

Final Report: Assessment of the behavioral effects of exposure to an expanded environmental enrichment program in baboons

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BACKGROUND

The systematic implementation of environmental enrichment programs began in earnest when amendments to the Animal Welfare Act in 1985 required researchers to actively promote the psychological well-being of nonhuman primates (Woolverton et al. 1989). Neither a specific definition of psychological well-being, nor methods of measurement, were provided by the amendments. It has been proposed, however, that the psychological well-being of nonhuman primates should be based on the needs of individual animals and may be determined by assessing physical health, opportunities for species-specific behavior, pathological behavior, and temperament (National Research Council [NRC] 1998). Specifically, species-specific behavior might include opportunities to forage for food, while signs of psychological distress may include self-injurious behaviors, repetitive and stereotypical movements, significant decreases or increases in food consumption, or any other radical change in behavior (Mallapur et al. 2003). Because primates that are physically or psychologically unhealthy make poor research subjects, and environmental deprivation may contribute to the development of abnormal cage behaviors (Bellanca et al. 2002; Mallapur et al. 2003), it is in the best interest of both researchers and their subjects to design an effective plan to promote the psychological well-being of subjects.

Enrichment devices currently available for non-human primate enrichment range from simple devices (e.g., rubber toys and mirrors) to complex devices (e.g., foraging boards and puzzle balls). Such things as phone books, cardboard tubes, or paper for shredding are also used for enrichment, while more complex enrichment plans may involve combinations of devices and activities. It has also been suggested that group housing nonhuman primates is beneficial (Eaton et al. 1994; ²Novak et al. 1991; Schapiro et al. 2000), although it may also increase aggression and the spread of illness (Woolverton et al. 1989). While creating a “natural” environment in the laboratory is not feasible, enrichment programs designed to promote species-specific behaviors and decrease abnormal behaviors reportedly aid in enhancing the psychological well-being of laboratory primates (Brinkman 1996; Fajzi et al. 1989; Hienz et al. 2002; ¹Novak et al. 1991; Schub et al. 2003). Moreover, exposure to complex environments reportedly has both mental and physical health benefits to nonhuman primates (Schub et al. 2003).

Environmental enrichment is clearly a fundamental aspect of all primate research programs. It is up to individual laboratories and research programs to develop and implement enrichment programs. There are no universally accepted standards for what components should comprise an enrichment program, and researchers are not eager to supply public information about issues in their own labs, as this exposes them to substantial political and societal scrutiny. Thus, the *essential* components of an enrichment program and how to measure the effectiveness of those components remains unknown. Human interaction, forage boxes, puzzle feeders, mirrors, kong toys, wood logs, and behavioral reinforcement are just some of the devices and procedures currently used for enrichment in the Division of Behavioral Biology (DBB) baboon colony. The goals of the present study were to create an area large enough for baboons to safely engage in free movement and exploratory behavior (i.e., exercising), and to characterize how exposure to this environment changes behaviors designated as indicators of psychological well-being in the home cage.

METHODS

Subjects

Six adult male baboons (*Papio anubis*; Primate Imports, New York, NY and South West Foundation for Biomedical Research, San Antonio, TX) served as subjects. The six baboons (BB, DC, SY, CY, DE and SC) had been subjects in numerous behavioral pharmacology studies in the Behavioral Biology Research Center and so had variable experimental histories. During the present study, subjects were participants in other ongoing behavioral pharmacology studies that included acute exposure to psychoactive compounds. Subjects were individually housed in standard stainless steel primate cages equipped with a bench running along one cage wall. The home cages provided 11.7 ft² of floor space (55.1 ft³ total space) and baboons had visual and auditory access to other baboons. The enrichment program in their home cages was not altered as part of the current study. Subjects had continuous access to tap water from a spout at the front of their cage and received a daily ration of laboratory animal biscuits, daily fresh fruits and vegetables, and a children's multivitamin. The overhead lights in the room were illuminated for 13 h/day (6:00-19:00 h) and then off for the remaining 11 h/day. This protocol was approved by the JHMI Animal Care and Use Committee and followed

the "Guide for the Care and use of Laboratory Animals" (1996). Facilities were maintained in accordance with USDA and AALAC standards.

