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Performance Correlates of Social Behavior and Organization of Non-Human Primates

Annual Report

1 December, 1975 - 31 March, 1977

Bradford N. Bunnell

Joseph D. Allen

Supported by

U. S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND

Contract No. DADA 17-73-C-3007

Department of Psychology
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Athens, Georgia 30602

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS
BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

⑥ 4. TITLE (and Subtitle)
Performance Correlates of Social Behavior and Organization of Non-Human Primates,

⑨ 5. TYPE OF REPORT & PERIOD COVERED
Annual Report.
1 Dec. 1975 - 31 Mar. 1977,

6. PERFORMING ORG. REPORT NUMBER

⑩ 7. AUTHOR(s)
Bradford N. Bunnell and Joseph D. Allen

⑮ 8. CONTRACT OR GRANT NUMBER(s)
DADA 17-73-C-3007

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Department of Psychology
University of Georgia
Athens, Georgia 30602

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
U.S. Army Medical Research and Development Command
Washington, D.C. 20315

⑪ 12. REPORT DATE
31 March, 1977

13. NUMBER OF PAGES
30

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
⑫ 32p.

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution of this document is unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Social Behavior, Non-Human Primates, Operant Performance, Complex Learning Tass

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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As a group, subadult males have tended to perform better on all of the laboratory tasks we have used to date. It may be that these animals are simply adapting to the test conditions better than the adults and that they are bolder, or less conservative, in their response to new situations, potential hazards, and the like. We are testing this idea directly with the use of the open field situation. Data from T-troop obtained from the free exploration, bare-field situation, while still incomplete, strongly suggests that this is not the case - the younger animals have been much less willing to enter the field voluntarily, and their behavior in the arena can best be described as "cautious" in comparison with that of the older animals.

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Table of Contents

Summary, Abstract or Digest

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Forward

In conducting the research described in this report, the investigators adhered to the "Guide for Laboratory Facilities and Care" as promulgated by the Committee on the Guide for Laboratory Animal Resources, National Academy of Sciences - National Research Council.

Body of the Report

A. Social Behavior and Organization:

In December, 1974, 55 Java monkeys (Macaca fascicularis) that had been living together as a breeding group at the Yerkes Field Station in Lawrenceville, Georgia, were brought to our laboratories at the University of Georgia. They were divided into two groups of approximately equal size in such a way that familial relationships were kept as intact as possible. As originally constituted, one group, named "T-troop," contained three fully adult males, 6-14 years old, three 4-year old males, one 3-year old, one 2-year old, one 1-year old and one infant male; there were four old females (10-13 years), two 5-6 year old females, one 4 year old, two 3 year old, three 2 year old, three 1 year old and three infant females. In the fall of 1975 and winter of 1976, three adult males, 7-13 years old, were added to this group. The composition of T-troop, as of 1 December 1976, is given in Table 1a.

The second group, named "NT-troop," contained five adult males, 6-8 years old, two 4-year old, three 3-year old, one 2-year old, one 1-year old, and two infant males. There were four 12-13 year old females, two 5-7 year old, one 4-year old, one 3-year old, two 2-year old, two 1-year old, and three infant females at the time the group was formed. In the winter of 1976, one 7-year old male was added to NT-troop. The composition of NT-troop, as of 1 December, 1976, is given in Table 1b.

Each group of animals is housed in an outdoor compound 12.2 x 3.4 x 2.0 meters high. The compounds are connected to indoor quarters that are heated and air conditioned. Each indoor cage is 6.1 x 1.2 x 7.5 meters high; the runways connecting the compounds with the indoor cages are 1.3 meters wide and 1.3 meters high. Metal perches and water fonts are located in both the indoor and outdoor sections. Sections of metal fencing, placed lengthwise in the outdoor compounds, serve to provide partial separation of the animals and, in effect, to increase the living space of each group. An observation station, 1.5 x 1.6 meters in area and containing electrical power and plug in jacks for the keyboards system used in recording social data, is centrally located in each outdoor compound. Swinging doors provide passage between the indoor quarters and the runways and guillotine doors are located between the runways and the compounds.

Observations of social behavior (usually one hour per group, five times a week, weather permitting) are scheduled in accordance with the laboratory tests being conducted with the animals. In recording social behavior, the observers use a keyboard-tape punch system, entering the code for the animal exhibiting a behavior, the code for the behavior itself, and then the code for the animal toward which the behavior is directed for each event which occurs. The system automatically punches the time of occurrence of the behavior and a code symbol which identifies the keyboard on which the behavior was recorded. As many as four keyboards may be used with the system. Frequency, latency, durational information and response sequences may be obtained from the data tapes. Additional analyses provide response matrices for each animal with respect to every other animal in the group. The behaviors that are currently being scored with the Java monkey groups are given in Table 2.

TABLE 1

Composition of Java Monkey Groups as of 1 December, 1976*

MALES		FEMALES	
A. "T-Troop"			
Animal	Age	Animal	Age
Capone	16	Quail	15
Gus	12	Undies	12
Easy	14	Yerkes	15
Legs	9	Zelda	8
Madison	8	Juana	7
Weed	8	Nasturtium	6
Oliver	6	Zoe	5
Ralph	6	Bebe	5
Spiro	6	Genie	4
Cracker	5	Ogre	4
Nod	4	Queen	3
Yamamoto	3	Ural	3
Jesus	1	Whiskey	3
Sc	5 mos	Daisy	2
Vulcan	3 mos	Gorgeous	2
		Uxlob	3 mos
B. "NT-Troop"			
Ian	10	Naughty	14
Knees	9	Toad	15
Alabama	8	Victoria	9
Barker	8	Unanimous	6
Daque	8	Dusty	5
Eju	8	Kali	4
Quotation	6	Lily	4
Tag	6	Roberta	3
Yuk	5	Sabra	3
Aristotle	5	Cathy	2
Equal	5	Quiet	7 mos
Hobbit	4	Wind	2 mos
Telemachus	3		
Allen	2		
Horatio	1		
Kukla	1		
Pete	7 mos		
Rasputin	5 mos		
Tolstoy	3 mos		

* Males over 6 years old and females over 4 years old are classified as adults. Males 4-6 years old and females 4 years old are subadults (Angst, 1975).

Social rank is defined by defeats. The occurrence in any animal of a submissive behavior indicates that that animal is inferior in rank to the animal toward which the submissive signal is directed. The means by which one animal establishes and maintains dominance over another (e.g. by attack, threat, teaming up with another animal) may vary from animal to animal, from group to group, and from situation to situation. By recording and analyzing the social behavior of our animals, we define both the behavioral constancies and the range of variation seen in each of our subjects. This gives us a more sophisticated measure of social status and social organization than a simple assignment of rank. With such measures, the probability of detecting additional correlations between social behavior and performance on laboratory tasks is enhanced and the attempts to perform the essential causal analyses of these relationships will be greatly facilitated.

In the analyses of social behavior we are now using, each day's tape is initially analyzed by a PDP-8 computer which gives:

(1) A listing of the number of behaviors recorded for each animal for that observation period and a listing of the total frequency of occurrence of each behavior.
(2) A listing of the frequency with which each animal exhibited each behavior during the observation period.
(3) A listing of the frequency with which each behavior exhibited by a given animal was directed toward each of the other animals in the troop.

