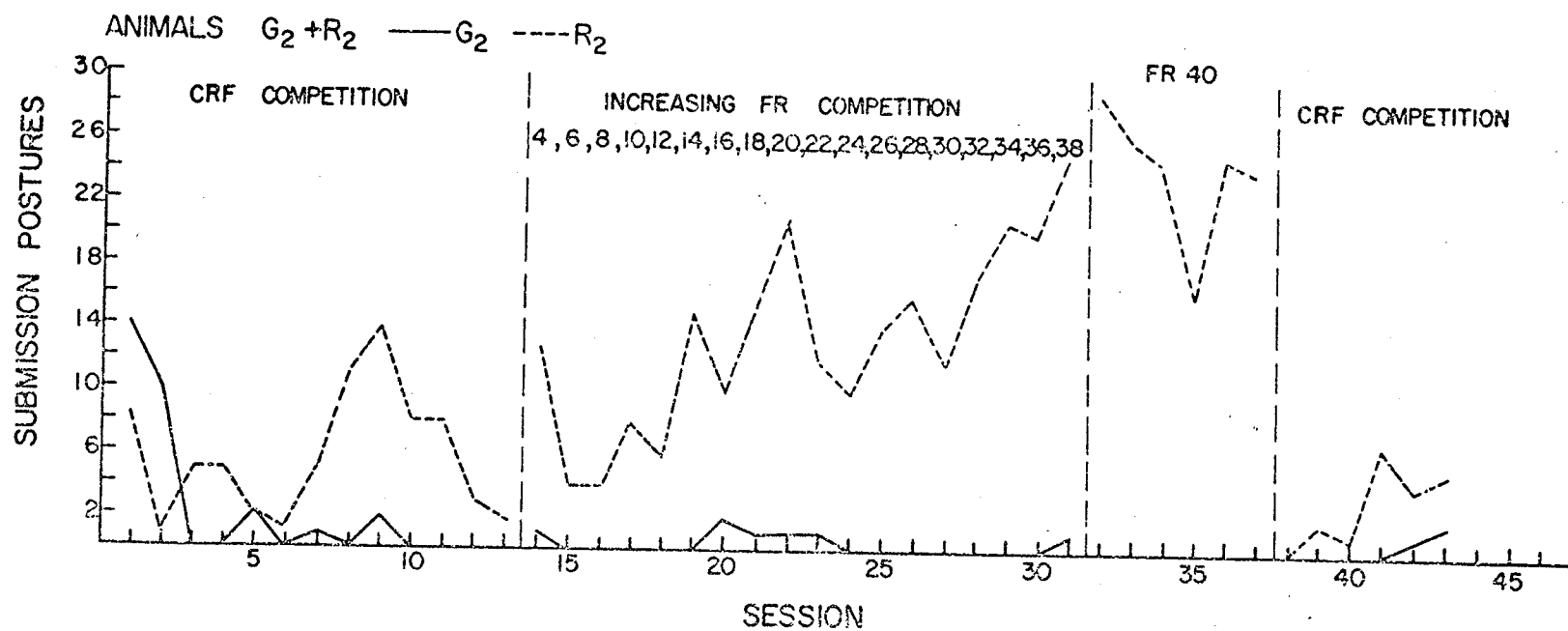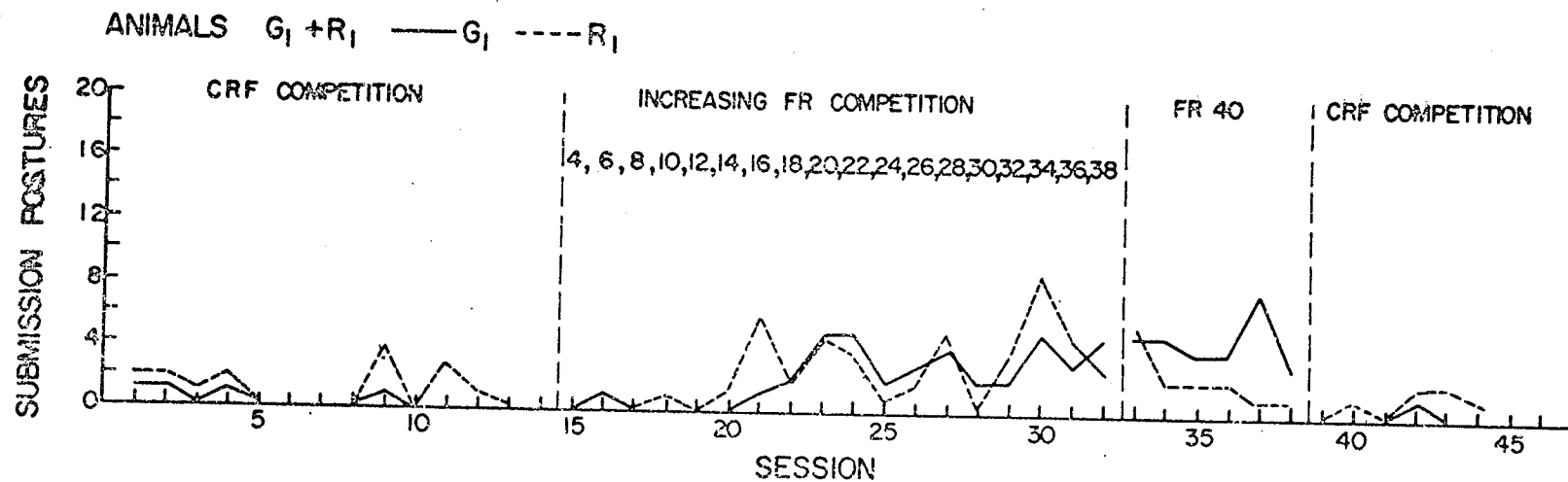
Fig. 11. Number of submissive postures exhibited each session by each animal in competition pairs G1 and R1; G2 and R2, competing on CRF, increasing FR, and FR 40 schedules.

exhibiting 6 submissive postures while its opponent G1 exhibited 1.
It was thus only during the FR 40 competition sessions that R1 became
slightly dominant in terms of exhibiting fewer submissive postures
than its opponent G1.

Observations of competition pair R2 and G2 revealed a much
clearer and greater degree of dominance-subordination behavior in
terms of this measure (see Fig. 11). In all phases of the experim-
ent, rat G2 was dominant over its competitor R2 in terms of exhib-
iting fewer submissive postures. The number of submissive postures
increased as the FR schedule under which they were competing in-
creased, but only in the subordinate animal R2. In the 6 subsequent
sessions under the terminal FR 40 schedule, the number of submissive
postures exhibited by R2 increased still further while rat G2 exhib-
ited no submissive posture during these sessions. A return to the
CRF schedule baseline condition saw a return of the degree of dom-
inance-subordination behavior in terms of this measure observed un-
der the initial CRF baseline.

Additional observations. Observations of competition sessions
under the initial CRF baseline condition revealed that in the initial
8 or 9 sessions, animals in each competition pair switched or altern-
ated very frequently in terms of controlling the aperture containing
the food lever. In the subsequent sessions under this condition, this
high rate of alternation decreased and stabilized, and the frequency
with which each animal in a competition pair controlled the aperture
became more equal. A rat (e.g. R1) would enter the aperture, press
the lever and receive a food pellet. It would then typically hover

over the lever, eating the food pellet, after which it pressed the lever once again for another food pellet. This would continue until its opponent G1 would push R1 out of the aperture, typically by climbing over R1's back and kicking its back feet, thereby forcing R1 out of the aperture.

Changing the schedule from CRF to FR 4 immediately increased both the lever press rate and the frequency of alternation at the aperture. The frequency of alternation at the aperture continued to increase as the lever press value of the increasing FR schedules increased, until a maximum rate of alternation was reached at approximately FR 20. In the remaining sessions of the increasing FR schedules phase, the number of alternations at the aperture in each pair of animals gradually decreased and stabilized to a relatively constant level, with the dominant animal controlling the aperture for the largest portion of the session time. A return to the CRF schedule baseline saw a return of the level of alternation observed under the initial baseline condition.

The subordinate animal, when not at the aperture, would engage in a "displacement activity" such as grooming. It would also frequently nuzzle the flank of the dominant animal while this animal was engaged at the aperture. If this nuzzling behavior persisted, the dominant animal would most frequently turn on the subordinate and often force it into a submissive posture.

IV. Discussion

In some phase of the experiment, the four measures of the

degree of dominance-subordination behavior did not seem to be measuring the same phenomenon. This discrepancy among the measures occurred in both competition pairs.

The initial CRF baseline phase. Under this condition, the degree of dominance-subordination behavior observed in each of the two competition pairs was very similar on the first two measures; the number of lever presses emitted (see Figs. 5 & 6) and the percentage of time spent controlling the aperture (see Fig. 9). During these sessions, the dominant and subordinate animals in each competition pair held the same relative positions on both measures.

The third measure, the number of reinforcements obtained by each animal in a competition pair, was not calculated for the CRF schedule baseline sessions. However, the fourth measure of the degree of dominance-subordination behavior, the number of submissive postures exhibited by each animal in a pair, deviated from the dominance-subordination behavior portrayed by the lever press and the percentage of time in the aperture measures (see Fig. 11). In competition pair R1 and G1, rat R1 was slightly dominant over G1 in terms of both the lever press and the percentage of time in the aperture measures during the later sessions under the CRF schedule baseline condition. However, rat R1 exhibited a slightly larger number of submissive postures than its opponent G1 during these same sessions, suggesting that on this measure the dominance-subordination relationship was reversed and rat G1 was somewhat more dominant.

Similarly, in pair R2 and G2, R2 was slightly dominant in terms of both the lever press and the percentage of time in the aperture

measures during the later sessions of the initial baseline condition. But in terms of the number of submissive postures exhibited, this pair also showed a reversal of the dominance-subordination relationship portrayed by the above two measures. R2 exhibited a far greater number of submissive postures during these same sessions, suggesting that in terms of this measure rat R2 became subordinate and its opponent G2 dominant.

The increasing FR schedules phase. In this phase, the degree of dominance-subordination behavior exhibited by each of the two pairs of animals again corresponded quite closely in terms of the lever press and the time in the aperture measures, particularly in competition pair R2 and G2 (see Figs. 6 & 9). After the initial three sessions under this condition, R2's lever press rate fell sharply and continued to decline throughout the remainder of the sessions under this condition while rat G2 maintained its relatively high number of lever presses. Very similar dominance-subordination behavior was observed in terms of the time in the aperture measure for this competition pair.

However, in competition pair R1 and G1 (see Fig. 5), rat R1 was dominant in terms of the lever press measure with the exception of sessions 26 and 27, sessions in which its number of lever presses fell to that of its competitor G1. The number of lever presses emitted by R1 rose again and remained high relative to the number of lever presses emitted by its opponent G1 for the remaining sessions of this phase. Rat G1's number of lever presses fell sharply in these same remaining sessions. In terms of the time in the

aperture measure for this competition pair, no apparent degree of dominance-subordination behavior was observed until session 29 under the FR 32 schedule, at which time rat R1 became dominant by maintaining its percentage of time in the aperture while that of its opponent G1 fell sharply during the remaining sessions of this phase. It was thus only in these later sessions that rat R1's dominance in terms of the time in the aperture measure paralleled the dominance it displayed in terms of the lever press measure.

The degree of dominance-subordination behavior observed in terms of the reinforcements obtained per session measure paralleled that observed in terms of the lever press and time in the aperture measures for competition pair R2 and G2. In competition pair R1 and G1, the dominance-subordination relationship observed in terms of the lever press and time in the aperture measures reversed. G1 was clearly dominant with the exception of session 17 for the first 17 sessions of this phase of the experiment (see Fig. 10). It was not until session 31 under the FR 36 schedule that R1 became dominant in terms of this measure.

The final measure of the degree of dominance-subordination behavior, the number of submissive postures exhibited by each rat in each competition pair, again paralleled the dominance-subordination relationship observed in terms of the above three measures for competition pair R2 and G2. However, this measure failed to show a consistent degree of dominance-subordination behavior in competition pair R1 and G1 (see Fig. 11), and thus did not reveal the dominance-subordination relationship observed in terms of the first three measures in the later sessions in this phase of the experiment.

The FR 40 schedule phase. The degree of dominance-subordination behavior was maximized in each of the two competition pairs in terms of all four measures of dominance-subordination behavior in this phase of the experiment. Rat R1 in competition pair R1 and G1 and rat G2 in competition pair R2 and G2 were dominant in terms of all four measures. It was thus only in lever press competition for food under the terminal FR 40 schedule that all four measures of dominance-subordination behavior showed parallel dominance-subordination relationships in each of the two competition pairs.

Return to the CRF schedule baseline. Both the degree of dominance-subordination behavior and the nature of the dominance-subordination relationships returned to approximately those observed under the initial CRF schedule baseline condition in each of the two competition pairs in terms of all four measures in this phase of the experiment.

By examining the dominance-subordination behavior in each of the two competition pairs, it was apparent that in competition pair R2 and G2, a clear degree of dominance-subordination behavior was established earlier in the increasing FR schedules phase, and that this behavior was of greater magnitude, relative to the dominance-subordination behavior observed in competition pair R1 and G1 during these sessions. In addition, the degree of dominance-subordination behavior as well as the nature of the dominance-subordination relationship, was consistent in competition pair R2 and G2 across all measures in the increasing FR schedules phase. Rat G2 was dominant in terms of all four measures following the initial three sessions of this phase.

This degree and consistency of dominance-subordination across all measures of dominance-subordination behavior employed in this experiment failed to emerge in competition pair R1 and G1 during the increasing FR schedules phase. As was described earlier, rat R1 was dominant in terms of the lever press measure with the exception of sessions 27 and 28 under this condition of the experiment. However, this dominance-subordination relationship failed to emerge in terms of the time in the aperture measure until session 29. In terms of the reinforcements obtained per session measure, R1 was subordinate instead of dominant with the exception of session 17. It was not until session 31 under the FR 36 schedule that R1 gained the dominance it had shown under the first two measures. Finally, no clear degree of dominance-subordination behavior emerged in terms of the submissive postures measure in the increasing FR schedules phase.

The reason that R1 was dominant in terms of the number of lever presses emitted was its higher lever press rate relative to that of its opponent G1. This can be ascertained form R1's lack of dominance in terms of the percentage of time it spent controlling the aperture. When R1 became dominant in terms of the time in the aperture measure during the last four sessions of the increasing FR schedules phase, G1's number of lever presses dropped to a very low level while R1 maintained its relatively high lever press rate. It was approximately at this point in the increasing FR schedules phase that R1 also became dominant in terms of obtaining the largest number of reinforcements.

During the increasing FR schedules phase, rat G1 adopted a

"strategy" for maximizing the number of reinforcements it could obtain in competition with its opponent R1. Rat G1 would wait until R1 had fulfilled the largest portion of the lever presses needed to fulfill the FR requirement for a reinforcement. It would then remove R1 from the aperture, finish the lever press requirement for the FR schedule under which they were competing, and collect the reinforcement. This continued until session 31 under the FR 36 schedule, at which time R1 began to obtain the largest number of reinforcements and thus became dominant in terms of this measure. This strategy on the part of G1 thus accounts for the fact that it was dominant in terms of the number of reinforcements obtained per session measure, despite the fact that R1 was dominant in terms of the number of lever presses emitted each session.

Each of the two competition pairs showed a consistent and maximum degree of dominance-subordination behavior under the terminal FR 40 schedule in terms of all four measures. It thus required an FR schedule nearly as high or equal to the terminal FR 40 schedule in order to obtain dominance-subordination behavior in pair R1 and G1 which was consistent in terms of all four measures of dominance-subordination behavior and which was also consistent with the dominance-subordination behavior observed in competition pair R2 and G2.

The lower FR schedules in which competition pair R2 and G2 exhibited consistent dominance-subordination behavior across all four measures, relative to the high FR schedules needed to obtain the same phenomenon in pair R1 and G1, may be explained by the possible difference in the "spontaneous" dominance-subordination behavior in each of the two competition pairs. One source of data which may substantiate

this notion are the number of submissive postures exhibited by each rat in each competition pair. In competition pair R2 and G2, rat G2 was dominant in terms of this measure in all phases of the experiment, while in competition pair R1 and G1, rat R1 did not become dominant in terms of the number of submissive postures measure until the last 5 sessions of the terminal FR 40 schedule phase. It may thus be that competition pair R1 and G1 were more evenly matched in terms of dominance-subordination behavior, and that it required competition under high FR schedules before a consistent degree of dominance-subordination behavior emerged.

V. Conclusion

The following conclusions may be drawn for the data of this experiment:

1. The degree of dominance-subordination behavior exhibited by pairs of rats competing to lever press for food on a CRF schedule tends to become small and inconsequential as the sessions under this condition progress (in terms of response rate or time in the aperture).

2. As the lever press requirement of a gradually increasing FR schedule increases and reaches a relatively high value, this FR value differing between pairs of animals, the degree of dominance-subordination behavior increases (in terms of lever press rate, time in the aperture, or reinforcements obtained). Subsequent sessions under a still higher FR schedule (FR 40) maximizes and stabilizes this degree of dominance-subordination behavior.

3. A return to competition on a CRF schedule following FR

schedule competition reduces the degree of dominance-subordination behavior to the low level observed in the initial CRF baseline competition sessions (in terms of the lever press rate or time in the aperture).

4. Although there may sometimes be a lack of positive correlation between the lever press, time in the aperture, and the reinforcements obtained measures of dominance-subordination behavior at low FR schedule values, these measures all correlate positively during competition on higher FR values. The FR values at which these three measures begin to correlate positively and highly varies from one competition pair to another.

5. As the FR schedule on which animals are competing gradually increases, the frequency of aggressive encounters also increases. However, the submissive postures measure does not correlate highly with the other three measures of the degree of dominance-subordination behavior, except during the FR 40 competition sessions.

6. The lever press behavior characteristic of FR schedules is exhibited by the dominant animal in a competition pair during sessions on a high FR schedule (FR 40), but is not exhibited by the subordinate animal.

CHAPTER IV

EXPERIMENT II

I. Introduction

The object of this experiment was to observe the degree of dominance-subordination behavior exhibited by pairs of rats which were individually trained on an FR 40 schedule, subsequent to which they were placed together to form competition pairs, each of which competed to lever press for food on an FR 40 schedule.

II. Procedure

Four rats served as Ss, forming two competition pairs (G3 & R3, G4 & R4). The training and testing sequence began with 13 individual 15 minute sessions of lever training on CRF. All subsequent sessions were of 30 minutes duration. All animals were then trained up to an FR 40 schedule by increments of 10 FR steps per session. Each animal then received 12 sessions on an FR 40 schedule, this phase of the experiment constituting the baseline condition. Animals were subsequently placed in competition pairs and competed to lever press for food on an FR 40 schedule, each pair receiving 14 such competition sessions. In a return to the baseline condition, each animal received 6 individual sessions on an FR 40 schedule.

The four dependent measures of the degree of dominance-subordination behavior employed in Experiment I were again employed in the present study. Similarly, the definitions of dominance or subordination

behavior employed in this experiment were the same as those used in Experiment I.

III. Results

Number of lever press responses. During the FR 40 schedule baseline condition in which each rat in each competition pair was alone in the experimental chamber, animal G3 in competition pair G3 and R3 and animal R4 in competition pair G4 and R4 exhibited the higher lever press rates (see Figs. 12 & 13). When the animals were subsequently placed together into their respective competition pairs during the FR 40 schedule competition phase, rat G3's number of lever presses dropped sharply following the initial 9 competition sessions and continued to decline in the remaining sessions of this phase. Its opponent R3 maintained its relatively high number of lever presses in these same sessions (see Fig. 12). Rat R3 thus increased its dominance in terms of this measure for the remaining sessions of the FR 40 schedule competition phase.

Similarly in competition pair G4 and R4, rat R4's number of lever presses dropped to a low level following the initial 6 competition sessions and continued to decline in the remaining sessions of this phase. Rat R4's opponent G4 maintained its relatively high number of lever presses in these same sessions (see Fig. 13). Rat G4 thus became more dominant in terms of this measure for the remaining sessions of the FR 40 schedule competition phase.

In the subsequent sessions under the individual FR 40 schedule baseline condition, the relative lever press rates of each animal
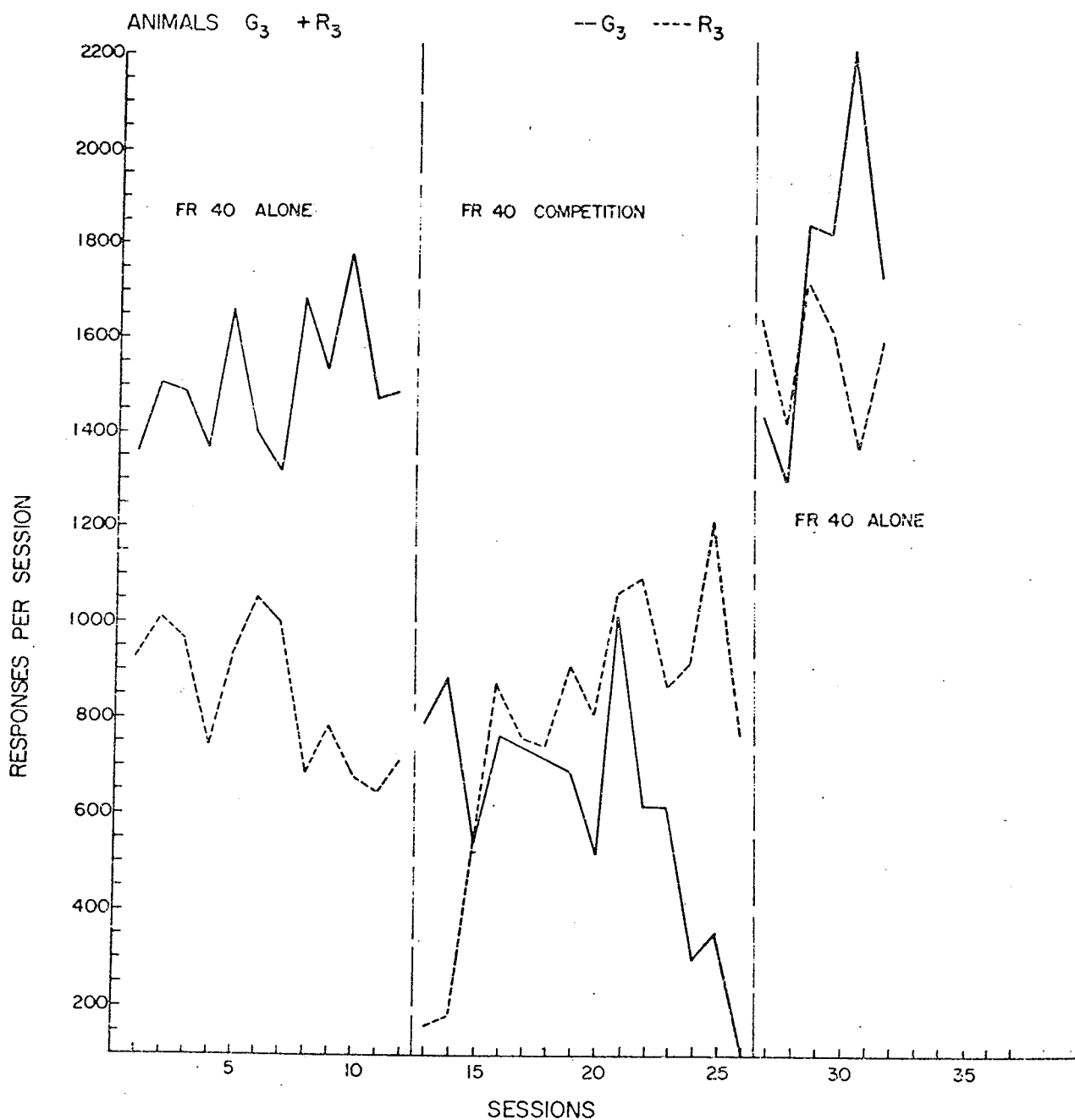
Fig. 12. Number of lever press responses emitted each session by each animal in competition pair G3 and R3 during individual sessions and competition sessions on an FR 40 schedule.
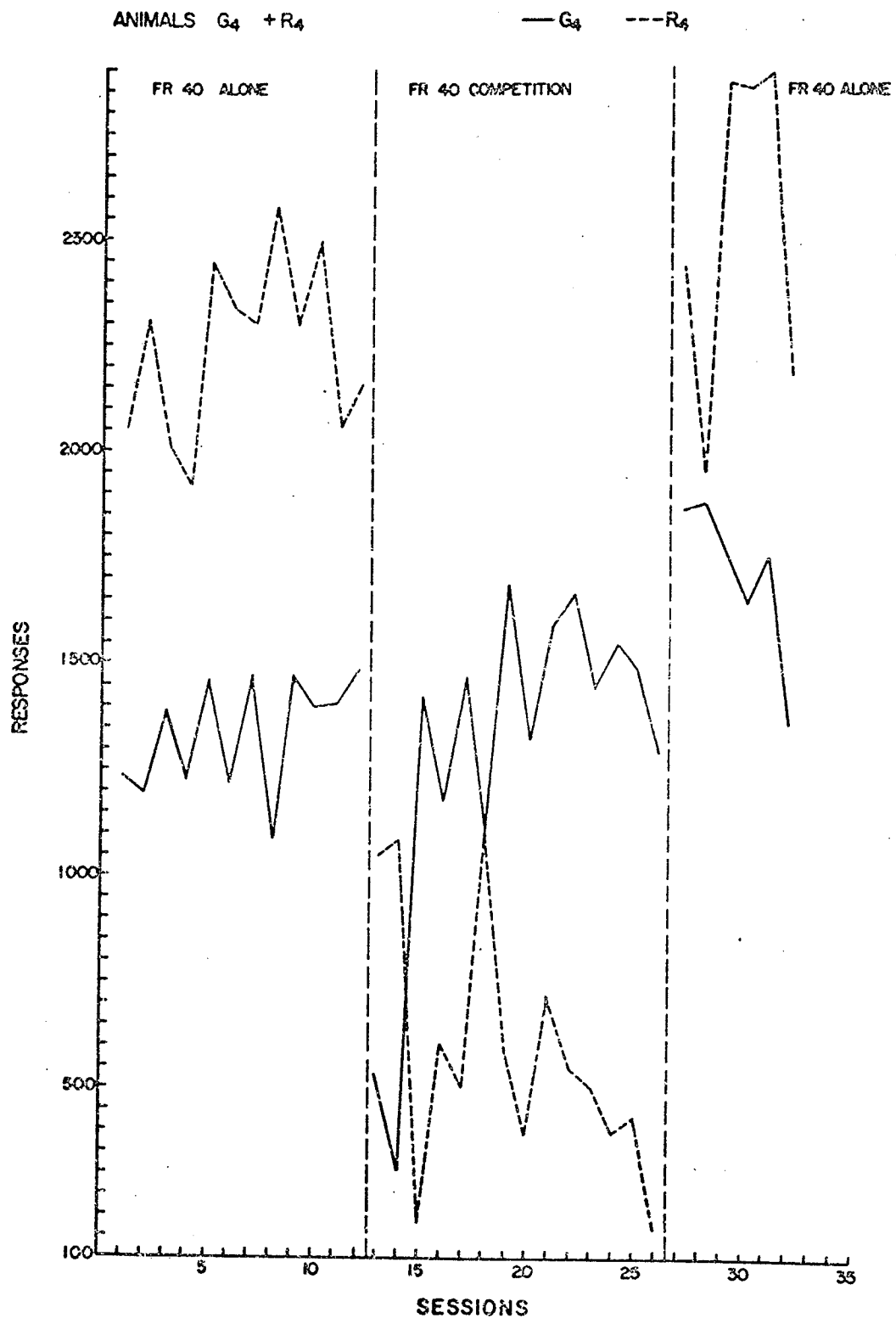
Fig. 13. Number of lever press responses emitted each session by each animal in competition pair G4 and R4 during individual- and competition sessions on an FR 40 schedule.

in each competition pair returned to that observed under the initial
baseline condition. Rat G3's lever press rate was again higher than
that of R3 and rat R4's lever press rate higher than that of G4. How-
ever, the lever press rates were slightly higher for all animals dur-
ing the return to baseline phase relative to the lever press rates
observed under the initial baseline condition, particularly for anim-
als R3 and G4, animals which had the lower lever press rates under
the initial baseline condition.

