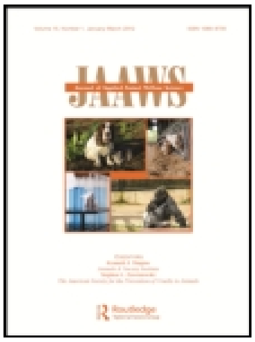

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Environmental Enrichments for a Group of Captive Macaws: Low Interaction Does Not Mean Low Behavioral Changes

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ABSTRACT

Environmental enrichment has been widely used to improve conditions for nonhuman animals in captivity. However, there is no consensus about the best way to evaluate the success of enrichments. This study evaluated whether the proportion of time spent interacting with enrichments indicated the proportion of overall behavioral changes. Six environmental enrichments were introduced in succession to 16 captive macaws, and interaction of the animals with them as well as the behaviors of the group were recorded before and during the enrichments. All of the enrichments affected the proportions of time spent in different behaviors. Macaws interacted more with certain items (hibiscus and food tree) than with others (a toy or swings and stairs), but introduction of the enrichments that invoked the least interaction caused as many behavioral changes as those that invoked the most. Moreover, feeding behavior was only affected by the enrichment that invoked the least interaction, a change not detected by a general analysis of enrichment effects. In conclusion, little interaction with enrichment does not mean little change in behavior, and the effects of enrichments are more complex than previously considered.

KEYWORDS
Enrichment interaction; behavior; captivity; enrichment items

Many nonhuman animals in captivity are kept in zoos, which are recognized for their central role in the conservation of wildlife (Costa, 2004). However, captivity imposes restrictions on nonhuman animals that can result in abnormal behaviors (Carlstead, 1996; Morato et al., 2001), which can indicate poor welfare. In natural conditions, animals interact on a daily basis with a wild environment that is dynamic, complex, and usually unpredictable, while space and conditions in captivity are usually much more limited. Human visitors to zoos can also affect the behavior of animals (e.g., Maia, Volpato, & Santos, 2012; Nimon & Dalziel, 1992)—for example, by promoting stereotypies (Glatson, Soeteman, Pecek, & Hooff, 1984). Stereotyped behaviors are regularly repeated movements without an apparent purpose or goal (Dantzer & Mormède, 1983) that may be induced by frustration, repeated attempts to cope, or brain dysfunction (Mason, 2006).

Environmental enrichment involves changes made in the environment of captive animals by using materials or devices that may simulate natural situations and increase behavioral opportunities for the animals (Young, 2003). This practice aims to improve the ability of animals to cope with the challenges of captivity (Young, 2003). Thus, environmental enrichment aims to increase behavioral repertoire and positive use of the environment by the animals, in addition to reducing or eliminating abnormal behavior such as stereotypies (Young, 2003). In this context, studies of environmental enrichment have increased in number since the 1980s; this acceleration may have resulted partly from growing interest in this area by neuroscientists (for a review, see Azevedo, Cipreste, & Young, 2007).

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However, there is no consensus about the best way to evaluate environmental enrichment programs (Shepherdson, Mellen, & Hutchins, 1998). Many research projects providing environmental enrichment for different species in zoos have yielded success, normally by comparing animal behavior before and during enrichment implementation. Moreover, some researchers have evaluated the effects of enrichments on specific behaviors, such as aggression (Melotti, Oostindger, Bolhuis, Held, & Mendl, 2011; Torrezani, Pinho-Neto, Miyai, Sanches, & Barreto, 2013) or stereotypies (Swaisgood & Shepherdson, 2005, 2006). Although many studies have evaluated the effects of enrichments on the behaviors of the animals, especially on stereotypes (for a review, see Swaisgood & Shepherdson, 2005), little attention has been given to the possible effect of the intensity of interaction with the enrichments on such behavioral changes observed. If animals have little interaction with the enrichment, is there generally also little change in behavior? If so, does low interaction with environmental enrichment indicate that such enrichment is ineffective in increasing the behavioral repertoire of the animals? If this is true, it would be an easy way to evaluate the effect of enrichments, because by measuring the interaction with the enrichment, we would be able to infer if the animals change and significantly increase their behaviors.

Moreover, there are fewer peer-reviewed publications related to the effects of enrichment than expected, and systematic assessment of the effects in animals in zoos is the exception, not the rule. Generally, peer-reviewed articles about the effects of enrichment have focused on mammals, and few have focused on birds. Captive birds often show behavioral abnormalities, with feather-damaging behavior (Van Zeeland et al., 2009) and pacing being the most common abnormal behaviors (Mason & Rushen, 2006; Van Hoek & ten Cate, 1998; Young, 2003). Yet systematic assessment of enrichment for birds, especially in zoos, is still uncommon in the literature. For example, Coulon et al. (2014) recently published a study about the effects of enrichment on stereotypic and abnormal behaviors of birds, but this research was focused only on laboratory birds, not including zoo species.

