Environmental Enrichment: Behavioral Responses of Rhesus to Puzzle feeders

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THE 1985 AMENDMENTS to the Animal Welfare Act required the United States Department of Agriculture to develop standards for a physical environment adequate to promote the psychological well-being of laboratory primates. With the adoption of these requirements came the impetus for considerable research efforts to develop an understanding of the criteria and techniques to provide for such enrichment.

Principal areas of investigation have centered on the complex issues of housing and development of behavioral tasks and equipment. In the arena of caging, there is considerable controversy over the physical dimensions required by the numerous species of captive non-human primates. The important relationship between the amount of living space and the quality of that space remains a very volatile issue. While perhaps not as emotional a question as cage requirements, there are also many views of how to provide living conditions which meet the intent of the amended Animal Welfare act.

Line and Houghton[1], among others, suggested that providing the opportunity for activities similar to behavior in the wild is one way to enhance the psychological well-being of laboratory primates. Activities of primates in their natural habitats revolve primarily around feeding-related behaviors, resting, and social interaction. Appropriate means for providing social interaction are intimately tied to the relationship between types of cage environments and the merits of individual and group housing and are outside the scope of this paper.

In his review, Line[2] reported that environmental complexity is a major factor in successfully enriching a primate's living conditions. He also raised the issue of the need to match species specific natural behavior, with development of apparatus or techniques applied to caged monkeys. Techniques employing devices or objects to foster environmental enrichment by prompting behaviors simulating naturally occurring behaviors cluster predominantly into two categories: simulated foraging activity and "cage toys," which encourage manipulation of non-food related objects. Items suspended from the cage ceiling, such as hard nylon balls[3], swings, and nylon ropes[4] have produced equivocal results. Jerome and Szostak[5] provided paired housed baboons with various types of "play" and "foraging" devices. While the play objects (balls, chains, and ropes) elicited activity, the foraging devices, such as raisin boards, were used more consistently. In our laboratory, we have observed that similar manipulative objects often tend to be ignored once the novelty has worn off. Similar findings have been reported by other investigators.[1,3,4] Bryant et al[6] concluded that maintaining a monkey's interest in the home cage, especially when social interaction is limited or unavailable, may require enrichment of the environment in a way that is "biologically meaningful to the monkey."

Mr. Bloom and Mr. Cook are both research psychologists at the Letterman Army Institute of Research, Division of Ocular Hazards, Presidio of San Francisco, San Francisco, CA 94129. Reprint requests should be directed to Mr. Bloom. *In conducting the research described in this report, the investigation adhered to the Guide for the Care and Use of Laboratory Animals, as promulgated by the Committee on Revision of the Guide for Laboratory Animal Facilities and Care, Institute of Laboratory Animal Resources, National Research Council. This material has been reviewed by Letterman Army Institute of Research and there is no objection to its presentation and/or publication. The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of Army or the Department of Defense (AR 306-5).*

Attempting to approach the goal of providing biologically meaningful activity, we felt that environmental enrichment may best be served by providing monkeys with a combination of foraging and manipulative activities. All who have worked behaviorally with monkeys know of their initial curiosity and interest in touching and manipulating new objects. We hoped that such interest would be extended if feeding behavior was made an integral component of a manipulative device. The Primate Products Puzzle Feeder appears to meet that requirement by combining a simulated foraging activity with the opportunity to manipulate an object within the cage environment.

Apparatus

The Primate Products Puzzle Feeder shown in Fig. 1 is a rectangular clear plexiglass box 12″ high × 6″ wide × 2″ deep. It is easily attached to the cage by means of plastic tie-wraps. The feeder can be left on the cage during cage washing, or can be quickly removed by cutting the tie-wraps. The five upper levels of the feeder are made from individual horizontal or vertical pieces of red or blue plexiglass, which can be arranged to form hundreds of maze patterns. The uppermost level was loaded with 10 whole peanuts in the shell. Fig. 1 and 2 show the task facing the two adult male rhesus monkeys (*Macaca mulatta*). Moving the peanuts through the maze required putting a finger through openings into the puzzle and pushing the food along a level until it dropped to the next lower row. When the peanut was moved through all the levels, it dropped to the bottom of the maze where it could be retrieved through a larger oval opening. Only one opening is available for removing the food, as the remaining finger holes are large enough only to insert one or two fingers. The Puzzle Feeder was placed on the front door of the monkeys' home cage, above the opening through which the monkeys gained access to their regular feeding of Purina Monkey Chow. The peanuts were a supplement to the normal feeding, with all testing occurring after the one morning feeding. The room contained eight single bank cages facing each other, four to a side. No attempt was made to control the possible distractions caused by the activity or vocalizations of the other monkeys in the room. The time taken to retrieve and eat all ten peanuts was measured by an observer in the room.