These listings are used to monitor day-to-day interactions in each group and to pinpoint changes in the relationships between individuals. A typical strategy is then to summarize the group relationships occurring before and after a major change in group structure by combining several days' data in a matrix analysis. In this procedure, the computer goes through all of the data and determines the social rank of each animal on the basis of who is defeated by whom, using the submissive behavior categories shown in Table 2. It then prints a series of seven matrices, using this rank order, in which the frequency of occurrence of each class of behavior we are interested in is given for each animal with respect to every other animal in the group. (At present we are limited to a 26 x 26 matrix, and infant behavior is not included). Four of these matrices are combinations of the behaviors listed under the functional categories Aggressive, Submissive, Sexual, and Other Social that are given in Table 2. For the other three matrices, we select any three individual behaviors that may be of interest to us - for example, we might select Lip Smack, Groom, and Sit Next To as behaviors for these three matrices.

An example of the matrices derived from the social data is given in Table 3. To conserve space, only the males that were undergoing laboratory testing are listed, and only the matrices for submission and aggression are shown.

TABLE 2

Java Monkey Behavior Categories

Agonistic Behaviors:

- Aggressive
  - Chase
  - Threat (open-mouth)
  - Charge
  - Slaps
  - Bites
- Submissive
  - Avoid
  - Grimace
  - Squeal
  - Flee
- Other Agonistic *
  - Lid
  - Lip Smack
  - Enlist

Sexual Behaviors:

- Sexual Present
- Mount (no thrusting)
- Mount (with thrusting)
- Masturbate
- Genital Manipulation (other animal)
- Genital Sniff

Other Social Behaviors:

- Present to Groom
- Groom
- Ventral-Ventral Hug
- Ventral-Dorsal Hug
- Sit Next To (physical contact with other animal)
- Play *

Non-Social Behaviors:

- Self Groom
- Move
- Sit - No Social

* "Lid", a flash of the white eyelids, "Lip Smack", and "Enlist" are scored, but are not currently used in the analyses described in the text. Lid is a part of the "pout threat" (Angst, 1975) commonly used by subordinate animals, lip smack is ambiguous and perhaps should not even be classed as agonistic, while enlisting occurs very infrequently in our groups. "Play" occurs only in infant and juvenile animals and is difficult to define reliably.

The top pair of matrices (A.) in Table 3, show the T-Troop males during the fall of 1975. The group is very stable, and there is very little aggression among the six males. There are no agonistic reactions between the alpha male, Capone ("B") and Madison ("C"), the second ranked animal. However, reference to the data from preceding months shows that Capone's dominance over Madison was established in April, 1975, was unsuccessfully challenged in May, and that Madison had submitted to Capone in every agonistic encounter they had during and after June. Some instability in the relationships between the three subadult males, Oliver ("D"), Cracker ("F") and Spiro ("E") is evident from the matrices.

On November 1, 1975, Weed ("U") an adult male was introduced into T-Troop. The second set of matrices, (B.) in Table 3, summarizes the males' behavior for 12 observation periods subsequent to the introduction. There was a marked increase in agonistic interactions among all of the males as Weed moved to second rank beneath Capone. Note that the relationships between Capone and Weed and Madison and Weed are not fully resolved and that the relationship between Madison and Gus ("A") has become ambiguous.

The final set of matrices, (C.) in Table 3, combines the data for the 11 observation periods we were able to obtain for December, 1975 and early January, 1976. (Another adult male was introduced into the troop on January 19, 1976). The amount of aggression among the males dropped substantially (although Gus had a few problems with Madison and Capone). Weed had established himself as the alpha male, the relationships among the three subadult males had stabilized, and the hierarchy was linear.

On January 19, 1976, Legs, another adult male, was introduced into T-Troop. Of the four adult males already in the troop, only Gus, the fourth ranked animal, showed much aggression toward Legs; nevertheless, Legs submitted almost immediately to all four. There was a substantial amount of submissive behavior directed toward all of the animals with a higher rank by Capone, Madison, and Gus; however, in contrast to Weed's introduction, there was virtually no aggression among the males in the established hierarchy - the exhibition of submissive behaviors seemed simply to confirm the existing relationships. Legs directed most of his aggression toward Oliver and Spiro; they submitted to him initially, but over the following two weeks they, and the other subadult male, Cracker, established and maintained dominance over Legs.

On January 29, 1976, a third adult male, Easy, was placed in T-Troop. Easy was very aggressive toward the other males, but submitted quickly to Weed (who, incidentally, showed no aggression toward Easy). The other males were aggressive both toward Easy and toward each other. Easy rose to second rank, followed by Capone, Madison, and Gus. However, the agonistic interactions between Gus, Capone, and Madison, whose relative ranks had been stable for 11 months, appeared to initiate a gradual rise in rank by Gus who, by August, 1976 had displaced both Capone and Madison.

TABLE 3

Aggressive and Submissive Behavior Matrices for T-Troop Males Before, During, and After Introduction of Weed*

(A.) OCT '75 (12 Days)

RANK	ANIMAL	CODE	SUBMISSION							AGGRESSION							
			B	C	A	D	F	E	Total		B	C	A	D	F	E	Total
1	Capone	B	–	0	0	0	0	0	0	B	–	0	0	0	3	0	9
2	Madison	C	0	–	0	0	0	0	0	C	0	–	0	0	1	1	7
3	Gus	A	3	3	–	0	0	0	6	A	0	0	–	3	1	0	10
4	Oliver	D	2	4	10	–	0	1	17	D	0	0	0	–	0	6	16
6	Cracker	F	5	4	6	0	–	1	17	F	0	0	0	1	–	1	5
8	Spiro	E	3	2	1	9	2	–	20	E	0	0	0	0	0	–	1

(B.) NOV '75 (12 Days)
Weed Introduced

RANK	ANIMAL	CODE	SUBMISSION								AGGRESSION								
			B	U	C	A	F	D	E	Total		B	U	C	A	F	D	E	Total
1	Capone	B	–	2	0	0	0	0	0	2	B	–	14	1	4	1	4	0	50
2	Weed	U	27	–	11	0	0	0	0	39	U	0	–	5	0	2	3	2	20
3	Madison	C	4	12	–	2	0	0	1	19	C	0	12	–	1	1	4	4	23
4	Gus	A	5	9	5	–	0	0	0	19	A	0	1	2	–	4	8	8	33
6	Cracker	F	8	10	5	13	–	0	0	37	F	0	1	0	0	–	1	4	13
9	Oliver	D	5	8	7	18	0	–	0	40	D	1	21	0	0	1	–	4	38
10	Spiro	E	1	3	6	14	2	5	–	35	E	0	0	2	0	0	0	–	7

(C.) DEC '75 - JAN '76
(11 Days)