In one of the few studies about enrichment effects on zoo birds, Collins and Marples (2015) found that in some circumstances, Moluccan cockatoos avoided visitors, while citron-crested cockatoos did not avoid visitors and instead became more social in their presence. Thus, the effect of visitors as a source of enrichment may depend on the bird species. Moreover, it has been shown that environmental conditions, including enrichments, can influence the severity of stereotypic behaviors and feather-damaging behavior in the orange-winged Amazon parrot (Garner, Meehan, Famula, & Mench, 2006). In this context, it is important to test whether different environmental enrichments may improve the conditions of different zoo bird species. It is also important to determine if the enrichments with which the animals interact more are also the ones that cause more behavioral changes, as it could be a useful tool to evaluate enrichment effects. Thus, we studied a group of macaws in captivity to test the effects of different enrichments on their behaviors and whether the proportion of time interacting with such enrichments reflected the proportion of behavioral changes caused.

Materials and methods

Study area

The study was conducted at the Bosque dos Jequitibás Zoo in Campinas, São Paulo, Brazil, which is within a 4-ha public park, mostly consisting of native forest with free-living wild animals. The zoo attracts more than 1 million visitors per year (Santos, 2005).

Animals and conditions

The macaw enclosure (120 m^2, 8 m high) had natural shrub vegetation, including palm and small trees, with natural branches, wooden nests, aerial feeders, and a water cascade that flowed toward two pools. There were 16 macaws: 14 blue-and-yellow macaws (*Ara ararauna*) and 2 scarlet macaws (*Ara macao*). There were 3 pairs and 10 unpaired individuals of both genders. Six were born in the zoo, while the rearing of the others was unknown. During the study period, the macaws were always fed by the same zookeeper, at about 0900 hr, so they were habituated to the presence of this keeper in their enclosure. They received basic Psittacidae feed: fruit (watermelon or coconut and papaya or banana), vegetables (chicory or lettuce), and legumes (corn). Other species of birds were also kept in the enclosure, such as the nocturnal curassow (*Nothocrax urumutum*), razor-billed curassow (*Mitu mitu tuberosa*), and speckled chachalaca (*Ortalis guttata*). As part of the routine procedures of the zoo, environmental enrichments, including some food-based items, were offered to the macaws and other birds at least twice per month.

Data collection

One of the authors had worked in the zoo for more than 12 years and had been involved with the routine enrichments offered to the macaws, which included the implementation of different types of enrichment over the years, as physical, sensory, cognitive, and social enrichments. Preliminary, ad-libitum observations were carried out from 0800 hr to 1800 hr on 1 day, and these observations were used to create an ethogram of seven behavioral categories (Table 1).

Baseline experimental observations, without environmental enrichment, were then carried out during 4 consecutive days (between August and September 2010). These observations took place from 0700 hr to 1200 hr in the morning sessions and from 1200 hr to 1700 hr in afternoon sessions, for 20 hr each, totaling 40 hr. Instantaneous scan sampling, widely used to record behaviors of large groups (Altmann, 1974; Del Claro, 2004), was used with an interval of 5 min (established as appropriate in preliminary observations). In each scan, the number of macaws engaged in each behavioral category in Table 1 was recorded. We did not record the behavior of individual birds, because they had been housed together for many years, so their behavior was not independent.

Six different environmental enrichments were then introduced in turn for about 2 months (from September 15, 2010, to November 19, 2010), with the order randomized. We applied enrichments only on weekdays when the zoo was opened for public visiting, and we avoided weekends when visiting was intensified. Each enrichment was introduced once, always during the same period (morning), because we found differences in baseline behaviors between the periods (Figure 1).

Introduction of the same enrichment was not repeated to prevent habituation. Immediately after introduction, observations were conducted in the morning and afternoon of the same day and finished at 1700 hr by removing the enrichment. As the time necessary to assemble different enrichments varied, the time of introduction and the total observation period for each enrichment also varied. Results are therefore expressed as proportions of observations. Scan sampling with a 5-min interval was used, as it was for the baseline period, but it included interactions with the enrichment. There was a break of at least 6 days before each enrichment (including the first one) to minimize the interference of previous enrichments. A total of 45 hr of observations was made to cover all the enrichments.

Table 1. Macaws' ethogram describing all of the behavioral categories registered.

