A Review of Environmental Enrichment Strategies for Singly-Caged Nonhuman Primates

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Because nonhuman primates are recognized as man's closet living relatives, they are used in numerous scientific studies ranging from biomedical to behavioral research. Nonhuman primates, however, are not merely research tools. They are intelligent animals with highly developed social skills. It is an ethical imperative to provide them not only with optimal care but also with an optimal environment.

In their natural habitat, primates spend a high proportion of time foraging, exploring their complex environment, and interacting with conspecifics. Life in barren cages drastically reduces such basic activities. The practice of providing captive primates with dry commercial food twice daily minimizes the expression of the animals' natural foraging behavior Small cage dimensions also restrict movement. No opportunities for direct social contact with conspecifics occur. The lack of physical, mental, and social stimulation leads to boredom; often to depression and reproductive deficiency; and in extreme cases to the manifestation of stress symptoms and behavioral disorders (Berkson, 1967; Sackett, 1968; Mitchel, 1970; Gluck and Sackett, 1974; Snyder, 1975; Faucheux et al., 1978; Erwin and Deni 1979; Anderson and Chamove, 1980; Clarke et al., 1982; Maple, 1983; Moberg, 1985; Brent et al., 1988).

The recent interest in the psychological well-being of primates has three sources:

1. From an ethical point of view, there is an increasing concern and pressure from animal welfare groups for improving captive animal husbandry in general.
2. Growing evidence indicates that primates living under deprived conditions without appropriate stimulation may suffer from physiological disorders such as impaired immune and reproductive functions. Using such animals as models of normal function and behavior is obviously questionable.
3. In 1985 Congress passed an amendment to the Animal Welfare Act, requiring revisions in laboratory animal husbandry. According to the preliminary version of the pending USDA regulation, requirements will include the following:
    a. provision of adequate space for physical activities consistent with each species' natural behavior,
    b. enrichment of primary enclosure to provide for activities typical of the age and species of the nonhuman primates housed;
    c. provision of paired, family, or group-housing whenever possible, and of human contact when such socialization is not possible.

GROUP HOUSING VERSUS SINGLE HOUSING

A variety of methods have been developed to provide group-housed primates with more opportunities for species-typical behavior and for a wider range of activities (Markowitz, 1979; Hutchins et al., 1984, Chamove et al., 1982; Clarke et al., 1982; Westergaard and Fragaszy, 1985; Tripp, 1985; Bloornstrand et al., 1986; McKenzie et al., 1986; Markowitz and Spinelli,

1986; Bramblett and Bramblett, 1988; Bloomstrand, 1988; Beckley and Novak, 1988; Keeling et al., 1988; Schefferly, 1988; Tompkins et al., 1988; O'Neill, 1988; Bloomsmith et al., 1988). Unfortunately, information on environmental enrichment for singly housed primates is scarce. Since the majority of primates used for research are singly caged and since such individuals suffer more from social deprivation, the need to enrich the environment of singly caged primates is even more urgent than it is for group-caged primates. (Harlow and Harlow, 1962; Suomi et al., 1971). The following review discusses environmental enrichment strategies for singly-caged primates.

ENRICHMENT STRATEGIES USING INANIMATE OBJECTS

Environmental enrichment for individually housed primates has been attempted by using inanimate objects. While cage size is a very important factor for the well-being of primates (Draper and Bernstein, 1963; Paulk et al., 1977, Goosen et al., 1984), simply enlarging the cage is not sufficient. More than thirty years ago it was demonstrated that nonhuman primates have a strong, innate urge for exploratory and manipulatory behavior. Given the opportunity, primates continue to operate mechanical puzzles even in the absence of food rewards, suggesting that the activity per se is rewarding (Harlow et al., 1950; Harlow, 1953; Harlow and McClearn, 1954; Butler, 1965). This inherent need to explore and manipulate is currently being exploited to enhance the well-being of singly caged animals.

Line and Houghton (1987) evaluated the usefulness of a Plexiglas food puzzle attached to the home cage as an environmental enrichment device in 5 singly caged adult female rhesus macaques over a period of 4 weeks. The food puzzle required little maintenance, and most animals learned to use it without training. The authors provide no quantitative data.

