

Porches as Enrichment for Singly Housed Cynomolgus Macaques (*Macaca fascicularis*)

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Effective environmental enrichment is used by animals, promotes species-typical behavior, and decreases abnormal behavior. Porches attached to the front of an animal's cage provide additional space, perching opportunities, and a better view of the surroundings. Here we assessed the effectiveness of porches as a form of enrichment and identified characteristics of the animals most likely to use the porches. We videorecorded and scored the behavior of 18 (9 male, 9 female) singly housed cynomolgus macaques (*Macaca fascicularis*) during 3 observation intervals (15 min each) the week before, during, and after exposure to the porches. Changes in abnormal and tension-related behaviors (pacing, yawning, scratching) and species-typical behaviors were compared across the 3 wk of observation. Novel object temperament tests were performed before and after the study. During observation periods, subjects spent an average of 75% of time in the porch. No changes in pacing or tension-related behaviors occurred, but activity decreased during and after porch exposure, rest increased during the porch exposure, and consumption decreased afterward. Eight subjects were categorized as having a bold temperament, and the remaining 10 subjects had an intermediate temperament. Sex and a temperament \times cage location interaction were predictors of porch usage. Males used the porches more than did females, and those with an intermediate temperament were less likely to use the porches when they were located in the lower cages. Porches are beneficial in that they are used for extensive periods of time, but the benefits can vary according to the individual animal.

Environmental enrichment is a method of modifying an animal's captive environment to promote welfare. An enriched environment reduces boredom and stress, encourages species-typical behavior and decreases abnormal behavior, provides behavioral choices, and promotes psychologic wellbeing. Psychologic wellbeing can be measured in a number of ways including physical health, the display of species-typical behavior, the ability to adequately cope with stress, and the ability to respond appropriately to environmental stimuli.²² Environmental enrichment is not only provided out of ethical concerns and to promote wellbeing, it is also required by law. The Animal Welfare Act² states that facilities must have an environmental enhancement plan in place for promoting psychologic wellbeing in NHP. In addition, because psychosocial stress can have a physiologic effect on the animal,^{10,25} promoting psychologic wellbeing supports good science.

Environmental enrichment for NHP can be classified into 5 categories, including social (housing animals in pairs or groups), nutritional (fruits, vegetables, novel food items), sensory (novel scents, television, radio), occupational (food puzzles, positive reinforcement training), and physical (perches, chew toys, manipulable objects).⁴ The cage itself can be considered an aspect of physical enrichment. Although larger cages typically are deemed preferable, minor or moderate increases in cage size have little effect on behavior^{9,14,17} and may even increase levels of abnormal behavior.³ Perhaps quality, rather than quantity, of the added space is the relevant factor regarding behavioral change and improved psychologic wellbeing.

Porches are cage additions that can be attached to the front of the cage, allowing the animals to access additional space. In addition to increased space, the animals have a wider view of

the room in which they are housed and are better able to see their neighbors. Although the addition of the porch does not add a significant increase in space, porches do provide behavioral choice to the animals, allow for increased social interaction, and provide an additional above-ground perch. These attributes of porches improve the quality of the space beyond simple square footage.

Not all enrichment has the same benefits for each animal. Therefore, the effectiveness of an enrichment device needs to be assessed. This evaluation can be accomplished in a number of ways including determining whether and how much the item is used, whether it increases species-typical behavior, and whether it decreases levels of abnormal behavior.¹⁸ In addition to measuring the effectiveness of an enrichment device, it is important to identify which animals would benefit the most from the enrichment item to better tailor enrichment to the animals' needs. For example, an animal's temperament, age, and sex can all affect its response to enrichment.^{1,6,16,20,21,23} Therefore, the purpose of our current study was to assess the effectiveness of porches as an enrichment device for singly housed cynomolgus macaques (*Macaca fascicularis*) and to identify potential predictors for determining which animals would benefit the most from porches.

Materials and Methods

Subjects. The subjects were 18 cynomolgus macaques (*Macaca fascicularis*; 9 male, 9 female; age: range, 3.6 to 5.5 y; mean, 4.3 y) with no prior porch experience. At the time of observation, the subjects were singly housed indoors according to IACUC-approved research requirements at the Southwest National Primate Research Center (San Antonio, Texas). They were fed a nutritionally complete diet supplemented with fruits, vegetables, and grains and were provided with toys, foraging devices, and novel food treats on a rotating schedule. The facility