Category	Description
Locomotion	Individual moves around the enclosure, walking, climbing, or taking short flights.
Inactive	Individual is sleeping or immobile, with the head raised or underneath one of the wings.
Feeding	Individual ingests food either at or outside feeders.
Environment interaction	Individual forages and/or explores the enclosure. This includes pecking at plants, perches, railings, or trunks or digging the soil.
Maintenance	Individual aligns his/her plumage, cleans his/her feathers/body parts (tail, neck, and legs) with his/her beak, rubs the beak against perches, stretches, or scratches himself/herself.
Allopreening	Individual aligns the feathers or cleans the head, claws, or wings of his/her mate with his/her beak.
Other social interaction	Two or more individuals (excluding pairs) interact, intraspecifically or interspecifically, including disputes or vocalizations; or one or more individual(s) interact with the human visitors.

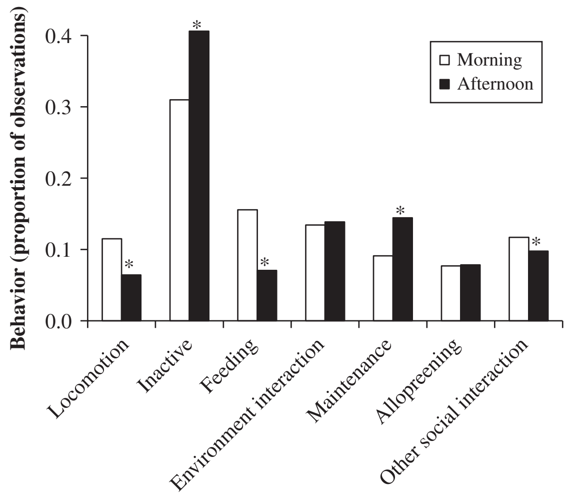

Figure 1. Baseline behavior in mornings and afternoons. *Significant difference between morning and afternoon (Goodman's test, $p < .05$).

Environmental enrichments

We made enrichments to enable the macaws to perch and move at different heights and to use their strong beaks and feed on larger pieces of fruits or vegetables. The different items we used (Figure 2) were easy to make and safe for the animals. Although the other birds in the enclosure could also access the enrichments, it rarely happened. The following list includes descriptions of the enrichments applied and the times and days they were implemented.

(a) Hibiscus: Branches with leaves and flowers of this nontoxic, fibrous shrub (*Malvaviscus arboreus*) were inserted on the perches at 1020 hr on September 15, 2010.

Figure 2. Environmental enrichments: (a) hibiscus, (b) swings and stairs, (c) toy, (d) food tree, (e) vine balls with coconut, and (f) dried leaves.

(b) Swings and stairs: Three swings and three stairs were made from dried eucalyptus trunks, pine wood, and sisal rope, measuring 1.4 m to 1.6 m long and 0.6 m to 1 m wide. One of the stairs was placed between the ground and a feeder. The other stairs and swings were hung from perches. This enrichment was implemented at 0850 hr on September 22, 2010.
(c) Toy: The toy consisted of a square, pinewood frame, with pieces of sisal rope stretched horizontally across it. Bells, plastic caps, colorful beads, and wooden curtain rings were hung on the rope. The toy was introduced at 0800 hr on October 6, 2010.
(d) Food tree: We inserted five large, well-branched, dried branches into the ground in the enclosure. We placed or hung different kinds of food in them: bananas, apples, carrots, cooked beets, corncobs, pieces of coconut, pumpkin in different shapes, and pieces of watermelon with the rind. This enrichment was implemented at 1000 hr on October 15, 2010.
(e) Vine balls with coconut: We inserted pieces of coconut, peeled or not, into 25 hollow balls made of intertwined vine, approximately 15 cm in diameter, hung on perches at different heights. These vine balls were introduced at 0900 hr on October 22, 2010.
(f) Dried leaves: We placed dry palm-tree leaves, with or without the sheath, between perches to form a structure resembling a roof, at 1000 hr on November 19, 2010.

As the animals were fed every morning around 0900 hr and the enrichments that included food were always available at the same time or later, the macaws did not interact more with some enrichments than with others because of strong hunger.

Statistical analysis

Behavioral frequencies were summed from the morning and afternoon periods to give daily results, totaling 40 hr of baseline observations and 45 hr of enrichment observations, to avoid the interference of possible baseline differences in behaviors between the morning and afternoon periods. Variation in the morning observation periods was proportionally corrected as mentioned above. We used Goodman's proportion test for multinomial populations (Goodman, 1964) to analyze differences in behavior both between morning and afternoon sessions before enrichment and in response to the different enrichments.

As this test is used to compare proportions, its application does not depend on normal or homoscedastic distribution of the data (Zar, 2009). In our general analysis, we added the frequencies of each category of behavior across all enrichments and compared these totals to the frequencies before enrichment. Then, to analyze the effects of each enrichment separately, we compared the frequencies of each behavioral category with each enrichment in turn to the corresponding frequency before enrichment. We also applied Goodman's (1964) test to compare interaction responses to different enrichments directly. For all analyses, we used $\alpha = .05$.