In the Behavioral Biology Research Center, periodic cage washes (e.g., every two weeks) require baboons to be transferred out of their home cage and into a temporary cage via a "shuttle". After the shuttle is attached to the front of a baboon's home cage, the guillotine style doors on the cage front and shuttle front are lifted and the baboon is able to enter the shuttle. The doors are then shut and the baboon is transferred to a temporary cage while his home cage is washed. The same procedures are used to transfer the baboons back to their home cages. While using this shuttle system for the routine transferring of baboons during cage washes is not invasive in any way, some baboons consistently require coaxing to enter the shuttle. Typically, veterinary technicians will attempt to coax baboons into the shuttle with fruit and when this fails, the back wall of the home cage is cranked forward so baboons have no choice but to enter the shuttle. In these extreme situations, baboons may experience some level of stress associated with the cage wall being cranked forward.

Experimental Design

A single subject design was used in which each subject served as their own experimental control. In this way, a subject's behavior was measured before the intervention (i.e., exposure to enrichment room), during the intervention, and after the intervention in order to characterize how exposure to the enrichment room altered behavior. Two dependent variables were used to measure the effectiveness of exposure to the enrichment room:

1. *Cage/Abnormal Behaviors*: the frequency of cage/abnormal behaviors were systematically recorded by trained observers before the intervention by using checklists created for individual baboons. For example, the frequency of excessive grooming was recorded for one subject known to engage in that specific behavior, while the occurrence of a "huddled body posture" was recorded for a different subject. Prior to any exposure to the enrichment room, the frequency of cage/abnormal behaviors in home cage was recorded at pre-determined time points (i.e., two minute observations every hour for 8 hours) for at least three weeks. After subjects began spending time in the enrichment room the home cage observations occurred once per week.
2. *Shuttle Behavior*: the duration for subjects to enter the shuttle for transportation was recorded in multiple instances before any exposure to the enrichment room and then continued after exposure to the enrichment began. As noted above, for some baboons the routine transferring out of the home cage and into a temporary cage for periodic cage washes can become a stressful experience when the back wall of the cage must be cranked to get a baboon into the shuttle. The maximum duration to enter the shuttle was defined as five minutes, after which time the back wall was cranked forward to leave the baboon with no choice but to enter the shuttle.

Pre-intervention data (frequency of cage/abnormal behaviors, duration to enter the shuttle) were collected for at least three weeks prior to introducing subjects to the enrichment room. The baboons were then exposed to between two and three 30-min sessions in the enrichment room each week. Baboons were observed while in the room in order to record behavior and identify preferred reinforcers. Following the first exposure to the enrichment room, subjects were observed in their home cages once a week (2 min observations every hour for eight hours) to characterize the effects of enrichment room exposure on behaviors in their home cages.

Target Behaviors

Three baboons (BB, DC, and SY) were identified as exhibiting behaviors in their home cage where a decrease in the frequency may indicate improvement in psychological well-being. For baboon BB, pacing and circling in his home cage were identified as behaviors that may decrease after exposure to the enrichment room, thus indicating an improvement in psychological well-being. A "huddled" posture, operationally defined as sitting with chin on chest and being unresponsive to normal stimuli, was identified as a behavior where a decrease might signal an improvement in psychological well-being for baboons DC and SY. In addition, baboon SY was identified as engaging in excessive grooming, a behavior that when decreased may indicate improvement in psychological well-being. Behaviors where increases in the frequency may signal improvements in psychological well-being (playing with toys, lip smacking, and grunting), were also characterized for each baboon.

Three baboons (CY, DE, and SC) were identified as baboons that consistently required coaxing and/or cranking of the back wall in their home cage in order to transfer them in the shuttle for routine cage washes. Decreases in the duration required by these baboons to enter the shuttle would lower the stress levels experienced by these baboons when they are transferred from their home cage.

