EFFECTIVE FEEDING ENRICHMENT FOR NON-HUMAN PRIMATES: A BRIEF REVIEW

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There is a growing awareness that non-human primates kept in zoos and laboratories deserve more species-appropriate stimulation because of their biological adaptation to a challenging environment.

Numerous attempts have been made to effectively emulate the gathering and processing aspects of natural feeding. Whole natural food-items, woodchips mixed with seeds, the puzzle ceiling and the puzzle feeder stocked with ordinary biscuits, cost little or nothing but induce sustained food gathering and/or food processing. Turf and fleece substrates sprinkled with particles of flavoured food, foraging trays, probe feeders and puzzles baited with food treats also promote more foraging behaviour, but they are relatively expensive and require added labour time to load and clean them.

Keywords: *animal welfare, behavioural health, enrichment, feeding, foraging, non-human primates*

Introduction

Captive non-human primates often lack sufficient opportunities to express food gathering (foraging) and food processing activities because food is usually made available in such a way that no effort or skills are required to find, retrieve and prepare it. It has been demonstrated in numerous vertebrate species, including non-human primates, that individuals readily work for food in the presence of freely accessible identical food (eg Neuringer 1969; Reinhardt 1994). This suggests that inherent drives make food gathering and food processing rewarding experiences on their own. A lack of opportunities to engage in these appetitive behaviours (Craig 1918) is conducive to the development of behavioural disorders (Hediger 1955; Meyer-Holzapfel 1968) and hence is likely to impair the subject's behavioural health and general well-being.

The present review summarizes feeding enrichment options that have been shown to effectively promote more foraging and/or food processing activities while ameliorating behavioural pathologies in captive non-human primates.

Feeding enrichment options

Substrates

Substrates mixed with edible items stimulate the subject to search for food and extract it from the substrate.

Anderson and Chamove (1984) and Combette and Anderson (1991) tested a group of 10 stump-tailed macaques *(Macaca arctoides)* and a group of six capuchin monkeys *(Cebus apella)* in three different situations: bare floor, floor covered with woodchips for one to three weeks and food raked into the woodchips on two days. During 20-minute observations, individuals spent practically no time in food-related activities when the floor was bare, less than 2 minutes when the floor was covered with woodchips and approximately 6 minutes when a mixture of seeds was added to the substrate. In the latter situation, behavioural disorders decreased while affiliative interactions increased.

A litter system can also be created for caged animals by placing a woodchip-filled tray below the grid floor of the cage. Bryant *et al* (1988) observed six long-tailed macaques *(Macaca fascicularis)* after daily transfers into single cages, each containing a tray holding woodchips plus seeds. Subjects foraged for an average of 11 minutes during the first 30 minutes following transfer.

Boinski *et al* (1994) were unable to induce more foraging in 16 singly-caged squirrel monkeys *(Saimiri sciureus)* by scattering standard biscuits into their woodchip litter trays. A similar observation was made by Byrne and Suomi (1991) who reported that adding biscuits to woodchips had little effect on the behaviour of 10 group-housed rhesus macaques. The addition of sunflower seeds, however, resulted in a substantial increase in foraging activity, indicating that the usefulness of woodchips as a foraging substrate depends on the presence of special rather than ordinary food.

Lambeth and Bloomsmith (1994) studied five pairs of chimpanzees and one group of four chimpanzees *(Pan troglodytes)* who had access to a polyvinyl chloride (PVC) pipe cut in half lengthwise and planted with ryegrass. The container was attached to the outside of the fencing and subjects could reach the grass with their fingers. The chimpanzees were exposed to the planter six times when sunflower seeds were scattered on the grass. Mean foraging time per individual during the first 30 minutes of exposure was 3.6 minutes.

Bayne *et al* (1991, 1992) examined a fleece-covered and a turf-covered foraging board in two separate studies involving eight singly-caged rhesus macaques *(Macaca mulatta)*. The fleece board was mounted to the outside, the turf board on the floor of the cage. Both devices were sprinkled daily with flavoured food-particles. During the first 30 minutes after baiting, individuals spent 12.1 minutes foraging from and grooming the fleece and 15.5 minutes foraging from the turf while concurrently displaying fewer behavioural disorders. These effects were consistent throughout six-month study periods. Pyle *et al* (1996) observed six singly-housed baboons *(Papio* spp.) who had access to fleece boards replenished daily with flavoured food-crumbles over a two-week period. During the first hour after the boards were baited, subjects spent approximately 1.6 minutes 'interacting' with them and stopped exhibiting stereotypic behaviours. Lutz and Farrow (1996) exposed 10 individually-caged long-tailed macaques to a sunflower seed-loaded turf board daily for 30 minutes during a four-week period. The feeder was secured to the outside of the cage directly below the opening through which the monkeys normally obtained their food. Average board use per animal was 3.4 minutes. Turf and fleece boards are commercially available for US$50 (turf

