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Behavioural response of zoo-housed Japanese macaques (*Macaca fuscata*) to changes in exhibit and social group

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Abstract

Moving animals to a new exhibit within a zoo is generally done with that animal's well-being in mind. However, there are many factors that need to be considered when evaluating changes in well-being associated with environmental changes, such as the amount of time needed to habituate to the novel environment, and, for social animals, the effect of moving on the group's stability. In 2015, five individuals from each of the two groups of Japanese macaques (*Macaca fuscata*) at the Zoo de Granby were moved to the indoor area in a new exhibit, combined to form a new group of 10 individuals and subsequently introduced to the new on-display exhibit. The exhibit, designed specifically for Japanese macaques, was bigger and more structurally complex than their previous exhibit. The macaques' behaviour was studied throughout their translocation to investigate whether habituation to the new exhibit occurred and how the combined change in exhibit and social group affected welfare. In the new exhibit, there was significantly less inactivity and more vigilance the first week that the macaques were fully introduced compared to four months later. There were few significant differences in behaviour between the old exhibit/social grouping (2014) and the new exhibit/social grouping (2015); individuals from group A were more inactive in 2015 than in 2014 and individuals from group B allogroomed more in 2015. The results suggested that some degree of habituation did occur. However, behaviour, and by proxy welfare, for individuals from both group A and B, did not change a great deal between years. This was possibly due to the length of the study, the nature of the exhibits or the social instability due to the recent group formation. Suggestions are made as to how to better manage the social component of animal translocations.

Introduction

Exhibit design plays an important role in determining zoo animal welfare: a well-designed exhibit can buffer stressors (e.g. visitor presence, environmental conditions) and serve as passive enrichment (Stoinski et al. 2001; Little and Sommer 2002; Clark et al. 2012). Animals in complex, spacious and biologically appropriate exhibits often express a wide range of behaviours and activity budgets comparable to their wild counterparts (Melfi and Feistner 2002). Behavioural studies can help in developing exhibits that accommodate an animal's needs. For example, Beisner and Isbell (2008) found that rhesus macaques (*Macaca mulatta*) housed on grass groomed less and foraged more than macaques housed on gravel; the proportion of time they spent performing these behaviours was more like their wild counterparts, which could be evidence of the rhesus macaques' need for an appropriate substrate.

In 2014, the Zoo de Granby in Granby, Quebec, Canada, housed 14 adult Japanese macaques (*Macaca fuscata*; two groups of seven), many of whom were suffering from hair loss, or alopecia. Alopecia in primates has been linked to several endogenous and exogenous factors (Steinmetz et al. 2006: Novak and Meyer 2009; Kroeker et al. 2014). Skin biopsies and other veterinary tests performed on the macaques did not reveal any medical issues and changes in diet did not improve coat condition; an exogenous stressor was believed to be the cause. Studies have found that several aspects of an individual's physical environment, such as substrate, enclosure size and level of enrichment, seem to contribute to hair loss (Steinmetz et al. 2006; Beisner and Isbell 2008; Bechard et al. 2011); animals housed in large, enriched areas tend to suffer from hair loss less than those in smaller, more barren environments. The Zoo de Granby decided to build a new exhibit for the macaques that would be larger, with more complex climbing structures and species-specific elements. Studying the macaques throughout their translocation to a new exhibit was a unique opportunity.

To take advantage of this opportunity, the Japanese macaques were observed during their introduction to the new exhibit and four months later. Behaviour, including exploratory behaviours such as object manipulation, vigilance and movement, was measured to determine whether habituation to the new exhibit had occurred (Thorp 1956; Ogden et al. 1990). The macaques' behaviour was also observed in the old exhibit and compared to their behaviour in the new exhibit with the goal of determining if the new exhibit increased their welfare.

However, shortly prior to the introduction to the new exhibit, the decision was made to combine several members of the two original groups of Japanese macaques to form one larger group. Manipulation of social groups is relatively common-place in zoos. In this case, having one group would be beneficial as it would allow all the animals to have access to the on-display exhibit as opposed to being rotated between the on- and off-display exhibits, which are usually smaller and less complex. Conversely, changes in a social group can result in an unstable hierarchy, which can negatively affect the physical and psychological health of the animals (Gust et al. 1991; Kaplan et al. 1983; Sapolsky 2005). Therefore, in this study, we explored: (1) habituation by the Zoo de Granby Japanese macaques to a simultaneous change in exhibit and in social group, (2) how the macaques' behaviour changed from 2014 to 2015 given the changes in social and physical environment, and (3) the implications of this for animal welfare and management.

