Full Title: Effect of Environmental Enrichment on Singly- and Group-housed Squirrel Monkeys

Author's Full name, Degree, and Address:

Sarah E. Spring B.S.

Gravitational Research Branch,
Life Science Division
NASA Ames Research Center
Mail Stop 242-3
Moffett Field CA, 94035-1000

James O. Clifford Ph.D.

Gravitational Research Section
Lockheed-Martin Engineering, Science & Services
NASA Ames Research Center
Mail Stop 242-3
Moffett Field, California 94035-1000

David L. Tomko Ph.D.

Gravitational Research Branch,
Life Science Division
NASA Ames Research Center
Mail Stop 242-3
Moffett Field, California 94035-1000

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NASA Ames Research Center
Moffett Field, CA 94035-1000

Nonhuman primates display an interest in novel places, habituate to new situations, and spend most of their daily activity in the wild in large groups engaging in feeding behaviors. Captivity changes these behaviors, and disrupts normal social hierarchies. In captivity, animals may exhibit stereotypical behaviors which are thought to indicate decreased psychological well-being (PWB). If an animal's behaviors can be made to approach those seen in the wild, and stereotypical behaviors are minimal it is assumed that PWB is adequate. Environmental enrichment (EE) devices have been used to address the Animal Welfare Act's requirement (1985) that the PWB of captive nonhuman primates be considered. The purpose of the present study was to examine whether various EE devices improve the PWB of captive squirrel monkeys. The present study used behavioral observation to quantify the effectiveness of several EE devices in reducing stereotypical behaviors in squirrel monkeys housed singly or in groups. Results showed that the EE devices used did ***not*** affect the expression of normal or stereotypical behaviors, but that the type of housing did.

Squirrel monkeys (*Saimiri sciureus*) are arboreal primates that inhabit the under canopy of forests in equatorial South America. They have been subjects for a large variety of laboratory studies. In the wild, squirrel monkeys spend approximately 90-95% of their waking time during the day foraging and traveling within a home range greater than 250 hectares (1, 2). Consistent with their observed behaviors in the wild, captive squirrel monkeys display an interest in novel places, are quick to habituate to new situations, and often engage in repetitive foraging activities (3). However, captivity may restrict these behaviors, and disrupt the social hierarchy found in the wild (4, 5). In these situations, stereotyped actions, considered to be habitual patterns of responses, are often exhibited (6).

Foraging is also a social event which can occur in troops of 10-200 individuals (7, 8). In captivity, some research situations require housing animals in single cages, which allows easier access to subjects, but may affect the animal's natural behaviors. Single housing often provides the animals with visual, auditory, and olfactory contact, but may reduce their natural social interactions by restricting range or physically isolating them. This situation may affect their normal self-grooming and sexual activities, and result in abnormal behaviors (9-16). The range of behaviors is described in Table 1. In contrast, animals housed in groups must fit into social hierarchies which may be ambiguous and reduce species typical behavior (13, 17). In these cases, forming social relationships has been shown to reduce agitation (18-24).

Thus, captivity may affect the animals' psychological well being by restricting their natural behaviors. If so, this may potentially confound their contributions in the research projects they are involved in (18, 22, 25-27). A variety of environmental enrichment techniques, formulated in response to the 1985 amendment to the Animal Welfare Act (28), have been used to promote

the psychological well-being of captive primates. Interaction with these devices is thought to stimulate the animal independent of the consequences of interaction. Thus, the device's ability to engage and maintain the animals' interest independent of reward is the critical determinant of success. Non-human primates play an important role in scientific research. Therefore it is important to provide favorable environments for them to minimize stress and reduce the affect of psychological variables on data collection and interpretation. The primary goal of this study was to examine whether providing squirrel monkeys housed singly or in groups with enrichment devices significantly effects observed behaviors. In theory, interaction with these devices should redirect energy spent on stereotyped behaviors and/or increase species-typical ones.

