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Authors
Kuczaj, Stan
Lacinak, Thad
Fad, Otto
et al.

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Keeping Environmental Enrichment Enriching

Stan Kuczaj,
University of Southern Mississippi, U.S.A.

Thad Lacinak, Otto Fad,
Sea World Orlando, U.S.A.

Marie Trone
University of Southern Mississippi, U.S.A.

Moby Solangi,
Institute for Marine Mammal Studies, U.S.A.
and
Joana Ramos
University of Southern Mississippi, U.S.A.

The use of novel objects as environmental enrichment devices is a key aspect of many environmental enrichment programs, regardless of whether the animals being enriched are housed in aquaria, zoos, or laboratories. The effectiveness of novel objects as enrichment devices depends on a number of factors, many of which are based on findings from comparative psychology. For example, the literature on habituation predicts that an object that is always in an animal's environment will be less interesting than a similar object that is available only on an intermittent basis. To test the hypothesis that type of exposure to objects affects the objects' enriching qualities, we exposed sixteen animals from ten different species to novel objects in two different conditions. In the first condition, animals were exposed to a novel object for a total of 120 min, 60 min at a time on two separate occasions. Approximately three weeks later, the animals were once again given a total of 120 min to interact with the object that they had experienced in the first condition, but the amount of time the object was available per session was much more variable. The results demonstrate that variable presentations are more likely to maintain the enriching qualities of objects, consistent with the literature on habituation.

Throughout history, humans have kept animals for a variety of reasons, including labor, food, research, education, entertainment, and companionship. In recent years, there has been growing concern about the well-being of animals maintained by humans, regardless of whether the animals are being raised for food, housed in laboratories for research purposes, or kept in a zoological setting for educational and entertainment reasons (e.g., see Holst, 1997; Sheperdson, Mellen, & Hutchins, 1998). As a result, many aquaria, laboratories and zoos have developed programs designed to enhance the "quality of life" of the animals in their care. These programs are often called environmental enrichment programs, a name which aptly reflects their goals. The premise of environmental enrichment programs is straightforward: Enhance the quality of an animal's environment and the

We wish to express our sincere appreciation and tremendous debt to the training staffs at SeaWorld© Orlando and MarineLife Oceanarium for their invaluable assistance and support during this project. Their suggestions concerning possible enrichment devices and ways in which to enhance the quality of the lives of the animals under their care were insightful and illuminating. In addition, their help with the actual implementation of the procedures described in this paper was essential. Address for correspondence: Stan Kuczaj, Department of Psychology, University of Southern Mississippi. Box 5025, USM, Hattiesburg, MS 39406-5025, U.S.A. (s.kuczaj@usm.edu).

animal's psychological and physiological well-being will improve. And in fact, the results of many enrichment programs suggest that improving an animal's environment benefits the animal (e.g., Holst, 1997; Mellen & Sevenich MacPhee, 2001; Sheperdson, Mellen, & Hutchins, 1998; Renner & Lussier, 2002).

Although environmental enrichment has been readily embraced by many individuals and institutions, it is becoming increasingly evident that not all enrichment is equally enriching (Crockett, 1998; Galef, 1999; Lacinak, Turner, & Kuczaj, 1997; Mellen & Sevenich MacPhee, 2001). For example, some animal housing renovations and policies that were intended to reduce abnormal behaviors among the target animals did not produce long lasting beneficial effects (Crockett, 1998; Galef, 1999). The mixed results of enrichment efforts demonstrate the need for systematic evaluations of the effectiveness of all aspects of environmental enrichment programs (Galef, 1999; Mason, McFarland, & Garner, 1998; Mellen & Sevenich MacPhee, 2001; Morgan, Line, & Markowitz, 1998). As evidenced by the following quote, Galef (1999, p. 279) has been one of the most forceful proponents of the need for a scientific approach in the evaluation of environmental enrichment programs:

> Enrichment programs based on unscientific belief systems or unscientific methods must be counterproductive in the end. Good will toward animals plus professional judgment is simply not enough. We need to undertake research on the efficacy of whatever enrichment programs we propose to implement. If we do not, we are not meeting our moral obligations, either to the animals…or to the public that asks that we treat our animals as humanely as we can.

