SHORT COMMUNICATION

USING THE MESH CEILING AS A FOOD PUZZLE TO ENCOURAGE FOREGING BEHAVIOUR IN CAGED RHESUS MACAQUES *(MACACA MULATTA)*

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Abstract *Animal Welfare 1993, 2:* 165-172

An attempt was made to encourage more foraging behaviour in eight pair-housed adult rhesus macaques (Macaca mulatta). *No special device and no special food were used.*

Daily commercial dry food rations (238g per animal) consisting of 33 bar-shaped or 16 star-shaped biscuits per animal were placed on the mesh ceiling of the cages instead of in the feed-boxes. This induced an 80-fold increase (17.0 vs 1362.9s) and 289-fold increase (12.3 vs 3551.4s), respectively, in foraging time. The animals spent on average 9.6 per cent and 24.7 per cent respectively, of four-hour observation sessions foraging for biscuits from the mesh ceiling. Working for their food did not discourage them from eating all left-overs in the course of a day regardless of the shape of the biscuits.

It was concluded that the new feeding procedure enhanced the animals' behavioural well-being by encouraging foraging activities thereby helping to counteract understimulation.

Keywords: *animal welfare, behavioural well-being, foraging, housing, rhesus macaques*

Introduction

Chronic understimulation is a major problem for caged non-human primates. The situation is unsatisfactory for both the animal, which is deprived of expressing species-typical activities, and for the scientist who has to consider undefinable variables associated with possibly decreased well-being of the research subject. This issue has recently been taken into account by US federal rules which stipulate that the environment of such animals 'must be enriched by providing means of expressing noninjurious species-typical activities' (US Department of Agriculture 1991). Of these activities, foraging is predominant in wild and feral animals (eg Teas *et al* 1980, O'Keeffe & Lifshitz 1985, Malik 1986, Seth & Seth 1986, Malik & Southwick 1988, Marriott 1988). Caged animals, however, have little or no opportunity to express foraging activities because processed food is usually directly accessible. Environmental enrichment strategies have therefore largely focused on the development of devices that enhance more food retrieval behaviour under such unnatural conditions. The following devices have been described: pickup boards (Moazed & Wolff 1988, Evans *et al* 1989), puzzle feeders (Line & Houghton 1987, Bloom & Cook 1989, Line *et al* 1989, Murchison 1991, Gilloux *et al* 1992, Heath *et al* 1992, Murchison 1992), foraging boxes (Meunier *et al* 1989), food dispensers (Preilowski *et al* 1988, Markowitz & Line 1989, Gullekson *et al*

1991, Line & Morgan 1991), fleece boards (Bayne *et al* 1991), fleece cushions (Lam *et al* 1991), turf boards (Bayne *et al* 1992). Such foraging devices are relatively expensive and their maintenance work-intensive, requiring extra baiting with supplemental food items and regular cleaning and sanitation.

The present study is based on the premise that any foraging enhancement programme has to be inexpensive, both in terms of material and maintenance, to make it attractive to institutions with a large number of animals. Standard dry food rations were used to foster foraging activities in caged rhesus macaques. No special device was required, but commercial food biscuits were placed on the mesh ceilings of the cages instead of in the feed-boxes. This technique had originally been developed for group-housed rhesus macaques living in pens (Reinhardt 1992). It was hypothesized that total foraging time would be increased substantially, when the animals were obliged to retrieve the biscuits one by one using their manipulative skills.

Methods

The subjects of this study were eight adult (six years old), physically and behaviourally healthy (no clinical disease symptoms and no behavioural disorders) male rhesus macaques *(Macaca mulatta)*. They shared a room with 101 conspecifics and were kept as four compatible pairs, each pair in a 70 x 150 x 77cm high lower-row cage, provided with a privacy panel, two diagonally suspended perches and two gnawing sticks. Room temperature was maintained at 20-22°C, with a relative air humidity of approximately 50 per cent and a 12h light/dark (0630h/1830h) cycle. A visual health check of every animal was done between 0645h and 0715h; this was followed by cage washing with pressurized water. Drop pans were flushed at two-hour intervals.

