Objective Evaluation of a Behavioral Enrichment Device for Captive Chimpanzees (Pan troglodytes)

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A quantitative evaluation was made of a food puzzle designed to be a behavioral enrichment device for captive chimpanzees. Subjects were two social groups of chimpanzees housed in semifree-ranging conditions at the University of Texas Science Park in Bastrop. Subjects used the device for a mean of 91.6 minutes after it was filled with peanuts. Group levels of agonistic interactions, displays, coprophagy, regurgitation, excessive grooming, and consumption of wood were not significantly altered by the use of the peanut box. However, the data indicate that some of these categories of behavior were significantly increased or decreased in individual animals. Although the food puzzle box appears to be a promising behavioral enrichment tool, the necessity of recognizing individual differences in response to environmental manipulations must be emphasized.

Key words: evaluation, captivity, food puzzle, husbandry

INTRODUCTION

The detrimental effects of environmental impoverishment on captive animals have long been recognized [cf Maple, 1979; Markowitz, 1982]. In 1925, Robert M. Yerkes noted that “the greatest possibility of improvement in our provision for captive primates lies in the invention and installation of apparatus which can be used for play or work” (p. 229). However, despite the pioneering work of Markowitz and others, the vast majority of captive animals still do not have access to behavioral enrichment devices.

In an effort to provide a convenient and cost-effective device, Riddle designed a “food puzzle box” for use by the chimpanzees in residence at the University of Texas System Cancer Center. The apparatus requires the animals to perform time-consuming manipulations to obtain peanuts or other desirable food items. This initial
study was an attempt to evaluate objectively the effect of such a device on the behavior of animals that were exposed to it. The importance of scientifically evaluating attempts to enrich captive animal environments cannot be over-emphasized. Without such evaluation, ineffective manipulations or possible negative consequences may not be recognized and would go unsolved. The beneficial outcomes of enrichment attempts should also be documented.

METHOD
Subjects

Subjects were two social groups of chimpanzees (Pan troglodytes) housed in semifree-ranging environments at the chimpanzee facility of the University of Texas Science Park in Bastrop. The facilities and colony management have been previously described [Riddle et al., 1982]. Each octagonal outdoor enclosure was 22m in diameter and contained a large climbing structure, movable objects, and natural ground cover. The animals had free access to an indoor area as well. All animals were housed under the routine care of staff at the time of this study. One group consisted of three adult males (age 20 to 23) and six adult females (age 16 to 18). The second group consisted of three adult males (age 16 to 18). The second group consisted of three adult males (age 14 to 18), four adult females (age 9 to 18), and one juvenile female. Three females in each group had infants present during the study.

Apparatus

The food puzzle box measured 50.8 cm in height, 55.9 cm in width, 6.9 cm in depth, and was made of standard 0.063 sheet aluminum (see Fig. 1). It was attached to the bars of a ventilation window in the wall of the outdoor compound. The box had three rows of five finger holes and a larger opening near the base intended as a location for the easy removal of peanuts (see Fig. 2).

The box contained two shelves that corresponded to the top two rows of finger holes. Each shelf had holes in it through which peanuts dropped to the next lower level. The hinged top of the box allowed filling from outside the enclosure.

The expected behavior pattern was for a chimpanzee to insert a finger into a hole in the top row, feel a peanut resting on the top shelf and push the peanut until it fell through a hole in the shelf and onto the next shelf level. This process was expected to be repeated until the peanut was propelled along the floor of the box to the larger opening where it could be removed and consumed.

Procedure

One puzzle box had been attached to an exterior, barred window in each of the enclosures for several days prior to the onset of the study so that animals could become familiar with use of the device. Data were collected between June 10 and June 29, 1983, using a scan-sampling technique with a 1 minute intersample interval. An all events sampling method was not possible because of the number of behaviors being recorded. Twelve 2-hour sessions of data were collected for each group of animals, with observations equally divided between morning (8:00 to 10:00 A.M.) and afternoon (2:00 to 4:00 P.M.) time periods. In half of the sessions the peanut box was filled with approximately 1 lb of unshelled peanuts, and this defined the beginning of the observation period. The box remained empty during the other
Fig. 1. Side view of the food puzzle box.