Materials and Methods

Subjects

Nine adult squirrel monkeys were randomly selected for observation at the AAALAC-accredited Animal Care Facility (ACF) at NASA Ames Research Center at Moffett Field. Four were housed in single cages and five were housed in a group cage. The monkeys ranged from 2 to 18 years of age. Single caged animals had visual, auditory, and olfactory contact with other monkeys in the room. The single cages were arranged with two rows of four to six cages (45.72 x 64.77 x 77.47 cm) facing one another. The group cages consisted of two adjacent runs (1.27 x 2.44 x 2.03 m), each housing four to six animals of the same sex. All monkeys had free access to monkey chow and water, and animal care-givers administered fruit and treats daily. All animal husbandry and care was performed according to ACF Standard Operating Procedures. The room lights were on a 12L:12D cycle.

Enrichment

Standard primate enrichment devices were provided to the animals. Each cage was equipped with a puzzle board holding 10 peanuts (Primate Products, Redwood City, Calif.) and either a puzzle toss ball (Primates Products, Redwood City, Calif.), squeaky rubber dog toy (Ruff Toys, San Diego, Calif.), Kong toy (The Kong Company, Lakewood, Colo.), or a parrot carrousel treat dispenser (Jungle Talk International, Lafayette, Colo.) each containing 4 to 5 peanuts. Peanuts in the puzzle feeder were replenished daily, while the contents of the other devices were replaced once a week while the cages were cleaned. The monkeys' usual feeding stations were not altered. The enrichment devices did not interfere with the monkeys' usual diet, and no adverse behavioral consequences were either anticipated or observed when enrichment was introduced.

Observations

Pre- and post-enrichment behaviors were recorded over a one month period. Each animal was observed for seven ten minute periods prior to installing the enrichment devices, and seven after enrichment was introduced. The duration and frequency of behaviors were recorded and summarized individually for each monkey and then compiled into an activity budget using the categories listed in Table 1.

To avoid reaction to an observer's presence, the monkeys were habituated to the observer during three 10-minute sessions. All observations were made by the same person between the hours of 9:00 AM and 12:00 PM, from a distance no closer than one meter in front of each cage, and 24 hours after enrichment devices were stocked.

Results

Figure 1 shows the mean percentage of time that singly and grouped housed animals exhibited the behaviors described in Table 1, before and after addition of the environmental enrichment devices. All animals spent about 50% of their time being inactive, whether they had enrichment or not.

Figure 2 shows the proportion of the "active" time during which all other behaviors were observed. This figure shows that independent of enrichment, group housed animals spent a greater percentage of time grooming and locomoting than did single housed animals. In contrast, the singly housed animals spent a greater percentage of time exhibiting stereotypical behaviors than the group housed animals. Both groups spent similar percentages of time foraging. Enrichment decreased the percentage of time the group housed animals exhibited normal locomotion, but slightly increased this value for the singly housed animals. Enrichment decreased the percentage of time the singly housed animals spent exhibiting stereotypical behaviors, while it increased this value for the group housed animals.

Discussion

Using primates as biomedical experimental subjects usually limits their natural behaviors. Left unattended this may result in the animal exhibiting abnormal behaviors, which may indicate psychological problems that could negatively impact the animal's well being, or confound measurements in other systems (18, 25). Enrichment devices are thought to alleviate the expression of these behaviors by giving the animals objects to explore and/or tasks to gain control over (29, 30). For enrichment to be considered successful the animals must interact with it. Although observations were made for short periods, our results show that while the contents of the devices were taken, which shows

that the animals mastered the use of the devices, both populations spent less than two percent of their time interacting with enrichment. Because these animals had all acclimated to the presence of humans, this result may suggest that these devices are not challenging enough, or may reflect ethological observations that the squirrel monkey habituates quickly to novel experiences in its natural environment (3). In this situation the animals may have responded to the food rewards rather than to the device.

While the literature concerned with laboratory animals and the psychological response to different housing situations has documented the incidence of overtly displayed abnormal behaviors, these observations are not always related to the observations made in the wild that are often reported in the anthropologic literature, which has shown that the squirrel monkey spends a large proportion of its waking time foraging, grooming, and locomoting (1, 2). In this case inactivity may be considered a stereotypical behavior. If so, our results show that regardless of enrichment, both populations spent approximately 50% of their time inactive, which may have occurred because no new or challenging experiences were used to replace the ones to which the animal has habituated.

