A COMPARISON OF THE EFFECTS OF SIMPLE VERSUS COMPLEX ENVIRONMENTAL ENRICHMENT ON THE BEHAVIOUR OF GROUP-HOUSED, SUBADULT RHESUS MACAQUES

S J Schapiro†, M A Bloomsmith, S A Suarez and L M Porter

Department of Veterinary Sciences, The University of Texas MD Anderson Cancer Center, Science Park, Bastrop, TX 78602, USA

† Contact for correspondence and requests for reprints

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Abstract *Animal Welfare 1997, 6:* 17-28

*Enrichment of the environments of captive primates is currently of interest as both a basic and an applied research question, particularly when social and inanimate enhancements are used simultaneously. We measured the behavioural effects of two intensities of inanimate enrichment on 12 unimale-multifemale groups and 12 all-male groups from three cohorts of three to four-year-old rhesus macaques (*Macaca mulatta*). Half of the groups received a simple, inexpensive enrichment programme while the other groups received a more complex and costly combination of physical and feeding enhancements. Observations were conducted on 93 subadults of both sexes during their initial year of group housing. Intensity of enrichment did not differentially affect the amount of time subjects spent in any of the activities analysed. Subjects that received the more complex programme spent only 8.3 per cent of their time using the extra enhancements. Therefore, there was little demonstrated benefit of the more costly enrichment programme. The three cohorts differed in the amount of time that they spent inactive, behaving agonistically, playing and located near a group mate. A planned comparison of one cohort that had been single-housed without visual access to social groups, to the two cohorts that had visual access to social groups during single caging, revealed differences in play and socially-located behaviour, which may have been due to differences in extra-cage conditions two years prior to the present study. When primates are housed socially with conspecifics as 'social enhancements', the relatively simple inanimate enrichment programme we used was as effective as the more costly programme. When enrichment resources are limited, inanimate enrichment efforts should be focused on monkeys that are not socially enriched.*

Keywords: *animal welfare, environmental enrichment, group housing, inanimate enrichment, rhesus macaque, social enrichment*

Introduction

There is considerable motivation, from basic and applied research perspectives, to determine whether enriching the environments of captive primates will yield beneficial consequences.

Recent investigations have demonstrated that enrichment procedures often lead to desirable behavioural changes (Novak & Drewsen 1989; Bloomsmith *et al* 1990; Bayne *et al* 1991; Schapiro & Bloomsmith 1994, 1995), although a few studies have found that certain types of enrichment had little or no effect on behaviour (Line & Morgan 1991; Line *et al* 1991; Bayne *et al* 1993). Other published work has focused on the practical implications of implementing an enrichment programme (Gilbert & Wrenshall 1989; Rumbaugh *et al* 1989; Bloomsmith *et al* 1991). From either perspective, it is important to determine whether enrichment efforts result in beneficial outcomes. Enhancements that positively affect psychological well-being may or may not be justifiable depending on the balance of benefits and the human and monetary efforts required.

Most species of primates live in groups in which their social systems are characterized by a complex set of interactions and relationships (Smuts *et al* 1987). It is difficult to duplicate the full complement of social interactions and relationships in the captive setting, yet in many situations, a large subset of these interactions can be maintained by some types of social housing (Mason 1991; Novak & Suomi 1991; Reinhardt 1994). In general, social housing provides primates with numerous opportunities to perform many components of the species-typical behavioural repertoire, and thus is considered extremely enriching (Reinhardt *et al* 1988, 1995; Bramblett 1989; Reinhardt 1989, 1994; Line *et al* 1990; Mason 1991; O'Neill *et al* 1991; Schapiro *et al* 1996). Although situations have been identified in which social housing was detrimental for a particular age, sex or species of primate (Coe 1991; Ruppenthal *et al* 1991; Crockett *et al* 1994; Clarke *et al* 1995), housing primates with species-appropriate and/or compatible partners may be the most important component of many enrichment programmes.

The behavioural effects of inanimate enrichment may be influenced by the social opportunities available within a group. For example, feeding enrichment devices affect feeding-related behaviours (Bloomsmith *et al* 1988; Byrne & Suomi 1991; Bayne *et al* 1992; Reinhardt 1993; Schapiro & Bloomsmith 1995; Schapiro *et al* 1995b), but the presence of group mates also affects feeding behaviour (Brent *et al* 1993). Within the context of a social group, behaviour related to a feeding device occurs within a system of social relationships that may more strongly affect behaviour than the enrichment procedures. If behavioural benefits of inanimate enrichment cannot be distinguished when animals are housed socially, then other enhancements should be investigated.