RANK	ANIMAL	CODE	SUBMISSION								AGGRESSION								
			U	B	C	A	D	F	E	Total		U	B	C	A	D	F	E	Total
1	Weed	U	–	0	0	0	0	0	0	0	U	–	0	1	1	0	0	0	4
2	Capone	B	5	–	0	0	0	0	0	6	B	0	–	0	4	0	3	0	11
3	Madison	C	10	0	–	0	0	0	0	10	C	0	0	–	4	0	0	0	12
4	Gus	A	10	15	7	–	0	0	0	33	A	0	0	1	–	0	3	5	31
5	Oliver	D	2	1	1	1	–	0	0	5	D	0	0	0	0	–	3	2	10
6	Cracker	F	2	0	1	8	6	–	0	18	F	0	0	0	0	0	–	2	4
7	Spiro	E	0	7	2	7	7	2	–	25	E	0	0	0	0	0	0	–	3

* Ranks are determined on the basis of defeats. Data are given only for males being tested on laboratory tasks. Where ranks of males are not consecutive, adult females hold the intervening positions. Reading the matrix horizontally indicates the number of times the animal "does" the behavior to each other animal. Reading vertically gives the number of times the animal "receives" the behavior from the other animals. For example, in the November matrix, Capone ("B") submits twice to Weed ("U") and aggresses against him 14 times; Weed submits to him 27 times and Capone receives only one aggressive response, by Oliver ("D") during this period. The total number of responses directed toward <u>all</u> animals in the troop by each male is given at the right of each matrix in the "total" column. Further details may be found in the text.

In contrast to T-Troop, the hierarchy of males in NT-Troop has been somewhat unstable. There have been some "spontaneous" shifts in rank in the two years the group has been in existence and the experimental procedure of removing and then replacing different males has also resulted in rank changes. In fact, five of the six oldest males (Ian, Eju, Alabama, Knees, and Barker) have been the alpha male at some point during the past two years. Only Daque, who was not introduced to the troop until February, 1976, has not been a factor in the hierarchy shifts that have taken place. Overall, the frequency of aggressive responses between the males in NT-Troop is higher than it is in T-Troop.

The introduction of Daque, whose behavior toward the group was similar to that of Legs when the latter was introduced into T-Troop, provides another contrast between the two groups of animals. All of the males were very aggressive toward Daque, despite the fact that he was not aggressive and submitted to them almost at once. There was also a substantial increase in aggression among the five established males in the group. In other words, Daque was treated by NT-troop the same way the aggressive Easy was treated by T-Troop and Daque's introduction produced a similar increase in intermale aggression. The one similarity between the responses to Legs and to Daque was that the greatest amount of aggression directed at both new animals was exhibited by the lowest ranking adult male in each of the two groups.

At present, then, we appear to have two rather different groups as far as the male hierarchies and agonistic behaviors are concerned. On the one hand, T-Troop is relatively stable and exhibits less agonistic behavior by its adult males in comparison to NT-Troop. The alpha male in T-Troop is Weed, who is not very aggressive and who, while his rank is unequivocal, interacts relatively little with the other males and often seems to be in the group but not of it. Weed's behavior is of particular interest because he appears to be similar, in many respects, to what Angst (1975) has called a semisolitary dominant male. Semisolitary and other peripheral males, who are an important part of the social organization of wild troops of M. fascicularis, are rarely, if ever seen in captivity. According to Angst, it is impossible for a male to rise in rank as a peripheral or to become a dominant semisolitary animal because of the spatial limitations produced by confinement.

The relative instability of the hierarchy in NT-Troop may be a function of the age of the males. Ian, now 10 years old, is the oldest male and there is very little age range among the adult males in this troop.

As will be seen in later sections of this proposal, some of the relationships between social behavior and status and performance on laboratory tasks which we have uncovered hold for both T and NT Troops while others may be unique to one group or the other. While a failure to confirm a relationship found in one group when the other group is studied could mean that the relationship is spurious, it may also be attributable to the kinds of differences in group behavior and organization that have been noted above. Confirmation of the hypothesis that differences in social behavior and organization between groups can account for quantitative and qualitative differences in relationships between social and performance variables would be an exciting finding and an important first step in the causal analysis of these relationships. On the other hand, a failure to reject the null hypothesis in this case will lead us to concentrate on those social-performance relationships that cut across groups and will simplify our task by reducing the number of relationships to be analyzed.

We are currently in the process of removing and reintroducing males in both T- and NT-Troops in conjunction with the operant tests being administered to the animals. These experimental manipulations have been slowed by unusually severe weather conditions during the fall and early winter. (Social testing is not done during foul weather or when outside temperatures do not rise above 40° F during the day as the animals are too inactive and spend most of their time in the indoor quarters.) The disc storage system that was ordered last spring for use in computer data analysis has just arrived and is currently being programmed to give us more complete data analysis than has been practicable until now.

Once the scheduled social manipulations have been completed, we will have the data for an extensive analysis of the groups' social organization and dynamics and their response to the addition and removal of individual animals. The literature on social organization and behavior in wild and captive Java groups has recently been supplemented by two thorough papers on the subject; there is the one by Angst (1975) already mentioned and one by de Waal and his coworkers (1976). This gives us a good background against which to interpret our own data which, in turn, offers some interesting information about differences in group dynamics and structure and group response changes in composition. The de Waal, et al paper has stressed the importance of analyzing multiple animal agonistic interactions and not just dyadic interactions. Most studies of social behavior have concentrated on dyads, and our work is no exception. It will not be practical for us to concentrate on polyadic interactions - our group sizes, behavior inventory, observational procedures, and analysis capabilities are not now sufficiently sophisticated. Our present system does allow us to identify certain behaviors that can serve as markers for polyadic interactions, however. (Our categories of lip smack, lid, and enlist are related to the "sub-directed" behaviors of lip smack, pointing, and show-looking described by de Waal and we do take note of the presence of alliances between animals.) If it proves necessary, in terms of our major objectives of identifying and analyzing relationships between social behavior and laboratory performance, we can take the multiple animal interactions into account at some future date.

When T- and NT-Troops were formed, the age/sex composition of the groups was within the normal range of naturally occurring groups (Angst, 1975). Now, two years later, higher rate of female mortality, a preponderance of births of males, and the maturing of a substantial number of subadult males has resulted in an imbalance of age/sex ratios in both. During late summer, or early fall of 1977, when the laboratory testing scheduled for the coming year has been completed, we will remove some males from both groups to reestablish the age/sex ratios within normal limits. Some of these animals will be used to establish a third, all male, group, for use in testing hypotheses about social/performance relationships; the others will be held out for a time and then introduced to groups with which they have not previously been associated. This, too, will provide a vehicle for testing hypotheses about causal factors in social/performance relationships. (We have a compound that can be made available for a third group of Java monkeys).

B. Operant-Performance Tasks:

Meier and his coworkers (e.g. Bartlett and Meier, 1971) have looked at operant behavior in a communal group of rhesus macaques. Using Fixed-Ratio (FR) schedules for monkey chow (FR-32 for 22 hours a day) and fresh fruit (FR-16 for 2 hours a day) as incentives, they found that rate of bar pressing was significantly correlated with dominance status. The higher ranking animals responded at a slower rate. Individual differences in rate or intensity of response did not vary as a function of social context, suggesting that the differences might be quite stable, perhaps as a function of a history of differential learning of dominance related behaviors. (Dominant animals had priority at the manipulandum; they pressed at low rates, and paused to eat the food after it had been delivered. Subordinate animals would not respond in the presence of higher ranking animals; they pressed at high rates and would often resume pressing while eating a recently delivered piece of fruit).