Moazed and Wolff (1988) are using a so-called "raisin board" as an environmental enrichment device for several species of monkeys. The board is made of polypropylene and consists of 19 holes that can be filled with raisins. The animals tested in a preliminary observation showed great variation in their response to the board. Some of the monkeys remained afraid of the foreign object placed in their cage and did not investigate it at all, while others quickly learned to pick out the raisins. The disadvantages of the board included its weight - which could result in the injury of smaller species - and the time required for personnel to manually fill the holes with raisins. More quantitative information is needed to determine the board's practicality and long-term appeal to the animals.

Jerome and Szostak (1987), in addition to using raisin boards, also tried puzzle feeders and play objects such as nylon balls, ropes, and chains. Without providing quantitative data, the authors note that the foraging devices were used more frequently than were the play objects by adult baboons.

Nylon balls have been tested by Renquist and Judge (1985) as well as by Line (1987) and Bayne (1989). The authors report that macaques were rolling and rubbing the ball, chewing on it, or holding it as if it were a surrogate infant. However, Line (1987) found that all of 33 cynomolgus macaques and more than 90% of 148 singly caged rhesus macaques tested gradually stopped using the ball over the course of 11 months. Apparently the animals lost interest in this inanimate play object. Bayne's (1989) observation that singly caged rhesus monkeys manipulated the nylon ball in only about 10% (3/34) of cases corroborates these observation

A modified nylon ball device consisting of a nylon ball connected to a stainless steel chain has been described by Ross and Everitt (1988). The authors provide no information regarding the attractiveness of the suspended ball for singly caged monkeys.

Champoux et al. (1987) provided branch segments as manipulative objects for 48 rhesus monkeys (Figure 1.). Thirty-five percent of the animals used the wood pieces for gnawing or rolling throughout a 12-week study period.

Figure 1. A branch segment is better than nothing to decrease boredom.

Reinhardt et al. (1987a) installed deciduous tree branches in the cages of 86 singly housed rhesus macaques. Eight-seven percent of the animals were observed gnawing at the branches or using them as perches with consistent regularity over a 15-month study period (cf. Figure 3).

Reinhardt and Smith (1988) tested polyvinyl chloride (PVS) pipes as perches for rhesus macaques (Figure 2). As with the branches, the PVC pipes were positioned at a height that allowed the animals to use the entire floor space of the cage, or to sit or stand on the pipes. During a four-week observation period, eight out of the nine rhesus monkeys were observed perching on a regular basis. Wolff (1989) provided PVC pipes for 250 squirrel monkeys housed one to four in each cage. After one month of introduction, all animals used the pipes. The pipes were used for sitting eating, sleeping, and locomotion in a fashion similar to tree limb use in wild monkeys. An additional unexpected benefit of the PVC perch was a decrease in dorsal tail-head abrasions, frequently seen in squirrel monkeys that sit on the stainless steel flooring of standard primates cages.

Figure 2. When property installed PVC pipes or branches increase the usable space for the caged animal.

Bryant et al. (1988) examined the usefulness of a swing, nylon rope, telephone directory, surgical glove, viewing panel, and a tray containing deep woodchip litter scattered with sunflower seeds and peanuts as a means of environmental enrichment for 6 individually caged cynomolgus monkeys. The animals were temporarily transferred in pairs to a play pen containing all items; partners were separated by the viewing panel. The monkeys chose to forage for approximately 10 of 30 minutes during the time they were observed. The viewing panel and telephone directory attracted their attention for 2-3 minutes per 30-minute session. The other objects attracted hardly any attention.

Some investigators have used electrical manipulanda that animals can operate voluntarily. Myers (1978), devised a reaction-time contest that a baboon could play with visitors at the zoo. The panel consisted of three lights, one of which would turn on in a random fashion. Whoever turned off the light first would score a point, and the winner would receive a food pellet at the end of the session. The baboon was reported to have won about 87% of the contests.

Line and Markowitz (1987), Clarke et al. (1987), and Line et al. (1987) installed a radio and food dispenser apparatus that female rhesus monkeys could operate voluntarily in their home cages. Behavioral and physiological measurements, indicated great variation between individuals in their response. Without any training most of 5 animals tested learned how to use the apparatus within one week. Three monkeys left the radio on most of the time, and one ate about 2,000 banana pellets a day. The investigators conclude that this enrichment device could be adapted for use in a wide variety of laboratory settings.