To measure the effects of inanimate enrichment in a social setting we observed subadult rhesus macaques (*Macaca mulatta*) housed in small groups. Each group was provided with environmental enrichment at either a high or a low level of intensity.

Methods

Subjects

This study was conducted on subadult rhesus monkeys that were part of the specific pathogen free (SPF) breeding programme at The University of Texas MD Anderson Cancer Center, Science Park. Using a sequence of social and housing manipulations, we are converting the traditional breeding colony into a colony that is free of *Herpesvirus simiae* and three simian retroviruses (Voss *et al* 1991; Schapiro *et al* 1994, 1995a, 1995c). The study animals lived in either unimale-multifemale breeding groups or all-male groups of between five and eight monkeys. Subjects had spent consecutive years housed in their natal groups (0–1 years of

age), in single cages (1–2 years of age) and in mixed-sex pairs (2–3 years of age), prior to group housing (3+ years of age). Additional details on our SPF housing procedures have been reported elsewhere (Voss *et al* 1991; Schapiro & Bloomsmith 1994, 1995).

Three cohorts of rhesus monkeys, one consisting of 33 subadults born in 1988 (Group 1: 17 males and 16 females), a second consisting of 29 subadults born in 1989 (Group 2: 15 males and 14 females) and a third comprising 31 subadults born in 1990 (Group 3: 15 males and 16 females) served as subjects. These are the same cohorts that we have reported on previously (Schapiro & Bloomsmith 1994, 1995). All females were observed during their first year living in one of 12 unimale breeding groups containing between five and seven females each. Four males were studied as breeding males in these groups, while the remainder were observed while living in one of 12 same-age, all-male groups of five to seven monkeys each. Groups contained both study and non-study animals. In each cohort, half of the groups received a simple, inexpensive environmental enrichment programme and half received a more complex and costly enrichment programme. Subjects in the complex enrichment condition were the enriched subjects from our single-housed and pair-housed studies and subjects in the simple enrichment condition were our former control subjects (Schapiro & Bloomsmith 1994, 1995).

Housing and enrichment

Monkeys were housed in 2.4x3.4x2.7m kennel-type runs equipped with nine aluminum perches at various heights, two lengths of polyvinyl chloride (PVC) tubing (3cm outside diameter) suspended horizontally from the back of the run to the front of the run, and two polyethylene buckets hung on the PVC tubing. The runs were in outdoor buildings and subjects could see, hear and smell group-housed, and singly-housed or pair-housed conspecifics. All subjects were provided with monkey biscuits twice per day, oranges three times per week, additional produce once per week and a grain and seed mixture five times per week. All food items were presented in food boxes as well as scattered on the run floor, so that all group members had sufficient access to food items. Biscuits were available at almost all times and water was available ad libitum.

In addition to the treatment described above, subjects in the complex enrichment condition also received a combination of physical and feeding enhancements including: 1) two PVC swings and two chew-type toys that were constantly available (four different toys were presented on a weekly rotation); 2) hay bedding provided for five consecutive days per month; 3) a wading pool (1.1m in diameter) filled with water provided twice per week from May through October; 4) two artificial turf foraging mats (45x60cm) presented twice weekly (adapted from Bayne *et al* 1992 and Schapiro & Bloomsmith 1994, 1995); and 5) two liquid dispensers also presented twice weekly (filled with foods the consistency of fruit juice or apple sauce; adapted from Bramblett & Bramblett 1988). The more intense enrichment programme was intended to increase the amount of time that group-housed subjects spent in species-typical activities, including locomotion, play, and processing and eating food. Subjects in the complex enrichment condition had experience with three of the toys and both of the feeding enrichment devices during earlier housing conditions (Schapiro & Bloomsmith 1994, 1995).

Data collection

Fifteen-minute focal animal observations (Altmann 1974) were conducted on all monkeys during their initial year of group housing. Seven hundred and sixty hours of data were collected between May 1991 and May 1994 using a Tandy© 102 portable computer and The Observer® (Noldus 1991) software. Data were collected between 0830 and 1730h throughout the year, were balanced for time of day and included periods when the extra feeding enrichment devices varied between full and empty. As in our previous studies (Schapiro & Bloomsmith 1994, 1995), our goal was to assess the monkeys' response to overall enrichment programmes, not to individual enhancements.