Typical cumulative recordings of lever press behavior reveal
that both animals in competition pair G3 and R3 exhibited strong FR
behavior during the individual FR 40 baseline phase (see Fig. 14).
Cumulative records of lever press behavior during the FR 40 compet-
ition phase reveal that the dominant animal R3 had increased its
lever press rate and had retained its strong FR behavior, while the
subordinate animal G3 exhibited a low lever press rate and weak FR
behavior (see Fig. 15). Similarly, cumulative recordings of lever
press behavior of each animal in competition pair G4 and R4 reveal
that both animals exhibited strong FR behavior during the individ-
ual FR 40 baseline phase (see Fig. 16). Cumulative recordings of
lever press behavior during the FR 40 competition phase reveal that
the dominant animal G4 maintained its high lever press rate and
strong FR behavior while its opponent R4 exhibited weak FR behavior
and a low lever press rate (see Fig. 17).

Percentage of time spent in the aperture. Observations of the
percentage of time spent in the aperture reveal that animal G3 in
competition pair G3 and R3 and animal R4 in competition pair G4 and R4

G3 FR 40 ALONE

Fig. 14. Typical cumulative recordings of lever press behavior by animals R3 and G3 during individual sessions on an FR 40 schedule.

R3   FR 40 COMP.

G3   FR 40 COMP.

Fig. 15. Typical cumulative recordings of lever press behavior by animals R3 and G3 during competition sessions on an FR 40 schedule.
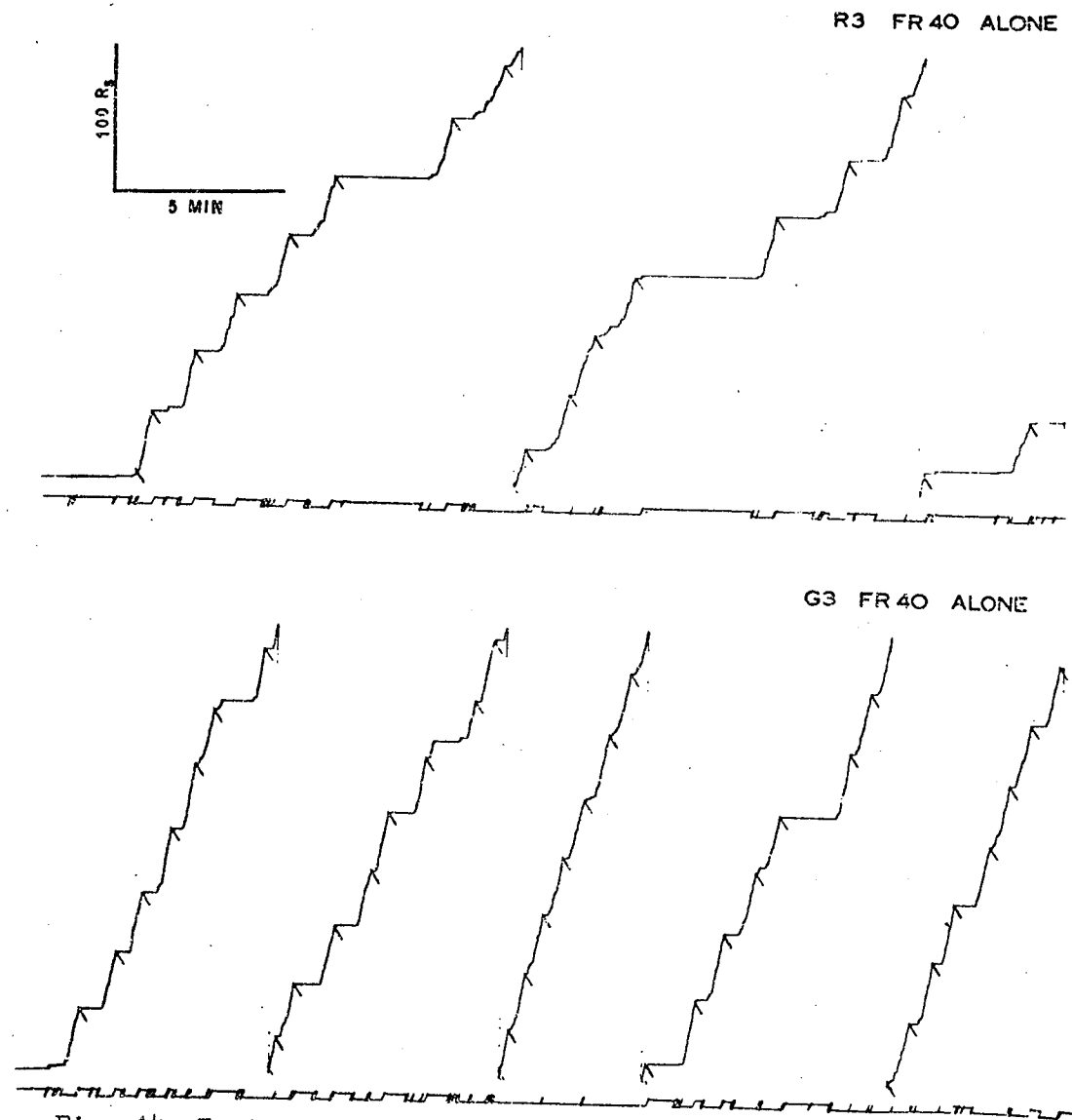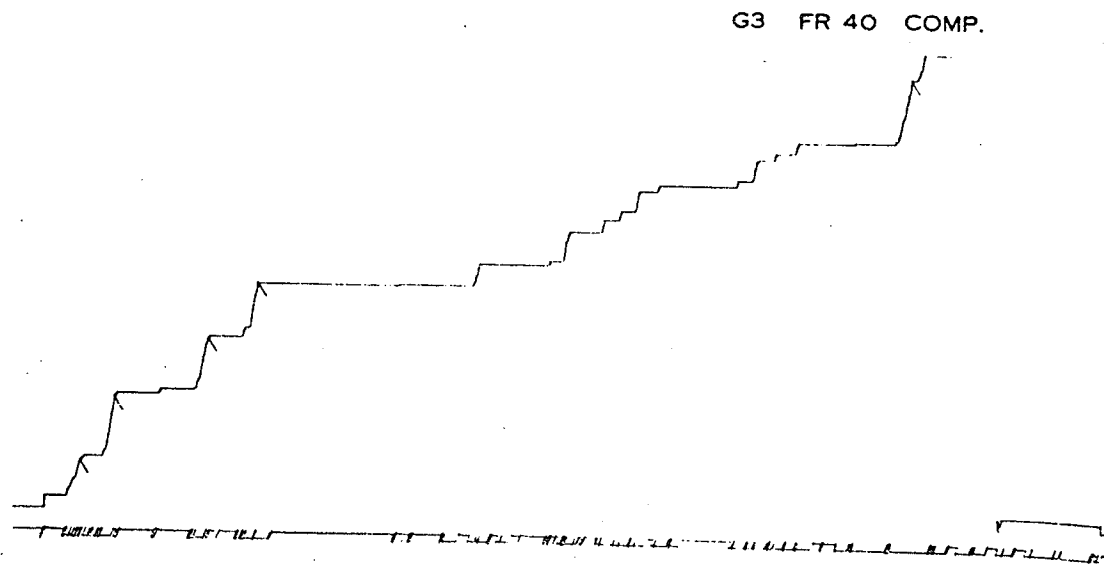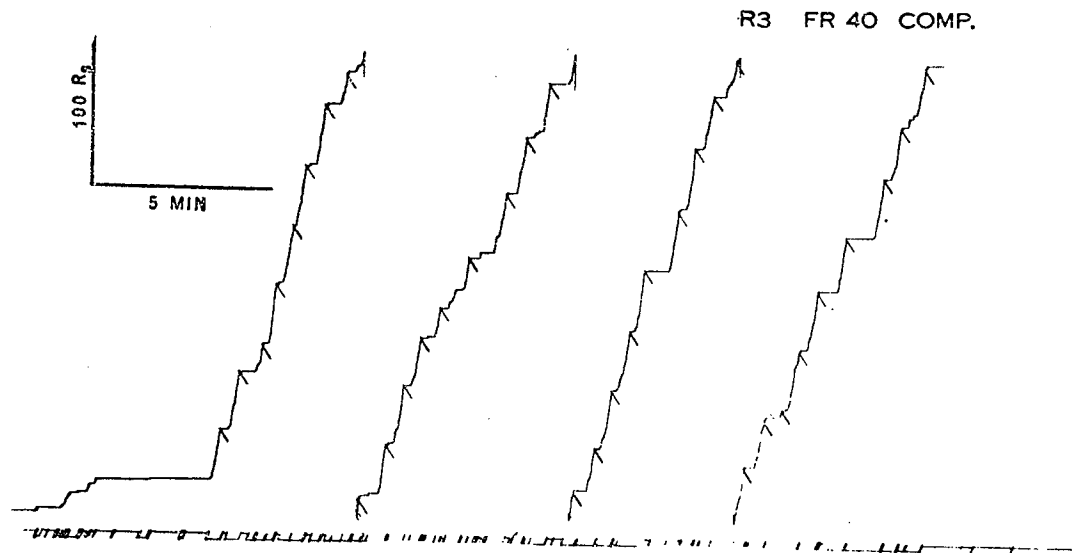
80.
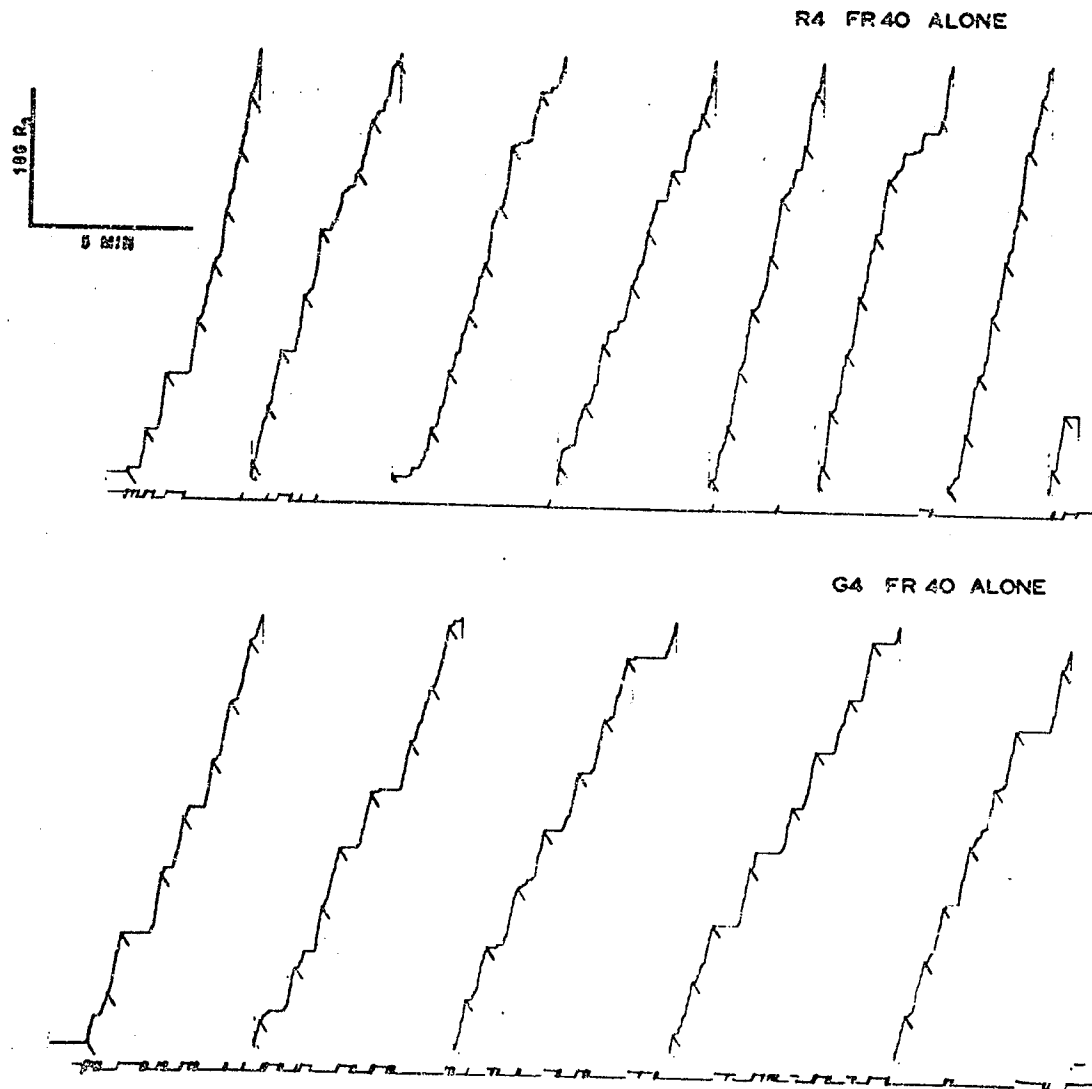
Fig. 16. Typical cumulative recordings of lever press behavior by animals R4 and G4 during individual sessions on an FR 40 schedule.
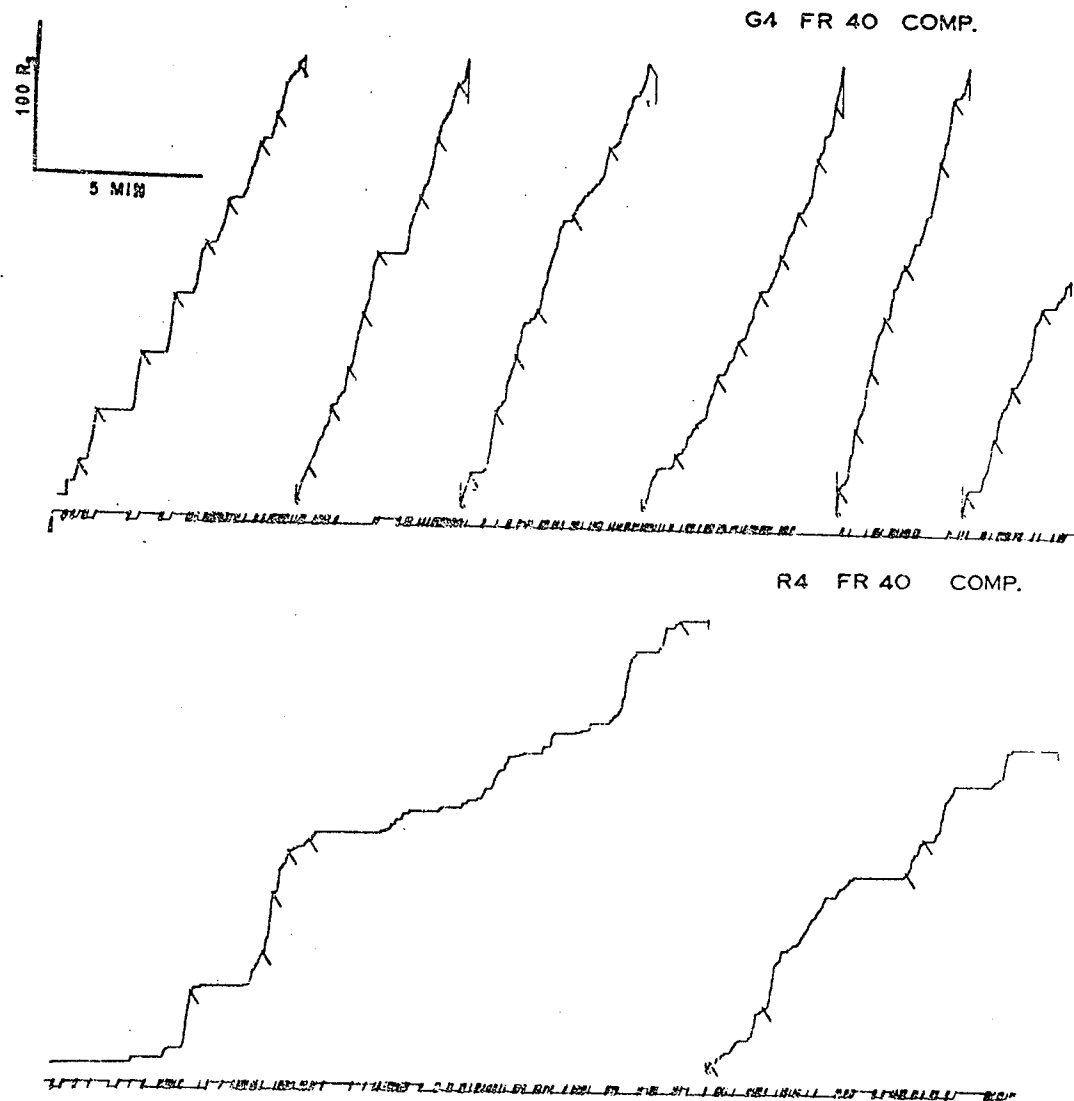
Fig. 17. Typical cumulative recordings of lever press behavior by animals G4 and R4 during competition sessions on an FR 40 schedule.

spent a larger percentage of the available session time in the apert-
ure than the animals assigned to be their opponents during the indiv-
idual FR 40 baseline phase (see Fig. 18). When the animals were sub-
sequently placed together in their respective competition pairs dur-
ing the FR 40 competition phase, rat G3 in competition pair G3 and R3
and rat R4 in competition pair G4 and R4 became dominant in terms of
this measure following the first two sessions under this phase of the
experiment. This degree of dominance-subordination behavior contin-
ued to increase in competition pair G4 and R4 following these ses-
sions and continued to increase in competition pair G3 and R3 fol-
lowing session 21 for the remaining sessions under this phase of the
experiment. In returning to the individual FR 40 baseline condition,
the percentage of time spent in the aperture by each animal in each
competition pair was somewhat greater than that observed during the
initial baseline phase, but the same relationship in terms of G3 and
R4 spending the larger percentage of time in the aperture was present.