Bloomstrand and Young (1988) tested the effectiveness of videotapes as a source of enrichment for chimpanzees. Each of six adult group-housed chimpanzees was placed in a single cage for 20-minute sessions during which a variety of tapes were shown to the animal. The chimpanzees' response to the tapes varied according to individuals and content of tape. The practical applications of these finding were not stated.

Prelowski et al. (1988) devised an automated device that allows animals to be tested in their home cages. The apparatus can be connected to a computer to collect information on the animal's performance and to a food dispenser that delivers the reward. In this study, each of the three rhesus macaques could operate the manipulandum voluntarily any time it chose throughout the day. According to the authors, this method of testing is beneficial both for the experimenter in collecting high-quality data and to the animal in reducing the frequency of certain types of cage stereotypes.

The high cost of electromechanical manipulanda and the time required to train animals to operate them may limit their usefulness on a large scale. Two inexpensive mechanical manipulanda are described by Borrebach (1977). The devices have been used in operant studies with rhesus monkeys, but their application as enrichment objects has not yet been investigated.

Restricted physical activity is a major problem for primates housed in cages. In order to provide more opportunities for physical activity, Tolan et al. (1980) constructed an exercise cage for rhesus macaques. Unfortunately no information is available regarding how the animals used such a cage and what effect it had on their behavior.

Glassman et al. (1987) attempted to overcome the lethargic behavior of a singly housed male lowland gorilla. The animal was provided with a plastic ball and burlap bags, and his food was intermixed with hay in order to encourage foraging behavior. Behavioral data collected before and during the study period indicated an increase in the animal's activity level and in its use of the cage space.

Glick (1977) offered a variety of objects to another individually housed male lowland gorilla to overcome the animal's practice of regurgitating and re-ingesting its food. The gorilla seemed to demonstrate great ingenuity in using rubber tires, hoses, tubs, branches, and burlap bags; no supporting data are provided.

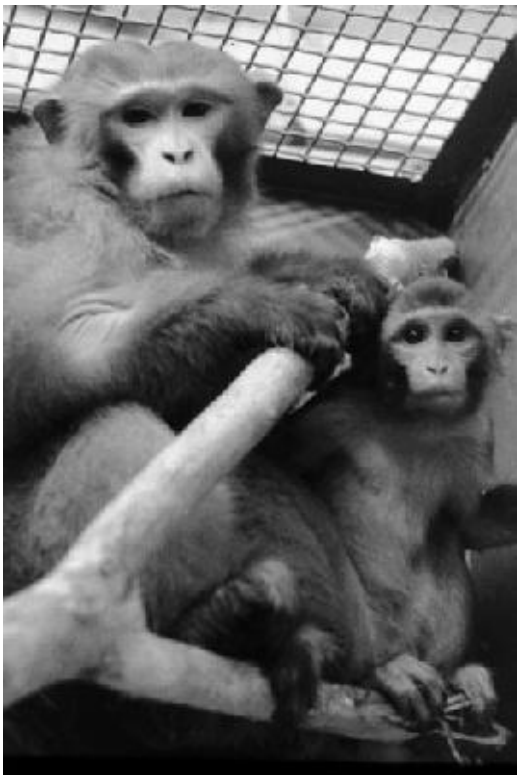

Figure 3. Eleven-year-old previously singly caged male with his infant companion on the third day

of pair formation.

SOCIALIZATION WITH CONSPECIFICS

Perhaps of even greater importance than relieving the boredom of singly caged primates with inanimate objects is the primate's innate need for social contact and interactions. "Animals are themselves a kind of stimulus, and can actually elicit activity from another animal" (Wilson, 1982). "A review of their social needs and intelligence makes it dear that the common practice of housing macaques, baboons, and chimpanzees in single cages is comparable to keeping fish out of water" (de Waal, 1988).

In many instances it is not necessary to house animals separately. According to Goosen et al. (1984), previously singly caged macaques can be housed in groups of two or more individuals with minimal risk. The authors recommend that adult rhesus monkeys of the same sex be placed in groups of two, four, or more animals. Groups of three would pose too much risk since pairs have a tendency to "conspire" against the third individual. The species of macaques that are to be socialized should be taken into consideration as well, since, while adult rhesus and stumptailed males accept other adult males of their own species, crab-eating macaque males do not (Goosen et al., 1984). Unfortunately these recommendations are speculative and lack supporting data.