Abnormal and social behaviours were emphasized on the ethogram of mutually exclusive behaviours. Table 1 contains a list of the behaviours recorded and the categories used for analysis; operational definitions of relevant behaviours have been published elsewhere (Schapiro & Bloomsmith 1994). The following measures were recorded simultaneously with behaviour: the location of the subject in relation to group mates (social location); whether the subject's behaviour was directed to a group mate, and, if so, to which group mate (social direction); and whether complex (extra) enrichment was being used by the subject (use of complex enrichment). For this study, the ethogram for pair-housed subjects (Schapiro & Bloomsmith 1994) was modified to distinguish recipients of socially-directed activities. This data collection system differentiated between socially-directed and self-directed occurrences of each behaviour (eg socially-directed grooming and self-directed grooming).

Table 1 **Ethogram of behaviours observed with activity categories for analysis (operational definitions in Schapiro & Bloomsmith 1994).**

Behaviours	Activity for analysis
Sit, Sleep	Inactivity
Abnormal sexual behaviour, Masturbate, Normal sexual behaviour (given and received)	Sexual behaviour
Self-groom, Social groom (given and received)	Grooming
Eat, Forage	Feeding
Social play, Self-directed play	Playing
Urophagy, Self-pick, Suck digit, Salute, Pace, Head toss, Coprophagy, Self-aggression, Abnormal (other)	Abnormal behaviour
Investigate, Look, Olfactory explore	Exploring
Social aggression (given and received), Threat (given and received), Submit, Take away, Social pick (given and received)	Agonistic behaviour
Drink, Locomote, Manipulate, Urinate, Defecate	Other behaviours
Vocalize	Vocalizing

Inter-observer reliability for cumulative durations of behaviours within observation sessions was measured monthly for a total of seven observers. Per cent agreement averaged 86.0 per cent for behaviours, 95.2 per cent for social location, 92.6 per cent for social direction and 97.9 per cent for use of complex enrichment.

Data analysis

Data were analysed using multivariate analysis of variance (MANOVA) techniques. Individual behaviours from the ethogram were grouped into the categories included in Table 2. The dependent measures used in the analysis were the cumulative durations of each activity category for each subject during the initial year of group housing. This resulted in a total of 93 data points per activity (47 in the complex enrichment condition and 46 in the simple condition).

A 2 x 3 MANOVA was performed examining *treatment* (simple or complex enrichment programme) and *group* (1, 2 or 3) effects on the mutually exclusive categories of activity. In addition, separate 2 x 3 analyses of variance (ANOVA) were conducted for these same effects on social location and on social direction of behaviour. Separate ANOVAs were necessary to prevent skewing of the main analysis because these measures included occurrences of more than one of the mutually exclusive behaviour categories. Where appropriate, planned comparisons of Group 1 to Groups 2 and 3 were conducted to verify long-lasting influences of the extra-cage environment (the environment outside the cage) from when subjects were single-housed (Schapiro & Bloomsmith 1995; Schapiro *et al* 1995b).

A one-way ANOVA of time spent using extra enrichment was also conducted for subjects in the complex enrichment condition only.

Results

The overall multivariate test for the experimental treatment was not significant (Wilks' lambda = 0.89, $F_{8,80} = 1.2$, $P > 0.05$). The group of subjects that received the complex enrichment programme did not differ from the group that received the simple enrichment programme in durations spent in any of the target behaviours, in time spent located near ($F_{1,87} = 2.2$, $P > 0.05$) or time spent interacting with group mates ($F_{1,87} = 0.4$, $P > 0.05$) (see Table 2).

Groups 1, 2 and 3 differed significantly overall (Wilks' lambda = 0.47, $F_{16,160} = 4.6$, $P \leq 0.001$) and subsequent univariate tests revealed that time spent inactive $F_{2,87} = 3.1$, $P \leq 0.05$), behaving agonistically ($F_{2,87} = 21.5$, $P \leq 0.001$), and playing ($F_{2,87} = 4.8$, $P \leq 0.01$) differed across groups. Time spent located near a group mate differed significantly across groups ($F_{2,87} = 3.4$, $P \leq 0.05$), but time spent interacting with a group mate did not $F_{2,87} = 0.7$, $P > 0.05$). Planned comparisons of Group 1 to Groups 2 and 3 revealed an overall significant difference (Wilks' lambda = 0.80, $F_{8,80} = 2.5$, $P \leq 0.05$) attributable entirely to greater amounts of time spent playing by subjects in Group 1 ($F_{1,87} = 8.3$, $P \leq 0.01$). Group 1 subjects spent significantly less time located within a social distance of a group mate than did subjects in Groups 2 and 3 ($F_{1,87} = 6.3$, $P \leq 0.05$).

There were no significant treatment-by-group interactions in any of the analyses.