Fig. 2. Front view of the food puzzle box.
TABLE 1. Definitions of behavioral categories recorded

<table>
<thead>
<tr>
<th>Behavioral category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggressive interaction</td>
<td>May include visual and vocal threats and physical contact such as hitting, trampling, and biting</td>
</tr>
<tr>
<td>Contacting food puzzle</td>
<td>Any part of a subject’s body physically touching any part of the food puzzle</td>
</tr>
<tr>
<td>Coprophagy</td>
<td>Ingesting of fecal material</td>
</tr>
<tr>
<td>Eating wood</td>
<td>Ingestion of small pieces of wood peeled off the climbing structures</td>
</tr>
<tr>
<td>Emotional display</td>
<td>May include piloerection, charging, stamping, moving objects, and vocalizing</td>
</tr>
<tr>
<td>Excessive grooming</td>
<td>Pulling out one’s own hair or that of another animal</td>
</tr>
<tr>
<td>Fecal smearing</td>
<td>Rubbing feces onto walls, bars, or other structure in the enclosure</td>
</tr>
<tr>
<td>Grooming other</td>
<td>Using fingers to part hair, pick at skin, or scratch or rub another animal</td>
</tr>
<tr>
<td>Grooming self</td>
<td>Using fingers to part hair, pick at skin, or scratch or rub self</td>
</tr>
<tr>
<td>Locomoting</td>
<td>Walking or running either bipedally or quadrupedally</td>
</tr>
<tr>
<td>Lying down</td>
<td>Lying on side, stomach, or back</td>
</tr>
<tr>
<td>Out of view</td>
<td>Animal not within observer’s view</td>
</tr>
<tr>
<td>Regurgitating and reingesting vomitus</td>
<td>Animal’s weight supported by haunches resting on a surface</td>
</tr>
<tr>
<td>Sitting</td>
<td>Animal’s weight supported by three or four appendages</td>
</tr>
<tr>
<td>Standing</td>
<td>Any vocalization audible to the observer</td>
</tr>
</tbody>
</table>

sessions. Thus, the experiment tested the effect of peanuts in the box rather than of the box itself.

The following behavioral categories were recorded: locomoting, sitting, standing, lying down, vocalizing, grooming self, grooming other, emotional display, aggressive encounter, contacting the puzzle box, coprophagy, regurgitating and reingesting vomitus, eating wood, excessive grooming, fecal smearing, and out of view of the observer (see Table 1 for behavior definitions).

RESULTS

Data were analyzed to quantify the manner in which the group of animals used the puzzle box as well as the responses of individuals. A mean of 91.6 minutes (SD = 22.7) elapsed from the time of filling until the last recorded contact of the box by a subject. During this time at least one animal was contacting the box for a mean of 64.7 minutes (SD = 16.7). When peanuts were not available there was a mean of only 2.6 minutes (SD = 3.4) of contacting the food puzzle. It was common for more than one animal to touch the box simultaneously. Group levels of agonistic interactions and display behaviors were compared between sessions when peanuts were available and when they were not. The Student’s t test revealed no significant difference between the two conditions. Similarly, group measures of coprophagy, regurgitation, excessive grooming, and the consumption of wood showed no significant differences associated with the availability of peanuts in the box.

Examination of the data suggested an analysis at the level of individuals as, for example, a wide range was evident in the amount of time subjects spent contacting
Behavioral Enrichment Device for Chimpanzees