We concur with this call for increased scientific vigor in the assessment of environmental enrichment. Moreover, we propose that the scientific evaluation of enrichment programs be based on principles discovered by comparative psychologists. After all, these principles form the bases for most environmental enrichment efforts. For example, in this paper we investigate the effectiveness of one common enrichment technique–providing an animal with a novel object. Many attempts to enrich the environment of various animals have involved the placement of objects in the animals' environment (Gilbert & Wrenshall, 1989; Line, Clarke, & Markowitz, 1989; Renquist & Judge, 1985; Ross & Everitt, 1988; Vick, Anderson, & Young, 2000; Wemelsfelder et al., 2000). When novel objects are first introduced, animals are likely to attend to them, as previous work on orienting responses would predict (e.g., see Domjan, 2000). However, the simple provision of novel objects into an animal's enclosure is not sufficient to produce consistent long term benefits (Lacinak et al., 1997; Line & Morgan, 1991; Maki & Bloodsmith, 1989; Markowitz & Aday, 1998; Schapiro et al., 1996). One reason for such failure is that the objects often lose their appeal, and so become just another aspect of an unstimulating environment (Lacinak et al., 1997). The loss of interest due to repeated or prolonged exposure to the object reflects habituation, a phenomenon that has been well documented in both animal and human learning (e.g., Domjan, 2000; Gallistel, 1990; Oakes, Madole, & Cohen, 1991). However, the effects of habituation on environmental enrichment programs have not been systematically investigated in an actual zoological setting.

In the current study we assessed the effectiveness of novel objects as enrichment devices under two conditions. In condition 1, the objects were presented continuously for a relatively long period of time on two separate occasions. In condition 2, the objects were presented for shorter variable intervals. We hypothesized that the animals would interact with the objects more in the second condition than in the first condition. This hypothesis is based on the likelihood that objects which are simply placed in an animal's environment and left for long periods of time lose their enriching effectiveness as a result of habituation. Given that habituation is likely to decrease the enriching qualities of objects (and other stimuli), specifying the nature of habituation effects will make it easier to avoid the negative consequences of such effects on environmental enrichment programs. Thus, in the present study, we investigated the manner in which length of exposure to novel objects was related to habituation to these objects. We believe that ascertaining this relationship will make it easier to develop and maintain environmental enrichment programs that are actually enriching for the animals.

The procedure that we used was quite simple. The novel object was placed into the animal's environment and the extent to which the animal interacted with the object was monitored and recorded. We assumed that animals interact with objects that they find enriching, and so used the amount of interaction with an object as an index of its enriching qualities.

Method

Subjects

Sixteen (7 males, 9 females) animals at two facilities participated in the present study. Subjects tested at SeaWorld, Orlando, Florida, included one bottlenose dolphin (*Tursiops truncatus*), one false killer whale (*Pseudorca crassidens*), one polar bear (*Ursus maritimus*), one Pacific walrus (*Odobenus rosmarus*), one killer whale (*Orcinus orca*), two North American river otters (*Lontra canadensis*), and two short-clawed Asian river otters (*Aonyx cinerea*). Subjects tested at MarineLife Oceanarium, Gulfport, Mississippi, consisted of three bottlenose dolphins, two California sea lions (*Zalophus californianus*), one sulfur-crested cockatoo (*Cacatua galerita*), and one scarlet macaw (*Ara macao*). We elected to use animals from a large number of species in order to assess (albeit in a very preliminary fashion) the extent to which habituation to novel objects is influenced by universal learning principles. More specifics about each animal are provided in Table 1.

Table 1
General Characteristics of each Animal and Description of Novel objects for each Animal.