An important distinction between the two populations was that while the group housed animals spent more time grooming and being active, the singly housed animals spent more time exhibiting stereotypical behaviors. In neither case did enrichment lower the absolute values of time spent displaying any of these activities, with the group animals twice as active as the single, and the opposite noted for stereotypical behaviors. Thus, when not inactive or foraging, the group housed animals displayed more appropriate behaviors than the single ones. This result suggests that enrichment provided by social interactions experienced in the two types of housing may play a greater role in

maintaining the animals' psychological well being than does physical enrichment devices.

Our results suggest that because the squirrel monkey habituates quickly (3), the complexity of the enrichment device may play a critical role in promoting the psychological well-being of the subjects and reducing any possible confounds during experimental tests (31, 32). However, because the animals under observation mastered the use of these devices, these data may indicate that while any single enrichment device may be effective, the animal's fast habituation rate allows this benefit to last only a short time so the animals simply responded to the food reward. In these cases motivation to interact with the device may have been reduced after the food was gone because both groups received a normal diet and treats. This problem may be overcome if the challenge the device poses to the animal is varied, which would limit the animal's ability to habituate to any one experience. In this situation, the animals may interact with the device simply to master it, independent of any food reward. This capability is provided by the "puzzle" devices, and is necessary for the device to be considered enriching.

The issue of task challenge was discussed in Clifford and Tomko (ms in preparation) (33), who showed that when the device is too difficult, animals maintained an aroused physiological state rather than decreasing and returning to a state of "inactivity". However, in that experiment the device controlled the animals' diet, increasing the importance of interaction past that of simple cognitive entertainment. Thus, to ensure the effectiveness of any device, the balance between its being too simple and too difficult, and the consequences that interaction with it has on the animal, should be established.

The results of the present study indicate that the act of attaching an enrichment device to a cage, or putting a toy inside it, may or may not increase the "quality of life" of the animal in the cage. Before concluding that a particular device is efficacious, its effectiveness must be measured and quantified (29-32, 34-41). Towards this end, the apparent social benefits during group housing should not be overlooked as an effective enrichment tool. More research needs to be conducted on how various enrichment devices, with varying degrees of food reward, affect the behavior and well-being of the primates before psychological variables can be considered not to confound measurement in other systems.

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Figure and Table Legends

Figure 1. Histogram of the mean percentage of time that singly-housed (top) and group-housed (bottom) animals exhibited various behaviors before (open bars) and after (closed bars) addition of environmental enrichment devices.

Figure 2. The proportion of time the group-housed (open symbols) and singly-housed (filled symbols) animals spent displaying various behaviors as a percentage of the total time the animal spent being active, before (circles) and after (triangles) addition of environmental enrichment devices.

Table 1. Descriptions of behavioral categories used in data collection.

TABLE 1

BEHAVIOR	DESCRIPTION
Activity	Non stereotypic walking, climbing, jumping, or running.
Enrichment device use -use of puzzle board -use of cage toy	Holding, sniffing, manipulating, investigating, or foraging at enrichment objects.
Forage	Manipulating, holding, or biting pieces of food, or drinking. Also includes sifting through the litter in the cage floor in search of food.
Groom	Stroking, picking, or scratching at fur using a hand, foot, or mouth.
Inactivity	Sleeping, crouching, sitting, standing, or lying while otherwise inactive. The position of the trunk remains constant and there may be minor movements of hands, feet, or head.
Stereotyped locomotion	Swinging, somersaulting, body rocking, body twirling, head rolling, or abnormal behaviors head banging, self-clasping, strange limb and body posturing, digit sucking, eye poking, self-biting, complex hand gestures, head tossing pacing, back flipping, jumping repetitively on all fours, and other abnormal repetitive behaviors.