TABLE 2. Record of individuals’ use of the puzzle box

<table>
<thead>
<tr>
<th>Subject</th>
<th>Sex</th>
<th>Mean duration contacting box Minutes</th>
<th>SD</th>
<th>Frequency of “early use” (first 30 minutes of sessions)</th>
<th>Dominance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pierre</td>
<td>Male</td>
<td>32.5</td>
<td>13.6</td>
<td>28</td>
<td>High group</td>
</tr>
<tr>
<td>Budda</td>
<td>Male</td>
<td>15.3</td>
<td>8.7</td>
<td>18</td>
<td>—</td>
</tr>
<tr>
<td>Perry</td>
<td>Male</td>
<td>10.7</td>
<td>7.1</td>
<td>8</td>
<td>Low group</td>
</tr>
<tr>
<td>Mary</td>
<td>Female</td>
<td>8.3</td>
<td>7.5</td>
<td>14</td>
<td>High group</td>
</tr>
<tr>
<td>Martha</td>
<td>Female</td>
<td>13.8</td>
<td>5.8</td>
<td>16</td>
<td>—</td>
</tr>
<tr>
<td>Dixie</td>
<td>Female</td>
<td>9.7</td>
<td>6.2</td>
<td>6</td>
<td>—</td>
</tr>
<tr>
<td>Kelley</td>
<td>Female</td>
<td>6.3</td>
<td>5.8</td>
<td>12</td>
<td>—</td>
</tr>
<tr>
<td>Derma</td>
<td>Female</td>
<td>3.2</td>
<td>1.9</td>
<td>8</td>
<td>—</td>
</tr>
<tr>
<td>Betsy</td>
<td>Female</td>
<td>8.0</td>
<td>7.3</td>
<td>0</td>
<td>Low group</td>
</tr>
<tr>
<td>Willy</td>
<td>Male</td>
<td>28.0</td>
<td>11.4</td>
<td>33</td>
<td>High group</td>
</tr>
<tr>
<td>C.J.</td>
<td>Male</td>
<td>4.3</td>
<td>9.7</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Zippy</td>
<td>Male</td>
<td>23.8</td>
<td>9.1</td>
<td>25</td>
<td>Low group</td>
</tr>
<tr>
<td>Bashful</td>
<td>Female</td>
<td>11.3</td>
<td>9.1</td>
<td>19</td>
<td>High group</td>
</tr>
<tr>
<td>Judy</td>
<td>Female</td>
<td>0.5</td>
<td>1.2</td>
<td>0</td>
<td>Low group</td>
</tr>
<tr>
<td>Delta</td>
<td>Female</td>
<td>2.7</td>
<td>3.3</td>
<td>2</td>
<td>—</td>
</tr>
<tr>
<td>Betty</td>
<td>Female</td>
<td>18.2</td>
<td>10.4</td>
<td>14</td>
<td>—</td>
</tr>
<tr>
<td>Agatha*</td>
<td>Female</td>
<td>24.3</td>
<td>13.0</td>
<td>10</td>
<td>—</td>
</tr>
</tbody>
</table>

*Juvenile.

the box. Mean durations of individual contact time per session ranged from 3.2 to 32.5 minutes in one group and from 0.5 to 28.0 minutes in the other (see Table 2).

A \( \chi^2 \) test revealed a significantly asymmetrical distribution of the frequency of box usage by various members in each group (group 1 \( \chi^2 = 367.2, \ df = 8 \); group 2 \( \chi^2 = 947.5, \ df = 7 \)). Individual animals also exhibited different temporal patterns for food puzzle use. The frequency of individual puzzle box contact in the first 30 minutes of the test sessions ranged from zero to 33 (see Table 2). This “early use” frequency was highest for the most dominant male in each group. (Dominance status information was based on information provided by staff and was independent of the subject’s behavior during the course of this study.) The two highest ranking females in group 1 and the highest ranking female in group 2 displayed the highest early use frequencies of all of the females. The lowest ranking female in group 1 had an early use frequency of zero. However, there was not a perfect correspondence between dominance standing and access to the food puzzle. For example, the second ranked male in group 2 received a score of one, while the lowest ranking female in that group scored 14. The second highest ranking female in that group made no contact with the food puzzle during these early periods of testing.

Since social status may be one mediating factor, an analysis of variance was performed with two subgroups of these chimpanzees that could be clearly labeled as high or low in dominance status. These subgroups were comprised of the highest and lowest ranking male and female of each group. A two-factor mixed-design analysis of variance was performed using dominance and frequencies of contacting the box during the first nine 10-minute intervals of the testing session. Although it is unusual
to use frequency data in an analysis of variance, it is considered appropriate if the
data are not truncated at zero. In this case the analysis is intended only as an attempt
at a post hoc explanation of the behavior observed. The results provide evidence for
the importance of dominance as there was a significant interaction between dominance
and the box usage pattern ($F = 142.9$, df = 6/48, $P < 0.001$). Animals at extreme
points on the social hierarchy exhibited differences in their frequency of puzzle box
use over time. The most dominant animals used the box early in the test sessions.