Species	Sex	Age (years)	Captive/wild born	Object
Asian otter	F	3	Captive	rubber chew toy
Asian otter	F	4	captive	rubber chew toy
Cockatoo	F	7	captive	rope with plastic beads
Dolphin	F	10	captive	football ½ full of water
Dolphin	M	6	captive	meter long plastic bat
Dolphin	F	17	captive	large ball with holes
Dolphin	F	~33	wild	rope with knots
False killer whale	F	3	captive	large ball with holes
Killer whale	M	~15	wild	large ball with holes
Macaw	M	12	captive	rope with plastic beads
North Amer. otter	F	4	wild	rubber chew toy
North Amer. otter	M	4	wild	rubber chew toy
Polar bear	M	6	captive	large tractor tire with holes
Sea lion	F	10	captive	small barrel with holes
Sea lion	M	8	captive	large heavy ball
Walrus	M	15	wild	small barrel

Novel objects

Prior to testing, each animal's history with objects was determined. Individual novel objects were selected for each animal in order to avoid confounds that might result from different past experiences with target objects. Some objects were modified to alter some of their qualities (e.g., buoyancy), or to make them safer (e.g., sand-down rough seams). Each object was evaluated on the basis of safety and required approval by the appropriate staff at each facility. A list of the specific objects used for each animal is provided in Table 1.

Procedure

At both facilities, the subjects continued to participate in their regular daily activities during the course of this study. Consequently, the main difference in the animals' lives during this time period was the presence of the novel objects. Test environments were selected on the basis of convenience, the availability of appropriate observation locales, and the reduction of potential distractions by conspecifics, staff, and guests. In an attempt to control competition, cooperative play, territoriality, or possessiveness effects, animals were tested individually whenever possible. This proved difficult for the otters, and so the *Lontra canadensis* and the *Aonyx cinerea* were tested in pairs. In these cases, each member of a pair was provided with an identical object. In all cases, the test area was part of the animal's normal living environment. As a result, it proved impossible to eliminate all potential distractions, even for animals that were tested individually. For example, conspecifics were often present in an adjacent area during testing, and so were sometimes visible and audible to the target animals.

Each animal participated in two conditions. The conditions were identical in terms of the objects that were used for the animal, the total amount of time the object was available, the physical test environments, and general time-of-day. The conditions differed in terms of the allocation of the time the object was in the animal's environment. Condition 1 consisted of two continuous 60-min sessions (for a total of 120 min), each 60 min session being separated by a three day interval. Approximately three weeks after the conclusion of condition 1, condition 2 began. In condition 2, session length was variable. There were 15 total sessions in condition 2 (for a total of 120 min). Each session in condition 2 lasted from 1 to 15 min. The presentation order of these variable session lengths was randomized. Condition 2 occurred over a two week period. During this time, the number of sessions per day was also variable (ranging from zero to three).

The novel object was introduced into the animal's environment at the beginning of each session in each condition, and the animal's interactions with the object were recorded over a total period of 120 min. Data were collected every 60-s via instantaneous scan sampling. The decision that was made at each 60-s interval concerned whether or not the animal was interacting with the novel object. Interaction was defined as direct physical contact with the novel object at the time the decision was made. Thus, there were 120 data points for each condition for each animal.

During both conditions, each animal was tested using the individual novel object that had been selected for it. The animals had access to the target objects only during the test trials. Both SeaWorld and MarineLife provide a variety of objects to the animals at their facilities. Thus, the subjects were exposed to other objects throughout the course of this study. The alpha value in all statistical tests was set at the 0.05 level.