The first reliable relationship between social variables and performance that we found was the result of studies using rhesus monkeys that were tested on a Fixed Interval 1-minute schedule (FI-1 min.). When reinforcements were omitted, randomly, after 20% of the intervals, the ratio of nonreinforced to reinforced responses (the so-call frustration ratio, or FR) was higher in high ranking animals than in low ranking animals. The details of this work have been reported in our previous annual reports, and a paper on this work is being submitted for publication (copies of the manuscript will accompany our current annual report).

When, in December, 1974, it became necessary to switch from rhesus to Java monkeys for the majority of the work on the project, we repeated the use of the frustration paradigm with the new species. T-troop males were adapted to the laboratory and trained on the FI-1 min schedule during the winter and spring of 1975, tested for "frustration" that summer, and then retested, during the fall and the winter of 1976 following the successive introduction of three adult males (Weed, Easy, and Legs) into T-troop. The nine T-troop males were shifted to a DRL operant task in the spring of 1976 and, after stabilization of DRL performance in the late summer of 1976, have been undergoing additional testing following removal and replacement of selected animals in T-troop.

Twelve NT-troop males were trained on the DRL schedule beginning in the late winter of 1975. Following stabilization of their DRL performance that summer, they were retested following removal and replacement of key animals in the group during the fall of 1975 and winter of 1976. They were shifted to the FI - 1 min schedule in the spring of 1976. FI performance did not stabilize until late summer, after which the frustration paradigm was introduced. As the final stage of the study, removals and reintroductions are in process, and, depending upon the weather, should be completed sometime in February, 1977.

1. Response to frustration:

Operant testing involves establishing a stable level of performance on a fixed-interval one-minute (FI-1 min) schedule of food reinforcement. (Criterion performance on the FI-1 min schedule is the achievement of an index of curvature (see Fry, Kelleher, and Cook, 1960) of .4 or greater for 14 consecutive trials. One session a day is given to each animal in which the animal receives 40 750 mg Noyes banana pellets under 100% reinforcement conditions. (The animals are given the remainder of their rations, consisting of monkey biscuits, vitamins, and fresh fruits and vegetables, after completing the daily tests. They are maintained at 90-95% of their free feeding weights). Once criterion is reached on 100% reinforcement, the frustration condition is introduced. Here, a probability generator is used so that only 80% of the FI intervals are randomly reinforced. Frustration behavior is defined as a disruption of normal fixed interval performance following the omission of reinforcement. This appears as an increased rate of response together with a partial loss of the scallop pattern normally observed with 100% reinforcement. As a measure of the effect, a Frustration Ratio (FR) - the ratio of responses following nonreinforced intervals to responses following reinforced intervals - is computed.

Shortly after T-Troop was formed, the six oldest males (three adults and three subadults) began training on the FI 1 min operant schedule. The index of curvature criterion was reached in early May, 1975 and testing on the frustration paradigm was begun. Twenty one days of testing on the .80 reinforcement schedule were given. The animals were then returned to 1.00 reinforcement on the FI schedule for 32 days. On seven occasions during this period, the frustration condition was introduced as a "probe." Intervals between probes ranged from three to seven days. The animals were then given daily frustration tests for nine days after which another adult male, Weed, was introduced to the group. Frustration testing continued from early November to the middle of January, 1976 at which time the adult male, Legs, was introduced to the group. Two weeks later, the last adult male, Easy, was introduced. Frustration testing continued through February 25 after which the animals were returned to 1.00 reinforcement. Two brief periods of testing on a .90 reinforcement schedule were introduced between March 1 and March 22 after which the animals began training on a DRL schedule. In the middle of May 12 adult, subadult, and juvenile males from NT-Troop were placed on the FI 1 min schedule. These animals did not meet the index of curvature criterion until September, 1976. They were given 40 days on the frustration paradigm with .80 reinforcement during which time two low ranking males were removed and replaced in the group. On November 29, 1976 the alpha male, Ian, was removed from the group. We had planned to keep him out for three weeks and then return him to the group; however, due to bad weather which has severely restricted social observations in December and the need to shut down operant testing for 10 days at the end of December and early January in order to install and program a disc system for the lab computer, Ian has not yet been reintroduced to the group. On December 15 Eju, the second ranked animal, defeated Knees, who had been alpha after Ian's removal, and is now ranked first.

The data from T-Troop are summarized in Table 4. The three subadult males tended to have the highest frustration ratios throughout the study. If they are considered as a subgroup, then the magnitude of their FRs reflects their relative rank prior to and during the first month after Weed's introduction and again at the end of the study, one month after the last adult male had been introduced. However, during December, January, and early February, no such relationship appeared. The separation of the experimental animals into adult and subadult subgroups may be questioned, but data from our other tests indicate younger animals, as a group, tend to perform somewhat differently from adults. This may be simply an age-dependent factor; however, we are examining the possibility that age-performance relationships reflect the different social environments and/or social roles of subadult, as opposed to adult, males.

From Table 4, it will be seen that, prior to the introduction of Weed, there was no evidence of a relationship between social rank and FR among the three adult males in T-Troop. Weed's rise to become the alpha male is accompanied by an increase in his FR, a result that was predictable from our earlier work with rhesus monkeys. Capone's increased FR was accompanied by a substantial decrease in responses/reinforcement (R/R); the same is true, to a lesser extent, with Gus. In early January, Weed's FR dropped, but this was accompanied by a sharp increase in responses/reinforcement; over the next two periods, covering the introduction of Legs and Easy, Weed's FRs increase, in spite of the fact that the higher R/R ratio is maintained. During the

TABLE 4

Social Rank, Median Frustration Ratios (FR) and Responses/Reinforcement (R/R) for Male Java Monkeys (T-Troop) *

Animal	Original Group			Weed Introduced									Legs Intro.			Easy Intro.			Last 2 Weeks		
	October			November			December			January			January			Jan-Feb			February		
	Rank	FR	R/R	Rank	FR	R/R	Rank	FR	R/R	Rank	FR	R/R	Rank	FR	R/R	Rank	FR	R/R	Rank	FR	R/R
Capone	1	1.70	79	1	1.97	61	2	2.19	33	2	1.97	37	2	2.08	18	3	1.51	47	3	1.40	42
Madison	2	2.30	4	3	1.70	3	3	2.22	2	3	1.96	6	3	2.49	4	4	1.85	9	4	1.85	10
Gus	3	1.57	13	4	1.56	8	4	1.76	8	4	1.73	9	4	1.50	10	5	1.87	8	5	1.55	9
Weed	-	1.68	6	2	2.04	5	1	2.77	5	1	1.73	18	1	2.00	16	1	2.23	18	1	1.80	14
Legs	-	-	-	-	-	-	-	1.43	8	-	1.95	11	5	2.16	11	9	1.95	11	9	1.85	9
Easy	-	-	-	-	-	-	-	-	-	-	2.18	17	-	2.06	20	2	0.65	3	2	0.99	7
Oliver	4	3.69	12	5	3.78	11	5	Subadults: 4.18	4	5	2.52	7	6	2.22	14	6	1.97	12	6	2.30	13
Cracker	5	2.99	8	6	3.52	4	6	-Ill-		6	2.66	7	7	2.47	9	7	2.02	8	7	2.10	7
Spiro	6	2.40	8	7	2.86	4	7	4.42	2	7	3.32	3	8	3.15	4	8	2.57	5	8	2.08	5

* Social rank is relative rank between males, not rank in entire group. (Oliver, Cracker, Spiro and Legs are often outranked by one or more adult females).

last two weeks in February, FRs overall are relatively low and there is no apparent relationship between FR and rank, although Weed's FR is higher than it was before he was placed in the group and the FRs of the original six males, who have all dropped two positions in rank, are somewhat lower.