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Active	The action of standing up or sitting down, or moving the body one step in any direction
Drink	Consumption of liquid from a source
Eat	Placement of food into mouth; can pause for a maximum of 2 s
Other-directed manipulation	Oral or manual manipulation of the cage or objects inside the cage
Pace	Repeated walking in the same pattern at least 3 times
Rest	Animal is sitting or standing motionless with the eyes open or closed for at least 2 s; includes slight shift of whole body
Scratch	Vigorous strokes of the hair with the hands or the feet
Self-directed manipulation (other than scratch)	Behaviors directed toward self, such as picking, grooming, rubbing, masturbation, licking, and so forth
Yawn	Opening mouth wide, displaying teeth

Figure 1. Behavioral ethogram.

is AAALAC-accredited, and the animals were maintained in accordance with the *Guide for the Care and Use of Laboratory Animals*.¹³ The research was approved by the IACUC and complied with the laws and regulations of the United States Animal Welfare Act.²

Porches. The porches (28 cm × 48 cm × 38 cm) were made of a stainless steel mesh (Suburban Surgical, Chicago, IL) and attached to the front of the cage.

Behavioral observations. The macaques were videotaped 15 min daily, 3 d weekly, for 3 wk. Week 1 was the pretest (no porch) condition; week 2 was the porch condition (porch attached to the cage throughout the entire week), and week 3 was the posttest condition (no porch). Duration of recorded behaviors (Figure 1) was determined by using Observer XT (Noldus, Leesburg, VA). The videorecording taped during the porch condition (week 2) was viewed a second time to determine the amount of time that the macaque spent in the porch.

Temperament testing. Novel object temperament testing⁷ was conducted on the day prior to the start of the behavioral observations and the day after they concluded. For each temperament test, 2 novel toys were hung on the outside of the cage, one after the other, for 2 min each. The temperament tests were videotaped, and the latency to touch the toy was measured. A macaque was considered to be bold when the average latency to touch the novel objects was less than 10 s, inhibited if it did not touch a novel object, and intermediate when the average latency to touch the novel objects was between 10 and 120 s.

Data analyses. Data analyses were conducted by using Systat 13 (Systat Software, Chicago, IL). Significance was set at a P value less than 0.05.

Behavior. Repeated-measures ANOVA were conducted to assess the effect of the porches on behavior. Test condition (before, during, and after porch exposure) was the independent variable, and duration of behavior was the dependent variable. Only 6 of the subjects exhibited pacing behavior, so they were analyzed separately for this behavior. Posthoc Bonferroni tests were conducted on tests with significant results.

Porch usage. A repeated-measures ANOVA was conducted to determine whether porch usage changed across the 3 d of observation.

Predictors of porch use. To identify the macaques most likely to use porches, a linear regression was conducted to examine the potential effects of age, sex, temperament, and cage location on porch usage. All variables and their interactions were

entered into the model initially, and a backward elimination procedure was used to determine the 'best fit' model. Terms with the highest P values were removed first. When a term did not show a significant main effect but contributed to a significant interaction, the main and interactive effects for that term remained in the model.

Results

Behavior. Because of low values, the behaviors scratch and yawn were combined into the single category of 'tension,'¹⁴ and the behaviors eat and drink were combined into the single category 'consumption.' Active behavior ($F_{2,34} = 7.146, P < 0.005$), rest ($F_{2,34} = 6.817, P < 0.005$), and consumption ($F_{2,34} = 4.642, P < 0.05$) differed significantly across the 3 wk of observation. Subjects were more active before exposure to the porches than during ($P < 0.05$) or after ($P < 0.005$; Figure 2) exposure; they rested more during than before porch exposure ($P < 0.005$, Figure 3); and they consumed more food and water before than after porch exposure ($P < 0.05$, Figure 4). The remaining behaviors did not differ significantly across test conditions (tension: $F_{2,34} = 0.863, P = 0.431$; self-directed behavior: $F_{2,34} = 1.744, P = 0.190$; other-directed behavior: $F_{2,34} = 1.472, P = 0.244$; and pace: $F_{2,10} = 0.816, P = 0.469$).

Temperament test. For the temperament test, 8 macaques (4 male, 4 female) were categorized as bold in temperament, with an average latency of 5.4 s (range, 1.0 to 9.0 s) to touch the novel objects. The remaining 10 subjects (5 male, 5 female) were categorized as intermediate in temperament, with an average latency of 29.7 s (range, 13.0 to 76.5 s) to touch the novel objects. No subjects were categorized as inhibited. Temperament categories were distributed equally across cage location (upper compared with lower).

Porch usage. The porches were used for an average of 75% of the observation time, and usage remained consistent across time ($F_{2,34} = 0.885, P = 0.422$).

Predictors of porch use. Sex ($b = -156.504, P < 0.05$) and the temperament × cage location interaction ($b = -251.786, P < 0.05$; Figure 5) contributed to porch usage. No other predictors were significant. Male macaques used the porches more than did females (82% compared with 68% of time), and the interaction data revealed that animals with an intermediate temperament were less likely to use the porches when they were located in the lower cages. Macaques with a bold temperament did not demonstrate this preference.