Reinforcements obtained per session. During the individual FR
40 baseline condition, rat G3 in competition pair G3 and R3 and rat
R4 in competition pair G4 and R4 obtained the larger number of rein-
forcements per session (see Fig. 19). During the FR 40 competition
phase, rat R3 in competition pair G3 and R3 became dominant follow-
ing the initial 4 sessions under this condition. Rat G4 in competit-
ion pair G4 and R4 became dominant in terms of this measure follow-
ing the initial 2 sessions of this phase. This degree of dominance-
subordination behavior continued to increase in competition pair
G3 and R3 following session 21 while competition pair G4 and R4
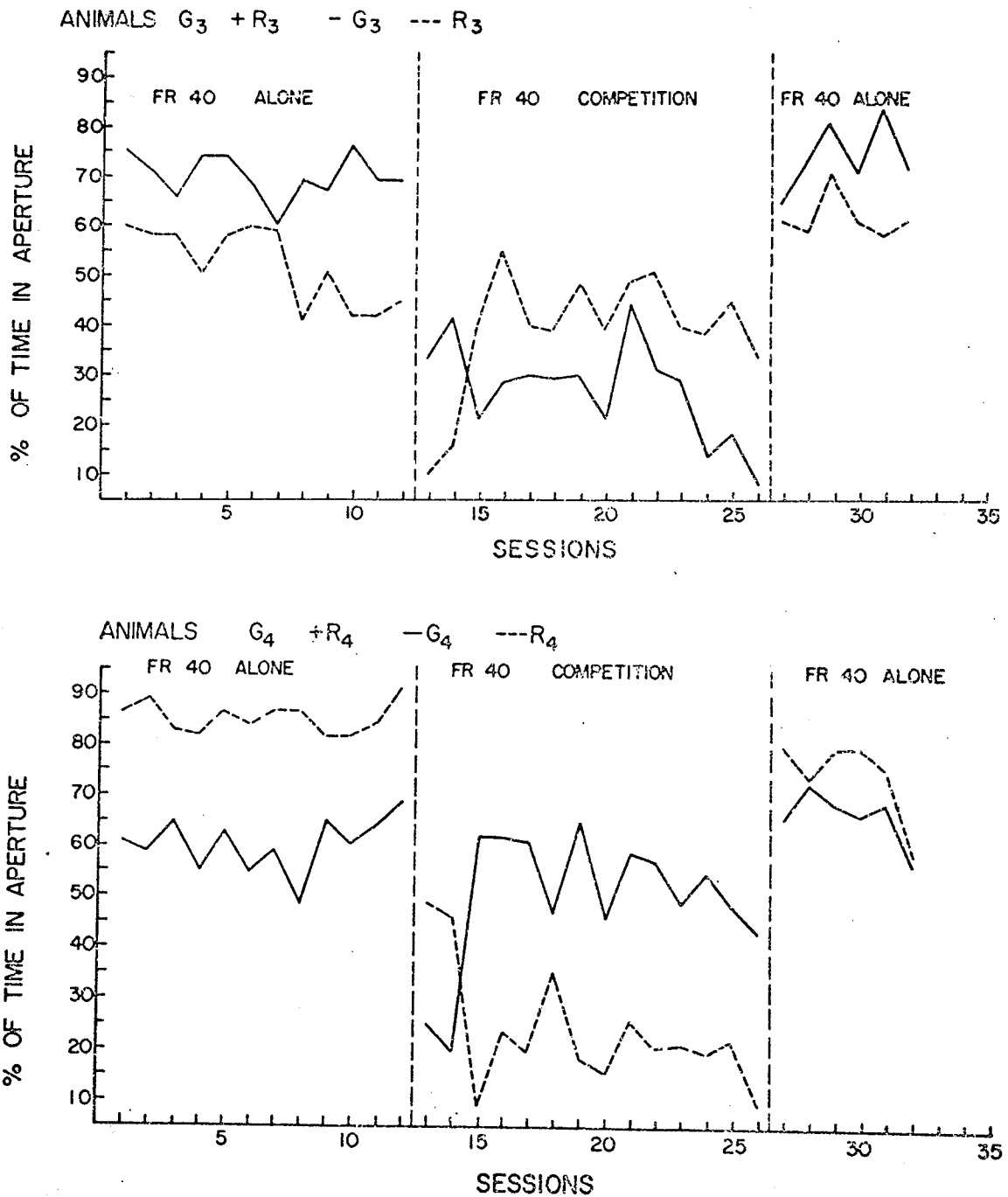
Fig. 18. Percentage of the total session time spent controlling the aperture by each animal in competition pairs G3 and R3; G4 and R4, during individual- and competition sessions on an FR 40 schedule.
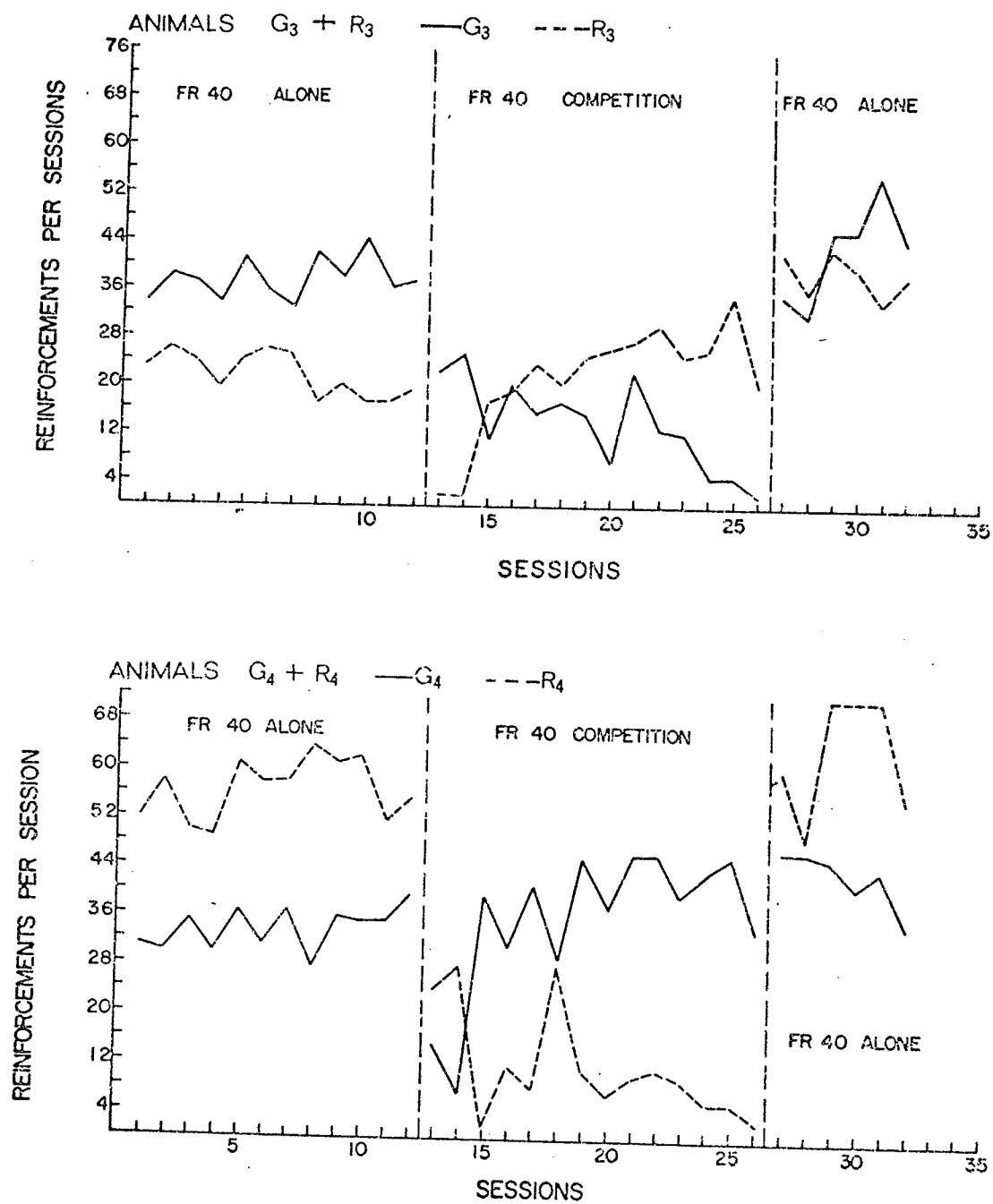
Fig. 19. Number of reinforcements obtained each session by each animal in competition pairs G3 and R3; G4 and R4, during individual- and competition sessions on an FR 40 schedule.

continued to increase in terms of this behavior following session 18

for the remaining sessions of the FR 40 schedule competition phase.

In returning to the individual FR 40 baseline condition, the number

of reinforcements obtained each session was somewhat greater than

that observed during the initial baseline phase, particularly in

competition pair G3 and R3, but the same relationship in terms of G3

and R4 obtaining the larger number of reinforcements was present.

Number of submissive postures. An animal was defined as domin-

ant in terms of this measure if it exhibited fewer submissive post-

ures than its opponent. During the FR 40 competition phase, rat G3

in competition pair G3 and R3 exhibited fewer submissive postures

in all sessions except sessions 17 and 26 (see Fig. 20). Rat G3 was

thus dominant in all but two competition sessions. Similarly, rat R4

in competition pair G4 and R4 exhibited fewer submissive postures in

all sessions except sessions 23, 24, and 26, and R4 was thus dominant

in the majority of the competition sessions in terms of this measure.

The submissive postures measure thus fails to agree with the

other three measures of the degree of dominance-subordination behav-

ior. Rat G3 in competition pair G3 and R3 was subordinate in terms

of the lever press, time in the aperture, and reinforcements obtained

measures, but was dominant in terms of the submissive postures meas-

ure. Similarly, rat G4 in competition pair G4 and R4 was dominant

in terms of all measures except the submissive postures measure, rat

R4 being dominant in terms of this latter measure.

Number of boli. An additional datum observed and recorded due

to its regularity was the number of boli dropped during each session

ANIMALS $G_3 + R_3$ ———G_3 ----R_3

FR 40 COMPETITION

ANIMALS $G_4 + R_4$ ———G_4 ----R_4
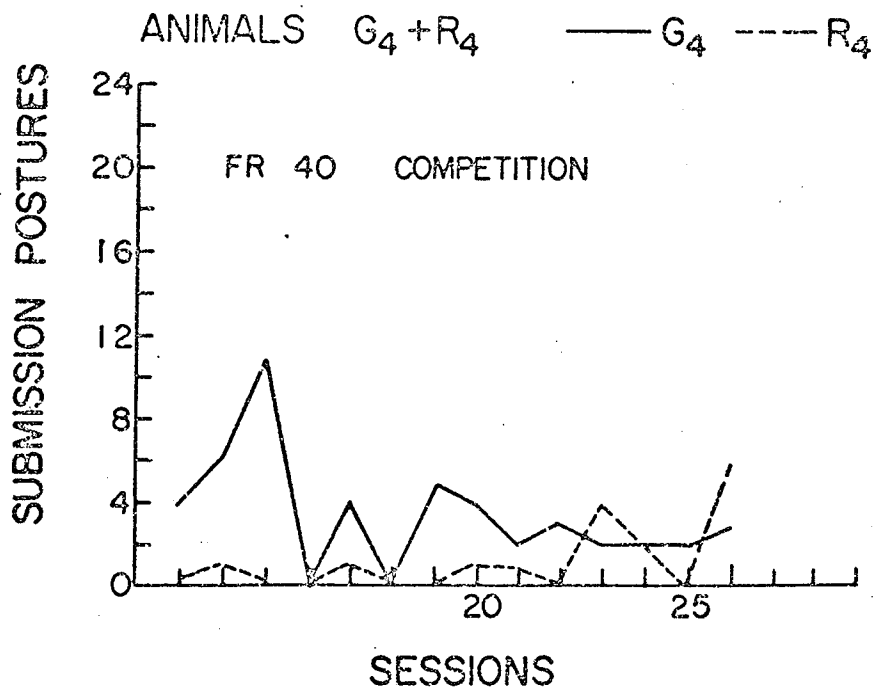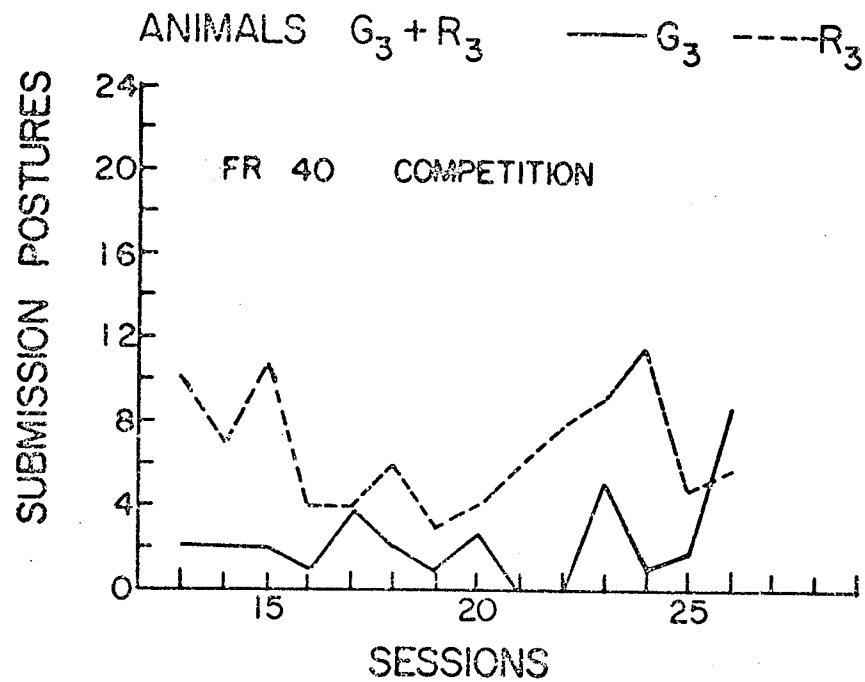
FR 40 COMPETITION

Fig. 20. Number of submission postures exhibited by each animal in competition pairs G3 and R3; G4 and R4, competing on an FR 40 schedule.

by each animal in each competition pair during all phases of the experiment. One interesting aspect of this data is that in both competition pairs, no boli were dropped by either animal in a competition pair during any of the sessions under the FR 40 competition phase. This data could possibly be relevant to dominance-subordination behavior in that in each of the competition pairs, the animals that dropped the greatest number of boli during the individual FR 40 baseline sessions were also the animals which were found to be dominant in terms of the same three out of four measures of dominance-subordination behavior employed in this experiment. They were also both found to be subordinate in terms of the fourth measure, that is, the submissive postures measure. Thus, rat R3 in competition pair G3 and R3 dropped boli in 5 out of the 12 sessions under the initial baseline condition and it also dropped boli in 5 out of the 6 sessions under the post-competition baseline condition (see Fig. 21). Its assigned opponent G3 dropped boli in only 1 session in each of the two baseline phases.

Similarly, rat G4 in competition pair G4 and R4 dropped boli in all 12 sessions under the initial baseline condition and it also dropped boli in all 6 sessions under the post-competition baseline phase (see Fig. 21). No boli were dropped by its assigned opponent R4 during these same baseline sessions.

Additional observations. Observations of competition sessions under the FR 40 competition phase revealed that in the initial 3 sessions, alternations at the aperture described in Experiment I were relatively infrequent. The animals in each of the two competition
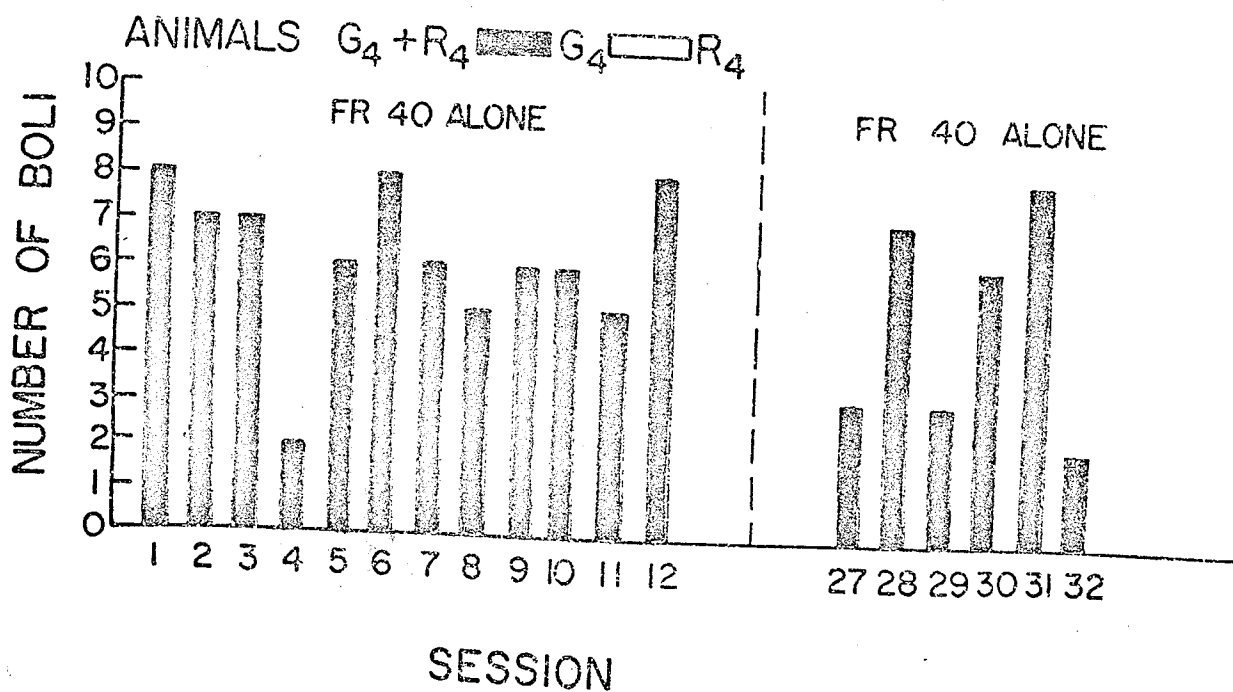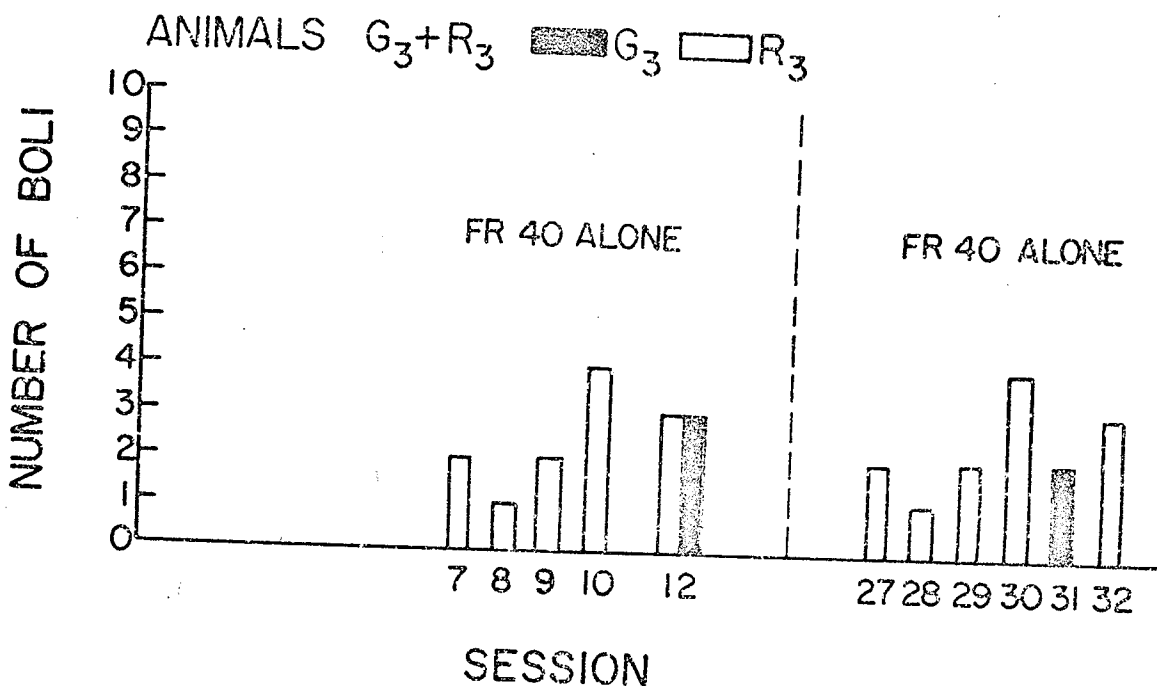
Fig. 21. Number of boli dropped each session by each animal in competition pairs G3 and R3; G4 and R4, during individual- and competition sessions on an FR 40 schedule.

pairs moved slowly and "cautiously", seeming to hesitate entering the aperture and turning their backs on their opponents. As the sessions progressed, this caution decreased and the rate of alternation at the aperture increased in frequency. This alternation remained frequent for all but the last two competition sessions in which the rate of alternation decreased somewhat, but nevertheless remained high relative to the alternation behavior observed in the initial 3 sessions.

IV. Discussion

Since the number of lever presses, the percentage of the available session time spent in the aperture, and the number of reinforcements obtained each session were all related measures, observations across these measures were all consistent for each animal in each competition pair during the sessions under the initial baseline condition. The observations across these three measures were also consistent during the sessions under the post-competition baseline condition. Eventhough all animals had increased somewhat in terms of these measures in the return to baseline condition, the relative position of each animal in each competition pair remained approximately the same as that observed under the initial baseline condition.

During the sessions under the FR 40 competition phase, the number of lever presses emitted, the time in the aperture, and the number of reinforcements obtained measures all portrayed approximately the same degree of dominance-subordination behavior and the same dominance-subordination relationship within each of the two competition pairs. Rat R3 in competition pair G3 and R3 was thus dominant

to approximately the same degree in terms of these three measures.
Similarly, these three measures all defined rat G4 in competition
pair G4 and R4 as dominant to approximately the same degree. Although
this degree of dominance-subordination behavior was somewhat greater
in competition pair G4 and R4 relative to the dominance-subordination
behavior observed in pair G3 and R3, this difference was quantitative
rather than qualitative.

The reverse dominance-subordination relationship relative to
that observed in terms of the above three measures was observed in
each of the two competition pairs in terms of the submissive postures
measure. Rather than being dominant, R3 in competition pair G3 and R3
and G4 in pair G4 and R4 were subordinate.

The data generated by the dominant and subordinate animals in
each competition pair was thus consistent across all measures of dom-
inance-subordination behavior employed in this experiment. In addit-
ion, the number of boli dropped by each animal in each competition
pair was consistent in terms of the dominance or subordination of
this animal. In each of the two competition pairs, the dominant an-
imal dropped the larger number of boli during the individual FR 40
baseline sessions.

V. Conclusion

The following conclusions may be drawn from the data of this
experiment:

1. Following an initial number of competition sessions on an
FR 40 schedule, the degree of dominance-subordination behavior

exhibited by pairs of rats competing to lever press for food increases sharply and becomes maximal in subsequent sessions on the FR 40 schedule (in terms of lever press rate, time in the aperture, or reinforcements obtained). This increase in the degree of dominance-subordination behavior is due to the increasing subordination behavior by the subordinate animal in a competition pair. The number of competition sessions required before this increase occurs varies between competition pairs.

2. The measure of aggressive interactions, the number of submissive postures exhibited by each animal in a competition pair, seems to be negatively related to the other measures of the degree of dominance-subordination behavior employed in this experiment. This may suggest that social dominance is not a unitary phenomenon, but that the dominance of an animal varies according to the measure employed to ascertain this dominance.

3. When two subjects are placed in competition together, the one with the higher response rate in isolation will not necessarily be dominant (in terms of response rate, reinforcements obtained, or time in the aperture). In fact the opposite would seem to be the case for FR schedules.

4. A return to the FR 40 schedule in isolation baseline following FR 40 competition seems to produce a slightly higher lever press rate relative to that observed under the initial baseline for all animals, but in each competition pair, the lever press rate of each animal relative to that of its opponent returns to that observed under the initial baseline condition.

5. The strong and characteristic FR lever press behavior

exhibited by each animal in isolation on an FR 40 schedule is maintained by the dominant animal in each competition pair during FR 40 competition sessions, but is not maintained by the subordinate animal.

6. Animals which regularly drop fecal boli during the individual FR 40 baseline sessions drop no boli during the FR 40 competition sessions. This may suggest that the competition situation contains stimulus components which inhibit defecation. This defecation measure may also be relevant as a predictor of dominance-subordination behavior in that in each competition pair of this experiment, the animal which dropped the greatest number of boli during the individual FR 40 baseline sessions was also the dominant animal (in terms of response rate, time in the aperture, or reinforcements obtained).

CHAPTER V

EXPERIMENT III

I. Introduction

The object of this experiment was to observe changes in the
degree of dominance-subordination behavior exhibited by pairs of rats
as the schedule demands under which each pair competed to lever press
for food was gradually changed from CRF to FI 50 seconds by increments
of 5 second FI steps per session.

II. Procedure

Four rats served as Ss, forming two competition pairs (G5 & R5,
G6 & R6). The training and testing sequence began with 13 individual
15 minute sessions of lever training on CRF. Animals were then placed
in competition pairs and competed to lever press for food on CRF,
this phase constituting the baseline condition. All subsequent ses-
sions were of 30 minutes duration. Each pair received 11 competition
sessions under the baseline condition. The schedule under which each
pair was competing was then changed from CRF to an increasing FI
schedule, beginning with FI 5 seconds and increasing by 5 second FI
steps each succeeding session until the terminal schedule of FI 50
seconds was reached. Each pair then competed on FI 50 seconds for
17 sessions. Finally, in a return to the baseline condition, each
pair competed for 6 sessions on CRF.

The four dependent measures of the degree of dominance-

subordination behavior employed in Experiment I and II were again employed in the present study. Similarly, the definitions of dominance or subordination behavior employed in this experiment were the same as those used in Experiment I and II.

III. Results

Number of lever press responses. During the CRF schedule baseline competition sessions, rat R5 in competition pair G5 and R5 and rat R6 in competition pair G6 and R6 were dominant in terms of emitting the larger number of lever press responses. This small degree of dominance-subordination behavior was approximately constant throughout the sessions under the initial baseline condition in each of the two competition pairs (see Figs. 22 & 23). With the schedule changing from CRF to an increasing FI schedule, both animals in competition pair G5 and R5 increased their lever press rates. However, R5 increased its lever press rate to a greater degree during the sessions under the increasing FI schedules phase relative to that of its opponent G5, and thus the degree of dominance-subordination behavior increased in this competition pair (see Fig. 22).