However, the trends relating high FRs to high social status do not hold at all in the data from Legs and Easy (Table 4). Legs' FR increases after his introduction despite his defeat by the other four adult males in January, and by the three subadults during the period after Easy was introduced; his R/R increased slightly during this time. Easy, on the other hand, had a marked drop in both FR and R/R, despite the fact that he rose to second rank almost immediately. Because high baseline responding (R/R) may limit the magnitude of the FR, and because the FR may therefore be higher in animals with low R/R ratios, we have examined the nature of the relationship between FR and R/R in each animal. The results suggest that the nature of this relationship may be helpful in interpreting the FR - social status relationship. The correlations between FR and R/R are given below for the entire study:

Rank:	1	Weed	-.31
	2	Easy	+.96
	3	Capone	-.38
	4	Madison	-.46
	5	Gus	-.48
	6	Oliver	-.55
	7	Cracker	-.66
	8	Spiro	-.78
	9	Legs	+.88

In instances where high frustration ratios are associated with low response rates there is a strong relationship between the magnitude of the relationship and social rank. In other words, given a negative correlation, the more independent the FR is from the R/R, the higher the rank of the animal. High positive relationships, low FRs with low R/Rs and high with high, are not related to rank.

These relationships have been examined in the data we have obtained from NT-Troop. Once again, there were differences between adults and younger males and we again have treated them as subgroups in examining the data. Prior to the introduction of the frustration condition, we found a correlation of +.68 between high response/reinforcement and high social rank in the seven oldest animals. This correlation is nonsignificant with only 5 degrees of freedom ($p=.09$, two-tailed), but when we correlated R/R with number of submissive responses by the animals, the correlation was -.82, which gives a $p = .02$.

After the frustration paradigm was introduced, there was no apparent relationship between the magnitude of FRs and social status, but the relationships between FRs and R/Rs after Ian's removal line up pretty much as they did for T-Troop. The correlations between FRs and R/Rs for the six oldest animals (Quotation's data have not yet been analyzed) for 39 test days prior to and 20 test days after Ian's removal from the group are given below:

Rank on 11/29		r (FR & R/R)	Rank on 1/7		r (FR & R/R)
1	Ian	+.15	(out of group)	Ian	(-.32)
2	Knees	-.47	1	Eju	-.06
3	Eju	-.63	2	Knees	-.64
4	Alabama	-.44	3	Alabama	-.74
5	Barker	-.48	4	Barker	-.75
6	Daque	+.25	5	Daque	+.36

We are still analyzing the data from this group, including that for the remaining, younger, animals, and the social manipulations have not yet been completed; nevertheless, the preliminary indications are that the relationships between FRs and R/Rs will be similar to what we found in T-Troop.

A question may be raised as to the validity of the FR as a measure of the concept of frustration. For example, Staddon (1970, 1972) has argued that the frustration effect is not due to an increase in excitation following nonreward, but is explained by an inhibitory effect of reinforcement, so that nonreinforcement leads to enhanced responding. It appears to us that both disinhibition and increased excitation may be operating in the FI 1-min frustration paradigm. It also would appear that the relative importance of one or the other effect in determining the magnitude of the FR is different from animal to animal and it may well be that these are the differences that are related to our social variables. With the better means of data analysis provided by the recent addition of the disc system to our computer, we will be able to analyze the data from both groups in considerably more detail than has been possible in the past.

The complex relationships emerging from the attempts to relate social variables to FRs generated by the schedule and apparatus we have been using have prompted us to seek another task which will have greater face validity as a measure of the concept of frustration. To this end, a manipulandum has been developed for producing "frustration." This consists of a food hopper with a clear plexiglass door. Pressing on the door serves as the response, and the door is automatically unlatched when the schedule contingencies have been met. A food pellet is present and can be seen by the animal while it is working on the schedule. On reinforced trials the animal can obtain the food when the door is unlatched by the program. On nonreinforced (frustration) trials a solenoid opens the bottom of the hopper so that the pellet disappears just as the schedule requirements are met so that the door opens on an empty hopper. Responses (door presses) following nonreinforcement are used to compute FRs in the usual way. The hopper is to be used in conjunction with a variable interval (VI) schedule in order to provide a stable, high baseline R/R - this should simplify our analytical task considerably in comparison to the analysis of the FI 1-min frustration data.

After development of the prototype of the new manipulandum, the devices were installed on all six of our operant boxes last summer. The animals have adapted to opening the plexiglass door to obtain food while working on the FI 1 min and DRL schedules using a lever as the manipulandum. Tag, one of the young males in NT-Troop has been run as a pilot animal on the FI 1 min frustration paradigm using the hopper as the manipulandum in order to check the functioning of the device. He learned to beat the machine by hanging up the door so that it would not relatch after reinforcement. Modifications to the device have eliminated this problem and these modifications will be done to the other hoppers as soon as the animals finish testing on the current schedules. We will then run all 21 males from both groups concurrently on a frustration task using the new manipulandum in combination with a VI schedule.

2. Differential reinforcement of low rate and social behavior:

A second operant task used with the monkeys is the differential reinforcement of low rate (DRL) schedule with a limited hold (LH) contingency added to it. In the DRL 18-sec LH 5-sec program we are using, a response within a 5 second window beginning 18 seconds after the preceding response results in reinforcement. Shorter or longer interresponse times (IRTs) are not reinforced and merely reset the DRL requirement.

Typical performance on this schedule results in a modal interresponse time which just exceeds the criterion value, t. However, a significant portion of the total responses in a session consists of series of short IRTs (response bursts) which often occur following the emission of a nonreinforced response and are detected as a smaller, second, mode in the IRT distribution. It has been argued that these bursts are the manifestation of frustration resulting from the emission of a nonreinforced response which extends the temporal requirement to the next available reinforcement. For instance, DRL schedules are preferred less than VI schedules having equal reinforcent frequency when programmed on a concurrent schedule (Rachlin, 1973), and produce positive behavioral contrast in the VI component of a multiple VI DRL schedule (Bloomfeld, 1967). High "frustration" on the DRL schedule would be manifested by a correspondingly high response to reinforcement ratio. A relatively independent measure of timing efficiency would be provided by calculating the median and variance of the IRT distribution from which the response bursts in the first bin have been deleted.