Table 2 **Mean durations spent in target activities, comparing groups that received either simple or complex enrichment programmes (in minutes per observation hour).**

Activity	Intensity of enrichment programme					
	Group 1		Group 2		Group 3	
	Simple	Complex	Simple	Complex	Simple	Complex
Inactivity[1]	3.60	3.17	2.24	3.73	4.21	5.12
Sexual behaviour	0.20	0.11	0.07	0.25	0.09	0.05
Grooming	11.13	12.28	13.00	10.78	11.62	12.53
Social	7.02	7.04	8.65	6.79	7.08	8.28
Self	4.11	5.24	4.35	3.99	4.54	4.25
Feeding	16.02	15.63	16.58	19.15	14.82	16.66
Playing[1,2]	1.89	1.26	1.09	0.99	0.97	0.46
Social	1.34	0.89	0.72	0.63	0.89	0.36
Self	0.55	0.37	0.37	0.36	0.08	0.10
Abnormal behaviour[1]	0.99	0.87	0.22	0.47	0.44	0.91
Exploring	14.06	15.53	16.65	14.89	17.90	15.43
Agonistic behaviour	0.73	0.69	0.84	0.88	0.45	0.35
Other	11.38	10.46	9.31	8.86	9.95	8.79
Vocalizing[3]	14.50	9.98	9.12	10.10	10.78	12.45
Use of complex enrichment	-	4.83	-	4.18	-	6.00
Socially-directed behaviour	11.30	10.99	12.78	11.13	10.41	10.70
Socially located[1,2]	16.27	15.58	22.53	16.29	20.46	20.50

[1] $P \leq 0.05$ for comparison of Group 1 to Group 2 to Group 3
[2] $P \leq 0.05$ for planned comparison of Group 1 to Groups 2 and 3
[3] Number of occurrences used for analysis, not duration.

Monkeys in the complex enrichment condition used the various extra enhancements for an average of 5 minutes per hour, or 8.3 per cent of the time (see Table 2). There were no significant differences in use of complex enrichment across the three cohorts ($F_{2,44} = 1.4$, $P > 0.05$).

Discussion

The complex physical and feeding enrichment programme provided to some groups of monkeys in this study did not affect behaviour when compared to the simple enrichment programme provided to the other groups. Many previous studies of inanimate enrichment for

group-housed primates have documented both significant behavioural changes as a function of physical (trees, structures, balls, pools) and feeding (devices, foods) enrichment, and considerable use of the enhancements (Chamove *et al* 1982; Bloomsmith *et al* 1988, 1990; Maki & Bloomsmith 1989; Novak & Drewsen 1989; Champoux *et al* 1990; Byrne & Suomi 1991; O'Neill *et al* 1991; Novak *et al* 1993; Anderson *et al* 1994; Kessel & Brent 1996). Thus, our data are not in agreement with much of the literature.

Our results are even more surprising when one considers that the subjects that received the complex enrichment programme received enrichment not only during the study period while group-housed, but also during two previous years of single and pair housing (Schapiro & Bloomsmith 1994, 1995). Apparently, the presence of group mates provides social opportunities and contingencies that influence the use of (Brent *et al* 1993) and may even obscure the behavioural effects of some inanimate enhancements. The influence of opportunities for social interactions may be so robust that they overrode differences between control and enriched groups that existed during the earlier two years. Unlike Champoux *et al*'s (1990) study of much younger subjects, we found no extended effect of enrichment.

The goal of all enrichment programmes is to provide opportunities for primates to exhibit species-typical behaviours. Improvements in psychological well-being as a function of enrichment are often measured in terms of changes in behaviour that more closely approximate species-typical levels (Line 1987; Novak & Suomi 1988). There can be little argument that, in many instances, social housing is likely to lead to such improvements (for notable exceptions, see Goo & Sassenrath 1980; Coe 1991; Ruppenthal *et al* 1991; Crockett *et al* 1994; Clarke *et al* 1995). The present study provides empirical support for the possibility that costly inanimate enrichment programmes may not *further* influence the behaviour of group-housed primates in species-appropriate directions when they are already benefiting from social enrichment (Schapiro *et al* 1996). The activity budgets of our subjects fall within reported ranges for wild (Lindburg 1971; Teas *et al* 1980) and captive (activity reported in terms of mean modified frequencies: O'Neill *et al* 1991; Novak *et al* 1992; Parks & Novak 1993) populations of rhesus macaques.