Similarly, both animals in competition pair G6 and R6 increased their lever press rates during the increasing FI schedules phase. The dominance-subordination relationship reversed in this competition pair with rat G6 increasing its lever press rate to a greater degree relative to that of its opponent R6. Consequently, with the exception of session 12 under the FI 5 seconds schedule, G6 became dominant in terms of this measure for the remaining sessions under
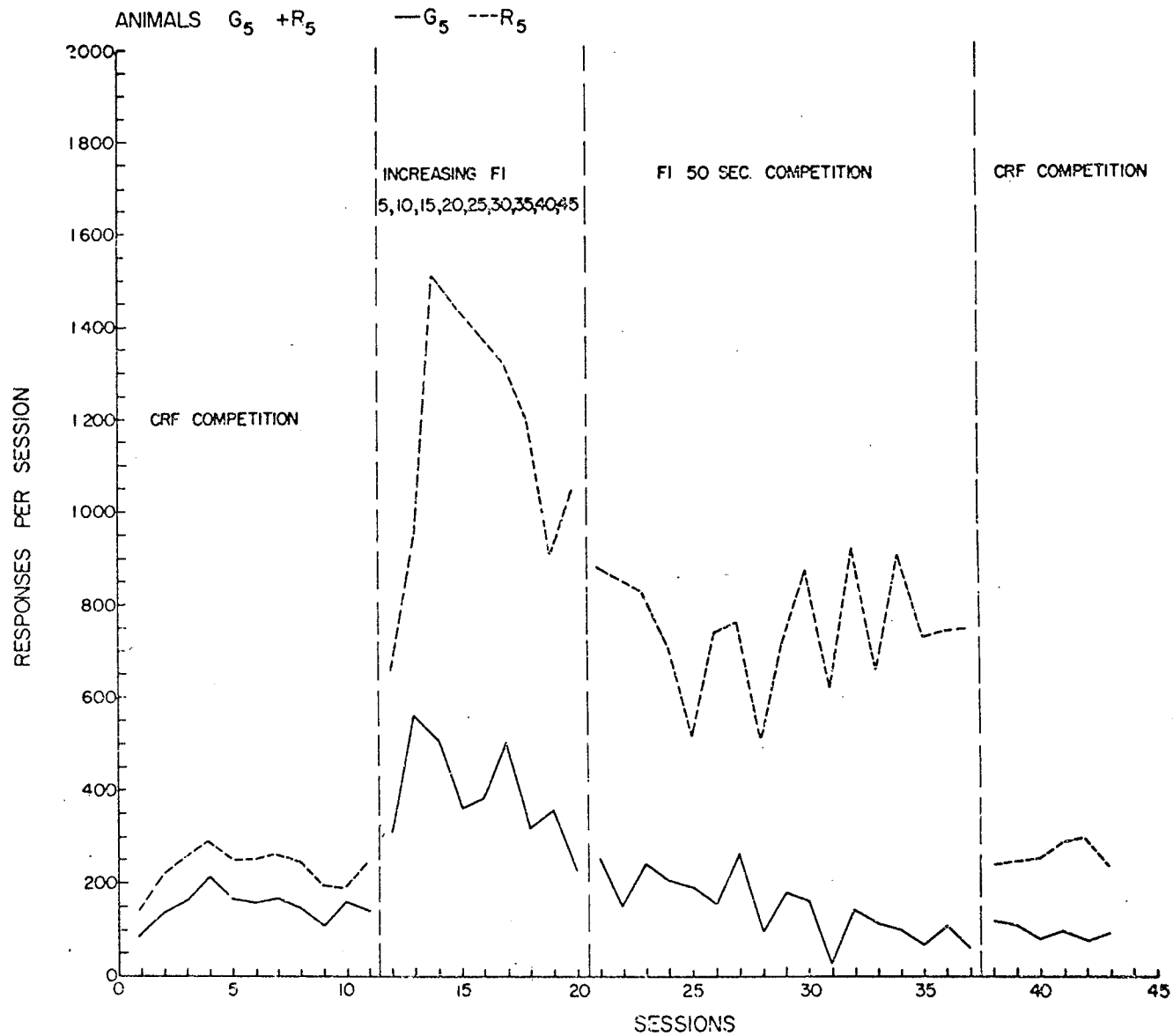
Fig. 22. Number of lever press responses emitted each session by each animal in competition pair G5 and R5, competing on CRF, increasing FI, and FI 50 sec. schedules.
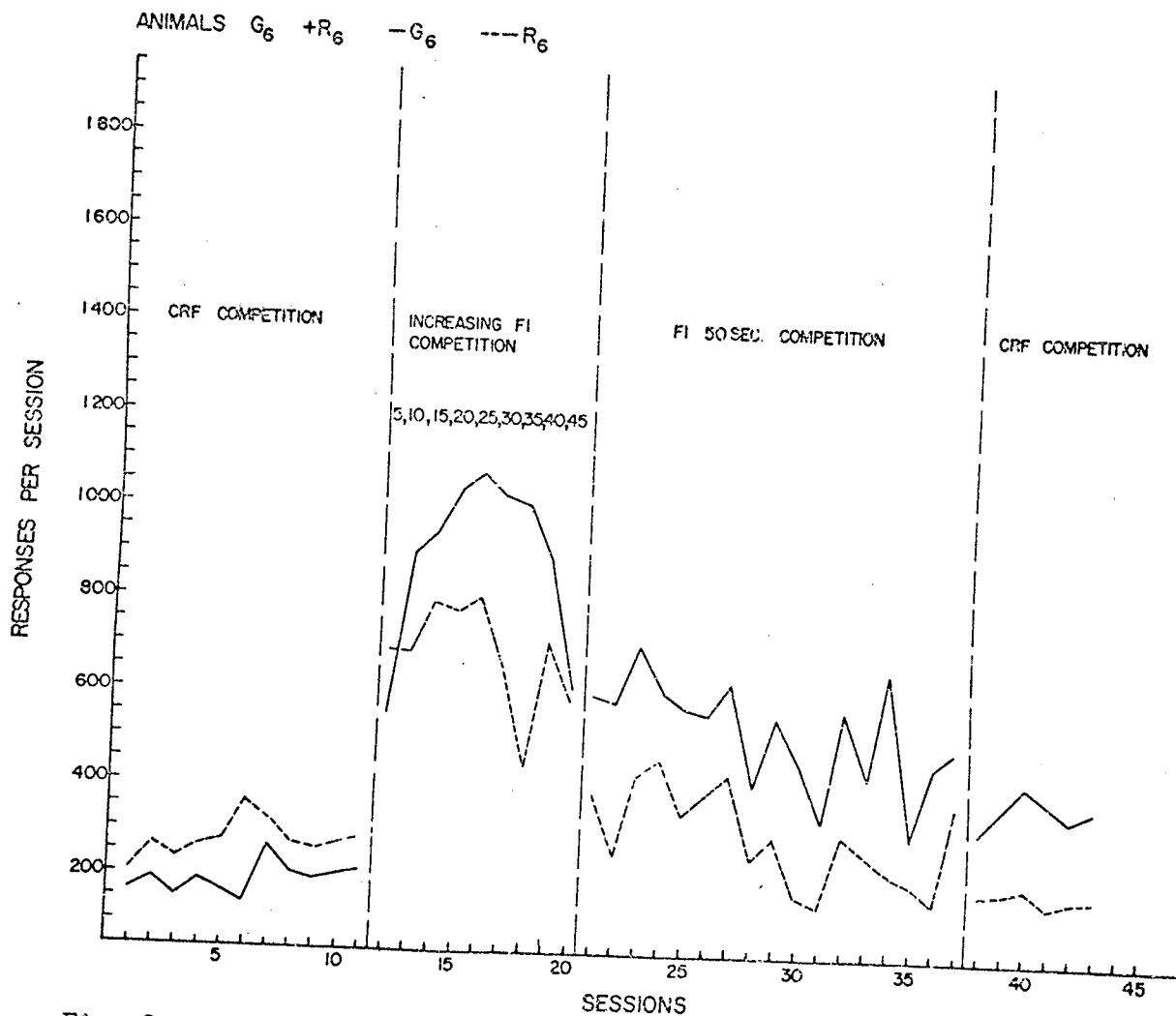
Fig. 23. Number of lever press responses emitted each session by each animal in competition pair G6 and R6, competing on CRF, increasing FI, and FI 50 sec. schedules.

the increasing FI schedules phase, the degree of dominance-subordination behavior exhibited in this competition pair becoming very small in the last session in this phase of the experiment (see Fig. 23).

In the subsequent 17 sessions under the terminal FI 50 seconds schedule, rat R5 in competition pair G5 and R5 remained dominant. The degree of dominance-subordination behavior in this pair decreased somewhat in the initial 8 sessions, but increased again slowly in the remaining sessions under the terminal FI 50 seconds schedule. Similarly, rat G6 in competition pair G6 and R6 remained dominant in this phase of the experiment, and the degree of dominance-subordination behavior remained approximately constant throughout the sessions under this condition in this competition pair.

Finally, in a return to the CRF schedule baseline condition, the degree of dominance-subordination behavior and the dominance-subordination relationship exhibited by competition pair G5 and R5 were similar to those observed during the initial baseline condition. In pair G6 and R6, however, the dominance-subordination relationship was the reverse of that observed under the initial baseline condition. Rat R6 failed to regain the dominance it had shown under the initial baseline condition. Typical cumulative recordings of lever press behavior under the terminal FI 50 seconds schedule (see Figs. 24 & 25) reveal that rat R5 in competition pair G5 and R5 and rat G6 in competition pair G6 and R6 exhibited higher lever press rates relative to the low lever press rates of their opponents.

Percentage of time in the aperture. Animal R5 in competition
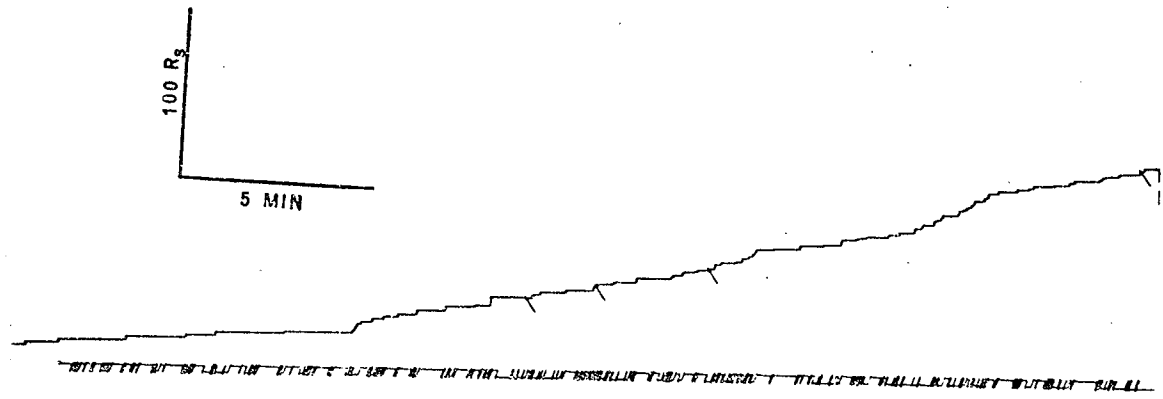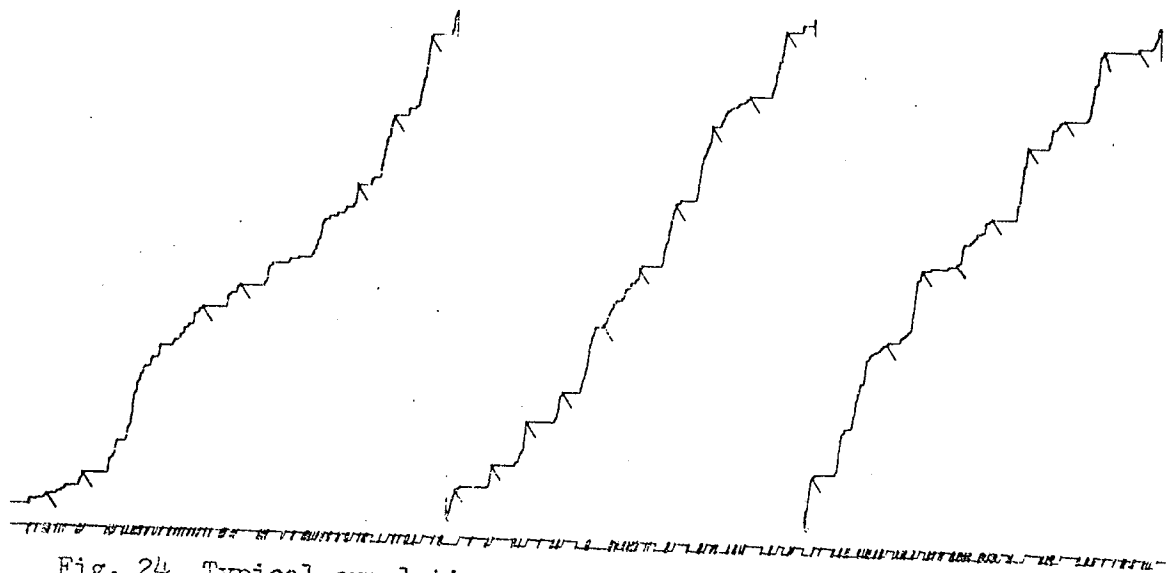
Fig. 24. Typical cumulative recordings of lever press behavior by animals G5 and R5 during competition sessions on an FI 50 sec. schedule.
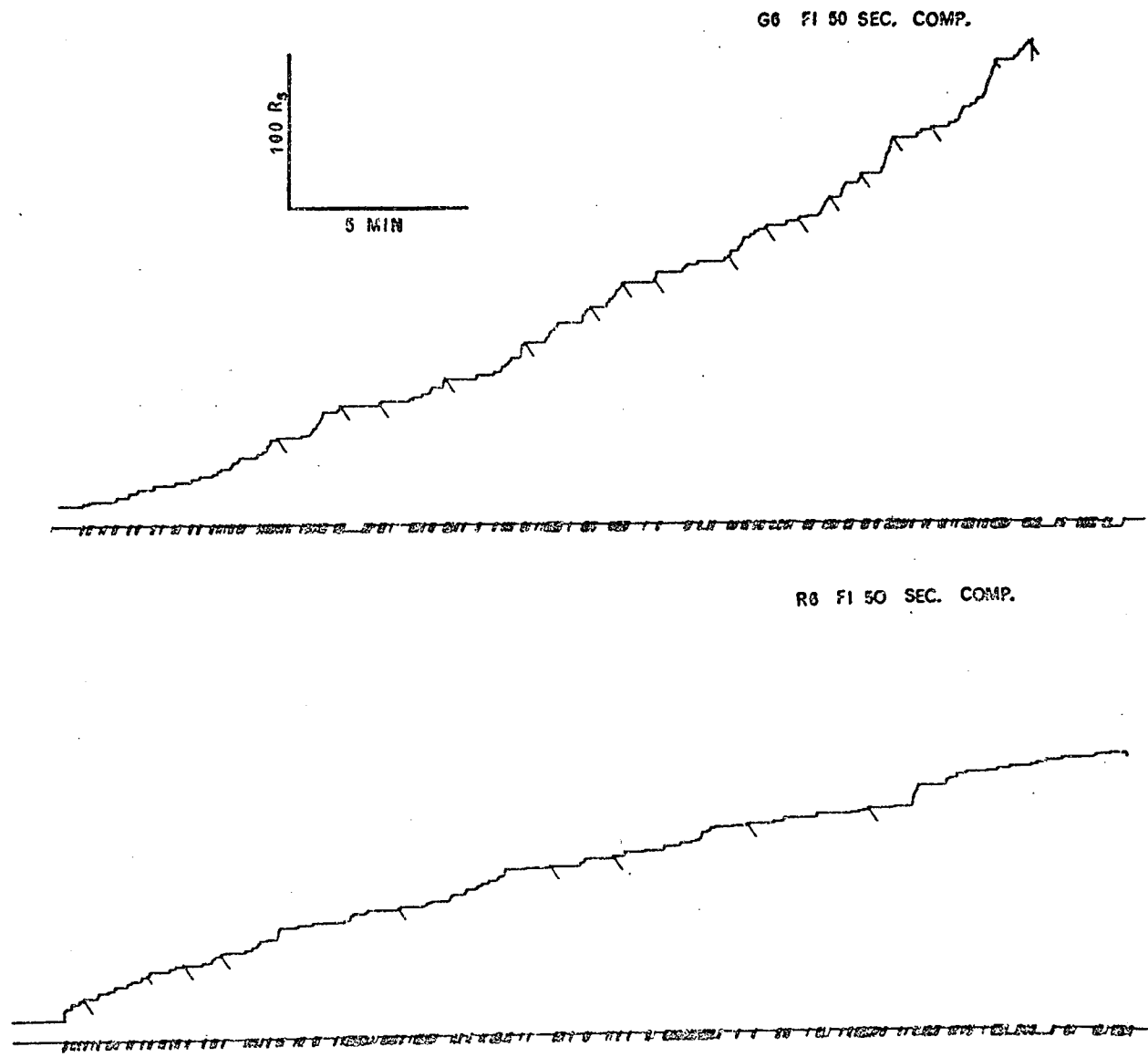
Fig. 25. Typical cumulative recordings of lever press behavior by animals G6 and R6 during competition sessions on an FI 50 sec. schedule.

pair G5 and R5 was consistently dominant in terms of this measure in all phases of the experiment. The degree of dominance-subordination behavior in this competition pair was relatively constant in all phases except in the return to baseline condition, in which this behavior was greater relative to that observed under the initial baseline condition (see Fig. 26). Rat R6 in competition pair G6 and R6 was marginally dominant during the sessions in the initial CRF baseline condition (see Fig. 26). During the increasing FI schedules competition sessions, G6 became marginally dominant, while in the FI 50 seconds competition sessions no clear degree of dominance-subordination behavior emerged in this competition pair. Only in the sessions on the return to baseline condition did a clear but small degree of dominance-subordination behavior emerge, with G6 becoming dominant in terms of this measure.

Reinforcements obtained per session. During the increasing FI schedules competition sessions, rat R5 in competition pair G5 and R5 was dominant in terms of this measure in all sessions under this condition. It should be noted that the number of reinforcements each animal could obtain in competition each session under the increasing FI schedules decreased rapidly as a function of the increasing fixed interval during which reinforcement was not available. This degree of dominance-subordination behavior increased as the sessions under this condition progressed (see Fig. 27). Rat R5 maintained its dominance in all sessions under the FI 50 seconds schedule phase and the degree of dominance-subordination behavior exhibited in this competition pair was approximately constant throughout these sessions.
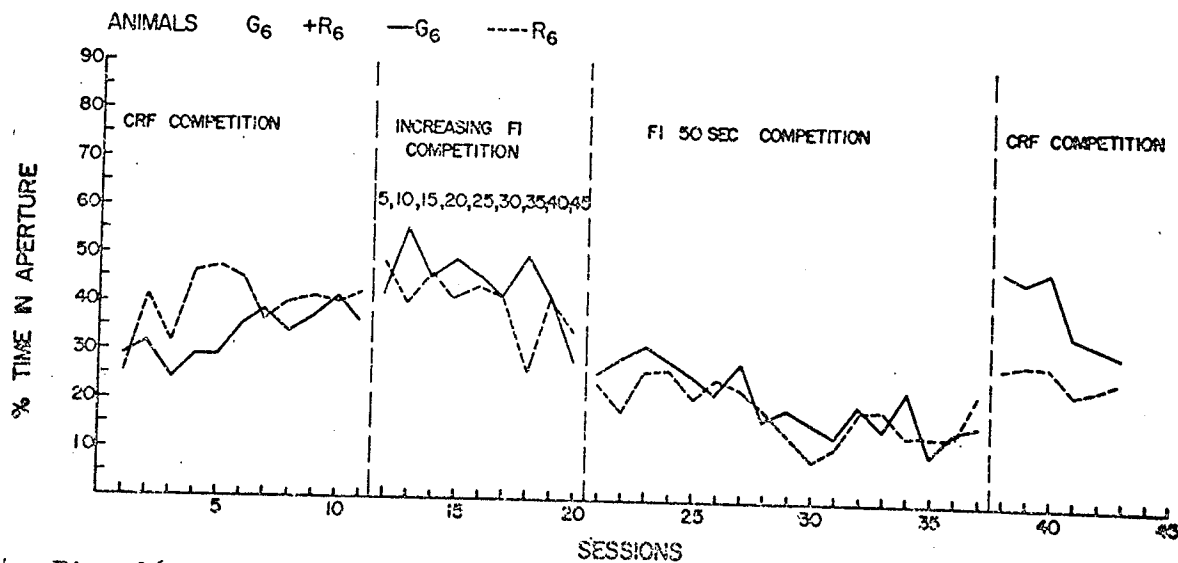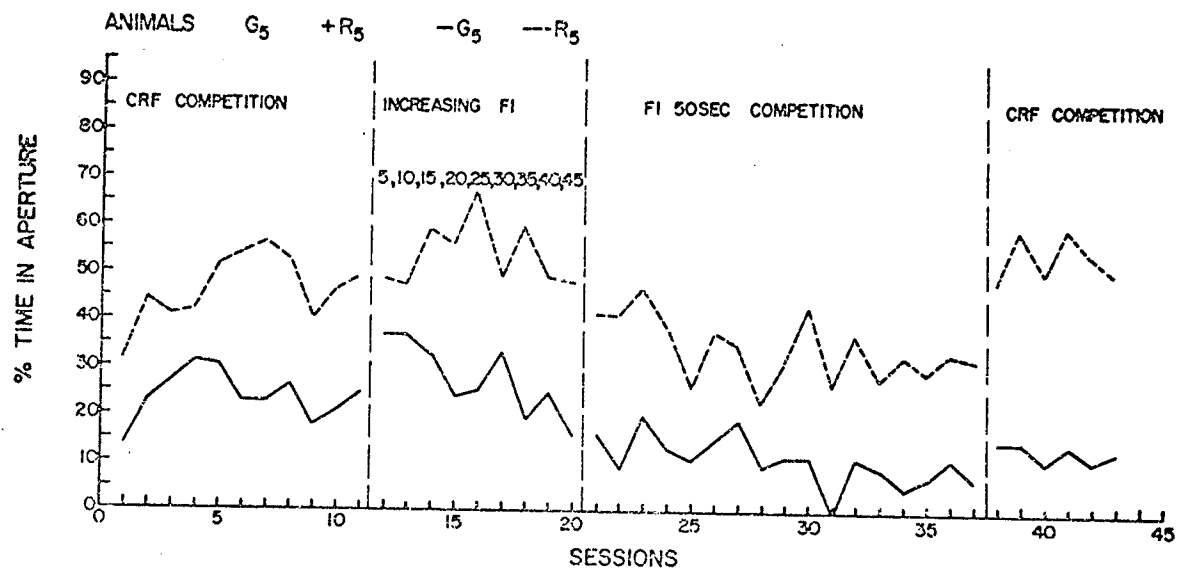
Fig. 26. Percentage of the total session time spent controlling the aperture by each animal in competition pairs G5 and R5; G6 and R6, competing under CRF, increasing FI, and FI 50 sec. schedules.
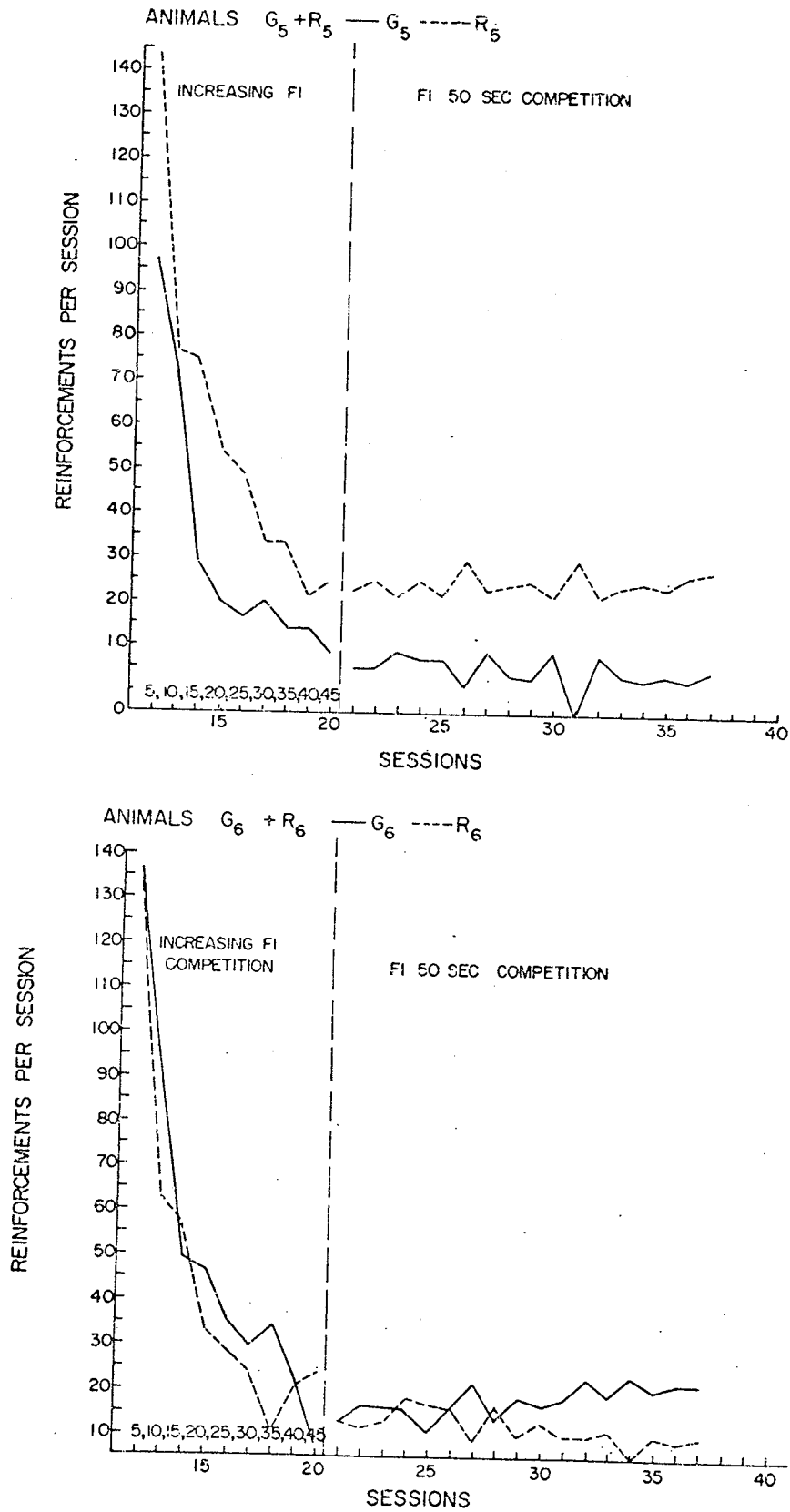
Fig. 27. Number of reinforcements obtained each session by each animal in competition pairs G5 and R5; G6 and R6, during sessions on an increasing FI schedule and on an FI 50 sec. schedule.

Rat G6 in competition pair G6 and R6 became dominant in terms of this measure in session 15 under the FI 20 seconds schedule of the increasing FI schedules phase, and it continued to be dominant until session 19 under the FI 40 seconds schedule (see Fig. 27). In session 20 under the FI 45 seconds schedule, the dominance-subordination relationship changed in that rat R6 became dominant. In the subsequent sessions under the terminal FI 50 seconds schedule, no clear degree of dominance-subordination behavior emerged until session 29, the session in which rat G6 became dominant. The degree of dominance-subordination behavior observed in this competition pair slowly increased, but continued to remain small in the remaining sessions under this condition.