Enrichment Room Construction

Prior to the present study, the space designated for the enrichment room functioned as a laboratory storage room and had to be emptied of storage boxes and old equipment. The room has 145.8 ft² of floor space (663.5 ft³ total space), a fully functional sink, and a metal railing on three walls. After clearing the room, the door had to be converted such that baboons would be able to safely transfer in and out of the room using the shuttle system described above. In order to accomplish this without permanently altering the room, an aluminum door was made out of 3" x 1.25" 6061 architectural aluminum encapsulated by two 0.125" thick aluminum panels. The door was specially designed and fabricated to be multifunctional such that baboons could enter and exit without altering the ability of personnel to enter and exit the room in the absence of baboons. A sub-frame containing a door mechanism very similar to the one on the home cages was mounted in the center of the new aluminum door. The "cage front" frame was welded to the larger door frame and placed in such a way that the shuttle cage could be connected to the door. Once the shuttle is attached to the door, the guillotine style doors on the shuttle cage and "cage front" door are opened and the baboon can pass from the shuttle into the room, and back into the shuttle at the end of their enrichment room experience. When a baboon is not in the room, the aluminum door functions as any door would, allowing personnel into the room so that it may be cleaned between baboons. A wooden structure was also manufactured to block baboon access to the sink located in the room, though the structure is hinged, allowing easy access to the sink by personnel. Clearing the room, designing the door, manufacturing the door, and outfitting the room required a full year to accomplish.

Enrichment Room Procedures

Between 7 am and 12 pm (i.e., prior to daily feedings), individual baboons were transported from their home cage to the enrichment room in the shuttle. For baboons CY, DE, and SC, the duration to enter the shuttle was recorded. Each baboon spent 30 minutes in the enrichment room where they had access to numerous objects and toys approved for primate use including tires, plastic balls, trees, mirrors, wood pieces, knotted ropes, plastic chains, jolly balls, klinker balls, zoo balls, etc. A log book was used by technicians to describe baboon behaviors while in the enrichment room.

After 30 minutes had elapsed, the lights in the room were dimmed and the baboon returned to the shuttle for transportation to their home cage. In the event a baboon did not readily return to the shuttle, a technician placed a piece of fruit in the shuttle in order to coax the baboon into the shuttle. Despite coaxing with fruit, one baboon (SC) failed to return to the shuttle after entering the enrichment room. The veterinary technician was required to sedate the animal with a small amount of ketamine hydrochloride in order to remove him from the enrichment room. When this occurred at the end of his second entry into the room he was dropped from the study.

Data Analysis

The psychological well-being of non-human primates must be based on individual needs, thus, data is presented for individual baboons. As subjects were also participants in other on-going behavioral pharmacology studies, only data collected on days when no drug compounds were administered were included in the data analysis. The mean (\pm SD) for each measure and each baboon prior to exposure to the enrichment is described, as is the mean (\pm SD) for each measure and each baboon since the first exposure. T-tests were used to determine if changes in the mean frequency of a specific behavior, or the mean duration to enter the shuttle, were statistically significant for individual baboons after exposure to the enrichment room. As described above, an interval sampling procedure was used to characterize the frequency of a specific behavior in the home cage for one day. That is, the frequency of a target behavior for one day was operationally defined as the total number of episodes across the eight 2-min observations (one each hour for eight hours) that occurred in one 24-hr period. The mean frequency of the target behavior prior to the intervention was calculated using data collected across three weeks.

The data is also presented in graph form as the mean (\pm SD) frequency of each measure for each baboon prior to any exposure in the enrichment room (PRE) and the frequency of that behavior following each exposure to the room. In this way, patterns of change over time as a result of repeated exposure to the enrichment room may be detected. It should also be noted that data collection remains on-going.