Each pair was fed a standard ration of 476g commercial dry food (15% crude protein) at 0900h, supplemented with fruit and bread or whole peanuts at 1600h. The food was normally placed in feed-boxes, each 14cm wide, 7cm deep, 17cm high, mounted 40cm off the cage floor over a 73 x 47mm access hole cut into the mesh on the front of each half of the cage. Water was available *ad libitum*. The dry food ration was offered in one of two different forms:

a. Thirty-two large biscuits (star-like shape with four spikes, about 15mm long and 15mm wide, protruding from a sphere measuring approximately 30mm in diameter; Purina Monkey Chow No 5037) per pair.
b. Sixty-six small biscuits (bar-like shaped, about 40mm long, 24mm wide and 16mm thick; Purina Monkey Chow No 5038) per pair.

Each pair was subjected to the following experimental feeding protocol at 0900h:

Day 1 (control situation A)

The ration of small biscuits was equally distributed into the two feed-boxes.

Days 2-14 (habituation A)

The ration of small biscuits was distributed on the 22 x 22mm square mesh ceiling, instead of into the feed-boxes.

Day 15 (control situation B)
The ration of large biscuits was equally distributed into the two feed-boxes.
Days 16-28 (habituation B)
The ration of large biscuits was distributed on the square mesh ceiling, instead of into the feed-boxes.

Time spent retrieving biscuits was recorded for each partner of each pair simultaneously during the two control situations, ie days 1 and 15, and at the end of the two habituation periods, ie days 14 and 28, from 0900h to 1300h. Retrieving was considered to be a foraging activity, ie the gathering of food (The Random House Dictionary of the English Language 1987). It included taking a biscuit out of the feed-box; manipulating a biscuit through the mesh of the ceiling (Figure 1); nibbling/biting at a biscuit that was partly protruding through the mesh, and pushing and pulling a biscuit or a fragment of it with the fingers and teeth through the mesh.

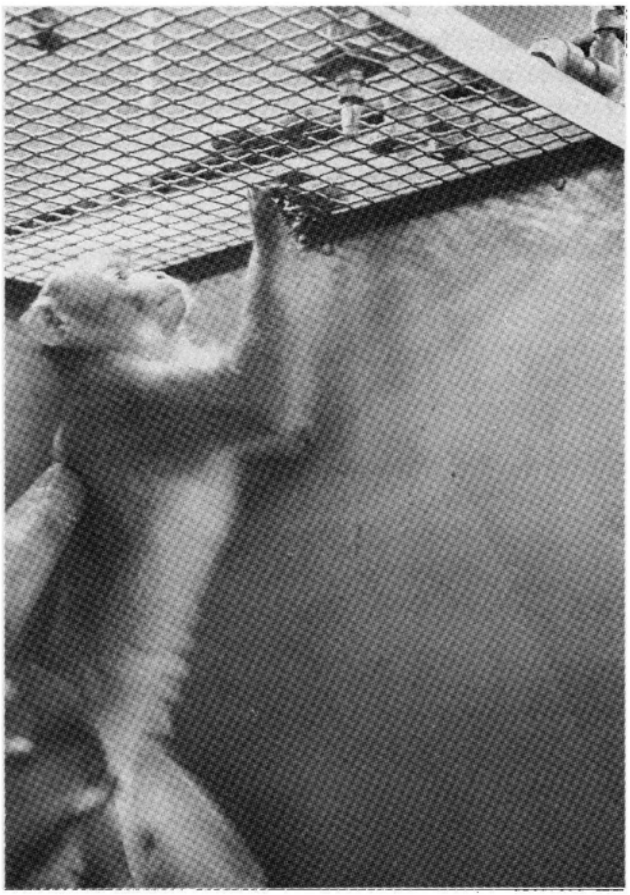

Figure 1 **Foraging for small biscuits placed on the mesh ceiling of the cage.**

Foraging activities did not include behaviours related to the actual consumption of food, eg emptying cheek pouches, chewing and swallowing.

Recordings were carried out manually by the author who sat at a distance of approximately 2m from the centre of the cages.

Biscuits that were thrown out of the feed-boxes or pushed over the edge of the ceiling of the cage were weighed and replaced. All animals were weighed at the beginning (day 1) and at the end (day 28) of the four-week study period.

Statistical analysis was done using the Wilcoxon signed-rank test (Ferguson 1966).