Methods

Subjects, study area and husbandry

This study was performed at the Zoo de Granby in Granby, Quebec, Canada. During the 2014 field season, we observed the 14 Japanese macaques housed as two groups of seven (groups A and B; Table 1). The macaques were sexually mature adults and the group was non-reproducing as the males had been castrated or had received vasectomies. All individuals were captive-bred. They had been in the same groups for seven years prior. The social structures of the groups appeared to be relatively stable at the beginning of this study. In 2015, before being introduced to the on-display area of the new exhibit, five individuals from each of the original two groups were introduced to form a new group of 10 individuals (group AB; Table 1). The introductions were performed in the indoor area of the new exhibit. Data collection began 16 days after the last individual was introduced to the new group. During the observations, individuals were never separated from their respective groups, including during feedings and at night, unless an individual needed veterinary treatment or was involved in excessive, unresolved conflict.

The 2014 on-display exhibit consisted of a chain link dome measuring 227 m^2 (32.43 m^2 per individual) and is described in Figure 1. It was originally built for polar bears in 1962 before becoming home to the Japanese macaques in 2002. The two groups were rotated between the on-display exhibit and an off-display area, consisting of 53 m^2 of indoor space and 20 m^2 of outdoor space, on a weekly basis. The new exhibit measured 665 m^2 (66.5 m^2 per individual) and is described in Figure 2. Completed

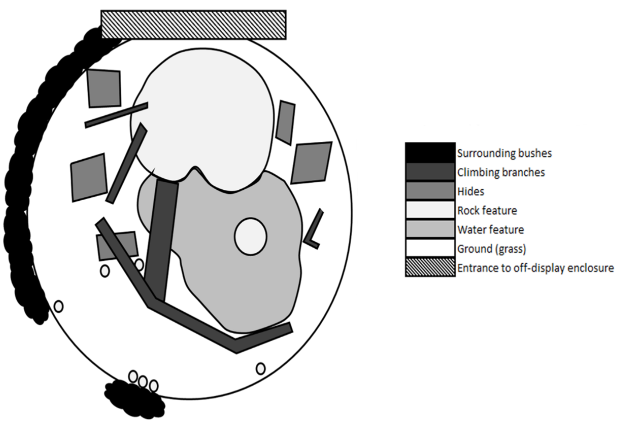

Figure 1. A top-view schematic image of the 2014 Japanese macaque on-display enclosure. The enclosure consisted of a chain link dome measuring 8.5 m in radius and was equipped with climbing branches, three wooden dens and two stone dens, an artificial stone hill and a water feature with waterfall and pool. The viewing area consisted of approximately two thirds the perimeter of the enclosure and there was approximately 1.5 m of space between the enclosure and the viewing area, maintained by a second chain-link barrier fence.

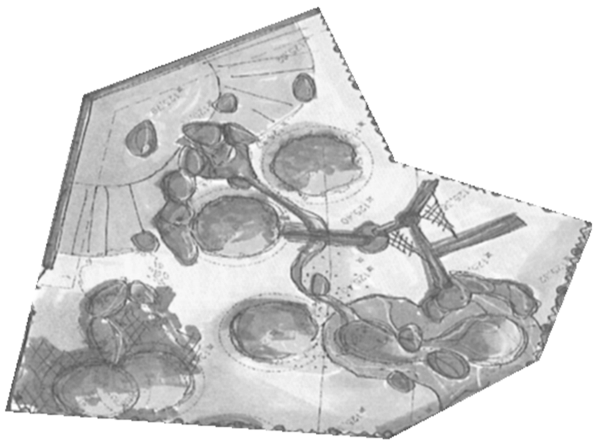

Figure 2. A top-view schematic image of the 2015 Japanese macaque enclosure created by EXP's architectural and design services. The exterior exhibit measured 665 m^2 and included an on-display indoor area that the macaques would have access to in winter. The outdoor area had grass substrate and included seven stone dens (four of which were equipped with heat lamps), a large climbing structure, a large stone hill structure, natural changes in elevation, a stream and a thermal pool. The exhibit was open-topped which allowed several large trees to be included in the design and electric fencing was used to prevent the macaques from climbing the trees and fencing. The exhibit afforded four main viewing opportunities for guests; two with a plexiglass barrier and the other two with a chain link fence and a barrier fence.