Data from NT-troop males, presented in our last annual report, indicated that there were two relationships between DRL performance and social variables that were of potential interest. The males in this group were first trained by introducing them to a DRL 3-sec schedule once they had been trained on CRF. The DRL requirement was increased in steps and the LH requirement was introduced and gradually shortened until all animals were on the DRL 18-sec LH 5-sec schedule. One hundred five additional sessions were then given. During this training it was found that, among the five oldest males, there was a positive relationship between social rank and acquisition of criterion performance on the schedule. (Criterion was set at an "efficiency ratio" - response/reinforcement ratio - of $<$ 2.00).

A series of removals and replacements of key males then followed while the animals were being run on the DRL schedule. It was found that the frequency of aggressive responses emitted by a particular animal was positively related to response bursting (IRT/OPS for the first response bin); in other words, animals with a high frequency of aggressive responses showed more bursting, regardless of their rank. (Once again, this held only for fully adult males).

During the current year, the nine oldest T-troop males have also been run on the DRL 18-sec LH 5-sec schedule. It took them a long time to stabilize on the DRL schedule after being switched from the FI 60-sec frustration schedule and several of the adults never reached an efficiency ratio of less than 2.00. The alpha male, Weed, was removed from the group on November 19, 1976 and replaced on December 15. Easy became the new alpha and held his rank when Weed was replaced. Weed has since dropped to fourth rank below Capone and above Madison and the evidence is that he is continuing to fall as he has now been defeated by Oliver, the highest ranking of the three youngest males in the group.

During the three weeks prior to Weed's removal, there was a correlation of +.77 between rank and efficiency ratio for the six oldest males; with Weed absent, the relationship was +.80, and after his replacement, it was +.83. As rank has changed, so have the efficiency ratios. The relationship seen in NT-troop between response bursting and frequency of aggressive behaviors is also present and holds pretty well across all nine males, not just in the oldest six. Prior to Weed's removal, this correlation is +.77. With Weed out of the group, relationship pretty well disappears; however, there was relatively little aggression during this time. Following Weed's reintroduction, with its accompanying increase in aggression in the group, the relationship between bursting and frequency of aggressive responses returns (+.68). We have also found that removing and replacing low ranked males, including the older male, Legs, produced little or no aggression and no change in efficiency ratios or bursting occurs.

We plan one more removal and replacement of a high ranking male as soon as the social structure of the group has stabilized and weather permits. The T- and NT- troop results are generally consistent and the only thing that remains for us to do is to complete the detailed analyses of the relationships between all of the social behavior categories and the performance variables. One thing that is of particular interest is the finding that high ranking animals acquire and perform better on the DRL schedule than do other adult males. This is the only instance we have yet found in which efficient performance goes with high social status. (It should be noted that young animals, as a group, consistently outperform the older males on the DRL, just as they do on the FI 60-sec and on the WGTA tasks we have run to date. The best DRL performance of the older males has, with one exception, been worse than that of the subadult males).

C. Complex Problem-Solving:

The early work on this project with rhesus macaques indicated that high ranking animals had higher non-reinforced to reinforced response ratios than low ranking animals on the fixed-interval (FI), "frustration" operant schedule. Analysis of these data indicated that the high ranking animals had a lower number of responses per reinforcement than subordinate animals. The lower baseline response frequencies of the higher ranked animals indicated that the animals were performing very efficiently on the FI schedule. This suggested an alternative to a frustration interpretation of the operant results: Perhaps the higher "frustration ratios" of the dominant animals occurred because a given increase in response rate following nonreward produces a higher ratio of nonreinforced to reinforced responses when superimposed upon a low baseline than it does on the higher baseline of the lower ranking animals. If this is the case, then, the relationship between high rank and high frustration ratios might simply indicate that dominant animals are more efficient in dealing with the operant schedule. It may be argued that a monkey's social status is, at least in part, determined by his efficiency in relating to his environment and especially to the complex social processes operating within his group. This led us to propose a "behavioral efficiency" interpretation of the operant data which we would test by giving the animal some complex problem-solving tasks. We predicted that high ranking animals would do better on these tasks than low ranking animals. The results have been just the opposite of our predictions. (Subsequently, we have also found that reinforced response rates can vary independently of the frustration ratios - see the next section).

1. Visual discrimination reversal learning:

The discrimination reversal problem was chosen because it is one of the most widely studied and thoroughly analyzed tasks used in studies of animal learning, because it can be counted upon to reveal stable individual differences in performance, and because it is amenable to analysis in which differences in original learning are separable from reversal performance.

In a reversal problem, the cue value in a discrimination problem (usually a simple spatial or visual discrimination task) is reversed after either a performance criterion has been reached or some predetermined number of trials has been given on the problem. In the uncued reversal task we have been using the reversal occurs without warning so that the animal receives the cue to shift to the other response option only after it has responded on the first trial (unrewarded) of the reversed problem. A series of reversals are given. In primates, performance on a series of reversals results in an initial increase on the first few reversals followed by a gradual decline in errors such that later reversals are learned with fewer errors than was the original discrimination. Good performers will often reverse their choices after only one trial late in the series. The improvement in performance over initial learning scores is often interpreted as reflecting the development of a reversal learning set, or a win-stay, lose-shift strategy indicating behavioral plasticity or flexibility, a factor which may be of great importance in an individual's adaptability to varying demands in a social group.

Two studies, one on crayfish (Costanzo, Rudolph, & Cox, 1972) and one on rats (Costanzo, Henke, & Bosley, 1975) found that socially dominant animals were inferior to subordinates in learning reversal. It is of interest to the present work to note that Costanzo, et al., (1975) interpreted their results in terms of the hypothesis that submissive rats develop a greater magnitude of primary frustration in response to nonreward. This leads, according to Amsel's (1958) theory, to a more rapid conditioning of a fractional anticipatory component which represents the inhibitory mechanism which is developed as a consequence of nonreinforcement. Our results from the frustration studies suggested just the opposite - high ranking animals appeared to exhibit more primary frustration.

The animals were trained and tested in a modified WGTA which was fitted with a grey stimulus tray containing two food wells (4 cm in diameter, 1.25 cm deep, 15 cm apart, and 6 cm from the edge of the tray). The discriminanda were two wooden cubes (6 cm^3), one painted black and the other painted white. For all sessions, the monkeys were placed in an individual cage (60 X 60 X 70 cm) situated in another room. The WGTA was constructed such that when the door was raised, the stimulus tray was available via a space at the bottom of the cage

(5 X 33 cm). A plexiglass window (13 X 33 cm) was mounted just above this space.

General procedures for pretraining and the reversal task were: (a) raisins were used for reinforcers, (b) the intertrial intervals were 30 seconds (c) the response intervals were 20 seconds, and (d) sessions lasted for 40 trials or until 10 trials had gone by without a response. A 50-W bulb mounted at the top center of the WGTA provided the only illumination during the session.