Recently, however, several researchers have demonstrated the feasibility of housing caged primates in social pairs. Jerome and Szostak (1987) reported that, based on informal observation, offering adult female baboons companionship with conspecifics for three to four hours a day, two or three times a week produced favorable results. The animals were also provided with a variety of play objects, foraging devices and perches, but "socialization was a safe and more effective environmental enrichment strategy" (Jerome and Szostak, 1987). Reinhardt et al. (1987b) paired naturally weaned infants, taken from breeding troops, with previously singly caged adult rhesus macaques of both sexes (Figures 3 and 4). Partners were considered to be compatible if they exhibited affiliative rather than agonistic behavior, if they shared food, and if neither showed signs of depression. Of 91 pairs tested, 88% (80/91) proved to be compatible throughout 2-27 months of follow-up observation (Reinhardt et al., 1989a). Mutual acceptance did not depend on the sex of either the infant or the adult.

Figure 4. Previously singly caged adult female with her infant companion on the first day of pair

formation.

Reinhardt et al. (1988a) also developed a low-risk method to pair previously singly caged female rhesus monkeys for the purpose of environmental enrichment. Initial compatibility was tested by placing two animals next to each other in two single cages divided by a grated partition. After a seven-day period of non-contact familiarization, animals that were not observed to threaten each other were placed together in double cages new to both. Partners were compatible in 83% (63/76) of the cases throughout 2-24 months of follow-up observations (Reinhardt et al., 1989a). Paired animals' body weights were found to remain stable throughout the study, suggesting that facilitated socialization does not have a negative impact on the animal's general health (Reinhardt et al., 1988b). Paired caging did not interfere with routine management procedures and common research protocols (Reinhardt et al., 1989b).

Slightly modifying the pairing procedure for adult female rhesus monkeys, Reinhardt (1988) has been successful in pairing previously individually caged adult male rhesus monkeys with each other. Partner compatibility was ascertained in 80% (4/5) of cases throughout a follow-up period of 9 months (Reinhardt, 1989). Fritz and Fritz (1988) reported a 98% (N=60) success rate in resocializing chimpanzees that were raised under restricted conditions such as single cage housing. Animals were gradually introduced into "increasingly complex social situations" under the careful supervision of personnel who were familiar with each chimpanzee's background and particular behavioral abnormalities. According to the authors, this method of placing behaviorally abnormal individuals into compatible social groups has been used successfully with chimpanzees since 1969.

Moore-Jankowsky and Mahoney (1989) have developed a method that permits the pairing of previously individually caged adult chimpanzees without undue risk. Potential companions are carefully pre-selected and familiarized prior to being joined in their home cages via an open-bared tunnel. In microbiological studies where research protocols demand single housing, the animals are kept in cages that permit unimpeded visual contact with each other. Even in viral hepatitis and AIDS studies, it is not necessary to keep the animals semi-isolated in solid- sided cages (Moore-Jankowsky and Mahoney, 1989).

ROLE OF ANIMAL CARE STAFF

Related to the idea of socialization is the importance of human contact with captive primates. As Fox (1986) pointed out, "the lack of socialization towards humans will not only make the animals difficult to handle but may also introduce an added social/emotional stress that could be detrimental to experimentation" (1986). Animal caretakers, who are often responsible for the routine handling of animals, play a significant role in the psychological well-being of their charges. The animal care staff, therefore, should be an integral part of enrichment programs (Roberts, 1988). The caretaker's role is of particular importance when single housing is stipulated by a specific research protocol. "These people should be selected for their understanding of animal behavior and their compassion and respect for, and dedication to, their charges" (Goodall, 1987). It is unfortunate that the interaction between the animal caretaker and the individually caged nonhuman primate has not yet received enough attention in the published literature.

SUMMARY

Environmental enrichment strategies for singly caged primates are apparently still very limited. Forty-five percent (13/29) of the available information is in the form of abstracts and brief communications (Borrebach, 1977; Glick, 1977; Renquist and Judge, 1985; Clarke et at., 1987; Glassman et al., 1987; Jerome and Szostak, 1987; Line and Houghton,1984; Line et al.,

1987; Moazed and Wolff, 1988; Bloomstrand and Young, 1988; Fritz and Fritz, 1988; Bayne, 1989; Wolf, 1989), generally lacking supporting data (Table 1 [not copied]). There is a strong need for more quantitative data, including follow-up studies, to determine the actual usefulness and long-term appeal of specific enrichment strategies.

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