Table 1. Information on the 14 Japanese macaques housed at the Granby de Zoo at the time of this study.

ID	Name	Group	Sex	Age as of June 2014	Reproductive Condition	Date Added to Group AB	Included in analysis?
M93199	Iosa	A, AB	F	20	Hormonal contraceptive	April 22nd, 2015	Yes
M96112	Magia	A, AB	F	17	Intact	April 22nd, 2015	Yes
M93198	Chilly	A	F	20	Intact	NA	No
M96110	Lullaby	A, AB	F	18	Intact	April 22nd, 2015	Yes
M06017	Remon	A	M	7	Vasectomized	NA	No
M05014	Madjae	A, AB	F	8	Intact	April 22nd, 2015	Yes
M06011	Miu	A, AB	F	8	Intact	May 4th, 2015	Yes
M98139	Iodine	B, AB	F	15	Intact	April 22nd, 2015	Yes
M93200	Mago	B, AB	M	20	Castrated	April 22nd, 2015	Yes
M94129	Ionica	B, AB	F	19	Intact	April 22nd, 2015	Yes
M97130	Iopolda	B	F	17	Intact	NA	No
M96111	Linus	B	M	17	Castrated	NA	No
M06027	Shiwa	B, AB	F	7	Intact	May 1st, 2015	Yes
M02019	Zoe	B, AB	F	11	Intact	April 29th, 2015	Yes

in 2015, it was designed specifically for the Japanese macaques and included species-specific elements such as a thermal pool and hides with heat lamps for winter, when temperatures can reach as low as -35°C.

Regular enrichment and feeding schedules were followed in both the old and new exhibit during the study period. This consisted of some of their regular diet and one food enrichment item (e.g. scattered grains, branches, dry pasta, etc.) in the morning before the zoo opened (800–900), and the rest of the regular diet scatter-fed in the late afternoon (1600–1700). The macaques would receive enrichment such as phonebooks, balls or ice treats on a random basis in both exhibits. To place the food and enrichment in the exhibit, the monkeys were transferred to their indoor area. In the 2014 exhibit, a snack was also provided in the early afternoon (1200–1330), during which time formulated monkey chow was passed through the fencing by a zookeeper while the monkeys were still in the exhibit. Both exhibits provided natural foraging opportunities, such as grass and fallen leaves. The new exhibit also had a small number of shrubs and live trees.

Behavioural observations

Data used in this study were collected during three periods: 1) late August to October 2014 in the old exhibit, 2) May 2015, when the macaques were introduced to the outdoor area of the new exhibit, and 3) late August to September 2015, in the new exhibit. These periods were chosen to reduce the potential effect of visitor presence during the zoo's busy season (July to mid-August). All data collection was performed in the outdoor areas of both enclosures while the indoor areas where closed.

A focal individual sampling technique was used to collect behavioural data whereby a single individual was observed for a period of 10 minutes (Martin and Bateson 2007). Behaviours were recorded instantaneously every 15 seconds for a total of 40 sampling points per 10-minute period. Data collection in 2014 and in August/Septembr 2015 started between 900 and 1000, when the macaques were let out into the display exhibit. Sampling continued for approximately 7.5 hours, excluding three short breaks (approximately 10 to 20 minutes, every two hours). In May 2015, the macaques were let out later and brought in early. The average day during this period started between 1000 and 1100 and continued for approximately 6.5 hours, including breaks. The exception was May 22nd, 2015 where data collection did not begin until 1314 and ended at approximately 1700. All data were collected by E. Anderson.

Prior to data collection, individuals within a group were randomly assigned a number (one through seven for groups A and B, and one through 10 for group AB). A sampling schedule was then created. Sampling began with a different individual each day and individuals were sampled in numerical order. If an individual was not in sight or not identifiable at the beginning of their sampling period, the observer would move on to the next individual scheduled. The original individual was sampled at the next possible period.