Results

As predicted, animals were more likely to interact with their novel object during condition 2 than during condition 1, $t(15) = 4.47$. (One-tailed tests were conducted since we had predicted that animals would interact with the target objects more in condition 2 than in condition 1.) As shown in Figure 1, each species (except for the walrus) demonstrated this same trend (the two species of otters were collapsed into one group and the two species of birds were collapsed into another group for ease of data presentation). Although the small sample sizes prohibited meaningful statistical comparisons for the false killer whale, the killer whale, the polar bear, and the walrus, t-tests were conducted to compare animal-object interaction in conditions 1 and 2 for birds, dolphins, otters, and sea lions. Although the difference for the birds was not statistically significant, the dolphins, $t(3) = 2.39$, the otters, $t(3) = 2.36$, and the sea lions, $t(1) = 12.81$, were significantly more likely to interact with the object during condition 2 than during condition 1.

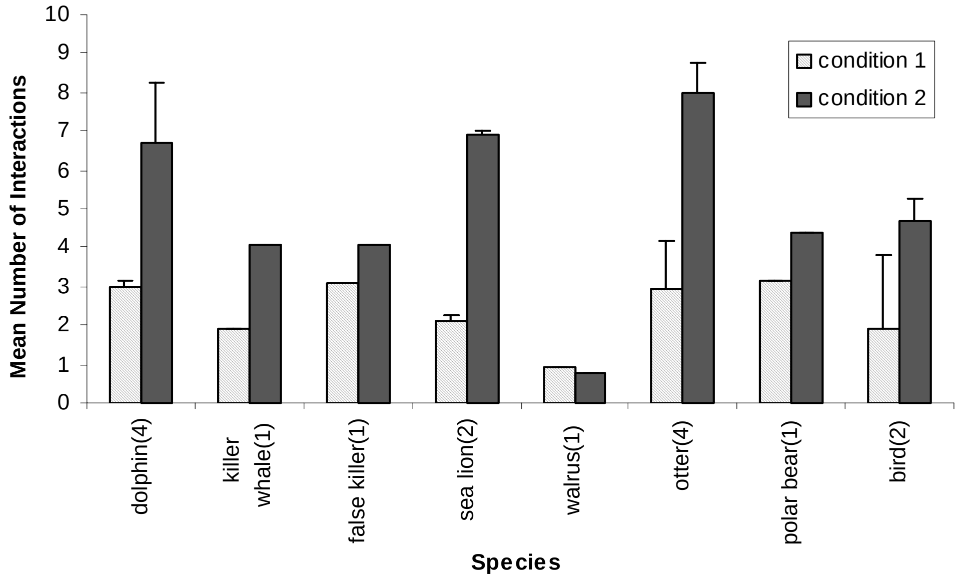

Figure 1. Mean number of interactions with target objects per condition, by species. Number of animals for each species type given in parentheses.

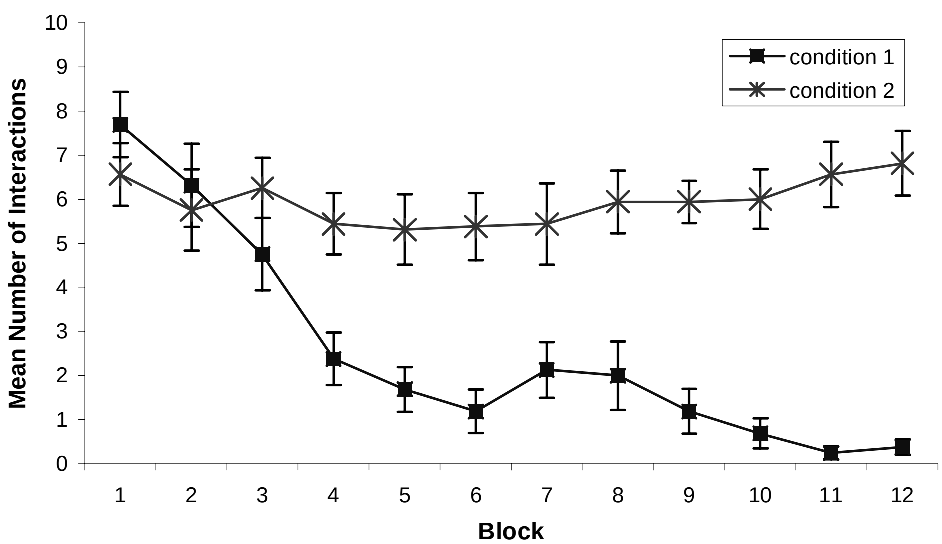

Figure 2. Mean number of interactions with target objects per ten trial block for all animals, by condition.