Results

Behavioral differences between times of day

The macaws displayed baseline behavioral differences between morning and afternoon sessions (Goodman's proportion test, $p < .05$; Figure 1). In the afternoon, inactivity and maintenance behavior were more frequent (1,982 records and 704 records, respectively, out of 4,880) than in the morning (1,512 and 444, respectively, out of 4,480). Locomotion, feeding, and other social interaction were less frequent in the afternoon (313, 345, and 477, respectively, out of 4,880) than in the morning (561, 760, and 571, respectively, out of 4,880).

General effects of enrichments

When categories of behavior were compared before and during enrichment, excluding interaction with the enrichments, there were significant differences (Goodman's test, $p < .05$; Figure 3). Locomotion,

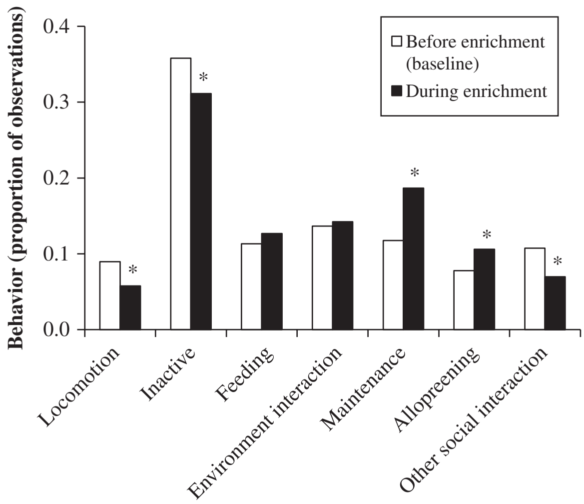

Figure 3. General effects of environmental enrichment, excluding interaction with the enrichments. *Significant difference between the periods before and during enrichment (Goodman's test, $p < .05$).

inactivity, and other social interaction were significantly reduced (874, 3,494, and 1,048 records, respectively, out of 9,760 before enrichment; 582, 2,804, and 629, respectively, out of 9,359 during enrichment). Maintenance and allopreening were increased (1,148 and 758 records, respectively, out of 9,760 before enrichment; 1,833 and 1,056, respectively, out of 9,359 during enrichment).

Interaction with enrichments

The macaws interacted significantly more with the hibiscus (376 out of 1,296 records) than with other enrichments, followed by the food tree (302 out of 1,360 records; Goodman's test, $p < .05$; Figure 4). The enrichments that invoked the least interaction were the toy (120 out of 1,744 records) and the swings and stairs (70 out of 1,568 records; Goodman's test, $p < .05$; Figure 4).

Specific effects of enrichments

There were differences in behavior in response to the different enrichments. Locomotion was significantly reduced by the hibiscus, swings and stairs, food tree, vine balls with coconut, and dried

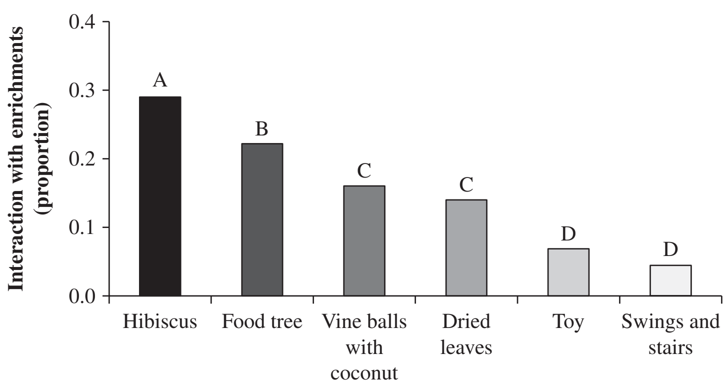

Figure 4. Interaction with each environmental enrichment, shown as proportions of the total behavioral observations per enrichment. Columns with different capital letters are significantly different (Goodman's test, $p < .05$).