Although it is possible to arrange many maze patterns, we limited the complexity of the patterns in this study to increasing the number of horizontal levels through which the peanuts had to be pushed. The initial and simplest pattern required moving the peanuts across the uppermost row of the blue plexiglass pieces where the peanuts had been loaded. An opening in all the rows at one end allowed the peanut to drop to the bottom level where it had to be moved to the oval opening for removal. The level of difficulty was increased by closing the blank positions

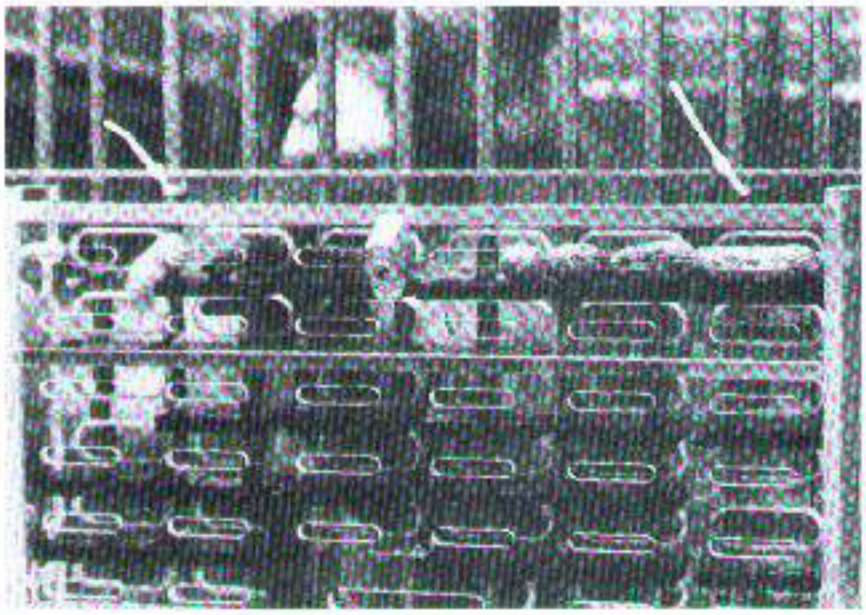


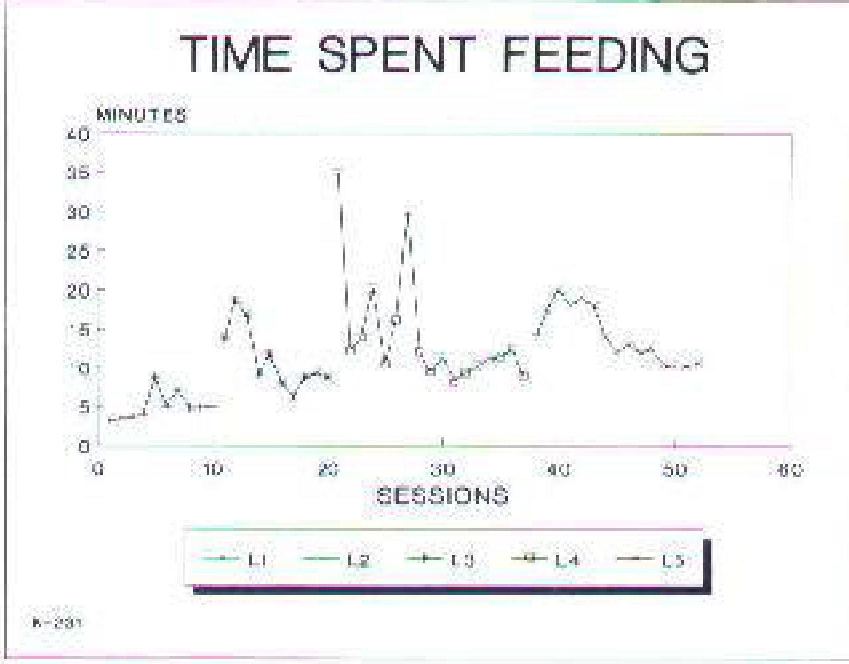
Figure 1. The Primate Products Puzzle Feeder attached to the front of the cage door. Rhesus N-231 can be seen pushing a peanut off the upper row. Holes on the outside of the feeder allow the handler to move the peanuts if the monkey requires assistance. No help was provided during the present study.