Number of submissive postures. No clear degree of dominance-subordination behavior was observed in terms of the number of submissive postures exhibited by each animal in either of the two competition pairs during the sessions under the initial baseline condition (see Fig. 28). In competition pair G5 and R5, no clear degree of this behavior emerged in the increasing FI schedules phase as well. In competition pair G6 and R6, rat R6 became dominant in terms of exhibiting the smaller number of submissive postures in session 17 under the FI 30 seconds schedule. It maintained this dominance during the remaining sessions under the increasing FI schedules phase.

During the terminal FI 50 seconds phase, the number of submissive postures observed in each competition pair increased as the sessions under this condition progressed. Rat G5 was marginally dominant during the initial 4 sessions under this phase of the experiment.
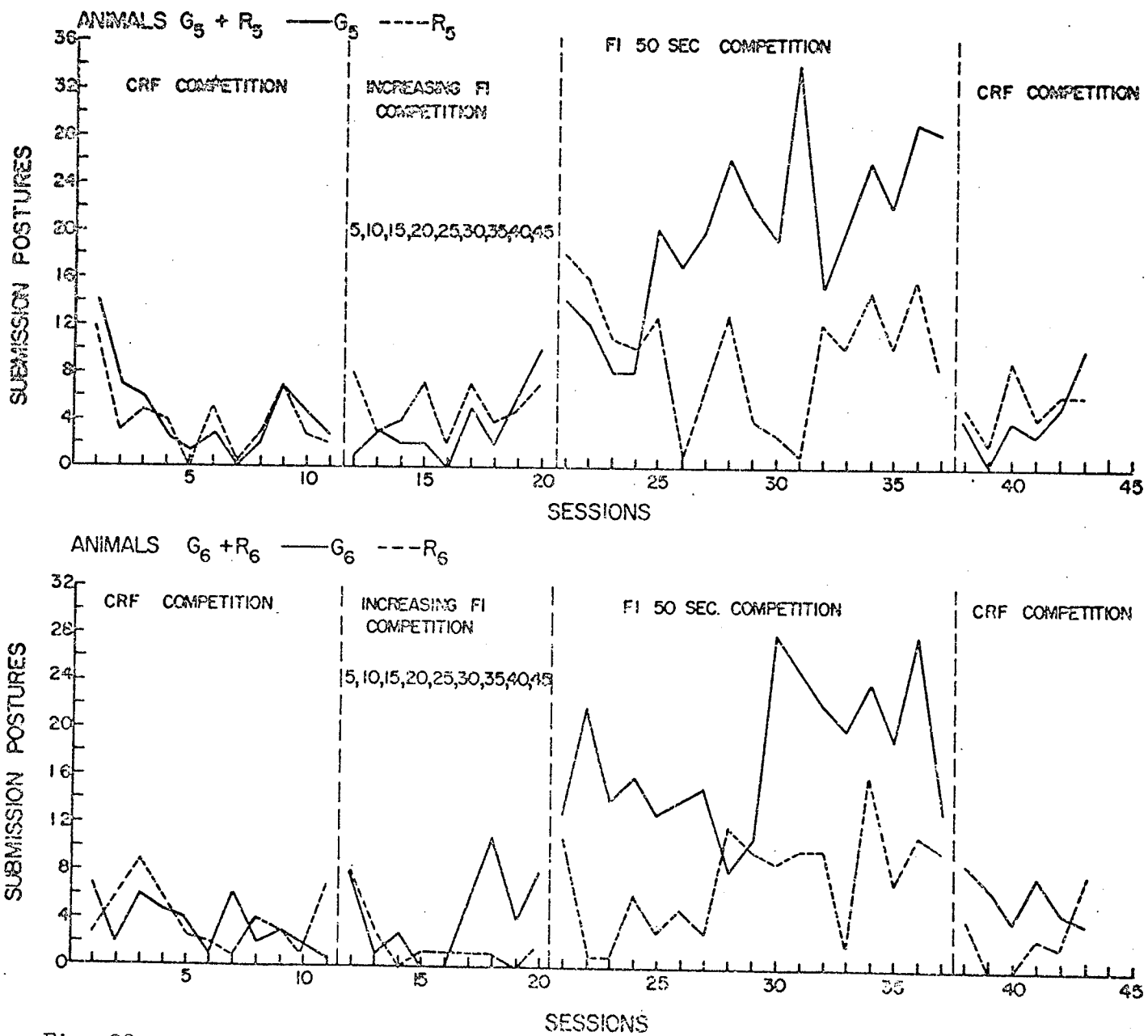
Fig. 28. Number of submission postures exhibited by each animal in competition pairs G5 and R5; G6 and R6, competing under CRF, increasing FI, and FI 50 sec. schedules.

Rat G5 was marginally dominant during the initial 4 sessions under this phase. In session 25, this dominance-subordination relationship reversed and animal R5 became dominant in terms of exhibiting the smaller number of submissive postures. Rat R5 maintained it dominance throughout the remaining sessions under this phase of the experiment, but the degree of dominance-subordination behavior observed in this competition pair varied widely from session to session. With the exception of session 28 and 29, rat R6 in competition pair G6 and R6 was dominant throughout the sessions under the FI 50 seconds schedule phase. The degree of dominance-subordination behavior observed in this competition pair also varied widely from session to session under this phase of the experiment.

Finally, in a return to the CRF baseline condition, rat G5 in competition pair G5 and R5 became marginally dominant in the initial 5 sessions under this phase. In session 6 this dominance-subordination relationship reversed and animal R5 became dominant. In competition pair G6 and R6, rat R6 maintained the dominance it had exhibited under the increasing FI 50 seconds schedule phase, but in the last session under the return to the CRF baseline condition, this dominance-subordination relationship reversed and rat G6 became dominant.

Additional observations. The frequency of switching or alternation at the aperture by animals in each of the two competition pairs of this experiment stabilized in approximately the same fashion as had been observed in Experiment I during competition sessions under the initial CRF baseline condition. In the subsequent sessions under the increasing FI schedules phase, the frequency of alternation at

the aperture between animals in each competition pair increased and continued to increase for the first 5 or 6 sessions. The alternation behavior then levelled off to a relatively constant but high rate in each competition pair. A return to the CRF schedule baseline condition saw a return of the level of alternation observed under the initial baseline condition.

In the initial sessions under the increasing FI schedules phase, animals in each competition pair exhibited lever press behavior which was similar to that observed under the FR schedules in Experiment I and II. In approximately the FI 35 seconds schedule session, the constant rate of lever pressing followed by a pause immediately subsequent to the reinforcement (i.e. typical FR behavior), changed to lever press behavior which was more typical of FI behavior. The animals in each competition pair would avoid entering the aperture immediately following a reinforcement. At various times during the fixed interval designated by the FI schedule under which they were competing to lever press for food, one or the other animal in each competition pair would enter the aperture and lever press several times in succession, as if to "test" whether the interval and consequently the period of non-reinforcement had ended.

As the sessions under the FI 50 seconds schedule phase progressed, the dominant animal in a competition pair would attempt to enter and control the aperture in the last 3 to 5 seconds of the 50 seconds interval, while the subordinate animal would more frequently enter the aperture at earlier times. A form of "wrestling" began to ensue in these sessions, in which one or the other animal in a

competition pair would force its opponent into a submissive posture, proceed to hold it in this position, and wait for the interval to terminate. In the 5 to 8 seconds prior to the termination of the interval, the dominant animal in terms of the submissive postures measure would release its opponent and rush to the aperture, closely followed by its opponent. A struggle would then ensue for control of the aperture, with the animal which had been in the submissive posture having the disadvantage of arriving at the aperture last. However, the animal which had been in the submissive posture could still win control of the aperture in the last few seconds before the interval ended, thereby obtaining the reinforcement, particularly if there were sufficient time for it to establish its dominance in terms of this measure.

This latter "strategy" was typical of animal G6 in competition pair G6 and R6. Although rat G6 exhibited many more submissive postures than its opponent R6, G6 nevertheless managed to displace its opponent from the aperture frequently enough during the last few seconds before the interval ended to obtain approximately the same number of reinforcements as its opponent in the FI 50 seconds competition sessions.

IV. Discussion

The four measures of the degree of dominance-subordination behavior employed in this experiment were not consistent in portraying the same dominance-subordination relationship or the same degree of dominance-subordination behavior in each of the two competition pairs

during some phases of the experiment.

The intial CRF baseline phase. Under this condition, the nat-
ure of the dominance-subordination relationship observed in compet-
ition pair G5 and R5 was consistent in terms of the first two meas-
ures; the number of lever presses emitted (see Fig. 22) nad the per-
centage of time spent controlling the aperture (see Fig. 26). The de-
gree of dominance-subordination behavior was somewhat greater in
terms of the percentage of time spent in the aperture relative to the
lever press measure in this competition pair. The third measure, the
number of reinforcements obtained each session by each animal in a
competition pair, was not calculated for the CRF schedule baseline
sessions. The fourth measure, the number of submissive postures
exhibited by each animal in a pair, failed to reveal a clear degree
of dominance-subordination behavior in this competition pair (see
Fig. 28), and thereby deviated from the degree of this behavior ob-
served in terms of the first two measures in this competition pair.

In competition pair G6 and R6, the degree of dominance-sub-
ordination behavior observed in terms of the lever press measure
(see Fig. 23) was only marginally reflected in terms of the time in
the aperture measure (see Fig. 26). The dominant rat R6 had a high-
er number of lever presses in all sessions under the initial base-
line condition, but failed to maintain control over the aperture for
the greater percentage of the session time in several of these ses-
sions. The number of submissive postures measure (see Fig. 28) failed
to reveal a clear degree of dominance-subordination behavior in this
pair as well during this phase of the experiment.

The increasing FI schedules phase. The degree of dominance-subordination behavior observed in competition pair G5 and R5 was consistent across the lever press, time in the paerture, and number of reinforcements obtained measures in this phase of the experiment. However, the number of submissive postures measure again failed to reveal a clear degree of dominance-subordination behavior during these sessions in this competition pair.

In competition pair G6 and R6, the dominance-subordination relationship observed under the initial baseline condition reversed. Rat G6 became dominant in terms of the lever press measure after the initial session under the increasing FI schedules phase, this dominance increasing throughout the sessions and then becoming very small in the last session. This degree of dominance-subordination behavior was much smaller in terms of the time in the aperture measure and thus only marginally reflected the degree of this behavior observed in terms of the lever press measure. Rat G6 did not become dominant in terms of the number of reinforcements obtained measure until session 15 under the FI 20 seconds schedule, maintaining this dominance for all but the last session under this condition. This measure thus also failed to be consistent with the lever press measure in the initial 3 and the last session under this phase of the experiment. Finally, the reverse dominance-subordination relationship to the above three measures was observed in terms of the submissive postures measure, in that rat R6 became dominant in the last 4 sessions under this phase.

The FI 50 seconds phase. In competition pair G5 and R5, the

degree of dominance-subordination behavior was consistent across the lever press, time in the aperture, and the number of reinforcements obtained measures in all sessions under this condition. After the initial 3 sessions, rat R5 also became dominant in terms of the submissive postures measure, and thus the dominance-subordination behavior portrayed by the first three measures in this competition pair was reflected in terms of this measure as well.

The degree of dominance-subordination behavior observed in competition pair G6 and R6 in terms of the lever press measure was not consistent with the time in the aperture measure. While rat G6 was consistently dominant in terms of the lever press measure in all sessions under this phase of the experiment, no clear degree of dominance-subordination behavior emerged in terms of the time in the aperture measure. Similarly, no clear degree of dominance-subordination behavior emerged in terms of the number of reinforcements obtained measure until session 29, the session in which G6 gained the dominance it exhibited in terms of the lever press measure. With the exception of session 27, the dominance-subordination relationship observed in terms of the submissive postures measure was the reverse of that exhibited in terms of the above measures. In terms of this latter measure, R6 was dominant in terms of exhibiting the smaller number of submissive postures.

Return to the CRF schedule baseline. The degree of dominance-subordination behavior observed in competition pair G5 and R5 in terms of the lever press and time in the aperture measures was somewhat greater in the sessions under this condition relative to that

observed under the initial CRF baseline condition. However, the rel-
ative positions of both animals in terms of these measures was approx-
imately that observed under the initial baseline. Similarly, although
rat G5 was somewhat more dominant in terms of the submissive postures
measure during the sessions under this condition relative to this
behavior under the initial baseline, this difference was marginal and
thus both baselines portrayed approximately the same dominance-sub-
ordination behavior.

In competition pair G6 and R6, the dominance-subordination
relationship observed under the initial baseline condition in terms
of the lever press and time in the aperture measures, failed to be
recovered in this return to baseline condition. Animal G6 rather than
animal R6 was dominant in terms of these measures during the sessions
under this phase of the experiment. In terms of the submissive post-
ures measure, no observed degree of dominance-subordination behavior
emerged under the initial baseline sessions. However, in the sessions
under this condition, rat R6 was dominant in 5 out of the 6 sessions.

The degree of dominance-subordination behavior observed in
competition pair G5 and R5 was thus consistent across the lever press,
time in the aperture, and number of reinforcements obtained measures
in all phases of the experiment. In addition, the submissive post-
ures measure reflected the dominance-subordination relationship ob-
served in terms of the first three measures in the latter 14 out of
17 sessions under the FI 50 seconds schedule phase. The baselines
in terms of these behaviors were all reversible, that is, the kind
and degree of behavior observed under the return to baseline phase
was approximately that observed under the initial baseline condition.

Finally, the dominance-subordination behavior observed in this competition pair was of greater magnitude relative to that observed in competition pair G6 and R6.

The degree of dominance-subordination behavior observed in competition pair G6 and R6 was relatively small in terms of the lever press measure. The degree of this behavior was not reflected in terms of the time in the aperture measure except during the return to baseline phase, was not reflected in terms of the number of reinforcements obtained measure until the last 9 sessions under the increasing FI schedules phase, and was reversed in terms of the submissive postures measure during the increasing FI, FI 50 seconds, and the return to baseline phases. In competition pair G6 and R6, the behavior observed under the initial baseline phase was not recovered in the return to baseline phase in terms of all dependent measures. This irreversability results in a failure to establish a functional relationship between the experimental manipulations and any subsequent behavioral changes. Thus, for this competition pair, the changes observed in the dominance-subordination relationship and the small increase in the degree of dominance-subordination behavior in terms of the lever press rate during the increasing FI and FI 50 seconds schedule phases, may or may not have been due to the changes in the reinforcement schedules on which these animals were competing to lever press for food.

V. Conclusion

The following conclusions may be drawn from the data of this

experiment:

1. The degree of dominance-subordination behavior exhibited by pairs of rats competing to lever press for food on a CRF schedule is small (in terms of response rate or time in the aperture).

2. Competition to lever press for food on FI scheles may not be a reliable experimental procedure by which to increase the degree of dominance-subordination behavior in pairs of rats. Of the two competition pairs employed in this experiment, one pair (G6 & R6) generally failed to exhibit an increase in the degree of dominance-subordination behavior during FI schedule competition. The small changes in dominance-subordination behavior that did occur were not reversible during the return to baseline phase. The second pair (G5 & R5) exhibited a consistent degree of dominance-subordination behavior not only during the increasing FI and FI 50 seconds schedule phases, but also during the CRF schedule phase. This contradicts the results obtained from the other competition pair of this experiment and the results of CRF schedule competition in Experiment I. All these competition pairs exhibited a decreasing degree of dominance-subordination behavior as the sessions under the CRF schedule competition phase progressed. This may suggest that the dominant animal in competition pair G5 and R5 was "naturally" more dominant than its opponent, and that this dominance was merely maintained throughout all phases of the experiment without much change due to FI schedule competition.

3. The percentage of the session time spent in the aperture may not be a sensitive measure of dominance-subordination behavior in animals competing to lever press for food on FI schedules. In both competition pairs, the time spent in the aperture seemed to change

little as the FI schedules on which they were competing changed. This insensitivity may be due to the nature of FI schedules, in that only the last lever press immediately preceeding the elapse of a fixed interval is reinforced. Lever presses and consequent control of the aperture during earlier times of a fixed interval do not gain an animal more reinforcements.

4. As the FI schedule on which animals are competing is increased to a relatively high value (FI 50 seconds), the frequency of aggressive encounters also increases. However, the submissive postures measure, the measure of the outcome of these aggressive encounters, does not correlate positively with the other measures of the degree of dominance-subordination behavior employed in this experiment. This may suggest that dominance-subordination behavior is not a unitary phenomenon, but that the dominance of an animal varies depending on the measure used to ascertain this dominance.

CHAPTER VI

EXPERIMENT IV

I. Introduction

The object of this experiment was to observe the degree of dom-
inance-subordination behavior exhibited by pairs of rats which were
individually trained on an FI 50 seconds schedule, subsequent to which
they were placed together to form competition pairs, each of which
competed to lever press for food on an FI 50 seconds schedule.

II. Procedure

Four rats served as $\underline{S}$s, forming two competition pairs (G7 & R7,
G8 & R8). The training and testing sequence began with 13 individual
15 minute sessions of lever training on CRF. All subsequent sessions
were of 30 minutes duration. All animals were then trained up to an
FI 50 seconds schedule by increments of 10 second FI steps per session.
Each animal then received 13 sessions on an FI 50 seconds schedule,
this phase of the experiment constituting the baseline condition. An-
imals were subsequently placed in competition pairs and competed to
lever press for food on an FI 50 seconds schedule, each pair receiv-
ing 21 such competition sessions. In a return to the baseline condit-
ion, each animal received 6 individual sessions on an FI 50 seconds
schedule.

The four dependent measures of the degree of dominance-subord-
ination behavior employed in Experiments I, II, and III, were again

employed in the present study. Similarly, the definitions of dominance or subordination behavior employed in this experiment were the same as those used in the previous three experiments.

III. Results

Number of lever press responses. Throughout the sessions under the individual FI 50 seconds baseline condition, the overall lever press rate of each animal in competition pair G7 and R7 was approximately the same (see Fig. 29). When these animals subsequently competed to lever press for food under the FI 50 seconds competition phase, no clear degree of dominance-subordination behavior emerged. Rat G7 was marginally dominant in sessions 18 to 24 and sessions 31 to 34, but its number of lever presses were equal to or less than those emitted by its opponent R7 in the other 10 sessions under this condition. In the return to the individual FI 50 seconds baseline condition, the lever press rate of each animal was slightly higher than that observed under the initial baseline condition, but the relative lever press rates of the two animals were the same.

The lever press rate of animal R8 in competition pair G8 and R8 was slightly higher than that of its opponent G8 in all but one session under the initial baseline condition (see Fig. 30). Under the FI 50 seconds competition phase, no clear degree of dominance-subordination behavior emerged until session 29, the session in which rat R8 became dominant. Rat R8 maintained this dominance for the remaining 5 sessions under this condition. In the return to baseline condition, the lever press rates of both animals were somewhat
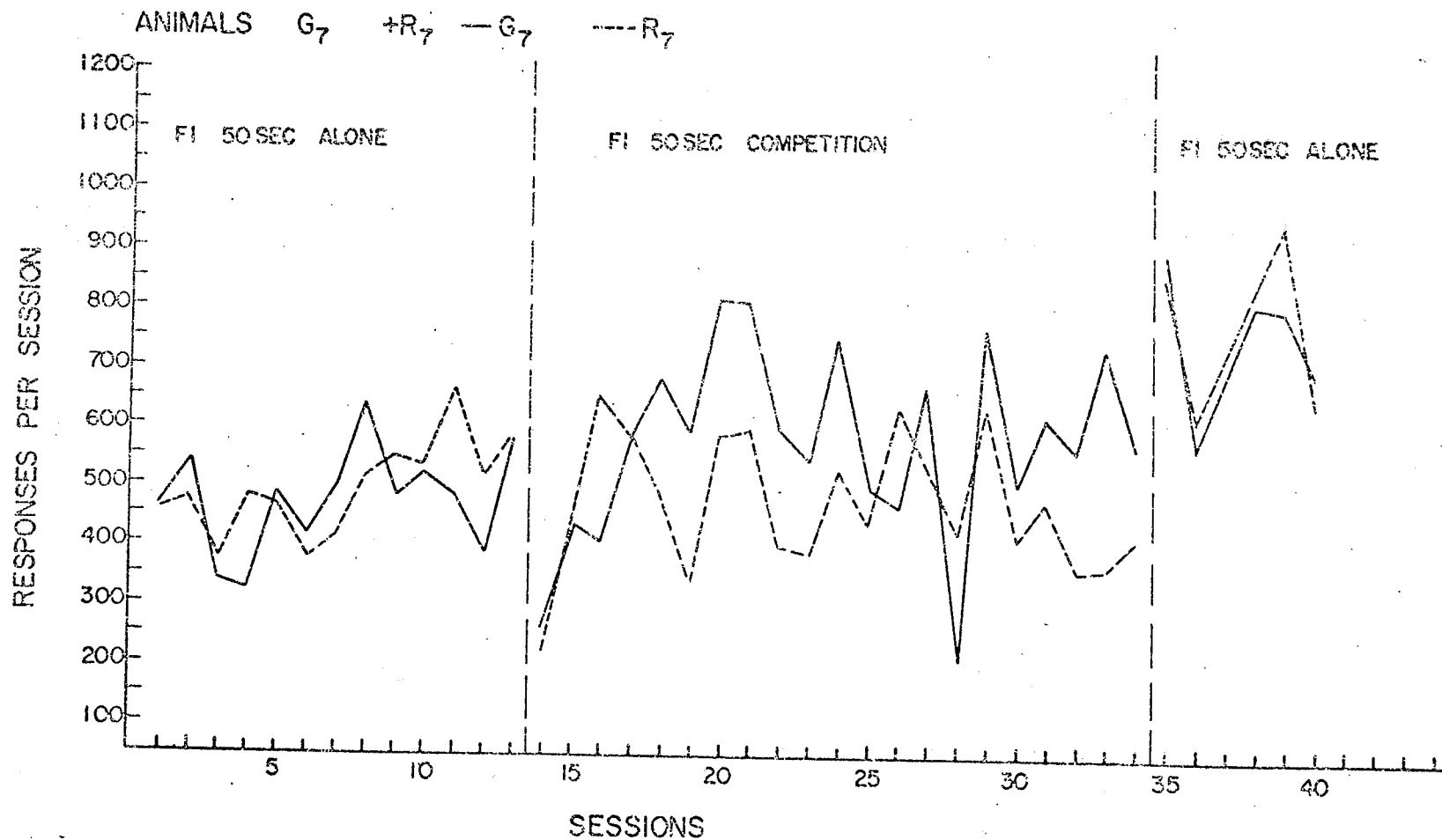
Fig. 29. Number of lever press responses emitted by each animal in competition pair G7 and R7 during individual sessions and competition sessions on an FI 50 sec. schedule.
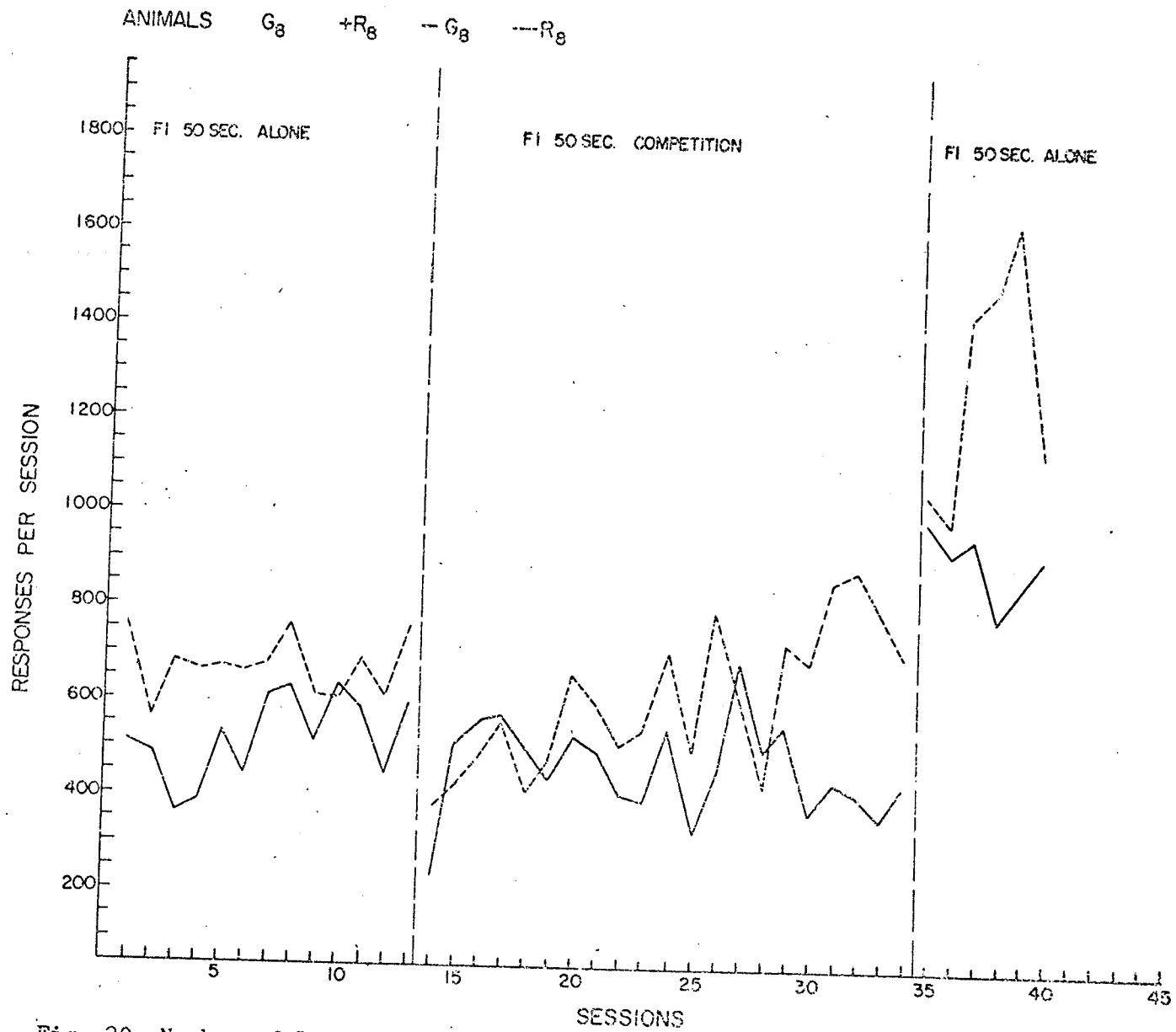
Fig. 30. Number of lever press responses emitted by each animal in competition pair G8 and R8 during individual sessions and competition sessions on an FI 50 sec. schedule.

higher relative to those observed under the initial baseline condition, particularly that of animal R8. However, the relative lever press rates of the two animals was the same as those observed under the initial baseline condition.