FIGURE 1

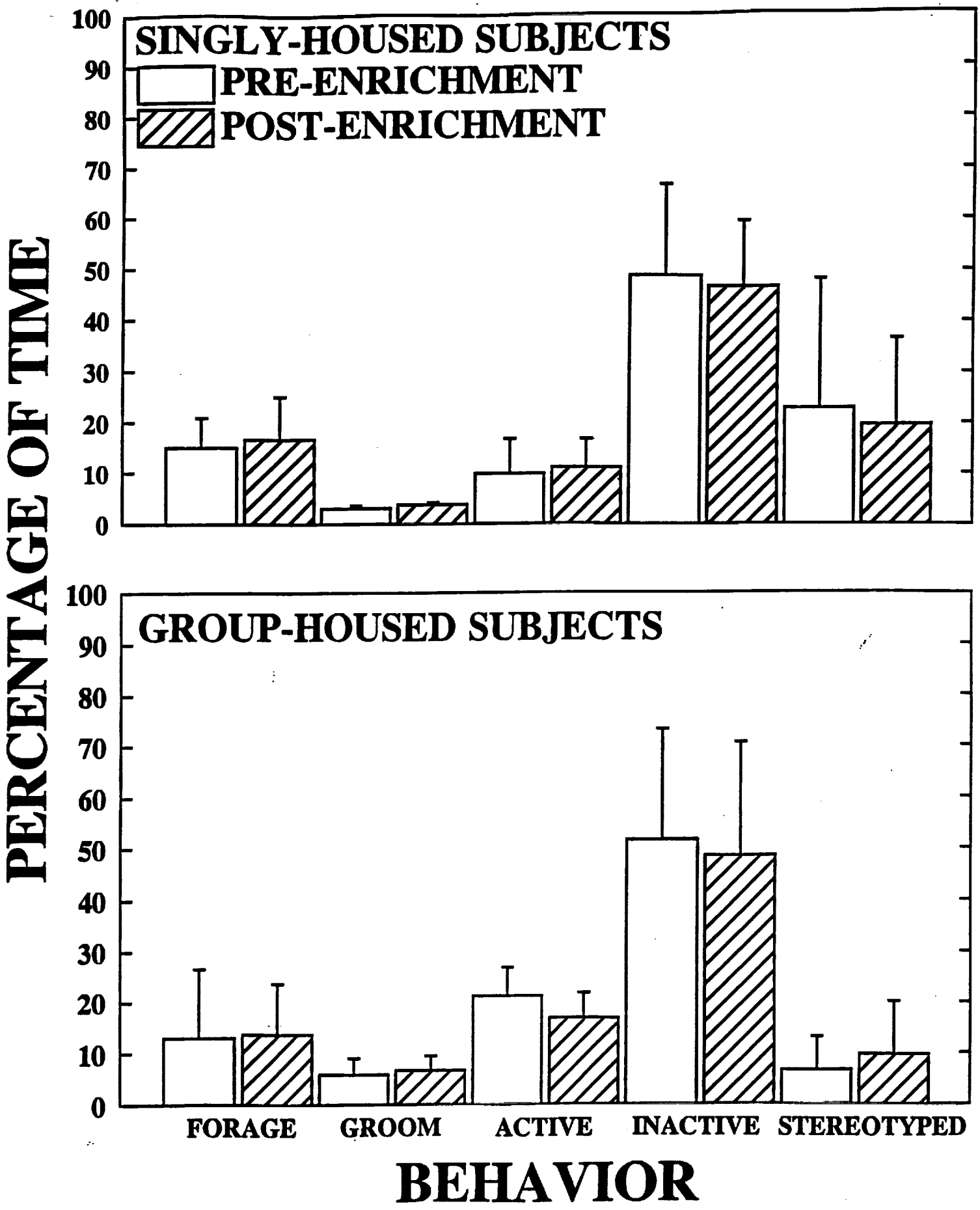
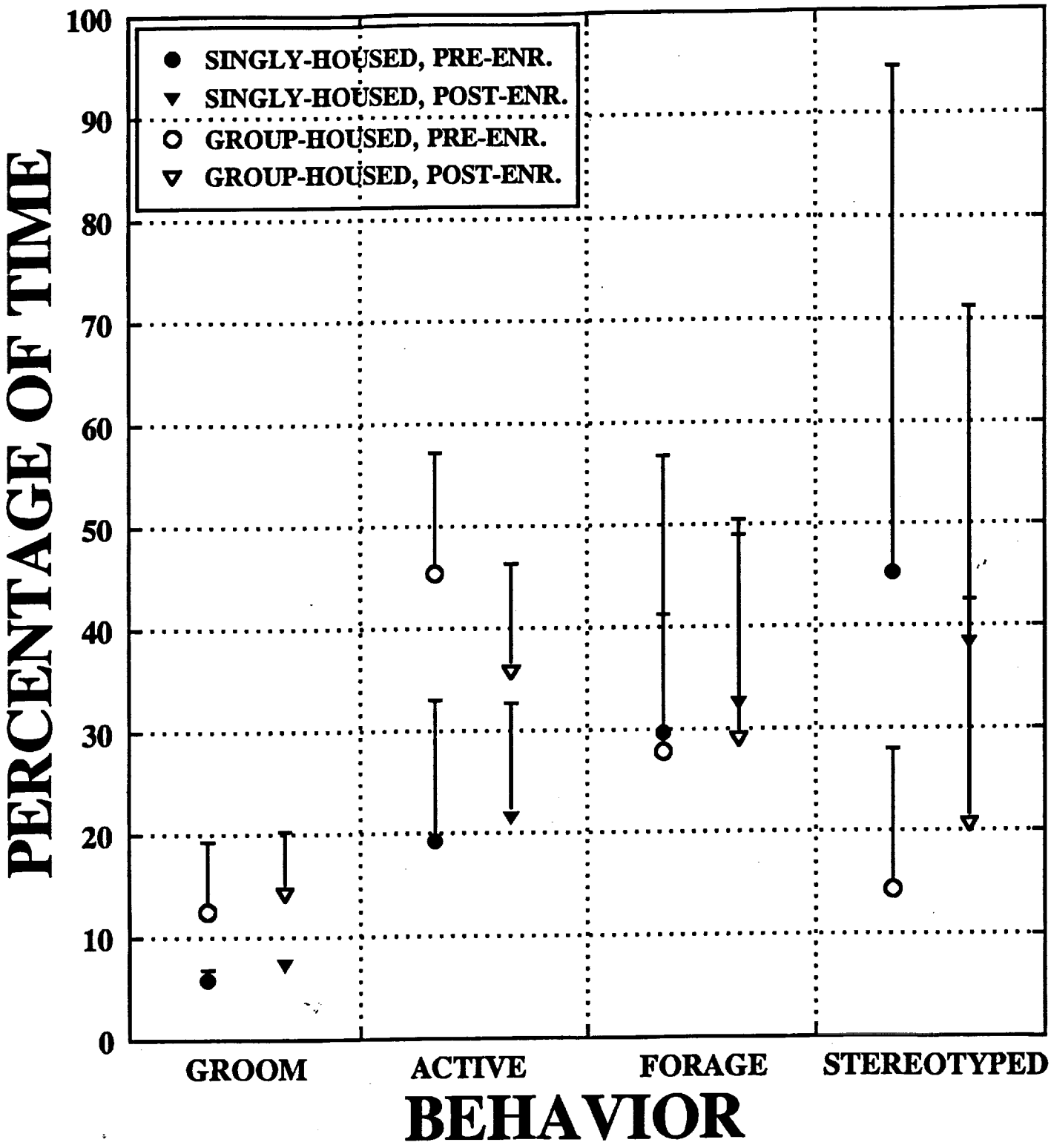

SINGLY-HOUSED SUBJECTS
PRE-ENRICHMENT
POST-ENRICHMENT
GROUP-HOUSED SUBJECTS
PERCENTAGE OF TIME
100
90
80
70
60
50
40
30
20
10
0
FORAGE
GROOM
ACTIVE
INACTIVE
STEREOTYPED
BEHAVIOR

FIGURE 2


SINGLY-HOUSED, PRE-ENR.
SINGLY-HOUSED, POST-ENR.
GROUP-HOUSED, PRE-ENR.
GROUP-HOUSED, POST-ENR.
PERCENTAGE OF TIME
100
90
80
70
60
50
40
30
20
10
0
GROOM
ACTIVE
FORAGE
STEREOTYPED
BEHAVIOR