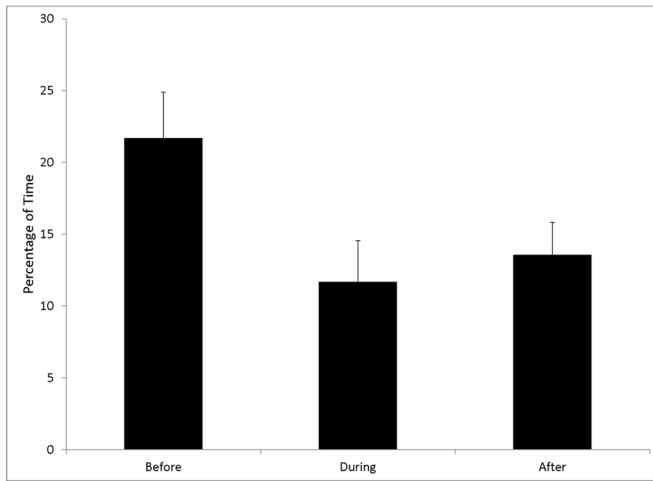


Figure 2. Active behavior (% of time; mean ± SEM) across test conditions (before, during, and after porch exposure).

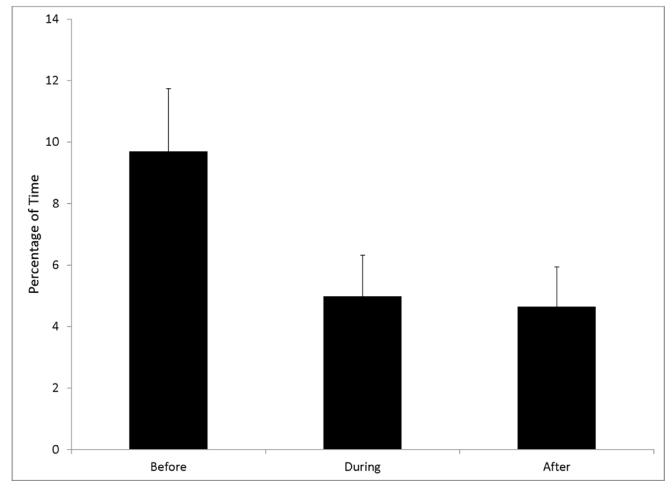


Figure 4. Consumption (% of time; mean ± SEM) across test conditions (before, during, and after porch exposure).

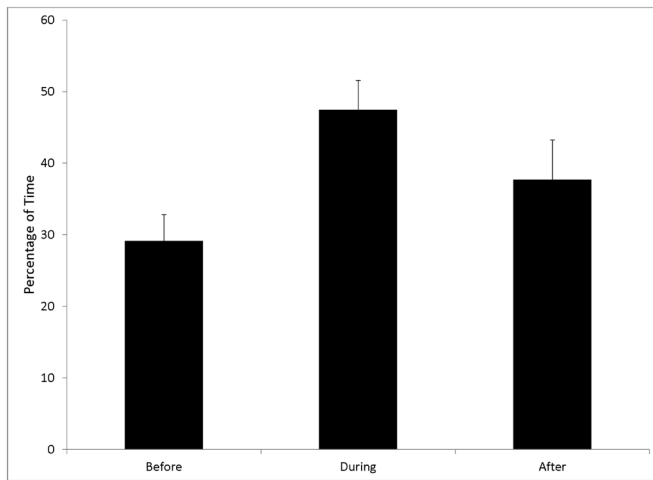


Figure 3. Rest (% of time; mean ± SEM) across test conditions (before, during, and after porch exposure).

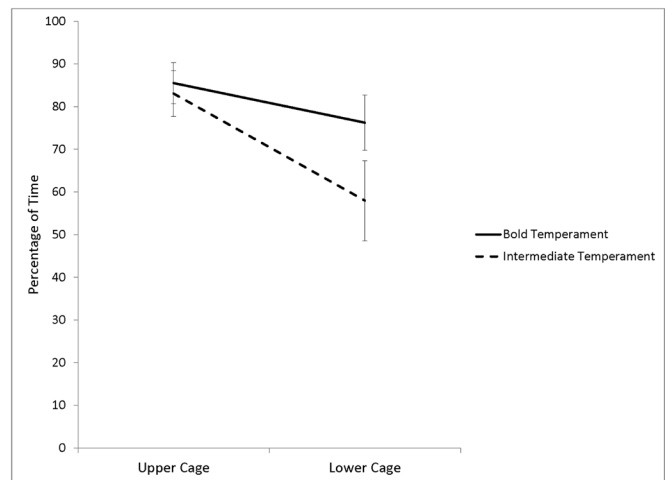


Figure 5. Temperament × cage location interaction in porch usage.