Typical cumulative recordings of lever press behavior reveal that both animals in competition pair G7 and R7 exhibited typical FI behavior during the individual FI 50 seconds baseline sessions (see Fig. 31). Cumulative recordings of lever press behavior during the FI 50 seconds competition sessions reveal, as does Fig. 29, that rat G7 had a somewhat higher lever press rate (see Fig. 32). The typical FI "scallop" effect observed in the recordings of lever press behavior under the individual FI 50 seconds phase are missing in the recordings of lever press behavior under the FI 50 seconds competition phase. Similarly, cumulative recordings of lever press behavior of each animal in competition pair G8 and R8 reveal that both animals exhibited typical FI behavior during the initial FI 50 seconds baseline phase (see Fig. 33). Cumulative recordings of lever press behavior during the FI 50 seconds competition phase reveal that rat R8 had a higher lever press rate relative to that of its opponent G8 (see Fig. 34). The typical FI scallop effect observed in the recordings of lever press behavior under the individual FI 50 seconds baseline phase are also missing in the recordings of lever press behavior under the FI 50 seconds competition phase in this pair.

Percentage of time spent in the aperture. In the sessions under the initial baseline condition, rat G7 spent a slightly greater percentage of time in the aperture than its assigned opponent R7

R7 FI 50 SEC. ALONE
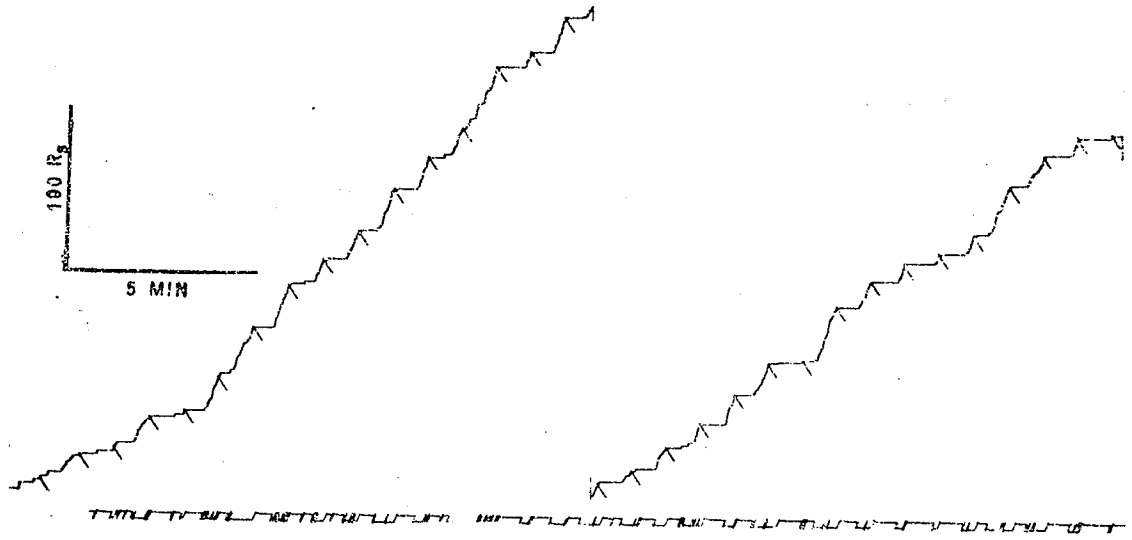
G7 FI 50 SEC. ALONE
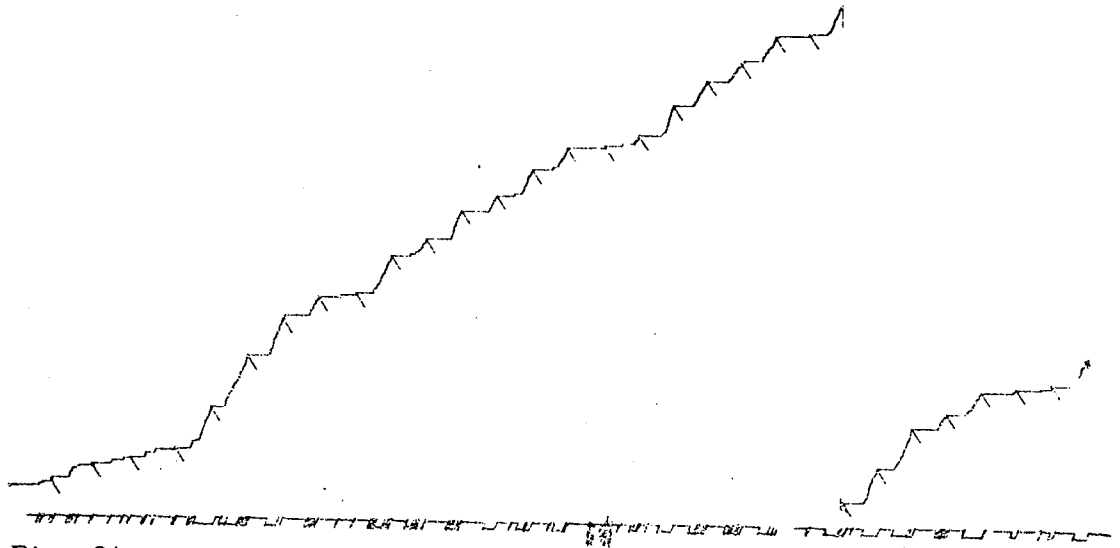
Fig. 31. Typical cumulative recordings of lever press behavior by animals R7 and G7 during individual sessions on an FI 50 sec. schedule.

R7 FI 50 SEC. COMP.

100 R.

5 MIN
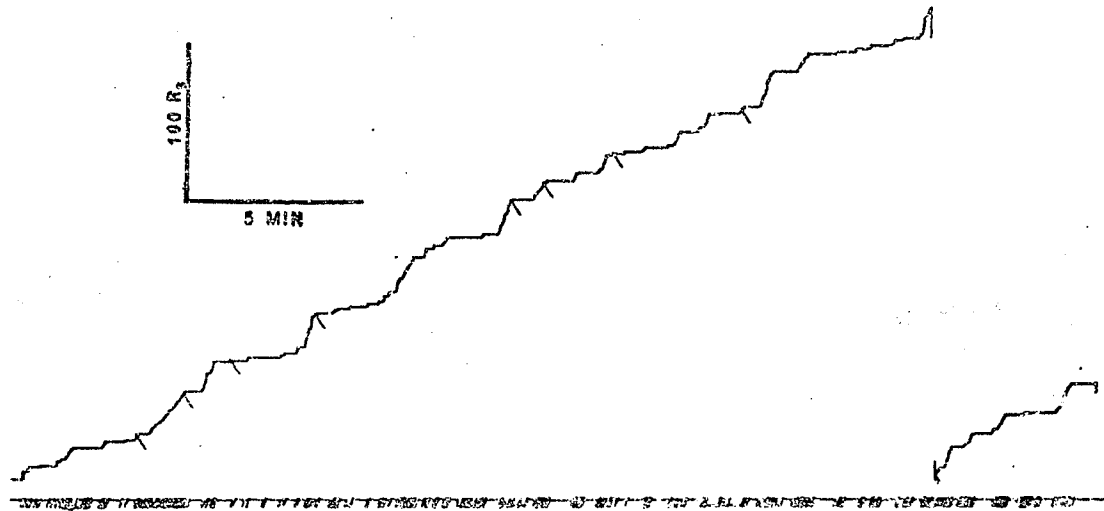
G7 FI 50 SEC. COMP.
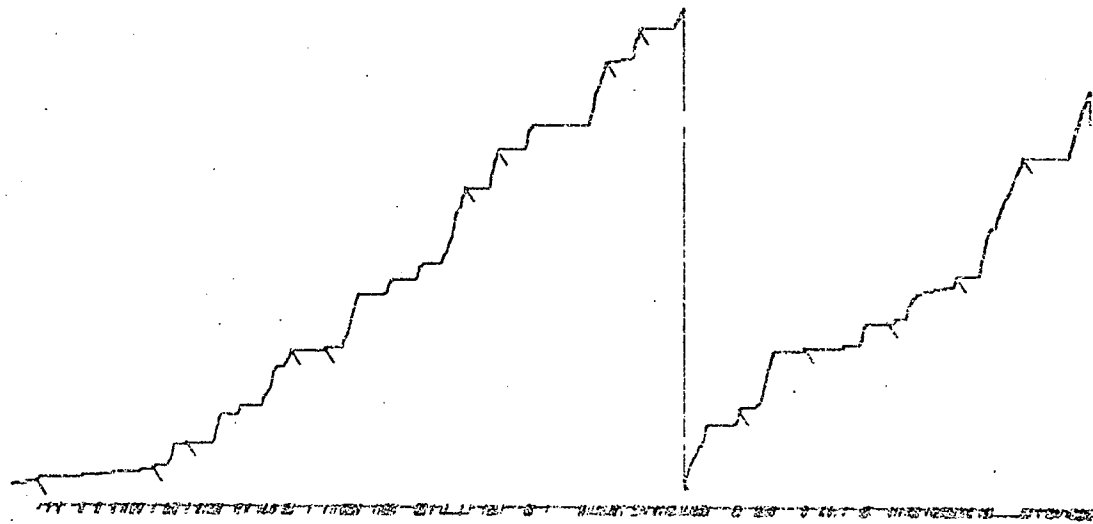
Fig. 32. Typical cumulative recordings of lever press behavior by animals R7 and G7 during competition sessions on an FI 50 sec. schedule.

R8 FI 50 SEC. ALONE

G8 FI 50 SEC. ALONE

100 R$_s$

5 MIN
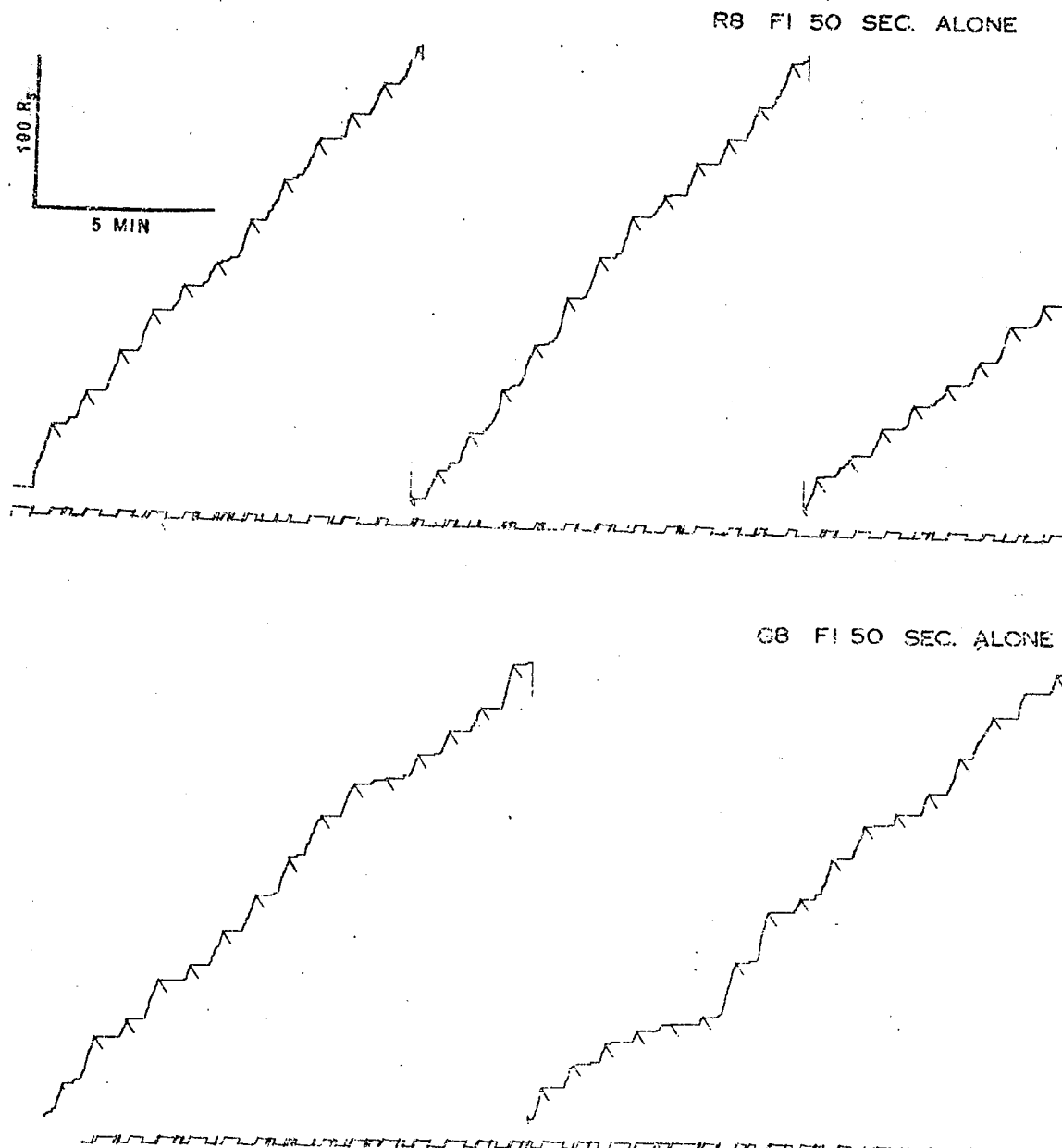
Fig. 33. Typical cumulative recordings of lever press behavior by animals R8 and G8 during individual sessions on an FI 50 sec. schedule.

G8 FI 50 SEC. COMP.

R8 FI 50 SEC. COMP.
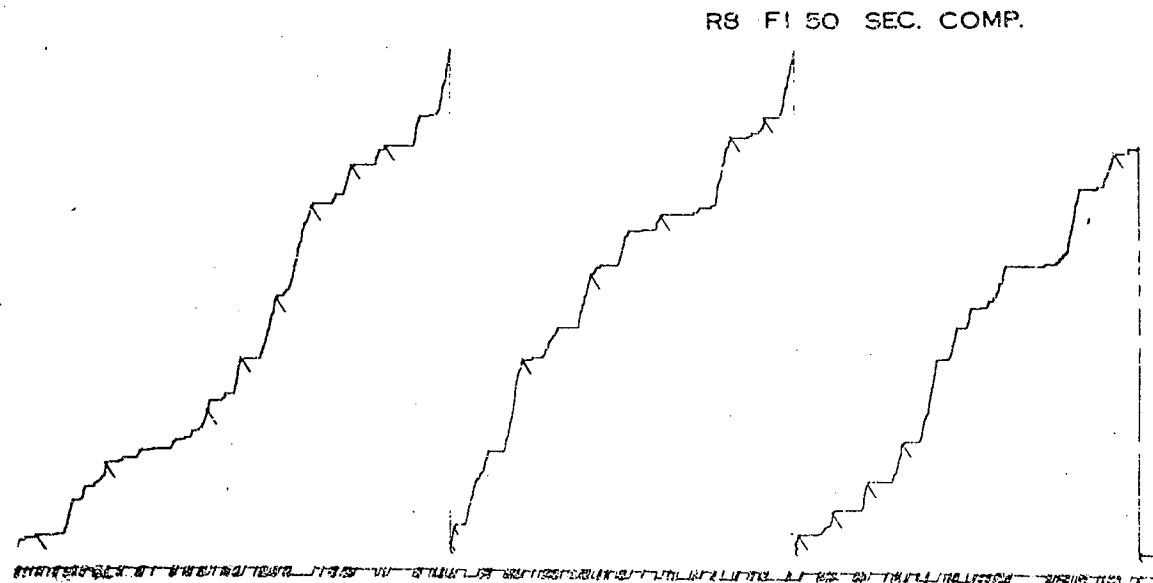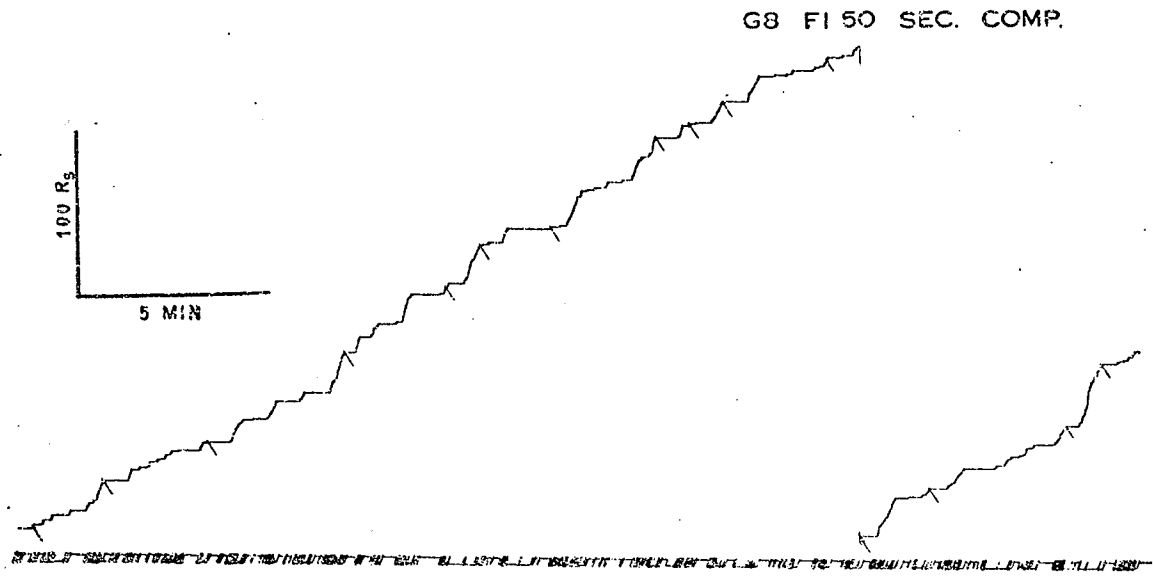
Fig. 34. Typical cumulative recordings of lever press behavior by animals G8 and R8 during competition sessions on an FI 50 sec. schedule.

during sessions 6 to 10 (see Fig. 35). However, the overall time spent in the aperture by each of the animals in this competition pair was approximately the same during these sessions. No clear degree of dominance-subordination behavior emerged in this competition pair in sessions under the FI 50 seconds schedule competition sessions. Rat R7 was marginally dominant in sessions 18 to 25 and sessions 31 to 34, but dominance or subordination behavior fluctuated from session to session in terms of this measure between the animals in this competition pair in the remaining sessions under this condition. In the return to the baseline condition, the percentage of time spent in the aperture by each animal in this competition pair was approximately that observed under the initial baseline condition.

The percentage of time spent in the aperture by animal R8 in competition pair G8 and R8 was somewhat greater than that of its opponent G8 in all but one session under the initial baseline condition (see Fig. 35). In the subsequent FI 50 seconds schedule competition sessions, rat R8 was marginally dominant in sessions 16 to 26 and sessions 29 to 34. In the return to baseline condition, both animals spent approximately the same percentage of time in the aperture, a similarity observed in sessions 7 to 10 under the initial baseline condition.