RESULTS

For baboon BB, repetitive pacing/circling in the home cage was identified as the target behavior prior to the start of the present study. Using the interval sampling procedure described above, the mean (\pm SD) frequency of pacing/circling episodes in the home cage prior to any visits to the enrichment room was 2.19 (\pm 1.39) (see figure 1). Since the first exposure to the enrichment room the mean (\pm SD) number of pacing/circling episodes has significantly decreased to 0.62 (\pm 0.65) ($p < 0.001$).

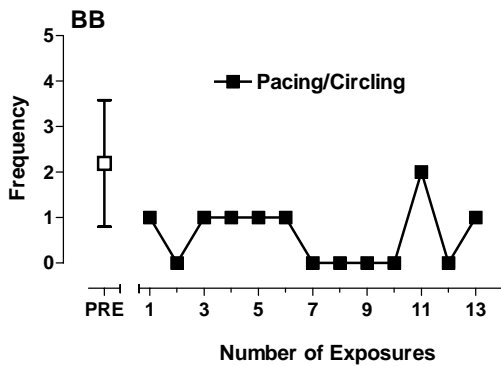
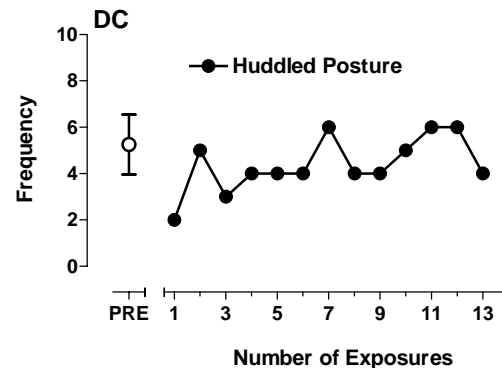


Figure 1. The frequency of pacing/circling episodes in the home cage of BB. Data are the mean (\pm SD) frequency obtained using an interval sampling procedure before exposure to the enrichment room (PRE), and the frequency observed following the corresponding number of exposures to the enrichment room.

For baboons DC and SY, a “huddled” posture was identified as a target behavior where a decrease following exposure to the enrichment room might indicate an improvement in their psychological well-being. As noted previously, the “huddled” posture is defined as sitting with their chin on their chest and being unresponsive to normal stimuli. For baboon DC, the mean (\pm SD) frequency of the “huddled” posture prior to exposure to the enrichment room was 5.25 (\pm 1.29). While the mean frequency since exposure decreased to 4.38 (\pm 1.19), the decrease is not significantly different ($p > 0.05$; see figure 2).

Figure 2. The frequency of “huddled” posture in the home cage of DC. Data are the mean (\pm SD) frequency obtained using an interval sampling procedure before exposure to the enrichment room (PRE), and the frequency observed following the corresponding number of exposures to the enrichment room



For baboon SY, the frequency of “huddled” posture observed in the home cage has significantly decreased since the first exposure to the enrichment room ($p < 0.05$). Before the first exposure to the enrichment room, the mean (\pm SD) frequency of a “huddled” posture was 1.88 (\pm 1.37) and since the first exposure to the enrichment room the mean has decreased to 0.75 (\pm 0.87). Figure 3 illustrates the change in the frequency of a “huddled” posture being observed for baboon SY.

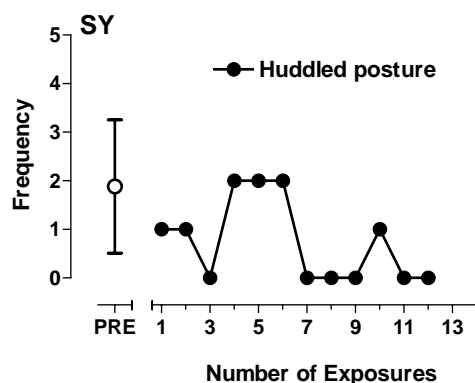
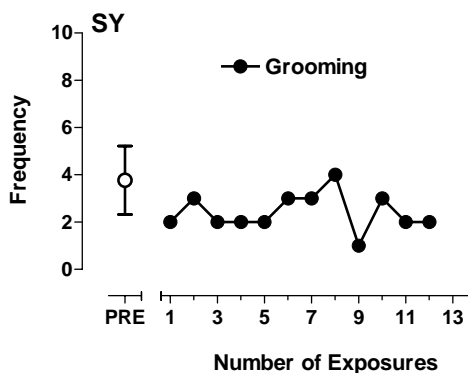