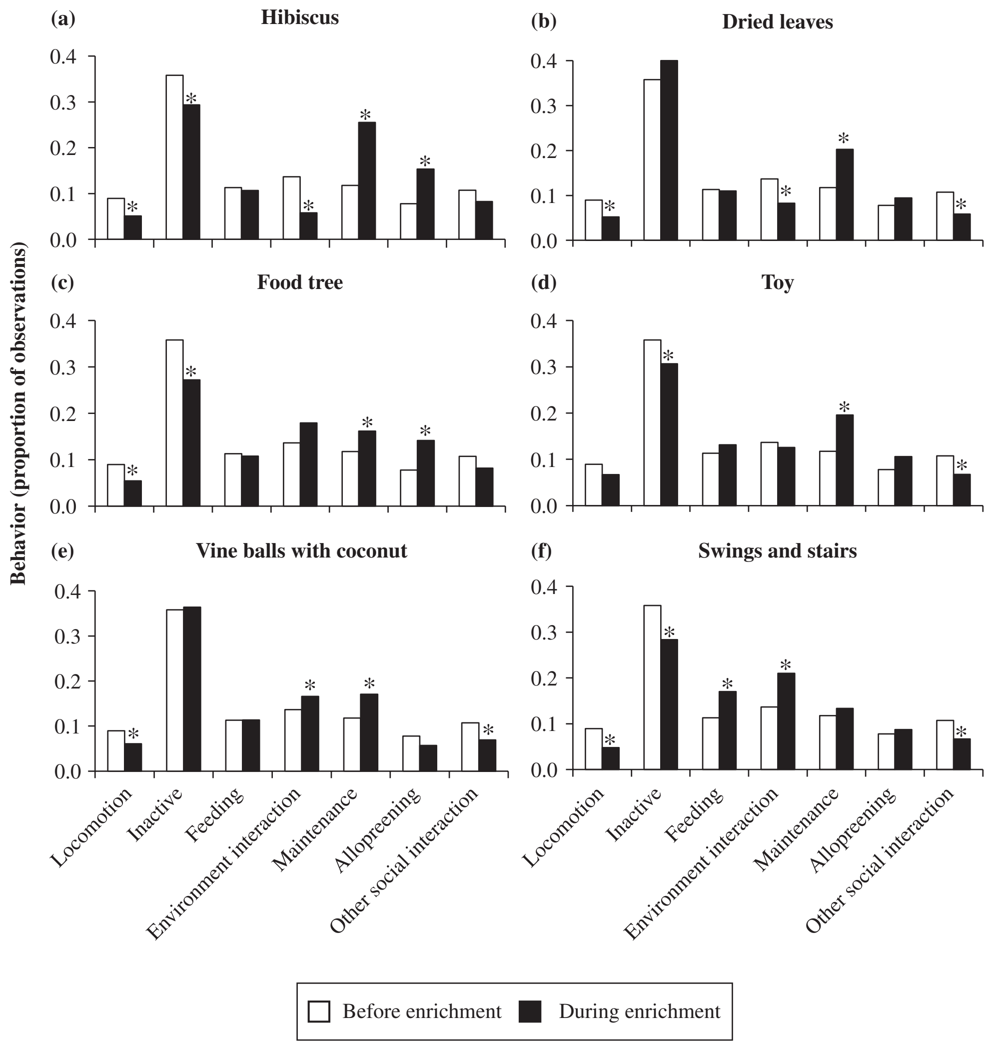

Figure 5. Effects of each environmental enrichment, excluding interaction with the enrichments. *Significant difference between the periods before and during enrichment (Goodman's test, $p < .05$).

leaves, while inactivity was reduced by the hibiscus, swings and stairs, toy, and food tree (Goodman's test, $p < .05$; Figure 5). Interaction with the environment, excluding the enrichments, was reduced by the hibiscus and dried leaves, but it was increased by swings and stairs and vine balls with coconut (Goodman's test, $p < .05$; Figure 5). Maintenance was increased by all the enrichments except the swings and stairs (Goodman's test, $p < .05$; Figure 5). However, allopreening was increased only by the hibiscus and food tree, and feeding was increased only by the swings and stairs (Goodman's test, $p < .05$; Figure 5). On the other hand, other social interaction was reduced by all the enrichments except the hibiscus and food tree (Goodman's test, $p < .05$; Figure 5).

Discussion

All of the environmental enrichments tested affected the behavior of the macaws, and each caused specific effects that were not necessarily detected by the general analysis. Importantly, even though the macaws interacted significantly more with the hibiscus and less with the toy and swings and stairs

(Figure 4), the latter resulted in as many behavioral changes as the former: five categories of behavior changed significantly in each case (Figure 5). Moreover, the swings and stairs caused an increase in feeding behavior, a change that did not occur with any other enrichment and that was not detected in our general analysis (Figure 5). Thus, the changes induced by enrichment must be more complex than previously thought. We conclude that low interaction with environmental enrichment does not necessarily mean fewer behavioral changes, and interpretation of its effects must depend on the observation of specific behaviors.

In the zoo concerned, there was variation in the number of visitors, and consequently, there was also noise in the environment over the days and between different days. We minimized this interference by restricting the study to weekdays when the zoo was open to visitors. We avoided Mondays, when the zoo was closed, and weekends, when there were more visitors. Therefore, we minimized the variation of public visitation around the macaws' enclosure, both in terms of number and noise caused. Moreover, we avoided any data collection during the reproductive season of the macaws' species evaluated here. According to Sick (1997), the reproductive season for *Ara ararauna* is from December to May, and for *Ara macao*, it is from December to March. Thus, as we collected all our behavioral data between August and November, the behavioral changes observed could not be explained by the influence of natural differences in behavioral expressions of macaws during their reproductive season. However, as we evaluated the macaws' behavior as a group rather than as individuals, our results were robust only for the group as a whole. More research is necessary to generalize the case reported here.