Figure 2 shows the overall data for each condition divided into 12 blocks, each block representing 10 min of object time. The animal-object interaction score for each block could range from zero (no interaction) to ten (interaction at every data point). An analysis of variance revealed significant main effects for condition, $F(1, 8) = 6.09$, and block, $F(11, 88) = 6.50$, as well as a significant interaction between condition and block, $F(11, 88) = 9.80$. As predicted, animals were more likely to become habituated to the object when it was presented for relatively long intervals (60 min) than when it was presented for shorter and more variable periods. Thus, activities associated with target objects were likely to decline during the course of condition 1, whereas interactions with the object during condition 2 remained relatively constant and high.

These conclusions are supported by subsequent analyses that compared the first, sixth, seventh, and twelfth blocks for each condition. Animals were as likely to interact with their novel object during the first ten minute block of condition 1 as they were to do so during the first ten minute block of condition 2. However, they were more likely to interact with the objects in block six of condition 2 than in block six of condition 1, $t(15) = 3.83$, demonstrating that more habituation had occurred in condition 1. Although the three day interval between the two one hour presentations in condition 1 resulted in an increase in interactions with the target object $t(15) = 1.86$, this increase was not sufficient to eliminate the overall difference between condition 1 and condition 2. As had been the case for block six, animals were more likely to interact with the target objects in block seven of condition 2 than in block seven of condition 1, $t(15) = 2.5$. This pattern was even more pronounced for block twelve $t(15) = 7.84$, once again demonstrating that habituation was more likely to occur in condition 1 than in condition 2.

The pattern described above held for individual animals as well. Thirteen of the sixteen animals interacted with the target object more often during condition 2 than condition 1 ($p = .05$, by sign test). The overall pattern of results for one of the dolphins demonstrates one way in which habituation may affect interaction with objects. As shown in Figure 3, when the novel object was first introduced, the dolphin interacted with it almost constantly, but quickly lost interest. When the object was put back into the dolphin's environment for the second 60 min period of condition 1, the dolphin was once again interested in the object. Dishabituation had occurred during the interval between the first and second 60 min presentations, resulting in increased interest in the object when it was initially presented for the second time. However, this interest quickly faded. In contrast, the variable and relatively short presentations that characterized condition 2 helped to maintain the dolphin's interest throughout much of condition 2. A similar pattern is shown in the results obtained for the killer whale shown in Figure 4.

The three animals that were exceptions to the general pattern included the walrus, an otter, and a dolphin. The walrus rarely interacted with the target object in either condition, suggesting that the object was of little interest to him. Objects have been used as part of an environmental enrichment program for walruses residing at the Brookfield Zoo (Dye et al., 2000), but it is unclear exactly how often the walruses in their study interacted with the objects. It is possible that walruses interact less often with novel objects than do other marine mammals. It is certainly true that the walrus in the present study interacted much less often with the target object than did the dolphin or the otter. The dolphin interacted with its object an average of 3.3 times per block during condition 1, similar to the other three dolphins. However, the dolphin exhibited little interest in the object during condition 2. It only interacted with the object an average of 2 times per block during condition 2, while each of the other dolphins more than doubled its interactions the respective target objects during condition 2. The otter was very interested in its object during both conditions, and so demonstrated high levels of interaction regardless of condition. Otters are notoriously playful (Butkiewicz, 1997), and it seems that the target object did fully engage this otter's attention in both conditions. However, the remaining otters did interact more with their objects in condition 2 than in condition 1, as expected.