Pretraining consisted of several stages. Training in each stage persisted until the monkey readily responded on 18 of 20 trials. First, in order to adapt the monkeys to the cage and the investigator, a single raisin was handed to the monkey approximately every 30 seconds. Second, the WGTA, with door open, was moved in front of the cage. Raisins were placed in one or the other food wells in a random order. The third stage was identical to the second, except that the door was raised at the beginning of each trial and lowered as soon as the raisin was retrieved. In the fourth stage, the door was raised, a raisin was placed in the food well, and one of the discriminanda was placed over the food well in full view of the monkey. The other food well remained uncovered. The monkey was required to move the discriminandum aside and retrieve the raisin. The position and color of the discriminandum was randomized. The fifth stage was identical to the fourth, except that the raisin was placed under the discriminandum while the door was lowered. When satisfactory performance occurred on the last stage, the session was ended and initial training began the next day.

At the beginning of the initial discrimination, one discriminandum was designated positive, and the other negative, in a random manner. For the remainder of the initial discrimination, a raisin was always under the positive stimulus, and never under the negative one. The position of the positive discriminandum was randomized with the stipulation that it would not appear in the same position for three consecutive trials. Training continued until the monkey made at least 36 out of 40 correct responses on two consecutive days.

The session after criterion was reached on the initial discrimination, the first reversal began. That is, the positive stimulus became negative, while the negative stimulus became positive. When the monkey reached criterion, the stimuli were reversed again. This was continued until a minimum of at least 12 reversals had been given to each animal.

Eight males from T-troop have completed 10 or more reversals. The rank order correlation between social rank and mean number of trials to criterion per reversal was +.79; rho for the five males in NT-Troop completing 10 or more reversals was +.80.

In other words, the higher the rank of the animal, the greater the number of trials required to meet criterion on reversals. Computing the correlation ratio for this data gave an $\eta = .94$ which yielded an $F = 6.83$, df 7,5 $p < .05$. (The correlation ratio allows us to combine the data from the two groups; the social ranks are classes of a variable, X, the variable Y is the mean value of trials to criterion for each social rank and the correlation ratio, the measure of association between the Y means and the X classification, is computed as the square root of the quantity: sum of squares between groups/total sum of squares).

Trials to criterion on initial learning were related to rank in T-Troop, but not in NT-troop. This is an interesting difference; it is possibly due to the fact that T had previous experience in the WGTA (they were run on the conservation problem - see next section) while NT did not. However, NT learned the acquisition task a bit faster than T, Mean trials to criterion were 103 for NT vs 155 for T, but the difference is not statistically significant. Analysis of the error factors, or strategies, used during acquisition showed no systematic differences between the groups. Thus, it does not appear that either positive or negative transfer of T's past WGTA experience accounts for the difference.

An analysis of error patterns (Levine, 1965) on the first reversal indicates that position preferences and perseverative errors are the most commonly occurring patterns in both groups. Random response shifts occurred significantly more often in NT than in T, however ($t = 5.61$, df = 9, $p < .01$). Error patterns over the first 10 reversals were dominated by position preference errors in both groups; the second most likely error pattern in T was the perseverative error, in NT it was random response shifts. T was slightly more likely to use win-stay/lose shift patterns within a reversal than was NT.

To further investigate the reversal-social behavior relationships, the animals of both groups, we have begun a new study in which the animals undergo cyclical extinction of reversal learning sets following the work of Meyer (1971). Meyer's finding that reversal learning following extinction resembles preset reversal learning gives us tool for studying the learning/social behavior relationships under conditions where we have altered the dominance hierarchy and social organization of our groups.

2. Other complex problem-solving tasks:

Our interest in the possible relationship between social rank and social behavior and what we have termed "behavioral efficiency" led to the selection of a "conservation" problem. (The concept of conservation (Piaget, 1968) involves the invariance of a characteristic, such as length, volume, number, in the face of transformations of an object, or set of objects, which possess that characteristic). The testing for conservation proceeds in four stages:

1. Using a modified WGTA apparatus, the animals are first given a sameness-difference problem. Two pairs of identical objects, in which the pairs differ in color, shape, and size, are used. Responses to one side are correct if identical objects are presented; responses to the other side are correct if different objects are presented.
2. A more complicated sameness-difference problem in which five pairs of five different colors, shapes, and sizes are used.
3. A transformational conservation task, using object length as the characteristic, is employed in which 50% of the trials are transformation trials and 50% are nontransformation trials. 50% of the transformation trials are identity transformations and 50% are difference transformations. The WGTA screen is open throughout all trials.
4. A static transformation conservation task which is identical to (3) above except that the WGTA screen is lowered between initial presentation of the stimuli and the transformation of the objects. (It is also lowered between first and second presentations of the stimuli on non-transformation trials.

This study was conducted with the six oldest T-troop males (3 adults and 3 subadults) that were in the group prior to the introduction of Weed, Easy, and Legs (the last three animals serves as pilot animals for the study). None of the animals reached criterion on the transformation task after over a year of testing and the study was terminated. The results from the various stages of the experiment indicated, however, that higher ranking animals did more poorly than lower ranking animals. Capone, the alpha male, was the poorest performer while Gus, the lowest ranking of the adult males and Spiro, the lowest ranking of the three subadults, performed best. Madison, the second ranked male, worked erratically, performing well for a time on a given stage and then regressing. Analysis of the response patterns indicated that both Gus and Spiro were quite flexible in shifting strategies and in transferring information from one stage to the next. Capone, on the other hand, was very inflexible, adopting a given strategy and then sticking with it despite its lack of payoff.

The study was run as a Master's thesis and the data are currently being prepared for presentation to the student's supervisory committee. Because of the extensive time required to test the animals, we do not plan to test NT-troop animals on the conservation paradigm. Instead, all animals will be run on an object-quality learning set task in combination with the cyclic extinction of reversal learning set problem mentioned in the preceding section. This will give us the opportunity to examine strategies and error factors in somewhat simpler situations than the one provided by the conservation task and will save us a considerable amount of time.

D. Open Field Testing:

A variety of tests are being run in an open field arena with all of the males that are undergoing our other operant and complex learning tasks. One of the earliest findings of the project was that animals with high social rank, when trained on a fixed interval-60 second operant schedule, showed a greater increase in responding than low ranking animals when some of the intervals were not reinforced. The omission of reinforcement on this schedule provides an operational definition of a "frustration" paradigm, and the ratio of nonreinforced to reinforced responses is sometimes referred to as a "frustration ratio." Whether or not the term "frustration" is a valid construct for interpreting the ratio of nonreinforced to reinforced responses, the possibility that there is an emotional component which is involved in the response to nonreward suggested that we look at individual animals' responses to novel situations and objects.

A square open field, 3.66 M on a side and 1.83 M high has been built inside the laboratory. The walls, constructed of asbestos cement board, and the concrete floor, are painted white; the floor is divided into 16 equal squares. The arena is covered with 2 in. chain link fence and illuminated by four 150 watt floodlights placed above the chain link ceiling. There are two guillotine doors, located at diagonally opposite corners of the arena which exactly fit the dimensions of the doors of our animal transport cages; a larger door, located along one wall, allows people to enter the arena to place objects in the field, and for cleanup. A platform is located along the outside of one wall which enables the observers to look down into the arena. The ceiling in front of the observer is covered with window screening, painted white, which provides an effective one way vision screen. The ropes controlling the guillotine doors are located at the observer's station, as is a keyboard which is connected directly into the laboratory computer across the hall. Punching the appropriate keys on the keyboard for the different behaviors exhibited by the animals, causes the data to be stored in the computer; at the end of a test session the data are punched onto paper tape using the same format employed in the social observations.