board, Bio-Environmental Modifiers, Olsburg, USA) and US$90 (fleece board, Bio-Serv, Frenchtown, USA), respectively.

Lam *et al* (1991) tested a custom-made fleece cushion sprinkled with flavoured food-items on three singly-caged long-tailed macaques. Each animal received the cushion once a day on six occasions. During the first hour after presentation of the cushion, individuals spent an average of 15.3 minutes foraging from it.

Probe feeders

Probe feeders stimulate the subject to probe for food before retrieving it from a concealed source.

Hayes (1990) observed a group of five capuchin monkeys *(Cebus capucinus)* when a mixture of hay and produce was offered, on five days, in two suspended PVC-tubes both fitted with three compartments. An animal could reach with a hand or with a finger through different-shaped holes in the tube, sift through the little food-piles and remove selected items by manoeuvring them through appropriate holes. Subjects spent on average 4.7 of the first 12 minutes after food presentation foraging from the tubes.

Gilloux *et al* (1992) tested the use of a probe pipe by a pair of orangutans *(Pongo pygmaeus)*, a group of four gorillas *(Gorilla gorilla)* and a group of seven chimpanzees *(Pan troglodytes)*. Each group had access to one feeder which consisted of an open-ended drainpipe attached horizontally to the outside of the enclosure. The feeder was filled with a mixture of produce and biscuits. The apes could manipulate food items to the end of the pipe by inserting sticks through holes drilled along the side of the pipe. Once the food was at the end, an animal could reach it with a hand. In the course of 12 trials, lasting 30 minutes each, average time spent in 'feeder-oriented behaviour' was approximately 8.4 minutes for orangutans, 8.1 minutes for chimpanzees and 5.1 minutes for gorillas.

Puzzles

Puzzles require manipulative skills and diligence to obtain food from a visible source.

The puzzle box is mounted on the outside of the enclosure. The subject has to put a finger into holes cut on the face of the gadget and push food items along horizontal shelves with passage holes, until they drop to the next lower row. Finally, the food is removed from the bottom level through a large opening. The apparatus is commercially available for US$180 (Primate Products, Florida, USA).

Bloomsmith *et al* (1988) observed six groups of chimpanzees, each ranging in size from four to seven individuals. Each group received popped corn, sunflower seeds or peanuts in three custom-made puzzle boxes several times weekly. During the first 30 minutes following food distribution, individuals spent an average of 10.6 minutes feeding from the puzzles. Feeding time did not diminish over a six-week study period.

The puzzle feeder is created by remounting an ordinary feeder box a few centimetres away from the access hole. The puzzle serves as primary feeder for the standard biscuit ration. It costs nothing since existing elements of the cage are used. Reinhardt (1993a) observed eight pair-housed rhesus monkeys when 66 bar-like shaped biscuits were offered in two feeder boxes mounted in the traditional way, or in the same containers remounted as puzzle feeders. The biscuits were slightly larger than the gauge of the mesh covering the puzzles. The animals had received their daily rations in the new feeders for a 30-day period;

they were tested thereafter on day 31. During the first 30 minutes following food distribution, individuals spent an average of 18.3 minutes extracting biscuits from the puzzles as opposed to 0.2 minutes collecting biscuits from the boxes. Monkeys took a mean cumulative total of 42.2 minutes retrieving their ration from the puzzle compared to 0.3 minutes retrieving it from the box. Repeating this experiment with 12 stump-tailed macaques yielded similar results (Reinhardt 1993b).