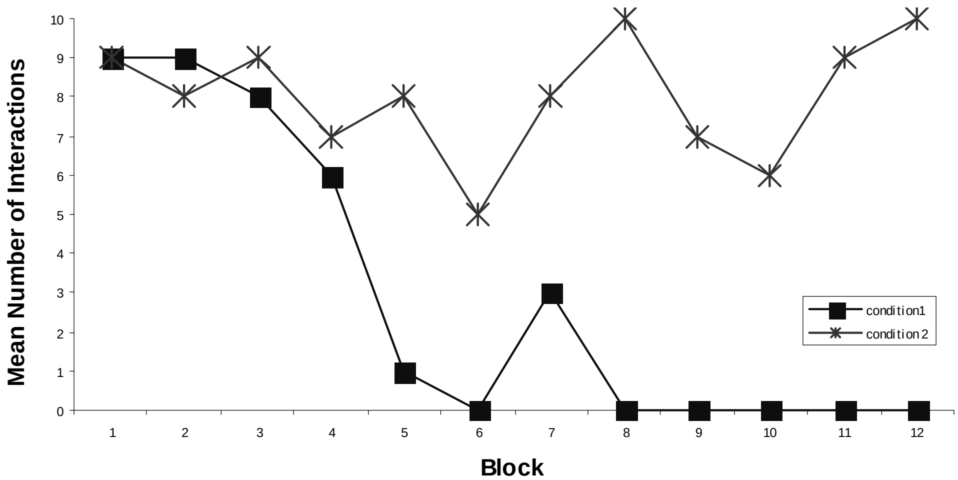

Figure 3. Mean number of interactions with target objects by one dolphin per ten trial block, by condition.

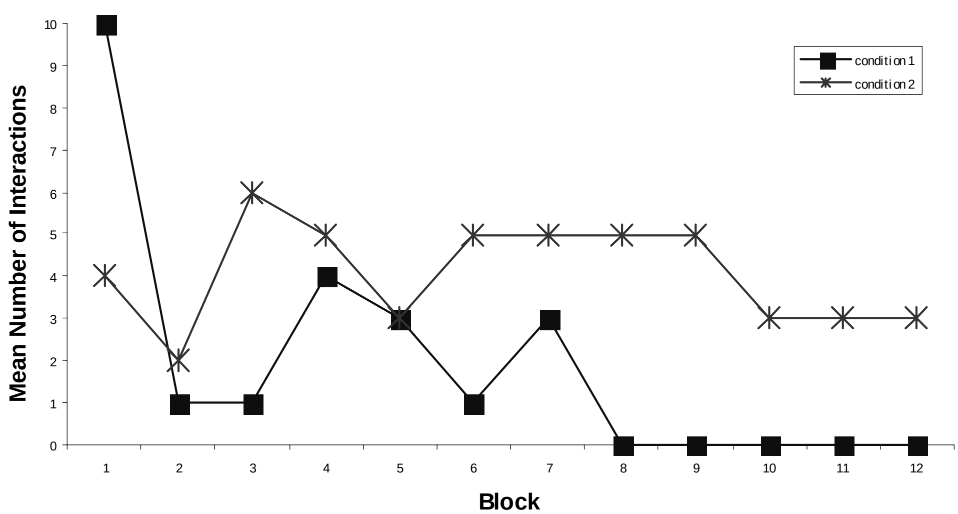

Figure 4. Mean number of interactions with target objects by the killer whale per ten trial block, by condition.

Discussion

The overall results are both straightforward and consistent with basic findings from comparative psychology. When a novel object was first introduced into an animal's environment, it elicited considerable attention from the animal, consistent with the notion of an orienting response (e.g., see Domjan, 2000). When the object was simply left in the animal's environment for a 60-min period, animals tired of the object and interacted with it less and less, demonstrating that habituation could occur even during the first hour of a novel object's introduction. When the object was reintroduced after a three day absence, animals tended to show more interest in the object, but not as much as they had when it was first introduced. When the same object was provided three weeks later, the animals interacted with the objects at about the same level as they had when it had been originally introduced, demonstrating that dishabituation had occurred. However, the shorter more variable presentation of the objects during condition 2 resulted in prolonged interest in the object. Thus, it is possible to reduce the effects of habituation when objects are used as environmental enrichment devices.