To investigate more precisely the individual changes in levels of agonistic
interactions and displays, animals were grouped according to whether they displayed
an increase or decrease in these behaviors when the peanuts were available. Subjects
that exhibited no change were not included in this analysis. After this grouping, the
Student’s t test for related measures revealed that levels of agonistic encounters and
displays did change significantly in each group (increase group $t = -3.708$; decrease
group $t = 3.164$; each significant at $\alpha = 0.02$). Combined levels of coprophagy,
regurgitation, excessive grooming, fecal smearing, and the consumption of wood
were similarly analyzed, but they did not reach significance in either group. However,
individual measures show some marked changes in these abnormal behaviors associ-
ated with the experimental manipulation and the animal’s early use of the food puzzle.
Descriptions of these data indicate that animals of similar dominance standing res-
ponded differently to the availability of peanuts. In one case, two group 1 males with
equivalent dominance positions responded differently. One of them ceased all abnor-
mal behaviors when peanuts were available and exhibited a relatively high early use
frequency of 18. The other male showed no change in his low level of abnormal
behavior (a mean frequency of 1), and a substantially lower early use frequency of 8.
Two similarly high ranking group 1 females responded quite differently even though
their early use scores were comparable. One showed a substantial increase in these
abnormal behaviors (from a mean frequency of 2 to 17), while the other showed
essentially no change. One of the two lowest ranking females expressed abnormal
behaviors at a lower level and had a moderate early use frequency of 8. The lowest
ranking animal experienced an increased level of abnormal behaviors (from a fre-
quency of 35 to 45), and she attained an early access score of 0. In group 2 only the
two lowest ranking females displayed any of the abnormal behaviors recorded in this
study. One displayed a decreased frequency of abnormal behaviors (from 17 to 6)
along with a fairly high early use frequency of 14. The other female increased her
level of abnormal behavior (from a frequency of 1 to 6) and exhibited a low early use
score of 2.

DISCUSSION

The food puzzle box evaluated herein has potential as a behavioral enrichment
device. It encourages species-appropriate behavior patterns requiring fine motor skills
that may share some characteristics with “ant-fishing” [cf. Goodall, 1965; Nash,
1982]. Chimpanzees of various age and sex classes used the puzzle box for approxi-
mately 90 minute sessions over the 3 week testing period. In general, behavioral
changes associated with the food puzzle were not consistently manifested in all group
members. Instead, wide individual variations were recorded. As Maple (1979) has
suggested, activity level can be an important influence on the occurrence of behaviors
such as coprophagy, repeated regurgitation of food, and excessive grooming. How-
ever, the current results reveal that this was not the case for every subject. Statistically significant behavioral differences were demonstrated between subjects in extreme positions in the dominance hierarchy, as the dominant subgroup used the food puzzle earlier in the testing sessions. The most dominant males displayed the highest levels of overall use of this enrichment device. However, dominance does not directly correspond to its use in many cases, so other determining factors must be involved. Possibilities include the animals’ histories of exposure to such an apparatus, individual responses to novel stimuli, individual motivation as determined by hunger or other factors and the responses of other animals.

Other individual differences were evident in the occurrence of aggression and abnormal behaviors such as coprophagy and repeated regurgitation. The data indicate that among those animals that showed changed levels of aggression because of the experimental manipulation, the changes (whether increases or decreases) were statistically significant. Analyzing only the group data does not lead to this conclusion, so the necessity of an individual analysis must be emphasized. In some cases early access to and use of the puzzle box affected the level of abnormal behaviors displayed. Two of the eight subjects that displayed some undesirable behaviors and had the lowest early use frequencies showed increased levels of these abnormal behaviors when the food puzzle was filled. Two animals with relatively high early use scores exhibited decrements in abnormal behavior. However, one female with a similar high use score increased her level of abnormal behaviors, while a fourth showed no change. Finally, one of the two subjects with moderate early use frequencies experienced a decreased frequency of abnormal behaviors, while the other showed no change. Access to the food puzzle as measured by a frequency of early contact was helpful to some individuals, detrimental to others, and had no effect on still others. Dominance standing may be involved, but it cannot be the only factor determining these effects. Individual responses to enrichment devices must be evaluated, because individual differences may be important in determining the usefulness of many such management tools.

The food puzzle or a similar device might be especially effective at alleviating the boredom of singly caged primates in the research laboratory, without the negative side effects induced by competition for use of the device. It may be possible to adapt this design to some nonprimates as well. To minimize the negative side effects in groups, it may be desirable to use this device in groups of animals with relatively stable relationships and/or to increase the numbers of puzzles available to the group. However, complications such as the expense of additional boxes and the increased cleaning time for multiple boxes may render this solution less attractive.

An unexpected outcome was the animals’ success in removing single peanuts through the finger holes instead of carefully pushing peanuts along the inner shelves until they dropped to the next level and eventually out the bottom (despite decreases that were made in the size of the finger openings between manufacture of the prototype device and subsequent puzzle devices!). In spite of this creative adaptation, time-consuming manipulation was required to obtain peanuts from the box, and the food puzzle was a catalyst for increasing the range of behaviors expressed by these captive chimpanzees. Perhaps further design changes in the device would make it even more effective in this manner. This enrichment device can be an effective means of increasing environmental complexity and an opportunity for expressing a greater range of primate behavior in captivity.
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