Animals are run for five consecutive days on each of the problems we have devised for use with the open field. The basic procedure is to bring the animal to the apparatus in a transport cage, open the guillotine door. Latencies for entrance into the field and for leaving the first square of the floor grid are recorded, as are returns to the transport cage, visual exploration of the arena while still in the transport cage, etc. When the animal leaves the first square, the guillotine door is closed and his behavior recorded for five minutes. At the end of five minutes, the guillotine door is reopened and both the time it takes him to reenter the transport cage and any intervening behaviors are recorded.

The test situations, in order of presentation, are as follows:

1. Completely empty arena.
2. Arena with piece of fruit placed 2 M directly in front of the guillotine door.
3. Arena with one inanimate object (stuffed teddy bear) placed in the center of the floor.
4. Arena with four novel inanimate objects spaced equidistant from walls and center of floor.
5. Arena with one of the four inanimate objects (4 above) replaced with a novel inanimate object.

Depending upon the results of the above tests, additional tests involving food, animate objects such as mechanical toys, or other monkeys may be employed.

The arena has been designed so that the Hebb-Williams series of maze problems can be run with the monkeys. This will provide us with another indicant of complex problem-solving behavior to supplement those we are obtaining from our WGTA testing program (see next section).

Pilot work on the procedures to be used in the various test situations is well along as this is being written, and actual testing on the first phase began the second week in February, 1977. The pilot data indicate that the latencies for entrance into the arena are rather long, particularly in young males, and while we hope the 21 males will complete one problem every two weeks, the time may have to be extended. We can, of course, go to a "forced," rather than a "free" exploration (e.g. Welker, 1957) situation for the later problems if it becomes necessary.

Conclusions and Recommendations

The work of the laboratory is providing a set of relationships between social behavior and organization on the one hand and individual differences in performance on a variety of operant and other learning tasks on the other. The relationships which are emerging suggest that: (1) There are individual differences in performance on laboratory tasks which are related to the ease with which a given animal can establish and maintain high social rank and (2) that performance on certain laboratory tasks is affected by day-to-day and week-to-week changes in, and pressures of, the social situation. It is our contention that poorer performance by the adults on learning and performance tasks is related to the pressures of the social situation. Older males, who are involved in the day to day maintenance of the group status and organization reflect this involvement in their performance on the laboratory tasks. We are in the process of analyzing all of our social data in relation to performance in terms of overall measures of social involvement, both agonistic and nonagonistic to see if such a relationship really does exist. A further test of this idea is found in the fact that a number of our animals, which were subadults when the project was begun, have now matured and are becoming more directly involved in the maintenance and changes of the hierarchy. Oliver, for example, has recently defeated Weed and may be in the process of moving even higher in T-troop - we are predicting that his performance on laboratory tasks is going to deteriorate; the somewhat older males, Legs and Daque, who are not factors in the agonistic interactions the groups, have a different relationship between FRs and R/R ratios on FI testing. (Easy is an exception to this trend, however). Overall, the general trend is apparent on the other tasks as well.

It is clear that both the social variables and the performance variables that we are dealing with are very complex. In order to dimensionalize the large body of data we have accumulated and will be accumulating, correlation matrices of the intercorrelations between performance and social variables will be computed and factor analyzed. Multiple regression equations will be derived from obtained factors using social rank and changes in social rank as criterion measures. The factors obtained will serve as hypotheses about the performance/social relationships which will guide our future testing as we attempt a causal analysis of these relationships. Several meaningful tasks have already been suggested on the basis of preliminary analyses.

The ability to "count" accurately would appear to be a meaningful component of behavioral efficiency, and would be particularly relevant to a social animal whose well being depends upon the accuracy of discriminating his position within the group hierarchy. A simple yet powerful measure of counting accuracy is provided by the change-over ratio schedule. A two-lever design is utilized in which a pre-set number of presses must be emitted on a FR-Count lever before a response on a second Change-Over lever produces a pellet. Responses on the Change-Over lever which follow an incorrect sequence length on the FR-Count lever reset the FR requirement which must again be met on the FR-Count lever. Efficiency is assessed by quantifying the median and variance of the resulting distribution of sequence lengths obtained over several sessions after performance has stabilized. This task will be introduced during the formation of the all male group described earlier; all three groups will receive the task during the same time period.

Finally, we may find it useful to use other tasks in order to test hypotheses about the obtained social/performance relationships. One such task will utilize a comparison of performance on a multiple VI EXT schedule. There is a response enhancement - "behavioral contrast" - effect which is quite reliable but which exhibits considerable individual differences from animal to animal. It will be of considerable importance if within-group variance on this measure is accounted for by social rank.

Bibliography

Angst, W. Basic data and concepts on the social organization of Macaca fascicularis. In Rosenblum, L. A. (Ed.) Primate Behavior, N.Y.: Academic Press, 1975, 325-388.

Bartlett, D. P. and Meier, G. W. Dominance status and certain operants in a communal colony of rhesus macaques. Primates, 1971, 12, 209-219.

Bloomfeld, T. M. Behavioral contrast and relative reinforcement frequency in two multiple schedules. Journal of Experimental Analysis of Behavior, 1967, 10, 151-158.

Costanzo, D. J., Henke, P. G., & Bosley, D. R. Reversal of visual discrimination problem and differential frustration effects in dominant and submissive rats. Animal Learning and Behavior, 1975, 3, 49-52.

Costanzo, D. J., Rudolph, G. R., & Cox, W. Social status and learning in crayfish. Journal of Biological Psychology, 1972, 14, 30-32.

Levine, M. Hypothesis behavior. In Schrier, A. M., Harlow, H. F. & Stollnitz, F. (Eds.) Behavior of Nonhuman Primates, Vol. I. New York: Academic Press, 1965, 97-127.

Meyer, D. R. The habits and concepts of monkeys. In Jarrard, L. E. (Ed.) Cognitive processes of nonhuman primates. N.Y.: Academic Press, 1971, 83-102.

Piaget, J. Quantification, conservation, and nativism. Science, 1968, 162, 976-979.

Rachlin, H. Contrast and matching. Psychological Review, 1973, 80, 217-234.

Staddon, J. E. R. Temporal control and the theory of reinforcement schedules. In R. M. Gilbert and J. R. Millenson (Eds.), Reinforcement: Behavioral analyses. New York: Academic Press, 1972.

Staddon, J. E. R. Temporal effects of reinforcement: A negative "frustration effect." Learning and Motivation, 1970, 41, 227-247.

Waal, F. B. M. de, Van Hooff, J. A. R. A. M., & Netto, W. J. An ethological analysis of types of agonistic interaction in a captive group of Java-Monkeys (Macaca fascicularis). Primates, 1976, 17, 257-290.

Welker, W. I. "Free" versus "Forced" exploration of a novel situation by rats. Psychological Reports, 1957, 3, 95-108.

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