The present study used objects that might best be characterized as toys. Such objects were chosen because enrichment often involves toys designed for use by human children or household pets (Renquist & Judge, 1985; Ross & Everitt, 1988; Gilbert & Wrenshall, 1989; Line et al., 1989). However, toys do not always produce the desired results as enrichment devices (Maki & Bloodsmith, 1989; Line et al., 1991; Schapiro et al., 1996; Markowitz & Aday, 1998), most likely because the animals quickly habituate to the objects. The results obtained in the present study demonstrate that simply placing objects in an animal's environment and leaving them there for prolonged periods of time is not the most ideal enrichment strategy, even if the "prolonged" period lasts for only 60 min. If the enriching qualities of objects are to be maintained, it is necessary to vary both the time of day and the length of time for which they are available (see also Lacinak et al., 1997; Line & Morgan, 1991; Line et al., 1991; Morgan et al. 1998; Vick, Anderson, & Young, 2000).

Both individual and species differences may influence the effectiveness of enrichment programs. Cognitively advanced species tend to be generalists that naturally inhabit complex environments (Kreger, Hutchins & Nina, 1998; Mench, 1998). These environments are often characterized by fluctuating physical features, such as aquatic environments (Steele, 1985), but might also involve intricate social structures (Tomasello, 1998; Mann et al., 2000). Members of such species might benefit the most from environmental enrichment involving objects, particularly if the objects are designed to engage the animals' attention. Play is typically an important feature of behavior for members of these species (Bekoff & Byers, 1998; Kuczaj & Trone, 2001), and so objects that facilitate play in captivity may serve important developmental and cognitive functions for some species. Thus, enrichment that provides opportunities for play is likely to enhance the well-being of such animals.

Although all of the species that we included in our study are known to play with objects (Bel'kovich, 1991; Brown & Norris, 1956; Jeffries, Giles, & Sousa, 1999; King, 1993; Mead & Hunter, 2001; van Hoek & ten Cate, 1998), there were individual differences in the extent to which the animals interacted with the target objects. For example, the walrus showed relatively little interest in the target object. It is possible that the object that was chosen was of little interest to this particular walrus, but it is also possible that object toys are poor choices for enrichment devices for this species. If the efficacy of environmental enrichment programs is to be properly addressed, the role of species differences must be considered. Similarly, individual differences are also likely to influence the success or failure of a particular enrichment program. In the present study, individual differences were found for both otters and dolphins, despite the small number of animals in each species. Thus, the comparative study of environmental enrichment requires an appreciation of individual differences as well as an understanding that what is enriching for one species may not be enriching for another. Careful analyses of individual differences might reveal the reasons underlying an animal's reaction to enrichment techniques. For example, animals that do not interact with novel objects as much as other members of their species might have endured impoverished conditions to the extent that their curiosity has been diminished (Wemelsfelder et al., 2000).

In summary, the results of the present study demonstrate that environmental enrichment programs that use objects should adopt variable schedules of object presentation in order to avoid the effects of habituation. Variable schedules help to maintain the novelty of enrichment devices. As a result, animals are more likely to interact with the objects and become less likely to produce stereotypic behaviors. Variable feeding schedules and variable object presentation schedules add elements of unpredictability to the animals' environments, which fosters exploratory behavior and seems to enhance well-being (Carlstead, 1998; Kuczaj, Lacinak & Turner, 1998; Mench, 1998). The creation and maintenance of successful enrichment programs requires an understanding of basic principles of learning, an appreciation of individual differences, and a recognition that the cognitive needs of species may differ. Consequently, comparative psychology has much to offer those who wish to better the lives of the animals for which they care.

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