The ethogram employed (Table 2) was loosely based on that of Maruhashi (1981). Object/environment manipulation and vigilance were included in the ethogram to better measure exploration and habituation in the new habitat (Ogden et al. 1990; Martin and Réale 2008; Soriano et al. 2013). A category for

Table 2. The ethogram of behaviours recorded during the sampling period for the activity budget, adapted from Maruhashi (1981).

Activity	Category for Analysis	Definitions
Inactivity	Inactivity	Animal is relaxed and not involved in any other activity
Moving	Moving	All types of locomotion not included in any other activity
Vigilance	Vigilance	While stationary, animal is alert and is actively looking around the enclosure, at an animal or at a visitor (see “vigilance” in Soriano et al. (2013) and “scanning” in Martin and Réale (2008))
Allogrooming	Allogrooming	Animal is grooming another animal, or is being groomed
Self-grooming	Self-grooming	Animal is grooming or scratching itself
Feed/Forage	Feed/Forage	Intake of solid food or water, including the process of searching for food items on the ground or in vegetation and cleaning food
Submissive Behaviour	Agonistic Behaviour	Agonistic behaviours indicating fear or submission. This includes flight, crouching or shrinking with intent to flee and other submissive postures and facial expressions (de Waal et al. 1976)
Dominant Behaviour	Agonistic Behaviour	Agonistic behaviour of an aggressive or dominant nature. This includes threats (e.g. branch shaking, open mouth display), chases and physical assault (de Waal et al. 1976)
Affiliative Behaviour	Other	Positive interactions between individuals such as affiliative contact (Kapsalis and Berman 1996; O'Keeffe et al. 1982/83) and social play (Aldis 1975)
Abnormal Behaviour	Other	Behaviours not considered to be a part of an animal’s natural repertoire such as self-aggression, autoerotic stimulation and stereotypies (Mallapur and Choudhury 2003)
Object Manipulation	Other	Picking up non-food objects or parts of the enclosure and manipulating them with their hands, feet or mouth (Ogden et al. 1990)
Other	Other	Behaviours that are not included in any of the above categories
Not in Sight	N/A	Animal is not visible to the observer

behaviours considered to be abnormal was also added (Mallapur and Choudhury 2003).

Additional data

Each focal sample was categorised by “Period”, where “AM” consisted of start times between 900 and 1200, “PM1” consisted of start times between 1200 and 1500 and “PM2” consisted of start times later than 1500. Sessions were also categorised by potential visitor presence. This was represented by the variable “Phase”, which had two levels: “Open”, meaning the zoo was open to the public, and “Closed”, where it was not.

Ethics statement

Data collection was in accordance with the Animal Care and Ethics certificate provided by Concordia University (AREC 30003983) and followed the research guidelines of the Zoo de Granby Committee on Conservation and Research Operations.

Statistical analysis

Due to low occurrences, submissive and dominant behaviours were combined to form “Agonistic behaviours” and object manipulation, affiliative and abnormal and other behaviours were combined to form “Other” (Table 2). Any focals having more than four sample points out of 40 recorded as “Not in Sight” were removed from the analysis (Lehner 1996; Jansen and Vogel 2006).

The dependant variable used in our behavioural models was the frequency of a given behaviour during a focal. As the data were overdispersed, generalised linear mixed models with a negative binomial distribution and log link function were performed using Proc Glimmix in SAS® 9.4 software (SAS Institute Inc., 2013). Tests were performed at a 5% level of significance. We included individual ID in our models as a random term to account for pseudoreplication and individual differences in behaviour. The natural logarithm of the total number of “In Sight” observations was used as an offset to account for differences in the number of “Not in Sight” observations in a focal (Agresti 1996). We controlled for phase (“Open” vs “Closed”) and period (“AM”, “PM1”, “PM2”) by including these variables as well as their respective interactions with behaviour type in both models.

To assess habituation to the new exhibit, we used data from the first seven days that the macaques of group AB were in their new exhibit with no access to the indoor exhibit (May 20th to 26th), which was labelled as the “Early week”, and the last seven days of observation (between September 10th and 17th), during which time the macaques also did not have access to indoors; this was labelled as the “Late week”. The model tested the effect of behaviour type, week and the interaction between week and activity type on the rate of occurrence. The variable of interest was the interaction between week and behaviour, which reflects the change in the rate of occurrence of the behaviours between

Table 3. Means, medians and first and third quartiles for the daily percent of observations of the low frequency behaviours of interest in the “Other” category for group AB during the early and the late weeks in the new enclosure. Values were calculated using R version 3.3.2.