Figure 3. The frequency of “huddled” posture in the home cage of SY. Data are the mean (\pm SD) frequency obtained using an interval sampling procedure before exposure to the enrichment room (PRE), and the frequency observed following the corresponding number of exposures to the enrichment room

Excessive grooming was also identified as a target behavior for baboon SY where a decrease in the frequency may signal an improvement in his psychological well-being (see figure 4). The mean (\pm SD) frequency, using the interval sampling procedure, of grooming episodes prior to exposure to the enrichment room was 3.77 (\pm 1.45). The mean (\pm SD) frequency of grooming episodes since the first exposure decreased to 2.42 (\pm 0.79), a statistically significant decrease ($p < 0.005$).

Figure 4. The frequency of grooming episodes in the home cage of SY. Data are the mean (\pm SD) frequency obtained using an interval sampling procedure before exposure to the enrichment room (PRE), and the frequency observed following the corresponding number of exposures to the enrichment room



Behaviors where an increase in frequency might signal improved psychological well-being were also characterized. For baboon BB, there was a significant increase in the frequency of “playing with toys” in his home cage when the mean frequency before exposure to the enrichment room was compared to the mean frequency since the first exposure ($p < 0.001$). As shown in figure 5, the frequency since the first exposure to the enrichment room has increased, though it has been variable. Prior to enrichment room exposure, the mean (\pm SD) frequency of baboon BB “playing with toys” in the home cage was 2.27 (\pm 1.91), and since the first exposure the mean (\pm SD) frequency is 5.0 (\pm 1.58).

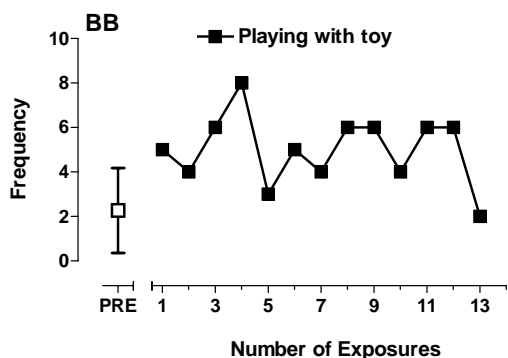
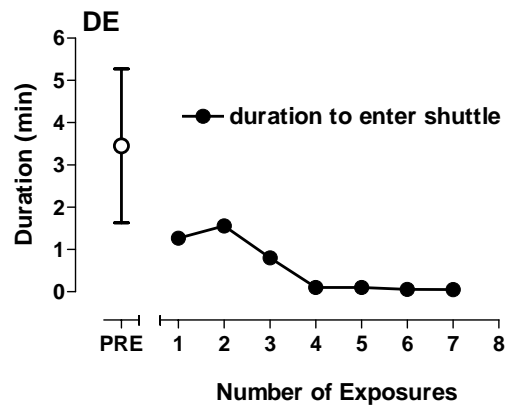


Figure 5. The frequency of episodes of “playing with toy” in the home cage of BB. Data are the mean (\pm SD) frequency obtained using an interval sampling procedure before exposure to the enrichment room (PRE), and the frequency observed following the corresponding number of exposures to the enrichment room.

Behaviors in the home cage that may signal improvement in psychological well-being when increased (i.e., playing with toys, lip smacking, and grunting) were not significantly changed after exposure to the enrichment room for baboons SY and DC.

The duration to enter the shuttle for transportation was characterized in three baboons (DE, CY, SC) known to require coaxing, and often cranking the back wall of the home cage, to get them into the shuttle. As shown in figure 6, baboon DE required a mean (\pm SD) duration of 3.45 (\pm 1.82) minutes to enter the shuttle prior to any exposure in the enrichment room. Since the first exposure, the mean duration to enter the shuttle has significantly decreased to 0.56 (0.64) minutes ($p < 0.001$).