Discussion

In our current study, porches were an effective enrichment device for cynomolgus macaques. Porch usage was high in comparison to other enrichment devices, such as cage toys or branches,^{15,16,23} and the use of the porches remained at high levels throughout the week. Anecdotal observations suggested that interest in the porches persisted even after weeks of use. In contrast, the use of enrichment devices such as manipulable toys typically declines dramatically once the novelty wears off.^{8,16} This factor alone demonstrates the unique properties of porches compared with other enrichment devices.

The behavioral data in part reflected porch usage. Because the porch was small, it provided limited space for movement. As a result, when porches were used, activity decreased and rest increased. This result is similar to that observed when overall cage size is reduced.⁹ The animals in the present study had the option of exiting the porch, but when they used the porch, their movement was restricted. Therefore, the reduction in active behavior and increase in rest are not unexpected. Although eating and drinking were reduced during exposure to the porch, the reduction was nonsignificant. In contrast, eating and drinking were decreased significantly after compared with before porch exposure. Perhaps eating and drinking reflect some amount of boredom in the animals. Although they frequently brought

food with them into the porch, their interest in the view from the porch may have provided sufficient behavioral alternatives, which persisted into the posttest phase.

Tension-related behaviors (scratch, yawn) did not decrease during the porch condition. Previous studies reported a decrease in tension-related behaviors in larger cages,¹⁴ perhaps because the macaques had more space to retreat. In contrast, the use of the porch brought the macaques forward in the cage, thus perhaps countering the effect of increased space on tension-behaviors. Similarly, abnormal pacing behavior did not decrease with the application of the porches. In a previous study, the use of porches helped to reduce abnormal feces-painting behavior in 8 rhesus macaques (*Macaca mulatta*);¹¹ in the cited case, the use of the porches may have provided alternatives to feces painting. Although a reduction in abnormal behavior is one goal of enrichment provisioning, this effect did not occur in the current study. Pacing is typically among the most common abnormal behaviors in macaques.^{12,19} However, in the current study, only 6 of the 18 animals were observed to pace, and of those 6, pacing accounted for an average of only 1% to 4% of the time. The lack of reduction in pacing may be due to the overall low levels of abnormal behavior in the population.

Age was not predictive of cage use, perhaps because of the limited age range of the subjects (less than 2 y between the

youngest and oldest animals). Studies showing significant age differences in enrichment use typically tested animals with a broader age range.^{20,23} For example, one study²³ demonstrated that older, adult animals used a suspended plastic pipe less than did younger subadults; however, the animals in the cited study ranged from 3.5 to 30 y of age (a spread of more than 25 y). If we had included a wider age range of subjects in the present study, age might have played a greater role in porch usage.

Sex was a significant predictor of porch usage. Previous studies have demonstrated sex-associated differences in exploratory behavior with enrichment;^{1,20,21} however, females were typically more interactive with enrichment than were males.^{20,21} In the present study, males used the porches more than did females. Perhaps the view provided by the porches and the opportunity to socially interact with neighbors were more desirable to male macaques.

Although temperament and cage location did not influence porch usage individually, their interaction played a significant role. Animals that demonstrated a bold temperament spent time in the porch almost equally whether it was in an upper or lower location. However, those animals that were less bold and reflected an intermediate temperament spent less time on the porch when it was located on a lower cage. Studies have demonstrated that when given a choice, macaques spent more time in an elevated position.⁵ Similarly, group-housed rhesus macaques spent significantly more time on perches (89.8%) than on the floor or cage mesh.²⁴ Perhaps when the porch was attached to an upper cage, it functioned better as an above-ground perch than when it was attached to a lower cage, resulting in increased usage. In addition, animals that were less bold may have felt safer when they had the opportunity to perch on a higher porch. These results suggest that macaques with an intermediate temperament may benefit more from a porch when they are housed in an upper cage. However, only 2 temperaments were evident in our study population. Because exploration and social interaction are essential aspects of porch use, temperament should be further assessed as a potential predictor.

In conclusion, porches are a useful addition to an enrichment program for cynomolgus macaques. They provide behavioral choice to the animals, a better view of the room, and increased ability to socialize with neighbors. These factors may contribute to the substantial amount of time that the macaques spent in the porch and its consistent use across time. In addition, increased species-typical behavior and decreased abnormal behavior are considered to be indicators of the efficacy of an enrichment device. Although tension and abnormal behavior did not decrease, the behavioral changes that did occur reflected porch usage and the limited size of the porch. Age did not play a role in porch usage, but sex, temperament, and cage location emerged as potential predictors. Even though usage is just one factor for measuring the efficacy of an enrichment item, our current data clearly demonstrate that porches are a beneficial addition to any enrichment program.

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