The puzzle ball is hung outside on the frame of the cage. Reaching through a small opening the subject holds the ball upside down with one hand and pulls food rewards through holes with the fingers of the other hand. The device costs about US$50 (Bio-Serv, Olsburg, USA). Murchison (1992) presented a peanut-filled ball each morning to four singly-housed pig-tailed macaques *(Macaca nemestrina)*. The animals spent about 17.4 minutes per four, 2-hour observation sessions 'manipulating' the device. A more complex version stimulates the animal to shake food items through a series of internal holes until they reach the opening of the puzzle. Schapiro *et al* (1996) exposed 63 individually-caged rhesus macaques to such a custom-made puzzle every weekday for a six-month period. The feeder was loaded daily with seeds, and the monkeys were observed during the first 90 minutes after loading the feeder. Average 'enrichment use' per individual animal was 33.2 minutes during this time period. A commercial version of the device costs US$16 (Bio-Environmental Modifiers, Frenchtown, USA).

The puzzle pipe is also suspended on the outside of the cage. An inner tube is coated with creamy foodstuff and is free-moving about its axis; an outer tube revolves around the inner tube and has several finger-slots for accessing the cream. The apparatus costs US$35 (Bio-Serv, Olsburg, USA). Pyle *et al* (1996) provided six individually-housed baboons with continuous access to a puzzle pipe which was replenished once a day with peanut butter. During the first hour, baboons stopped exhibiting stereotypic behaviours and spent approximately 10 minutes 'interacting' with the feeder.

The puzzle board is made of plexiglass with different-sized holes in the central area. It is attached on top of the cage ceiling and furnished with food treats. The animal below manipulates selected items to appropriate holes and retrieves them. One board costs approximately US$80 (Bio-Serv, Olsburg, USA). Brent and Eichberg (1991) tested this puzzle on 29 chimpanzees housed in groups of three or four. Each group was provided with one board which was baited on four different days. Average puzzle 'use' per individual was 9.9 minutes during the first hour after food distribution. Behavioural disorders were concurrently diminished.

Placing the food on the mesh or chain-link ceiling of the enclosure offers a simple alternative to the puzzle board. This change in feeding practice requires no extra material and no extra personnel time. Reinhardt (1993c) tested this technique on eight pairs of rhesus monkeys who had been habituated, during 12 days, to receiving their daily ration of 32 star-like shaped biscuits on the mesh ceiling of their double cages. Individuals increased their total cumulative foraging time per 4-hour observation from 0.2 minutes to 59.2 minutes, when the biscuits were distributed on the ceiling rather than in the two ordinary feeder boxes.

Not only the ceiling but also the floor may serve as a puzzle when a tray stocked with edible particles is mounted on the excreta pan. The animal extracts the food through the mesh of the cage floor. Spector *et al* (1994) filled the foraging trays of 24 baboons with a

seed mixture in the afternoon on alternate days. Subjects spent 30 minutes to more than 2 hours of the afternoon foraging from the trays. This response remained consistent throughout a two-year study period. Foraging trays are commercially available for about US$50 (Bio-Environmental Modifiers, Frenchtown, USA).

Whole natural food-items

Natural food-items promote processing behaviours if they are offered whole rather than peeled, shelled, cracked, stripped, cut or chopped. Nadler *et al* (1992) added an ear of unhusked corn every other day to the biscuit ration of eight singly-caged chimpanzees. One hour after food distribution individuals spent on average 5.5 minutes of 10-minute observations feeding when they had access to biscuits plus corn, compared to 0.5 minutes feeding when they had biscuits alone. This response was consistent over a six-week study period. Behavioural disorders were reduced when corn was available.

Beirise and Reinhardt (1992) observed a group of 16 rhesus macaques who received 1kg of whole peanuts or 32 ears of unhusked corn on different days once a week. The food was evenly scattered on the floor of the pen; biscuits were provided ad libitum. The monkeys were habituated to this feeding procedure for eight weeks and then tested during the following three weeks. In the course of the first 2 hours after food distribution, individuals spent 92.9 minutes foraging-and-processing when corn was available and 56.5 minutes when peanuts were available.

Conclusion

The variety of effective feeding enrichment options for captive primates is impressive and an incentive to provide all animals with means to express their drive to gather and process food. Feeding enrichment not only counteracts lack of stimulation by giving the animals something to do, but it also diverts their attention from exhibiting behavioural disorders which may be related to boredom.

The effectiveness of the various enrichment options cannot be compared without reservation because of the differences in food-items used and the heterogeneity of research methodologies applied. Table 1 lists the actual and estimated mean cumulative number of minutes and the mean percentage of time individual animals were recorded as engaging in food-related activities per 30-minute exposure to a particular feeding enrichment option. Whole natural food-items, and the puzzle feeder filled with biscuits seem to be most effective, stimulating the animals to engage in food gathering and food processing activities more than 50 per cent of the time.