Results

The eight rhesus macaques spent on average 17.0 and 12.3 seconds per four hours collecting their standard ration of small and large biscuits respectively from feed-boxes. Retrieving times were markedly longer when the same rations were placed on the mesh ceiling of the cages instead of in the feed-boxes (Table 1). Under these conditions, subjects spent on average 23.0 minutes, ie 9.6% of the four-hour test period retrieving small biscuits, and 59.2 minutes, ie 24.7% of the four hours retrieving large biscuits. The increase in retrieving time was significant for both types of biscuits ($P<0.001$; Table 1) with the amount of time devoted to the retrieval of large biscuits being significantly larger than that devoted to the retrieval of small biscuits ($P<0.001$; Table 1).

Table 1 **Time spent foraging by eight adult male rhesus macaques for commercial dry food presented in four different ways.**

Paired partners	Time spent foraging (s/4h)			
	Small biscuits		Large biscuits	
	In feed-box	On ceiling	In feed-box	On ceiling
Duke	15	1104	10	3258
Klaus	10	1242	11	2661
Thomas	19	2244	18	5084
Kay	18	1938	12	3255
Bruce	10	1209	10	2893
Ole	37	911	19	4862
Tedd	15	1350	9	3023
Arni	12	1065	9	3375
Average:				
Seconds	17.0	1382.9	12.3	3551.4
Minutes	0.3	23.0	0.2	59.2
Per cent/4h	0.1	9.6	0.1	24.7

When small or large biscuits were presented in the feed-boxes, individuals quickly took a few pieces in their cheek pouches and threw most of the remainder on to the floor of the cage while starting to eat. Feed-boxes were emptied within 7 to 28 minutes. When biscuits were placed on the mesh ceiling, retrieved pieces were never thrown on the floor but were either stored in the cheek pouches or eaten directly. Three pairs of macaques retrieved the last piece of their small biscuit ration during the second hour, the other pair during the fourth hour. No pair completely retrieved its large biscuit ration during the test period and subjects continued foraging on average 12.1 per cent of the time during the fourth hour. There were no left-overs by late afternoon, ie 1700h.

Total food wastage (whole biscuits and fragments of biscuits thrown out of the feed-boxes or pushed over the edge of the ceiling of the cage) of all eight subjects was 0.3 per cent and 1.3 per cent when small and large biscuits respectively were placed in feed-boxes, 1.6 per cent and 2.1 per cent when small and large biscuits were distributed on the mesh ceiling.

Mean body-weight balance of the eight rhesus macaques during the four-week study period was +2.5 per cent (day 1: 7.48 ± 0.88kg, day 28: 7.67 ± 0.76kg).

Discussion

The present data support the hypothesis that foraging activity can be enhanced substantially in adult rhesus macaques by simply placing the standard biscuit ration on the mesh ceiling of their cages instead of in the feed-boxes. The increase in foraging was determined by the size/configuration of the biscuits. Small, bar-shaped biscuits were relatively easy to manipulate, break and pull through the mesh; they induced an 80-fold extension of foraging time. Large, star-shaped biscuits were more difficult to pull through the mesh once all protruding parts were broken away; consequently more work was required to retrieve them and the increase in foraging time was even higher, ie 289-fold.

Food wastage was minimal. It could probably have been avoided altogether by fixing rims around the top of the cages.

The animals had to work for their food, but this did not discourage them from eating all left-overs in the course of a day regardless of the size of the biscuits. This ensured an adequate calorific intake, reflected in a moderate increase of the subjects' body-weight during the four-week study period.

The present routine feeding technique stimulated adult rhesus macaques to spend on average 23 and 59 minutes to perform skilful food retrieval behaviours of small and large biscuits respectively. These activities cannot be claimed to be species-typical due to the artificial context, but they are foraging, ie food gathering behaviours in the true sense. Working for their food, rather than directly eating it, is likely to enhance the animals' behavioural well-being (O'Neill 1988, Bayne *et al* 1992).

Animal welfare implications

Distributing the standard food ration of caged rhesus macaques on the mesh ceiling of their cages instead of in feed-boxes resulted in a marked increase of foraging time which promoted the subjects' well-being by helping to counteract understimulation. Making the animals work for their food did not jeopardize their general health status as reflected in body-weight maintenance.

Acknowledgements

I am grateful to Dan Houser, Chris Nywall and my wife Annie for critically reading this manuscript and to Jackie Kinney for proof reading it.

Supported by USPHS, NIH grant RR-00167. Publication number 32-053 WRPRC.

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