It might be said that using each enrichment for just 1 day was insufficient to make conclusions about the effects on the animals. We applied each item just once to detect only the first effects on the animals, because if enrichments were repeated, the animals could have habituated to them, thus adding no relevant stimulation to the environment over time. Moreover, the macaws were accustomed to receiving enrichments offered just for 1 day and that had not been repeated, at least, for 1 month, as it was part of the zoo routine. Thus, we minimized the influence of differences in common routine procedures in our results. On the other hand, the animals could have responded less to enrichment over time and interacted less with subsequent enrichments than with the first ones provided. However, there was no relation between interaction of the macaws with the enrichments (Figure 4) and the sequence of enrichment implementation, described in the "Materials and methods" section, thereby reinforcing the evidence that the amount of data collected was satisfactory to attain the aim of study.

Behavioral differences between mornings and afternoons (Figure 1) were expected, as much animal behavior shows circadian variation (Alcock, 1993; Goodenough, McGuire, & Wallacen, 1993; Volpato & Trajano, 2006). As the macaws were always fed in the morning and all the enrichments were also offered in the morning, the behavioral changes that resulted, especially in feeding behavior, may have been stronger in the morning than in the afternoon. However, this explanation does not account for the results presented here, which express behavioral changes and interaction with the enrichments over a whole day, not in separate periods.

In general, the enrichments reduced locomotion, inactivity, and other social interaction but increased maintenance and allopreening (Figure 3). One of the most frequent problems shown by animals in the zoo is excessive inactivity. Chamove, Hosey, and Schaetzel (1988) demonstrated that ring-tailed lemurs (*Lemur catta*) and Diana guenon (*Cercopihtecus diana*) were more inactive in the presence of visitors; such inactivity is considered to indicate that the animals are stressed (Davey, 2007). In our study, we defined "inactive" as when an individual was sleeping or immobile—forms of inactivity that in excess may represent stress or frustration. Thus, the reduction in such behavior here may indicate success of the enrichments in making the animals less stressed. The reduction in locomotion and other social interaction may be related to the fact that the animals spent time interacting with the enrichments rather than moving around or interacting with groupmates/visitors.

One possible explanation for the increase in maintenance behavior is that the animals may have cleaned themselves after interacting with enrichments. Three of the six enrichments included food and were those with which the macaws interacted most (Figure 4). Animals' interaction with such enrichments may have caused some food waste to remain on the body, eliciting maintenance such as cleaning feathers/body parts or rubbing the beak. The increase in allopreening, on the other hand, may be considered as another success of enrichments. For zoos to contribute to *ex-situ* conservation of species, by developing a stock of animals to promote local repopulation (Hutchins & Conway, 1995), successful reproduction of captive animals is fundamental. An increase in interaction between sexual partners may enhance the possibilities of reproduction in captivity, and this was achieved in this study in the form of increased allopreening.

Each of the environmental enrichments caused different effects on behavior, some of them not detected by the general analysis (compare Figures 3 and 5). The hibiscus and dried leaves reduced interactions with the rest of the captive environment, while the vine balls with coconut and swings and stairs increased such interactions (Figure 5). The frequency of feeding behavior was changed only by the introduction of the swings and stairs, as seen by an increase in the ingestion of normal food, not the intake of abnormal food or materials. The fact that the behavioral changes detected were influenced by the method of analysis is important. According to Shepherdson et al. (1998), there is no consensus about the best way to analyze the effects of environmental enrichments; thus, we recommend using more than one approach to analyze the behavioral changes when more than one kind of enrichment is applied.

One possible explanation for the fact that interaction with the enrichment does not necessarily correlate with behavioral changes (compare Figures 4 and 5) is that some enrichments may have stronger impacts on the animals than others. Even if interaction with these enrichments is not frequent, behavioral changes could be intense. However, this needs further investigation. We highlight the need to evaluate how the observed behaviors relate to the interactions of animals with each environmental enrichment. Some enrichments may be more relevant to specific behaviors (e.g., stereotypic behaviors; see Swaisgood & Shepherdson, 2006). If these kinds of enrichment cause fewer behavioral changes but do alter the target behavior, it is a positive outcome. Thus, interpretation of the absence of an overall relationship between enrichment interaction and behavioral changes may depend on the specific behavioral changes observed. In this context, our findings demonstrate that if an animal does not show much interaction with a specific enrichment, it does not mean that enrichment failed and should be removed because the item may be causing another behavioral effect.