Although the two different levels of enrichment intensity provided in this study did not affect the behaviour of subjects, there were several significant cohort effects. The three cohorts were born in different years and also varied slightly in several other respects, including 1) the order in which enrichment was received by some subjects during single caging and 2) the age of males used as breeders during group housing. It is unlikely however, that these disparities would account for the observed behavioural differences. More importantly, Group 1 was single caged for a year in indoor rooms without sensory access to group-housed conspecifics, while Groups 2 and 3 spent their single caged year in outdoor buildings in view of multiple social groups (Schapiro & Bloomsmith 1995; Schapiro *et al* 1995b). We have previously documented that indoor housing led to decreased feeding, and increased play, inactivity and use of enrichment compared to outdoor housing for monkeys while single-caged (Schapiro & Bloomsmith 1995; Schapiro *et al* 1995b). That subjects in Group 1 still spent more time playing than did Group 2 and 3 subjects, *two years after* single caging, suggests that long-term behaviour patterns may be altered by the extra-cage environment during single caging (between the ages of one and two years). Similarly, subjects that were single-caged in indoor rooms without sensory access to social groups spent less time near a group mate than did subjects that could see group-housed monkeys. It

appears that just as visual exposure to mothers and infants for single-caged weanlings increases maternal abilities (Dienske *et al* 1980), similar visual exposure to social groups may increase sociality.

Subjects in the complex enrichment condition across the three cohorts did not differ in their use of complex enrichment, spending an average of only 8.3 per cent of observation time using the extra enhancements. During the years living alone and in pairs, these same monkeys spent 22.3 per cent and 40.0 per cent, respectively of the observation time using enrichment (Schapiro & Bloomsmith 1994, 1995). We know that the inanimate enhancements we provided during group housing were of interest to the subjects, because they were very similar to those provided during previous years, when levels of use were higher. Subjects may have habituated to the enrichment devices by the time they encountered them during group housing. Alternatively, competition within social groups for access to extra enhancements may have limited their use by subordinate animals. Monkeys that received the complex enrichment programme did *not* engage in more overall agonistic activity than those that received the simple programme, but displacements and threats involving access to feeding devices (available only to subjects in the complex condition) did occur when they were filled with a limited quantity of attractive foods. We could not provide each group-housed monkey with its own feeding device as we had been able to do for subjects while they were housed alone and in pairs. Feeding enhancements have successfully affected behaviour in other studies of socially-living primates, even when there were similar levels of competition for access to limited quantities of enrichment foods and devices (Chamove *et al* 1982; Bloomsmith *et al* 1988; Beckley & Novak 1989; Hayes 1990; Brent & Eichberg 1991; Byrne & Suomi 1991). Although extra enhancements were used less frequently by subjects in this study than in previous work, any use of enhancements promotes expression of the range of species-typical behaviours and thus can be judged to improve well-being.

Many previous studies of enrichment have reported significant effects using within-subjects designs in which relatively short enriched periods are compared with pre-enrichment and/or post-enrichment conditions of similar durations (Bayne *et al* 1991, 1992; Byrne & Suomi 1991; Line & Morgan 1991; Parks & Novak 1993; Anderson *et al* 1994; Kessel & Brent 1996). Within-subjects designs are susceptible to temporal confounds and may be influenced by rebound effects (Bayne & Dexter 1992), where undesirable behaviours increase following the removal of enrichment. If the post-enrichment phase containing such a rebound is included as part of the baseline for statistical comparison, enrichment effects become inflated. Enrichment studies undertaken with appropriate control groups (Champoux *et al* 1990) are less susceptible to temporal confounds and rebound effects, and should allow direct attribution of behavioural effects to enrichment. Therefore, the observed lack of an effect in the present study may be at least partially due to our use of a between-subjects design. This design may be especially appropriate for evaluations of enrichment programmes for potential incorporation into standard housing and husbandry practices, where enhancements are likely to be regularly presented and removed for short periods, but are unlikely to be permanently removed.

The complex enrichment programme in this study did not affect behaviour, a finding which is especially pertinent since similar enhancements did affect the same monkeys in our previous studies. The data suggest that housing primates with conspecifics as social

enrichment obscures the benefits of inanimate enrichment and that the provision of a few, very simple, inexpensive enhancements for socially-housed primates may be an adequate enrichment strategy.

Animal welfare implications

The more elaborate enhancements included in this study did not have a measurable effect on behaviour, and thus were not cost-effective. Social housing may have overshadowed the behavioural effects of inanimate enrichment and eclipsed behavioural differences that existed prior to group housing. Providing additional toys, swings, hay bedding, pools and feeding devices to group-housed monkeys was no more effective than simply hanging perches, tubing and buckets and scattering grain or fruit on the floor. Therefore, a much greater enrichment effort than that of the complex enrichment condition studied here would be necessary to promote observable behavioural changes. Whether the resources necessary to maintain such an elaborate and expensive programme could be justified is unknown. Complex and costly enhancements may not be imperative for group-housed primates; the majority of the limited resources available for enrichment should be focused on animals that are socially restricted.

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