Reinforcements obtained per session. During the individual FI 50 seconds baseline condition, each animal in each of the two competition pairs obtained approximately the same number of reinforcements (see Fig. 36). In the subsequent FI 50 seconds competition phase, no clear degree of dominance-subordination behavior emerged in terms of
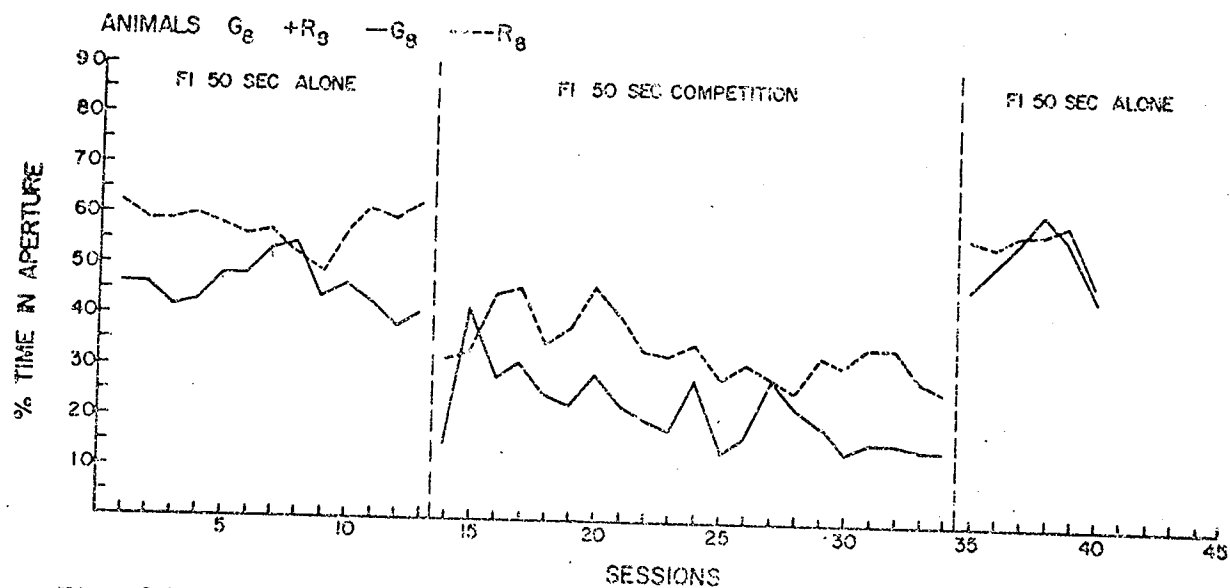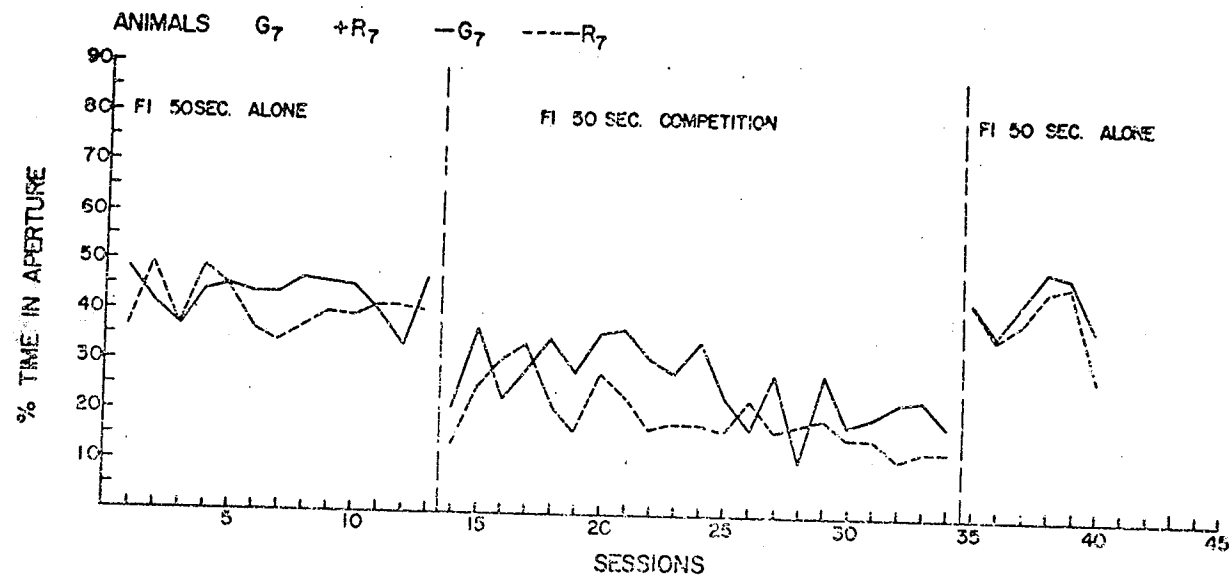
Fig. 35. Percentage of the total session time spent controlling the aperture by each animal in competition pairs G7 and R7; G8 and R8, during individual and competition sessions on an FI 50 sec. schedule.
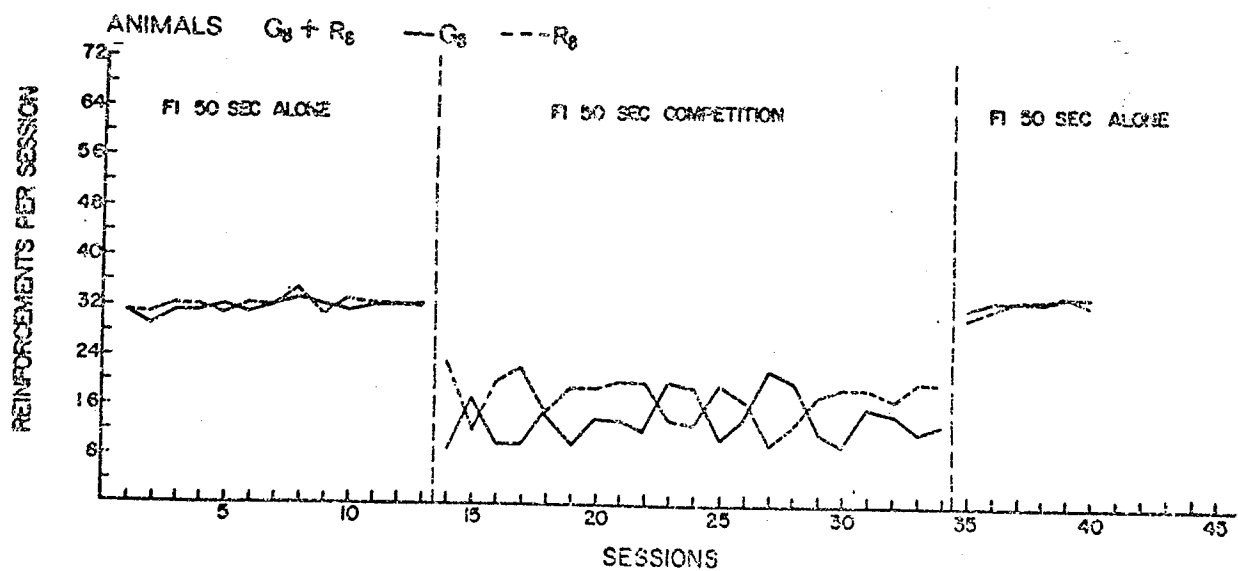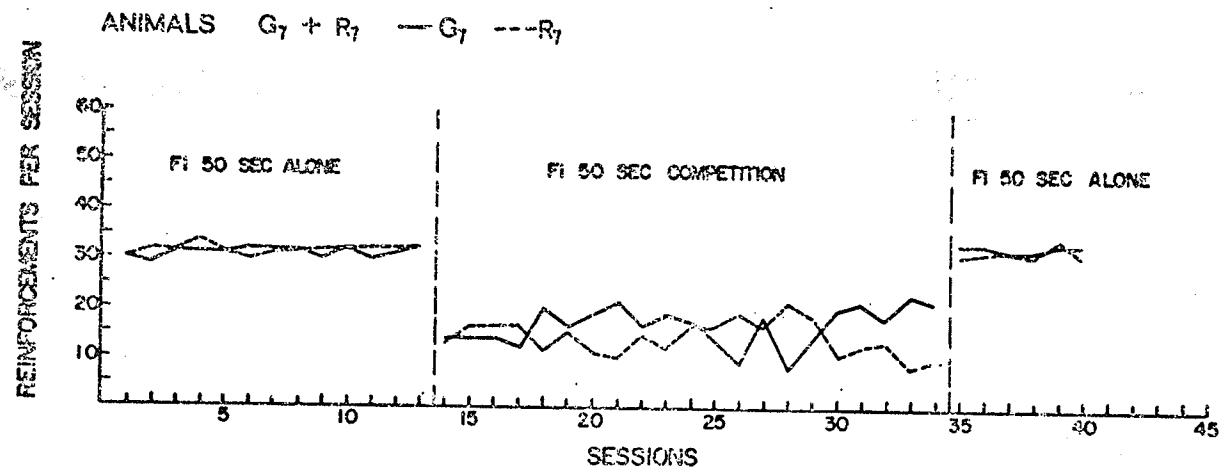
Fig. 36. Number of reinforcements obtained each session by each animal in competition pairs G7 and R7; G8 and R8, during individual and competition sessions on an FI 50 sec. schedule.

this measure in competition pair G7 and R7 until session 30. In session 30, G7 became dominant and maintained this dominance in the remaining 4 sessions under this condition. However, the degree of dominance-subordination behavior during these last few sessions was small.

Similarly, no clear degree of dominance-subordination behavior emerged during the FI 50 seconds schedule competition sessions in competition pair G8 and R8 except in sessions 19 to 22 and sessions 29 to 34, sessions in which R8 became marginally dominant. In a return to the baseline condition, the similarity observed under the initial baseline condition in terms of the number of reinforcements obtained by each animal in each of the two competition pairs, was again observed under the return to baseline condition.

Number of submissive postures. No clear degree of dominance-subordination behavior was observed in competition pair G7 and R7 throughout the sessions under the FI 50 seconds schedule competition phase in terms of this measure (see Fig. 37). In competition pair G8 and R8, rat R8 was dominant in many of the sessions under this condition, particularly in the sessions following session 24. Rat R8 exhibited fewer submissive postures in all these sessions with the exception of session 30. As the sessions under the FI 50 seconds competition phase progressed, the number of submissive postures exhibited by both animals increased, particularly by animal G8.

Number of boli. The number of boli dropped by each animal in each competition pair was recorded in all phases of the experiment. The number of boli dropped by each animal in competition pair G7 and
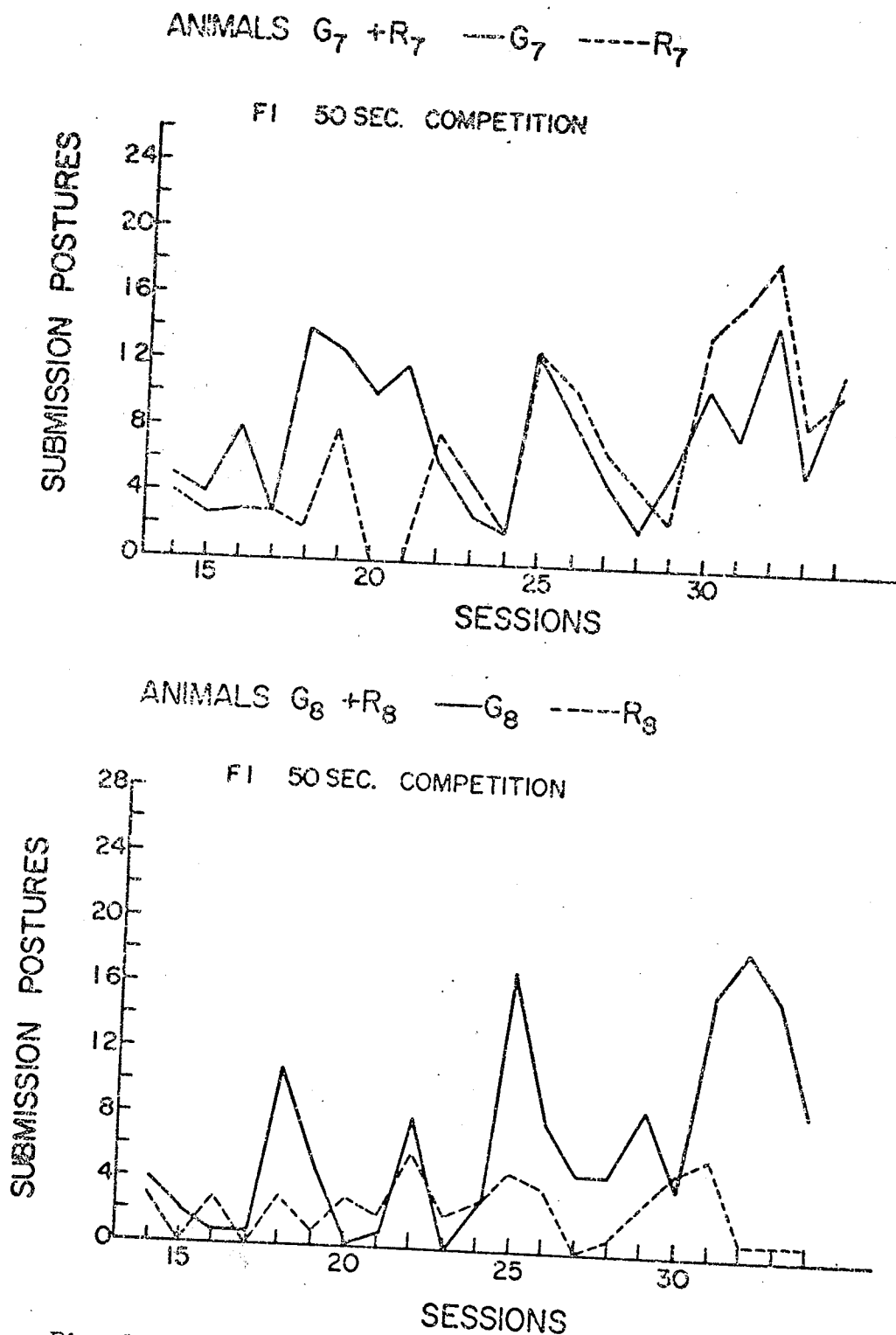
Fig. 37. Number of submission postures exhibited each session by each animal in competition pairs G7 and R7; G8 and R8, competing on an FI 50 sec. schedule.

R7 during the initial individual FI 50 seconds baseline condition was similar (see Fig. 38). Rat R8 in competition pair G8 and R8 dropped approximately twice as many boli during these sessions than its opponent G8. In only three sessions under the FI 50 seconds competition phase did the animals in pair G7 and R7 drop boli, while the animals in competition pair G8 and R8 dropped no boli during these sessions. In the return to baseline phase, the number of boli dropped in these sessions was approximately that observed in the sessions under the initial baseline condition in competition pair G7 and R7. In competition pair G8 and R8, rat R8 dropped fewer boli in these sessions relative to the number it dropped in the sessions under the initial baseline condition.

Additional observations. The rate of alternation at the aperture in each of the two competition pairs increased after the initial two sessions under the FI 50 seconds schedule competition phase and remained high during the subsequent sessions under this condition. The "wrestling" behavior described in Experiment III appeared following the initial 4 sessions under this condition. As was described in Experiment III, one rat or the other would hold its opponent in a submissive posture, wait until the 50 seconds interval had almost terminated, then release its opponent and rush to the aperture. As the sessions under this condition progressed, this wrestling behavior increased in both competition pairs.
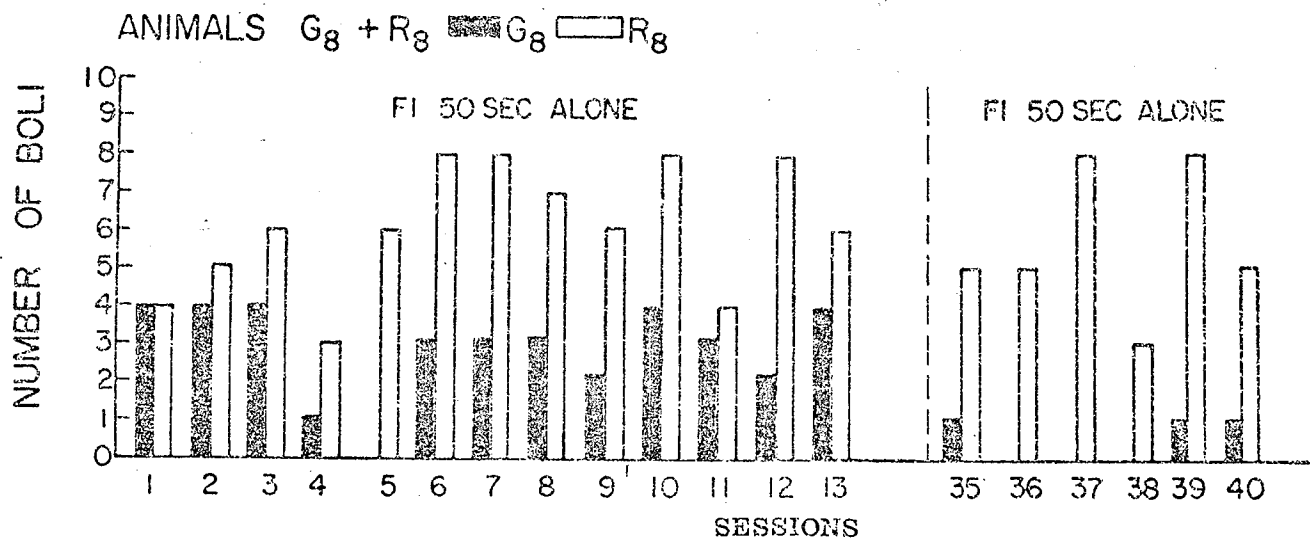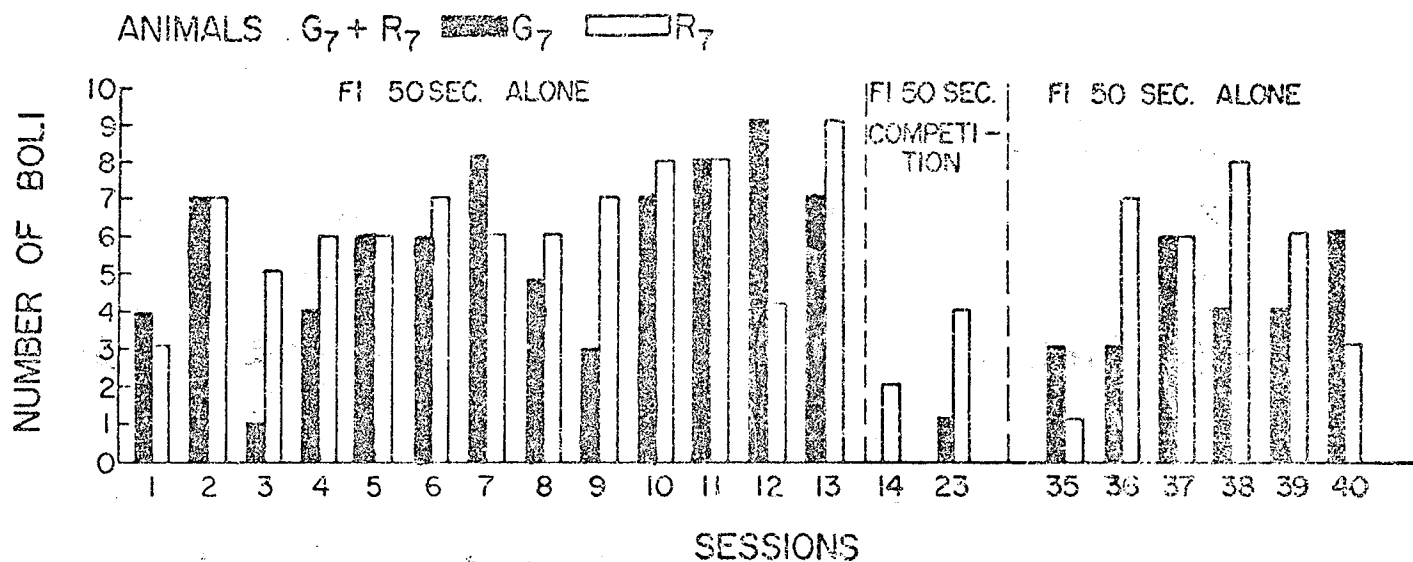
Fig. 38. Number of boli dropped each session by each animal in competition pairs G7 and R7; G8 and R8, during individual- and competition sessions on an FI 50 sec. schedule.

IV. Discussion

The degree of dominance-subordination behavior observed in each of the two competition pairs during the FI 50 seconds competition phase was unclear or small in terms of the lever press measure. This uncertain degree of dominance-subordination behavior was directly reflected in terms of the percentage of time in the aperture and the number of reinforcements obtained measures. No clear degree of dominance-subordination behavior was observed in competition pair G7 and R7 in terms of the number of submissive postures measure. In competition pair G8 and R8, rat R8's slight dominance in the last 6 sessions under this condition in terms of the above three measures was also reflected by the submissive postures measure. In these latter sessions, R8 exhibited fewer submissive postures than its opponent G8.

Animals in competition pair G7 and R7 were not consistently different in terms of the number of boli dropped during the FI 50 seconds schedule baseline condition. In competition pair G8 and R8, R8 dropped more boli during these sessions than its opponent G8.

V. Conclusion

The following conclusions may be drawn from the data of this experiment:

1. No clear degree of dominance-subordination behavior is exhibited by pairs of rats competing to lever press for food on a relatively high (FI 50 seconds) schedule (in terms of lever press rate,

time in the aperture, or reinforcements obtained).

2. The number of submissive postures exhibited by each animal in a competition pair, the measure of the outcomes of aggressive interactions, does not correlate highly with the other measures of the degree of dominance-subordination behavior employed in this experiment. One competition pair (G7 & R7) failed to exhibit a clear degree of dominance-subordination behavior in terms of this measure while the other competition pair (G8 & R8) exhibited a small degree of dominance-subordination behavior in the latter sessions of the FI 50 seconds competition phase. This degree of dominance-subordination was reflected by the slight degree of dominance-subordination exhibited in terms of the alternative three measures in the last 6 sessions of the FI 50 seconds schedule competition phase.

3. A return to the FI 50 seconds schedule in isolation baseline following FI 50 seconds schedule competition produces a slightly higher lever press rate relative to that observed under the initial baseline for all animals, but in each competition pair, the lever press rate of each animal relative to that of its opponent returned to that observed under the initial baseline condition.

4. The characteristic FI lever press behavior exhibited by each animal in isolation on a FI 50 seconds schedule is disrupted during competition, eventhough in a particular session one animal's response rate might be higher than that of its opponent.

5. Animals which regularly drop fecal boli during the individual FI 50 seconds baseline sessions drop few if any boli during the FI 50 seconds competition sessions. This may suggest that the competition situation contains stimulus components which inhibit defecation.

CHAPTER VII

GENERAL DISCUSSION AND CONCLUSION

I. Discussion

The purpose of this thesis was to discover under which sched-
ules of reinforcement, if any, the degree of dominance-subordination
behavior would be maximized and maintained in pairs of rats competing
to lever press for food. The thesis also attempted to study and relate
different measures of social dominance-subordination behavior in a
food competitive situation. It was found that high FR schedules were
the most effective in producing a large and consistent degree of this
behavior. Of the two experimental procedures which employed FR sched-
ules, the most efficient procedure was that employed in Experiment II.
In this study, rats were individually trained up to an FR 40 schedule
and were subsequently placed into competition pairs, each pair comp-
eting on an FR 40 schedule. One rat in each of the two competition
pairs in this experiment became dominant in terms of the lever press,
time in the aperture, and the number of reinforcements obtained meas-
ures. However, each of these dominant animals was subordinate in terms
of exhibiting a larger number of submissive postures relative to the
number exhibited by their opponents. This last measure, the measure
of wins or losses in aggressive interactions within competition pairs,
correlated negatively with the other three measures of the degree of
dominance-subordination behavior.

The alternative procedure which employed FR schedules was used

in Experiment I. In this study, pairs of rats competed to lever press for food on CRF, subsequent to which they competed on gradually increasing FR schedule to a terminal FR 40 schedule. They then competed on the FR 40 schedule for 6 sessions. In both the competition pairs of this study, the degree of dominance-subordination behavior exhibited on the CRF schedule was small and became inconsequential as the sessions under this condition progressed. Competition pair G2 and R2 exhibited a large degree of dominance-subordination behavior on the FR 10 schedule of the increasing FR schedules phase in terms of all four measures of dominance-subordination behavior employed. This degree of dominance-subordination behavior continued to increase throughout the remaining sessions under this condition and was subsequently maintained in the sessions under the FR 40 schedules phase. The other competition pair, pair G1 and R1, did not exhibit a clear degree of dominance-subordination behavior which was consistent across the lever press, time in the aperture, and reinforcements obtained measures until the FR 36 schedule was reached. It was also not until the last 5 sessions under the terminal FR 40 schedule that R1, the dominant animal in this competition pair, became marginally dominant in terms of the submissive postures measure. Prior to these sessions it had been subordinate in terms of this last measure in that it had exhibited a larger number of submissive postures in the majority of competition sessions relative to the number exhibited by its opponent G1. It was thus not until an FR schedule was reached which was almost equivalent to the terminal FR 40 schedule that this competition pair displayed the consistent degree of dominance-subordination behavior observed under the lower FR schedules in competition pair G2 and R2.

The procedure employed in Experiment I revealed that a relatively high FR schedule is needed to produce a consistent and clear degree of dominance-subordination behavior, at least in some competition pairs. However, having pairs of animals compete first under CRF, then under increasing FR, and finally under a terminal FR schedule such as FR 40 is laborious in terms of time and effort on the part of a researcher. To obtain the desired phenomenon, i.e. a large and consistent degree of dominance-subordination behavior, does not seem to require these preliminary steps. Therefore, the procedure employed in Experiment II seems to be more efficient.

Experiments III and IV each employed one of the two procedures involving competition to lever press for food on FI schedules. The degree of dominance-subordination behavior observed in competition on these schedules was not consistent across all competition pairs, but it was generally small or inconsequential across both sessions and the four dependent measures used.

In Experiment III, pairs of rats competed to lever press for food on CRF, then on gradually increasing FI schedules to a terminal FI 50 seconds schedule, and finally on the FI 50 seconds schedule. Of the two competition pairs of this experiment, pair G5 and R5 exhibited a consistent degree of dominance-subordination behavior in all phases of the experiment in terms of the lever press, time in the aperture, and reinforcements obtained measures. In addition R5, the dominant animal in this competition pair, was dominant in terms of the submissive postures measure as well during the FI 50 seconds schedule phase.

In the second competition pair of Experiment III, pair G6 and R6, the degree of dominance-subordination behavior observed was less defined. Rat R6 was marginally dominant in terms of the lever press and time in the aperture measures during the CRF schedule phase. This dominance-subordination relationship changed during the increasing FI schedules phase in that rat G6 became dominant and rat R6 subordinate in terms of these two measures. Rat G6 was only marginally dominant during the middle sessions under this condition in terms of the reinforcements obtained measure. During the FI 50 seconds schedule phase, rat G6 was marginally dominant in terms of the lever press measure, but a clear degree of dominance-subordination behavior failed to emerge in terms of the time in the aperture measure, and no clear degree of dominance-subordination behavior emerged in terms of the reinforcements obtained measure until the last 9 sessions under this condition. In these latter sessions, rat G6 became marginally dominant in terms of the reinforcements obtained measure. Finally, rat R6 was dominant in terms of the submissive postures measure in all but one of the sessions under the FI 50 seconds schedule phase. In the return to the CRF baseline condition, G6 remained dominant and consequently the behavior observed under the initial baseline condition, behavior in which R6 was dominant, was not recovered.

Of the two competition pairs in Experiment III, pair G5 and R5 showed a consistent degree of dominance-subordination behavior in all phases of the experiment, including the CRF baseline condition. This latter finding was not born out by the results of Experiment I, in which the degree of dominance-subordination exhibited by pairs of

rats tended to decrease and become inconsequential as the sessions under the CRF baseline condition progressed. This may suggest that rat R5, the dominant animal in competition pair G5 and R5, was "naturally" more dominant in competition with its opponent G5, and that this dominance was merely maintained throughout all phases of the experiment without much change. This notion may be supported by the fact that in terms of the time in the aperture, rat R5 occupied the aperture for approximately the same percentage of the total session time during all phases of the experiment. Similarly, the number of reinforcements obtained each session by R5 was approximately constant and changed little throughout the increasing FI and FI 50 seconds schedule phases. Thus, the degree of dominance-subordination behavior in terms of the lever press, time in the aperture, and reinforcements obtained measures may have been unchanged by competition under the FI schedules, but may merely have been an expression of a natural or "spontaneous" dominance-subordination relationship in this competition pair.

No differential experimental treatment calculated to affect social dominance had been administered to one or the other animal in each competition pair. It would be erroneous, however, to assume that the animals in each competition pair were equally matched in terms of dominance or subordination behavior, since the possible "spontaneous" dominance or subordination of each animal in each competition pair was unknown. The only control apparent to the experimenter, beyond restricted random assignment of animals to competition pairs, was body weight. Consequently the animals in each competition pair were matched in terms of this variable.

In addition to the marginal and inconsistent degree of dominance-subordination behavior observed in competition pair G6 and R6, the lack of recovery of behavior observed under the initial baseline condition during the return to baseline condition, precludes obtaining a cause and effect or functional relation between the experimental manipulation and the subsequent behavioral change. In terms of experimental techniques such as the ones used in the experiments comprising this thesis, Sidman (1960) states; "... the key to most of these techniques lies in the reversibility of behavioral phenomena. If an experimental manipulation produces an irreversible change in the aspect of an individual's behavior that we are observing, it may prove extremely difficult, if not impossible, to obtain functional relations..." (Sidman, 1960, p. 52).