As noted, there are relatively few peer-reviewed articles about the behavioral effects influenced by the enrichments, especially for captive birds, so our study adds new insights to this literature. Laurence et al. (2015) found that enrichments reduced some aspects of negative behavioral alterations induced by chronic stress in Japanese quail. Similarly, our results indicate that the enrichments tested here probably improved the conditions for the group of macaws studied. These results also agree with Telles et al. (2015), who demonstrated that environmental enrichment improved the behavioral repertoire and reduced the abnormal behavior of feather picking in parakeets, another psittacid species. Thus, the enrichments we tested here may be used for macaws in zoos or other captive environments, especially considering that feather damaging—an abnormal behavior often shown by captive birds (Mason & Rushen, 2006; Van Hoek & ten Cate, 1998; Young, 2003)—is common in captive psittacines such as macaws.

Conclusions and animal welfare implications

We conclude that the enrichments offered in this study improved the welfare conditions of the macaws studied and that behavioral changes did not depend on the level of interaction with the enrichments. How we interpret this lack of relationship may depend on the specific enrichments and behavioral changes. Thus, the changes induced by enrichment must be more complex than previously thought. We recommend caution in analyzing data when more than one enrichment is evaluated, as the way in which the analysis is conducted may influence the behavioral responses detected. Moreover, we suggest that future studies should analyze the effects of each applied enrichment separately and also the interaction of the animals with such enrichments. This should help to generalize the findings of this case study and should also improve understanding of the impacts of environmental enrichment for captive animals.

References

Alcock, J. (1993). The organization of behavior. In J. Alcock (Ed.), *Animal behaviour: An evolutionary approach* (pp. 159–190). Sunderland, MA: Sinauer Associates.

Altmann, J. (1974). Observational study of behavior: Sampling methods. *Behaviour*, *49*, 227–266.

Azevedo, C. S., Cipreste, C. F., & Young, R. J. (2007). Environmental enrichment: A GAP analysis. *Applied Animal Behaviour Science*, *102*, 329–343.

Carlstead, K. (1996). Effects of captivity on the behavior of wild mammals. In D. G. Kleiman, M. E. Allen, K. V. Thompson, & S. Lumpkin (Eds.), *Wild mammals in captivity* (pp. 317–333). Chicago, IL: University of Chicago Press.

Chamove, A., Hosey, G., & Schaetzel, P. (1988). Visitors excite primates in zoos. *Zoo Biology*, *7*, 359–369.

Collins, C. K., & Marples, N. M. (2015). Zoo playgrounds: A source of enrichment or stress for a group of nearby cockatoos? A case study. *Journal of Applied Animal Welfare Science*, *18*, 375–387.

Costa, G. O. (2004). Environmental education: Experience in Brazilian zoos. *Electronic Journal of Environmental Education*, *13*, 140–150. Retrieved from http://www.seer.furg.br/remea/article/view/2724/1557

Coulon, M., Henry, L., Perret, A., Cousillas, H., Hausberger, M., & George, I. (2014). Assessing video presentations as environmental enrichment for laboratory birds. *PLoS One*, *9*, e96949.

Dantzer, R., & Mormède, P. (1983). The arousal properties of stereotypical behavior. *Applied Animal Ethology*, *10*, 233–244.

Davey, G. (2007). Visitors' effects on the welfare of animals in the zoo: A review. *Journal of Applied Animal Welfare Science*, *10*, 169–183.

Del Claro, K. (2004). *Comportamento animal: uma introdução à ecologia comportamental* [Animal behavior: An introduction to behavioral ecology]. Jundiaí, Brazil: Livraria Conceito.

Garner, J. P., Meehan, C. L., Famula, T. R., & Mench, J. A. (2006). Genetic, environmental, and neighbor effects on the severity of stereotypies and feather picking in Orange-winged Amazon parrots (*Amazona amazonica*): An epidemiological study. *Applied Animal Behaviour Science*, *96*, 153–168.

Glatson, A. R., Soeteman, E. G., Pecek, E. H., & Hooff, J. A. R. A. M. V. (1984). The influence of the zoo environment on social behaviour of groups of cotton-topped tamarins. *Saguinus oedipus oedipus. Zoo Biology*, *3*, 241–253.

Goodenough, J., McGuire, B., & Wallacen, R. (1993). Biological clocks. In *Perspectives on animal behavior* (pp. 283–320). New York, NY: John Wiley & Sons.

Goodman, L. A. (1964). Simultaneous confidence intervals for contrasts among multinomial populations. *Annals of Mathematical Statistics, Hayward*, *35*, 716–725.

Hutchins, M., & Conway, W. G. (1995). Beyond Noah's ark: The evolving role of modern zoos and aquariums in field conservation. *International Zoo Yearbook*, *34*, 117–130.