Figure 2. The task presented to the monkeys requires inserting a finger into successive finger holes to push the food through the maze. Cage design can pose problems if the spacing of the bars or grids prevents access to necessary openings. The configurations of our cages made retrieval of the food from the bottom opening somewhat difficult because two vertical bars partially covered the hole. Peanuts, however, were easily removed. Single-size Purina Monkey Chow biscuits have also been used, with removal being somewhat more difficult.

leading to the lowest level so the peanut would only drop to the next lowest row. This procedure added levels that had to be traversed, up to a maximum of five rows. The addition of new levels required the monkeys to move the peanuts in different directions across the full width of each subsequent row. Each particular maze level was maintained until the total time for completion remained nominally within 1 minute over three consecutive days.

Results

Data for the last three days at each maze level were analyzed using the BMDP 3V mixed model analysis of variance (BMDP Statistical Software Inc., Los Angeles,



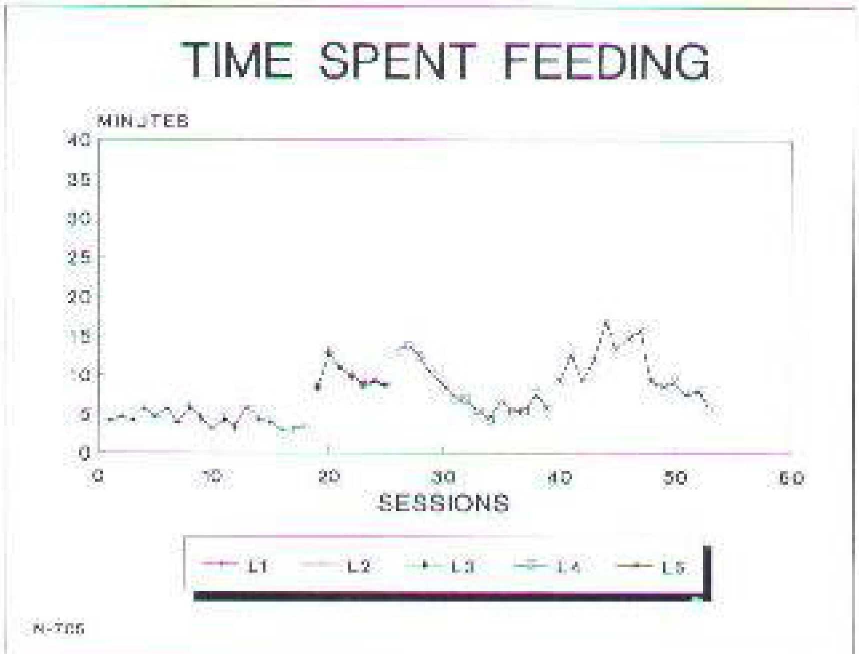


Figure 3. Puzzle feeder data for rhesus N-231. The total time in minutes to retrieve and consume 10 whole peanuts in the shell is displayed across sessions. The 5 levels of maze complexity are represented by L1 through L5.

Figure 4. Puzzle Feeder data for Rhesus N-705. Trends in the generalization curves for successive levels of difficulty are similar to those seen in Fig. 3. Individual differences are evident in the final times, with N-705 showing shorter durations. The success of N-705 resulted from his tendency to propel the peanuts across the rows with strong pushes and not pushing each peanut hole to hole as preferred by N-231.