Figure 6. The mean (\pm SD) duration (min) to enter the shuttle from the home cage for baboon DE before (PRE) exposure to the enrichment room and after the corresponding number of exposures. The maximum duration is 5-min, after which the back wall of the home cage is cranked forward.



There was no significant decrease in the duration (min) to enter the shuttle for baboon CY. The record does indicate that after the first exposure to the enrichment room baboon CY began grunting whenever the shuttle was present. As noted above, despite all the efforts of the technician, baboon (SC) failed to return to the shuttle after entering the enrichment room on two occasions. SC had to be sedated on those two occasions in order to return him to his home cage and so was dropped from the present study.

Conclusions

Ultimately, the objective of the present study was to improve the quality of life for baboons in our lab through exposure to an expanded environmental enrichment program. To accomplish this goal we first identified three baboons with behaviors where a decrease might signal an improvement in psychological well-being, as well as three baboons requiring excessive time to enter the shuttle required for routine baboon transportation. Following a characterization of behavior prior to any exposure to the enrichment room, these six baboons were exposed to 30-min periods of time in the enrichment room two or three days a week. Observations in the home cages continued to occur once a week. We found several indications that exposure to the enrichment room improved the psychological well-being of the baboons, including decreases in target behaviors designated as those that may be considered abnormal, and shorter durations to enter the shuttle for transport. Indeed, our data support the notion that at least three of the six baboons experienced a significant improvement in their psychological well-being after being exposed to the enrichment room. Although one baboon was dropped from the study because he required sedation to get him out of the room, it is entirely possible the remaining two baboons experienced significant increases in their psychological well-being that were undetected by our outcome measures. Moreover, because the design and creation of the enrichment room required a full year to complete, data collection remains on-going and significant behavioral changes may still emerge. In addition, by documenting the behaviors of the baboons while in the enrichment room, we were able to identify individual preferences of toys for individual baboons. This has resulted in more effective enrichment being provided in the home cages.

It is important to note that while the target behaviors may appear to occur at relatively low frequencies prior to exposure to the enrichment room, the true frequency of those behaviors would require observers to record behavior 24-hr a day. Since this isn't feasible, an interval sampling procedure was used to characterize the

frequency of the target behaviors (Arrington, 1937). For example, using the interval sampling procedure the mean (\pm SD) frequency of circling/pacing prior to exposure to the enrichment room for baboon BB was 2.19 (\pm 1.39). Although it may seem circling/pacing was occurring at a relative low rate, this mean was calculated from the frequency observed during eight 2-min intervals over a 24-hr period, and then averaged over three weeks of observations. In this way, we were able to manage the time required to collect data by using a valid and reliable interval sampling procedure.

Another goal was to simply increase the amount of activity baboons were able to engage in. Toward this goal, technicians have consistently noted in the enrichment room record that baboons spend a majority of time in the room moving around and “exploring”. Indeed, many personal observations about the benefits of the room for numerous baboons outside the present study have been described by technicians. One veterinary technician thought she was better able to monitor the healing of a surgery site (femoral site) in a baboon while he was in the enrichment room because he would periodically stand upright to explore the environment. When in their home cages baboons rarely extend their bodies such that surgery sites can be easily monitored, requiring baboons to be sedated for examination of the surgery site. Another technician noted that several of her aged baboons have become more mobile since spending time in the enrichment room. Similarly, while increases in behaviors indicative of psychological well-being (e.g., lip smacking and grunting) were not detected in the present study, technicians have noted that baboons being exposed to the enrichment room are more social in their home cages and engage in frequent grunting and lip smacking while in the enrichment room.

In conclusion, we are confident that participation in the expanded enrichment program, in combination with the established enrichment provided in the home cages, will continue to enhance the psychological well-being of the baboons in the Behavioral Biology Research Center. We will continue to collect data to support the notion that exposure to the enrichment room has positive effects on individual baboons.

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