Laurence, A., Houdelier, C., Calandreau, L., Arnould, C., Favreau-Peiqné, A., Leterrier, C., … Lumineau, S. (2015). Environmental enrichment reduces behavioural alterations induced by chronic stress in Japanese quail. *Animal*, *9*, 331–338.

Maia, C. M., Volpato, G. L., & Santos, E. F. (2012). A case study: The effect of visitors on two captive pumas with respect to the time of the day. *Journal of Applied Animal Welfare Science*, *15*, 222–235.

Mason, G. (2006). Stereotypic behaviour in captive animals: Fundamentals and implications for welfare and beyond. In G. Mason and J. Rushen (Eds.), *Stereotypic animal behaviour: Fundamentals and applications to welfare* (pp. 325–356). Wallingford, Oxfordshire: Centre for Agriculture and Biosciences International.

Mason, G., & Rushen, J. (2006). *Stereotypic animal behaviour: Fundamentals and applications to welfare*. Wallingford, Oxfordshire: Centre for Agriculture and Biosciences International.

Melotti, L., Oostindger, M., Bolhuis, J. E., Held, S., & Mendl, M. (2011). Coping personality type and environmental enrichment affect aggression at weaning in pigs. *Applied Animal Behaviour Science*, *133*, 144–153.

Morato, R. G., Confort, V. A., Azevedo, F. C., Jacomo, A. T., Silveira, L., Sana, D., … Barnabe, R. C. (2001). Comparative analyses of semen and endocrine characteristics of free-living versus captive jaguars (*Panthera onca*). *Reproduction*, *122*, 745–751.

Nimon, A. J., & Dalziel, F. R. (1992). Cross-species interaction and communication: A study method applied to captive siamang (*Hylobates syndactylus*) and long-billed corella (*Cacatua tenuirostris*) contacts with humans. *Applied Animal Behaviour Science*, *33*, 261–272.

Santos, E. F. (2005). Ecology of the Agouti *Dasyprocta leporina* (Linnaeus 1758) in an urban forest fragment in Campinas-SP (RODENTIA: DAYPROCTIDAE) (Unpublished Master's thesis), University of Sao Paulo State, Rio Claro.

Shepherdson, D. J., Mellen, J. D., & Hutchins, M. (1998). Tracing the path of environmental enrichment in zoos. In D. J. Shepherdson, J. D. Mellen, & M. Hutchins (Eds.), *Second nature: Environmental enrichment for captive animals* (pp. 1–12). Washington, DC: Smithsonian Institution Press.

Sick, H. (1997). *Ornitologia brasileira* [Brazilian ornithology]. Rio de Janeiro, Brazil: Editora Nova Fronteira.

Swaisgood, R. R., & Shepherdson, D. J. (2005). Scientific approaches to enrichment and stereotypies in zoo animals: What's been done and where should we go next? *Zoo Biology*, *24*, 499–518.

Swaisgood, R. R., & Shepherdson, D. J. (2006). Environmental enrichment as a strategy for mitigating stereotypies in zoo animals: A literature review and meta-analysis. In G. Mason & J. Rushen (Eds.), *Stereotypic animal behavior: Fundamentals and applications to welfare* (pp. 255–284). Wallingford, Oxfordshire: Centre for Agriculture and Biosciences International.

Telles, L. F., Malm, C., Melo, M. M., Vilela, D. A. R., Lago, L. A., Silva, M. X., & Martins, N. R. S. (2015). Psycogenic feather picking behavioral in parakeet: Haloperidol and environmental enrichment. *Ciência Rural*, *45*, 1099–1106.

Torrezani, C. S., Pinho-Neto, C. F., Miyai, C. A., Sanches, F. H. C., & Barreto, R. E. (2013). Structural enrichment reduces aggression in *Tilapia rendalli*. *Marine and Freshwater Behaviour and Physiology*, *46*, 183–190.

Van Hoek, C. S., & ten Cate, C. (1998). Abnormal behavior in caged birds kept as pets. *Journal of Applied Animal Welfare Science*, *1*, 51–64.

Van Zeeland, Y. R., Spruit, B. M., Rodenburg, T. B., Riedstra, B., Van Hierden, Y. M., Buitenhuis, B., … Lumeij, J. T. (2009). Feather damaging behaviour in parrots: A review with consideration of comparative aspects. *Applied Animal Behaviour Science*, *121*, 75–95.

Volpato, G. L., & Trajano, E. (2006). Biological rhythms. In A. L. Val, V. M. de Almeida-Val, & D. J. Randall (Eds.), *The physiology of tropical fishes* (pp. 101–153). London, England: Academic Press.

Young, R. J. (2003). *Environmental enrichment for captive animals*. Oxford, UK: Blackwell Science.

Zar, J. H. (2009). *Biostatistical analysis*. Upper Saddle River, NJ: Prentice Hall.