Feeding enrichment does not need to be expensive. Unprocessed produce, woodchips, the puzzle ceiling and the puzzle feeder cost relatively little but promote sustained food gathering-and-processing activities. The puzzle feeder and the puzzle ceiling are particularly cost-effective because ordinary rather than special food is used as a foraging incentive. Other options such as turf and fleece substrates, the foraging tray, probe feeders and puzzle devices are relatively expensive and require added labour investment in baiting them with special food rewards and in sanitizing them.

Table 1 **Actual and estimated (marked with *) mean cumulative minutes and mean percentage of time individual animals were seen to engage in food-related activities per 30-minute exposure to various feeding enrichment options.**

Option	Minutes	Per cent	Species	Reference
unhusked corn	23.2*	77	*Macaca mulatta*	Beirise and Reinhardt 1992
unhusked corn	16.5*	55	*Pan troglodytes*	Nadler *et al* 1992
whole peanuts	17.0*	56	*Macaca mulatta*	Beirise and Reinhardt 1992
puzzle feeder plus biscuits	18.3	61	*Macaca mulatta*	Reinhardt 1993b
puzzle feeder plus biscuits	17.7*	59	*Macaca arctoides*	Reinhardt 1993c
turf board plus treats	15.7	52	*Macaca mulatta*	Bayne *et al* 1992
turf board plus seeds	3.4	11	*Macaca fascicularis*	Lutz and Farrow 1996
fleece board plus treats	12.0	40	*Macaca mulatta*	Bayne *et al* 1991
fleece board plus treats	0.8*	3	*Papio* spp.	Pyle *et al* 1996
fleece cushion plus treats	7.7*	26	*Macaca fascicularis*	Lam *et al* 1991
woodchips plus seeds	11.0	37	*Macaca fascicularis*	Bryant *et al* 1988
woodchips plus seeds	9.6	32	*Cabus apella*	Combette and Anderson 1991
woodchips plus seeds	9.0*	30	*Macaca arctoides*	Anderson and Chamove 1994
woodchips plus seeds	6.0*	23	*Macaca mulatta*	Byrne and Suomi 1991
woodchips plus biscuits	0.6*	2	*Macaca mulatta*	Byrne and Suomi 1991
woodchips plus biscuits	0.0	0	*Saimiri sciuraus*	Boirski *et al* 1994
grass planter plus seeds	3.6	12	*Pan troglodytes*	Lambeth and Bloomsmith 1994
tray plus seeds	9.9*	33	*Papio* spp.	Spector *et al* 1994
probe tube plus hay/fruits	11.8*	39	*Cabus capucinus*	Hayes 1990
probe pipe plus fruits	8.4	28	*Pongo pygmaeus*	Gilloux *et al* 1992
probe pipe plus fruits	8.1	27	*Pan troglodytes*	Gilloux *et al* 1992
probe pipe plus fruits	5.1	17	*Gorilla gorilla*	Gilloux *et al* 1992
puzzle ball plus peanuts	10.6	35	*Macaca mulatta*	Schapiro *et al* 1996
puzzle ball plus peanuts	4.4*	15	*Macaca nemestrina*	Murchison 1992
puzzle box plus treats	10.6	35	*Pan troglodytes*	Bloomsmith *et al* 1988
puzzle pipe plus peanut butter	10.0*	17	*Papio* spp.	Pyle *et al* 1996
puzzle ceiling plus biscuits	7.4*	25	*Macaca mulatta*	Reinhardt 1993a
puzzle board plus treats	5.0*	17	*Pan troglodytes*	Brent and Eichberg 1991

The implementation of a feeding enrichment program requires some extra attention on the part of the attending animal care personnel in order to make sure that individual animals obtain enough food. Limitations for adequate food acquisition may be set by dexterity and strength of fingers, strength and prominence of incisors, general health status and

idiosyncrasies of the animals. An old animal, for example, with worn-down or broken incisors, with arthritic fingers or with chronic diarrhoea should not be required to engage in possibly painful and exhausting foraging activities but should have free access to the daily food ration.

Animal welfare implications

Allowing captive non-human primates to actively express food gathering and food processing behaviours counteracts lack of stimulation and hence promotes the animals' behavioural health and general well-being.

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