The alternative procedure which employed FI schedules was used in Experiment IV. In this study rats were individually trained up to an FI 50 seconds schedule and were subsequently placed into competition pairs, each pair competing on an FI 50 seconds schedule. The degree of dominance-subordination behavior observed in lever press competition on this schedule was small and inconsequential in both the competition pairs of this experiment.

On the basis of the data gained from these experiments, it seems that competition to lever press for food on high FR schedules maximizes and consistently maintains a high degree of dominance-subordination behavior in pairs of rats, particularly in terms of the lever press, time in the aperture, and number of reinforcements obtained measures. Lever press competition on CRF and FI schedules failed to produce a similar degree and consistency of dominance-

subordination behavior. This difference in the degree of dominance-subordination behavior may, at least partially, be explained by the kinds of competitive behaviors which competition to lever press for food on these various schedules generated.

Following the initial few sessions, each animal in a competition pair competing on a CRF schedule would alternate or take turns at the aperture with an approximately equal frequency. Each animal in these competition pairs would yield up control over the aperture with little or no fighting, and would wait beside the aperture until its opponent had obtained several reinforcements. It would then shove its opponent out of the aperture and proceed to take its turn. Consequently, the number of submissive postures exhibited in this phase of the experiments was low relative to the number exhibited under other phases of the experiments involving CRF schedule competition sessions. The experimenter was left with the somewhat anthropomorphic impression that the animals in these competition pairs found it to their benefit to "cooperate" under this condition.

Competition under the higher FR schedules generated competitive behaviors which in some ways were the direct opposite of those observed on the CRF schedule. In competition sessions under both the terminal FR 40 schedule and the higher FR schedules of the increasing FR schedules phase, the dominant animal in each competition pair would control the aperture for increasingly longer periods of time, and would resist yielding up control of the aperture to its opponent. As the sessions under these FR schedules progressed, the amount of fighting within competition pairs increased. Much of this fighting would take place elsewhere in the experimental chamber rather than

at or near the aperture, and although on many occasions the dominant animal exhibited submissive postures, this did not deter it from retaining its control of the aperture. Rather than waiting beside or near the aperture for its turn to lever press, the subordinate animal in each competition pair would engage in displacement activities such as grooming at some distance from the aperture. None of the "sharing" of control of the aperture observed in the CRF competition sessions was evident in competition sessions on the higher FR schedules.

In competition sessions on FI schedules as high or higher than FI 35 seconds, animals in each competition pair would enter the aperture at sporadic times in the later portions of the fixed interval designated by the FI schedule on which they were competing to lever press for food. As was observed in Experiment III, the dominant animal in each competition pair would attempt to gain control of the aperture in the last 3 to 5 seconds before the termination of the interval. As the sessions under these higher FI schedules progressed, a form of "wrestling" began to ensue in which one or the other of the animals in a competition pair would force its opponent into a submissive posture, proceed to hold it in this position until just before the termination of the interval. This animal would then release its opponent and rush to the aperture, closely followed by its opponent. A struggle would then ensue for control over the aperture, with the animal which had been in the submissive posture having the disadvantage of arriving at the aperture last. The animal which had been in the submissive posture could still make the terminal response if there was sufficient time to dislodge its opponent from the

aperture, thereby obtaining the reward. As the sessions under the FI 50 seconds schedule progressed, this "wrestling" behavior became increasingly more frequent.

In order to obtain the maximum number of reinforcements during a session, animals on higher FR schedules must emit a high and constant number of lever presses. This implies that in a competition session, an animal must be in control of the aperture, and since the lever press, time in the aperture, and the number of reinforcements obtained are all interrelated measures, an animal obtaining a large number of reinforcements would be dominant in terms of these three measures. This is supported by the data obtained from Experiments I and II in that all competition pairs competing to lever press for food on the terminal FR 40 schedule displayed a consistent and high degree of dominance-subordination behavior in terms of these three measures.

Competition on a CRF schedule does not place these lever press demands on each of the animals in a competition pair. Since every response is reinforced, relatively few responses result in the animal obtaining a relatively large number of reinforcements. Consequently, competition under this schedule is at a low level and the degree of dominance-subordination behavior generated in terms of the lever press, time in the aperture, and the number of reinforcements obtained measures would be small or inconsequential. This is supported by the data obtained from Experiments I and III in that competition pairs competing to lever press for food on a CRF schedule displayed a negligible degree of dominance-subordination behavior in terms of these three measures.

An animal needs to emit only one lever press response following

the elapse of a period of time in order to be reinforced on a fixed interval schedule. Therefore, in order to obtain the maximum number of reinforcements during a competition session, an animal needed to control the aperture and lever press only during the last few seconds before the elapse of the fixed interval. The inherent nature of FI schedules thus minimized the value of the lever press and time in the aperture measures as indicants of an animal's dominance or subordination. Also, an animal's ability to accurately judge when an interval has elapsed seems quite variable, in that it exhibits a relatively long period of high lever press responding prior to the fixed interval (the "scallop" effect noticible in cumulative recordings of lever press behavior during individual sessions on the FI 50 seconds schedule). It often seemed to the experimenter that "chance" rather than dominance was operating in determining which of the two animals in a competition pair obtained the reinforcement. Whichever animal managed to be first to lever press after the fixed interval had elapsed obtained the reward. These factors may thus explain the lack of a clear degree of dominance-subordination behavior in terms of the lever press, time in the aperture, and reinforcements obtained measures exhibited by the competition pairs of Experiments III and IV, experiments in which animals competed to lever press for food on FI schedules. They may also explain the "wrestling" or holding down behavior engaged in by these competition pairs.

A more hypothetical explanation of why higher FR schedules were effective in producing a large and consistent degree of dominance-subordination behavior is the alleged motivational effect of frustrative nonreward experienced by animals on an FR schedule.

According to this theory (Amsel, 1958; 1962), the animal would "expect a reward" following nonrewarded responses on an FR schedule. These nonrewarded responses create frustration, frustration which has a motivational effect which may be seen in the intensification of responses occurring within a short time after the animal experiences nonreward. One could argue that since FI schedules involve delayed responding rather than nonrewarded responding, they were less effective in producing a large degree of dominance-subordination behavior due to the lack of this motivational component.

Eventhough the number of lever presses emitted, the percentage of the total session time spent controlling the aperture, and the number of reinforcements obtained by each animal in a competition pair during a competition session are all interrelated measures, each of these three measures may be a seperate but relevant indicator of the degree of dominance-subordination behavior. Supposedly, if three measures of the same phenomenon are highly and positively correlated, these measures all measure the same thing and consequently any two of the three measures may be discarded. However, discarding any one of these measures at the present time may be premature. If only the number of lever presses emitted were to be employed as a measure of the degree of dominance-subordination behavior, this measure would be confounded with the degree of efficiency with which each animal in a competition pair would be pressing the lever. Animals often vary widely in terms of how efficiently and quickly they can lever press. Conclusions as to the degree of dominance-subordination behavior or the nature of the dominance-subordination relationship exhibited by a particular competition pair based on data gained from only the lever press

measure could thus be erroneous.

Similarly, were only the time spent in the aperture measure to be employed, erroneous conclusions as to which animal in a competition pair was dominant or the degree of dominance-subordination behavior exhibited by a pair could be arrived at. A greater percentage of the session time spent in the aperture does not necessarily imply that an animal would obtain the majority of reinforcements. Particularly near the end of a run on a high FR schedule, an animal's opponent could briefly remove it from the aperture, finish the last few responses required to fulfill the ratio requirement, obtain the reinforcement, and then vacate the aperture until the subsequent ratio requirement was almost completed. This "strategy" to obtain the largest number of reinforcements with a minimum amount of work was employed by rat G1 in competition pair G1 and R1 of Experiment I against its opponent R1 during the increasing FR schedules phase of that experiment.

The number of reinforcements obtained by an animal in a competition pair may most clearly designate its dominance or subordination, particularly when this dominance or subordination is defined in terms of which animal obtains the largest of smallest proportion of a common food source. Were this to be the only measure employed as an indicant of the degree of dominance-subordination behavior, a great deal of information relevant to the emergence and development of dominance-subordination behavior may be lost, information which may only be observable in terms of the lever press or time in the aperture measures. In addition, variables such as the size of an FR schedule on which animals are competing, or the relative efficiency

of the response topographies of the animals in a competition pair,
may prove to be possible controlling variables of dominance-subord-
ination behavior. These variables may also be only observable in
terms of the lever press or time in the aperture measures.

As the FI and FR schedules on which animals were competing ap-
proached the terminal FR 40 and FI 50 seconds schedules, the frequen-
cy of fighting increased in all competition pairs relative to the
frequency of fighting observed in competition sessions under the CRF
schedule. This phenomenon was reflected in terms of the submissive
postures measure. One possible explanation for this increased aggres-
sion is that competition on these higher FR and FI schedules produce
frustration, frustration in terms of one animal preventing the other
from entering the aperture as well as frustration generated by the
response requirements of the schedules themselves. Dollard et al
(1939) formulated the frustration-aggression hypothesis whose general
principle stated that frustration leads to aggressive action. It was
later necessary to correct the implications that aggression was the
only (or even an inevitable) consequence of frustration (Miller, 1941;
Sears, 1941), but experimental evidence gave abundant support to
the hypothesized linkage between experienced frustration and subse-
quent aggressive behavior.

A number of studies have demonstrated that higher FR schedules
induce intraspecies aggressive behavior in pigeons. Hutchinson, Azrin,
and Hunt (1968) have shown that aggressive behavior is also produced
in squirrel monkeys by FR schedules. However, the aggressive behavior
in this study was measured in terms of the frequency with which mon-
keys would bite a rubber hose, rather than aggression towards a

conspecific. It may be difficult to compare this technique of measur-
ing schedule induced aggression with the more "real life" situation
of attack on another monkey. Mechanisms such as posturing and threat
displays may not be released in this situation. These mechanisms are
of dicisive value in determining attack behavior in a natural setting.

In the first of the pigeon studies (Gentry, 1968), male white
pigeons were conditioned to peck a key for food reinforcement. These
birds were subsequently exposed to sessions of no reinforcement and
sessions in which they key-pecked on FR schedules. During the FR
reinforcement conditions, the pigeons attacked a restrained bird,
these attacks occurring primarily during the postreinforcement pause
following almost every instance of reinforcement. Except on the init-
ial days of these conditions, little or no aggressive behavior was
demonstrated during periods of no reinforcement. It thus seemed that
FR schedules of reinforcement had certain aggression producing char-
acteristics.

These results were supported by the findings of Cherek and
Pickens (1970). In this study pigeons which key pecked for food on
FR reinforcement schedules attacked restrained target birds when the
ratio value was increased, but not when the value was decreased. The
frequency of attacks peaked several days after the ratio value change,
and then gradually decreased to an original level. This would lead
to the conclusion that schedule induced aggression was transitory
and deminished as the birds became accustomed to the higher FR val-
ue. In another study, Knutson (1970) trained pigeons to key peck for
food on multiple reinforcement schedules which included components
of CRF. FR, and extinction. Attacks against restrained target pigeons

occurred during extinction after both CRF and FR reinforcements. Attacks also occurred occasionally during FR 25 and FR 40 schedules, but occurred frequently during FR 60 and FR 120 schedules. No attacks occurred during FR 15 and CRF schedules, implying that high FR schedules were required to induce frequent aggression.

A suggestion that FR schedule-induced aggression varies from one experimental situation to another may be implied by the findings of a study which employed rats as Ss. Gentry and Schaeffer (1969) found that aggressive behavior of water deprived female Sprague-Dawley rats increased relative to the baseline condition when these rats were exposed to an FR 20 water reinforcement schedule. However, the frequency of attack behavior observed on a FR 40 and FR 60 schedule was equal to or less than the frequency of attacks observed in the baseline condition. Attack responses were found to be equally probable in all segments of the interreinforcement interval, and were thus not confined primarely to the postreinforcement pause. This contradicts the findings of Gentry (1968) and Knutson (1970) in that attack behavior in these situations was most frequent during the postreinforcement pause and during extinction.

As in the Gentry and Schaeffer (1969) study, the aggressive attacks observed in the experiments employing FR schedules in this thesis were no more frequent during the postreinforcement pause than in any other segment of the interreinforcement interval. This may have been due to the experimental situation employed, in that the experimental situation used in these experiments involved two animals fighting each other, rather than one individual aggressing against a restrained opponent. Often the individual not pressing the lever, the

subordinate animal in terms of this measure, would initiate and win the fight. However, the level of aggression increased as either the FR or the FI schedule on which animals were competing was increased, suggesting that the aggression observed in these experiments may have, at least partially, been schedule induced.

The measure of aggressive behavior, the number of submissive postures exhibited by each rat in each pair during competition sessions in all phases of the experiments, did not consistently correlate positively with the other three measures of the degree of dominance-subordination behavior employed in this thesis. This may suggest that dominance behavior is not a unitary phenomenon, but that the dominance of an animal varies, depending upon the measure used to ascertain it.

In Experiment I, rat R1 was dominant in terms of the lever press, time in the aperture, and number of reinforcements obtained measures following the FR 32 schedule. Its opponent G1 was dominant in terms of the submissive postures measure until the last 5 sessions of the terminal FR 40 schedule, sessions in which rat R1 became slightly dominant in terms of this measure. Rat G2, the dominant animal in the other competition pair of this experiment, was highly dominant in terms of the submissive postures measure in the CRF, increasing FR, and the terminal FR 40 schedule phases. However, in terms of the alternative three measures of dominance-subordination behavior, its opponent R2 was slightly dominant during the CRF baseline sessions and the initial three FR schedules of the increasing FR schedules phase.

In Experiment II, one rat in each of the two competition pairs was clearly subordinate in terms of the submissive postures measure

during competition sessions on the FR 40 schedule. These same rats were clearly dominant in terms of the alternative three measures following the initial two competition sessions. In Experiment III, competition pair G5 and R5 exhibited a consistent degree of dominance-subordination behavior in terms of all four measures. However, in the second competition pair of this experiment, the subordinate animal in terms of the submissive postures measure was marginally dominant in two out of the three alternative measures of the degree of dominance-subordination behavior. Finally, both competition pairs of Experiment IV failed to exhibit a clear and consistent degree of dominance-subordination behavior in terms of all four measures with the exception of competition pair G8 and R8, in which animal R8 was clearly dominant in terms of the submissive postures measure.

This lack of positive correlation between aggression and the other three measures of the degree of dominance-subordination behavior is supported by the findings of Seward (1945c). In experiment 2 of this study, one rat competed with another for food at a hole which could accomodate only one animal at a time. It was found that aggression seemed to be independent of food competition. The rat which was successful at the food hole was most often the loser of fights. Little if any relation appeared between dominance established by fighting and success in obtaining food. Uhrich (1938) found the same to be true of mice in a similar experimental situation.

It seems reasonable to expect the animal which was dominant in terms of the lever press, time in the aperture, and number of reinforcements obtained measures to be also dominant in terms of the submissive postures measure. In fighting between animals competing for a

common food source, the winner of these fights would be expected to control the food source, which in these experiments meant control over the aperture containing the food lever. The data from the four exper- iment of this thesis do not consistently support this intuitive not- ion. One possible hypothesis to explain this discrepancy between the submissive postures measure and the other three measures of the degree of dominance-subordination behavior center around the concept of territoriality.

The social system of the rat is territorial rather than hier- archial. Although dominance-subordination relationships do exist be- tween members of territorial societies, they appear only when conflicts occur over a common food source or a territory. Fighting between mem- bers of such territorial societies fails to have the decisiveness typically observed in fighting between members of a hierarchial soc- iety. The outcome of a single or several conflicts would thus fail to establish the ridgid dominance-subordination relationships that are typical of hierarchial societies between members of a territorial society. Consequently fighting between rats would probably continue over long periods of time and the resulting dominance-subordination relationship would remain relatively unstable.

In a semi-natural experimental situation such as that employed by Calhoun (1962), a subordinate rat would avoid and run at the sight of a dominant animal. In the confined space of the experimental cham- ber employed in the experiments of this thesis, this avoidance behav- ior was not possible. Perhaps as a consequence of this, animals with- in a competition pair would have repeated fights, occasionally as many as 25 or 30 within a single 30 minutes session. Although there

was great variation within competition pairs, the defeats, ascertained in terms of the submissive posture exhibited by the defeated animal, would sometimes be suffered by one animal and sometimes by the other within the same competition pair during a single session.

A change occurred in the quality of fighting behavior between rats in competition pairs following the initial few fights. Fighting during the initial encounters was marked by an intensity which could be observed from the extreme pilo-erection of both animals, the arched backs, and the slow, tense, hip-throwing manouvering which would ultimately result in an explosion of squealling and tumbling bodies. One animal would eventually exhibit a submissive posture, its breathing spasmodic and labored, fending of the attack with all four feet while being immobilized against a corner or the floor of the experimental chamber by its teeth-chattering opponent. In subsequent fighting, little or none of these behaviors were observed. The subordinate animal would assume a submissive posture almost immediately and it seemed that it was "throwing the fight" at the first instance of physical contact.

The above considerations may provide a possible explanation for the discrepancies observed between the submissive postures measure and the alternative three measures of the degree of dominance-subordination behavior in pairs of rats competing to lever press for food on the higher FR schedules. As the ratio value of these schedules increased, one rat in a competition pair may have established the aperture and the immediately surrounding area as its territory, with its opponent claiming some or most of the rest of the experimental chamber as its territory. A rat could thus be dominant in terms of the

lever press, time in the aperture, and reinforcements obtained meas-
ures while still suffering defeats in conflicts with its opponent,
the opponent being dominant in its own territory. This is perhaps sup-
ported by the observation that much of the fighting took place at
some distance from the aperture.

Since it was of little value for one or the other animal in a
competition pair to occupy the aperture during most of the session
time in competition on FI schedules, this territoriality may not have
emerged under the FI schedule conditions. The aggression observed in
these competition pairs may have been "tactical" rather than expres-
sions of territorial defense. This notion is perhaps supported by the
observation that fighting within these competition pairs consisted of
the "holding down" or "wrestling" behavior described earlier in Exper-
iment III.

In Experiments II and IV bolus counts were taken during both
the individual and competition sessions on a FR 40 and FI 50 seconds
schedule respectively. The most consistent and striking aspect of
this data is that during the competition sessions on each of the two
schedules, no boli were dropped by any of the animals in three out of
the four competition pairs in these experiments. Either one or both
of the animals in each of these competition pairs regularly dropped
boli during the individual baseline sessions. In the fourth pair,
boli were dropped in only 3 out of the 21 FI 50 seconds schedule comp-
etition sessions, contrasted with regular boli dropping by each of
these animals in all 19 individual FI 50 seconds schedule baseline
sessions. Some aspect of the competition situation thus seems incomp-
atible with defecation.

In Experiment II the animals which were dominant in terms of the lever press, time in the aperture, and the number of reinforcements obtained measures, but which were subordinate in terms of the submissive postures measure, were the animals which dropped the largest number of boli during the individual FR 40 baseline sessions. In competition pair G3 and R3 of this experiment, the dominant animal R3 in terms of the first three measures dropped boli in 10 out of the 18 individual FR 40 baseline sessions. Its subordinate opponent G3 dropped boli in only 2 of these sessions. Similarly, in the second competition pair of this experiment, the animal which was dominant in terms of the first three measures of dominance-subordination behavior dropped boli in all 18 individual FR 40 baseline sessions. Its subordinate opponent dropped no boli during these same sessions. Thus, in both competition pairs, the animal which dropped few or no boli during the individual baseline sessions was the animal which was dominant in terms of the submissive postures measure and subordinate in terms of the alternative three measures of the degree of dominance-subordination behavior.

Both competition pairs in Experiment IV failed to exhibit a clear and consistent degree of dominance-subordination behavior in terms of the lever press, time in the aperture, and the number of reinforcements obtained measures. In competition pair G7 and R7 of this experiment, both animals dropped an approximately equal number of boli during the individual FI 50 seconds baseline sessions. This pair also failed to exhibit a clear degree of dominance-subordination behavior in terms of the submissive postures measure. In competition pair G8 and R8, the second competition pair of this experiment, rat

R8 dropped approximately twice the number of boli during the individual baseline sessions as its opponent G8. However, unlike the animals which consistently dropped the larger number of boli during individual sessions in Experiment II, rat R8 was dominant in terms of the submissive postures measure.

In Experiment II a consistency thus appeared between a larger number of boli dropped in individual baseline sessions by an animal and (1) its subordination in terms of the submissive postures measure and, (2) its dominance in terms of the alternative threee measures of the degree of dominance-subordination behavior. This relationship failed to emerge in competition pairs in Experiment IV. This difference may be attributable to the differing schedules of reinforcement employed in these two experiments.

Two of the effects of early handling are an increase in dominance in a food competition situation (Rosen, 1958) and a decrease in defecation after placement in a novel environment (Levine & Broadhurst, 1963). These findings may suggest that the high defecators in Experiment II should have been subordinate in competition to lever press for food. However, the situation in which these animals defecated was far from novel since each had experienced at least 17 sessions in the experimental chamber prior to the time when bolus counts were recorded. A repeated exposure to a novel environment is paralleled by a decrease in defecation. Consequently some other factor such as the individual response to the schedule on which these animals were lever pressing for food may account for the difference in the degree of defecation observed in these animals.

II. Conclusion

The data from the experiments of this thesis suggest the following conclusions:

1. The degree of dominance-subordination behavior exhibited by pairs of rats competing to lever press for food on a CRF schedule tends to become small and inconsequential as the sessions under this condition progress (in terms of response rate or time in the aperture). This experimental procedure will thus minimize the degree of dominance-subordination exhibited by pairs of rats competing for a common food source (see Experiments I and III).

2. The degree of dominance-subordination behavior between two animals is maximized and most ridgidly maintained on FR schedules approaching or equal to the terminal FR 40 schedule (in terms of response rate, time in the aperture, or reinforcements obtained). These experimental procedures will thus maximize the degree of dominance-subordination behavior exhibited by pairs of rats competing for a common food source (see Experiments I and II).

3. The experimental procedure of Experiment II, in which pairs of rats competed on an FR 40 schedule following individual FR 40 schedule sessions, seems to be the most efficient technique, in terms of experimental time and effort, by which to establish a large and consistent degree of dominance-subordination behavior in pairs of rats (in terms of response rate, time in the aperture, or reinforcements obtained). The procedure of Experiment I in which pairs of rats compete first on a CRF, then on an increasing FR, and finally on an FR 40 schedule also produces a large and consistent degree of dominance-

subordination behavior during the higher FR schedule competition sessions. However, the preliminary phases of CRF and increasing FR schedules seem unnecessary to produce the desired phenomenon, i.e. a large and consistent degree of dominance-subordination behavior.

4. The degree of dominance-subordination behavior exhibited by pairs of rats competing to lever press for food on FI schedules is not consistent across all competition pairs, but is generally small and inconsequential (in terms of time in the aperture, response rate, or reinforcements obtained). These experimental procedures thus fail to establish a clear and consistent degree of dominance-subordination behavior in rats competing for a common food source (see Experiments III and IV).

5. Of the four dependent measures of the degree of dominance-subordination behavior employed in the experiments of this thesis, the response rate, the time in the aperture, and the number of reinforcements obtained, all consistently designate the dominance or subordination of one or the other animal in a competition pair. The fourth measure, the number of submissive postures exhibited during aggressive encounters between opponents, seems unrelated to the other three dependent measures. This finding suggests that dominance is not a unitary phenomenon, but that the dominance of an animal will vary depending on the measure employed to ascertain this dominance. Thus, dominance established in terms of winning aggressive encounters seems to be independent of dominance established in terms of success in food competition (see Experiments I, II, III, and IV).

6. The frequency of aggressive encounters is minimal during CRF schedule competition sessions. The frequency or level of aggressive

encounters increases as the schedule value of either the FR or FI schedules on which animals are competing for food increases, suggesting that the aggression observed in these experiments may have, at least partially, been schedule induced (see Experiments I II III, and IV).

7. When two subjects are placed together in competition, the one with the higher response rate in isolation will not necessarily be dominant (in terms of response rate, time in the aperture, or reinforcements obtained). In fact the opposite would seem to be the case for FR schedules (see Experiment II).

8. Animals which regularly drop fecal boli during the FR 40 or FI 50 seconds individual baseline sessions drop few if any boli during the FR 40 or FI 50 seconds competition sessions. This may suggest that the competition situation under both FR and FI schedules contains stimulus components which inhibit defecation (see Experiments II and IV).

9. In competition sessions on an FR 40 schedule, the dominant animal exhibits strong and characteristic FR lever press behavior while the subordinate animal does not (see Experiments I and II).

10. The characteristic FI lever press behavior exhibited by each animal in isolation on a FI 50 seconds schedule is disrupted during competition, eventhough in a particular session one animal's response rate might be higher than that of its opponent. This may suggest that characteristic FI behavior is disrupted in the competition situation (see Experiment IV).

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