CA) to perform a chi-square analysis. Individual differences exist in the amount of time needed to complete the maze at each level of difficulty (chi-square $= 9.741$, DF $=$ 1, $p = .002$). The number of days needed to reach asymptotic levels also differed between monkeys.

While individual differences do exist, it is evident in Fig. 3 and 4, however, that the learning curves for each monkey show quite similar trends. The transition between levels of difficulty in the maze are usually marked by large increases in the total time taken to consume the 10 peanuts. Though numerous distractions, caused by outbreaks of vocalizations from the remaining 6 monkeys in the room occurred while the two test monkeys were engaged with the Puzzle Feeder, the subjects never stopped working the maze to respond or join the vocal activity. As the complexity of the task was increased, each monkey required significantly more time to finish the task. The maximum duration following the transition to the next level did not, however, consistently occur on the first day of increased difficulty. When the maze difficulty was increased generalization was delayed, with maximum times occurring as late as 7 days following a transition. As completion times became stable, they remained elevated above those at the previous level. Significant differences (chi-square $= 70.121$, DF $= 5$, $p < .001$) between final times at each maze level reflect the added difficulty faced by the monkeys at successive levels.

On a few occasions the time for monkey N-231 to finish level 4 was in excess of 30 minutes. Even though average completion time was in the 10 to 15 minute range, the monkey persevered. While watching the monkeys work the maze, one could readily see that there was almost total absorption in the task; thus the longest completion times did not occur because the monkey merely ignored the maze for periods of time.

Discussion

One of the generally agreed upon requirements for any behavioral engineering apparatus is that it provide an opportunity for the animal to perform a preferred, biologically meaningful task. If, as Line[1] suggests, one method for enrichment is the use of devices that contribute to environmental complexity and stimulate activity, then the results of the present study suggest that the puzzle feeder may be an appropriate candidate for improving the psychological well-being of laboratory primates. Evaluation of the responses of the two rhesus monkeys made clear that the variable maze patterns presented the animals with a stimulus for activity that provided both environmental complexity and the opportunity to engage in behaviors, which simulate, to some extent, foraging activities seen in feeding behavior in natural habitats.

While purely manipulative devices and objects may draw the monkey's attention initially, these types of techniques have usually failed to maintain that attention for more than relatively short periods of time.[2,3,4] The inclusion of food into the environmental enrichment regimen, however, may provide strong motivation even if the food provided is not the animal's primary diet. The strength of such a stimulus can be seen in the report of an electromechanical cage device combining a radio and food dispenser[6] where daily response to the feeder by some monkeys exceeded 2000/day. A growing number of studies are reporting that primates prefer to "work" for their food, even when food is provided freely if the enrichment devices are not used.[2,7]

In our laboratory, we have seen a similar "work ethic" in monkeys involved in behavioral research. Some animals "prefer" to work for liquid reinforcements even when they are supplemented to a consistent level in their home cage. In this vein, we should not overlook enriching aspects of a monkey's participation in behavioral experiments involving positive reinforcement. With proper precautions and consideration for the monkeys, they are not merely subjects of experimentation but can be willing and active participants. The activities provided by such research contain many of the positive factors desired in environmental enrichment programs. The monkeys are presented with tasks which require attention and consistent response and provide opportunities to manipulate their environment by directly controlling the delivery of food and/or liquids.

In summary, we are gratified to see the interest the rhesus show using the puzzle feeder. We feel that the combination of tactile manipulation and foraging behavior serves as a valuable component of any program aimed at improving living conditions for laboratory primates. While the total durations reported in this study are relatively short, this study has not attempted to define the limits of the monkeys' use of the puzzle. The two monkeys involved in this study are currently using the puzzle feeders as a primary feeding device. Using standard single portion Purina Monkey Chow, feeding times have been extended from approximately 10 minutes without the puzzle feeder to a duration of 20-to-30 minutes when presented with the relatively low difficulty of Level 5. If the monkeys will continue to use the maze with more complex paths, perhaps the feeding times can begin to approach those seen in the wild. ■

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