Behaviour	Week	Mean	Median	First Quartile	Third Quartile
Abnormal Behaviour	Early	1.98%	0.11%	0.00%	0.63%
	Late	0.04%	0.00%	0.00%	0.03%
Affiliative Behaviour	Early	0.04%	0.00%	0.00%	0.06%
	Late	0.10%	0.00%	0.00%	0.01%
Object Manipulation	Early	0.84%	0.27%	0.00%	1.18%
	Late	2.90%	2.53%	1.91%	3.61%

Table 4. Means, medians and first and third quartiles for the daily percent of observations of the low frequency behaviours of interest in the “Other” category for individuals in each of the two Japanese macaque groups in the old and new exhibits. Values were calculated using R version 3.3.2.

Behaviour	Group	Year	Mean	Median	First Quart	Third Quart
Affiliative Behaviour	A	2014	0.14%	0.00%	0.00%	0.08%
		2015	0.14%	0.00%	0.00%	0.05%
	B	2014	0.07%	0.00%	0.00%	0.00%
		2015	0.11%	0.00%	0.00%	0.00%
Abnormal Behaviour	A	2014	0.08%	0.00%	0.00%	0.00%
		2015	0.04%	0.00%	0.00%	0.00%
	B	2014	0.19%	0.12%	0.00%	0.40%
		2015	0.09%	0.00%	0.00%	0.00%
Object Manipulation	A	2014	3.59%	1.27%	0.95%	2.82%
		2015	2.17%	0.92%	0.00%	3.99%
	B	2014	1.13%	0.37%	0.00%	1.08%
		2015	0.99%	0.29%	0.00%	0.89%

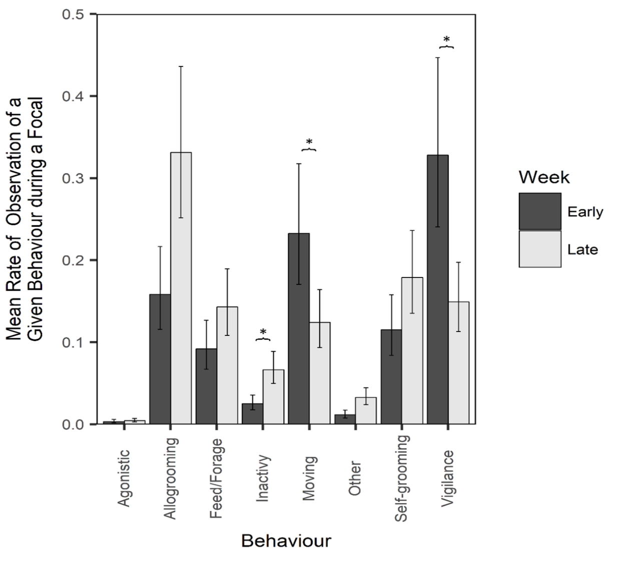

Figure 3. Mean rate of observations and 95% confidence interval bars for each behaviour type during the early and late week in the new enclosure (2015). Means and confidence intervals were generated from the least squares means of the model. Asterisks indicate statistically significant difference between weeks.

the early and late weeks.

Two models were used for the year-to-year comparison, one for individuals in group A and one for individuals in group B. The models tested how the rate of occurrence was affected by behaviour type, year and the interaction between year and activity type for each of the two groups. Only focals from individuals that were present in both years were included in these analyses. As it was not possible to isolate the effect of the exhibit change from the effect of social group change, the variable of interest, the interaction between year and behaviour, reflects the effects of both these factors cumulatively on the rate of occurrence of each groups’ behaviour.

Pairwise comparisons were performed using the Tukey-Kramer method for the interaction term of activity type and year for the year-to-year model and of activity type and week for the habituation model. For the low frequency behaviours of interest (affiliative behaviours, abnormal behaviour and object manipulation) that were included in the “Other” category for the models, the raw data were pooled by day and the percent of observations each one represented in the activity budget was calculated. To compare the values of these behaviours between years and between weeks, means, medians and first and third quartiles were calculated for the daily percent of observations using R version 3.3.2.

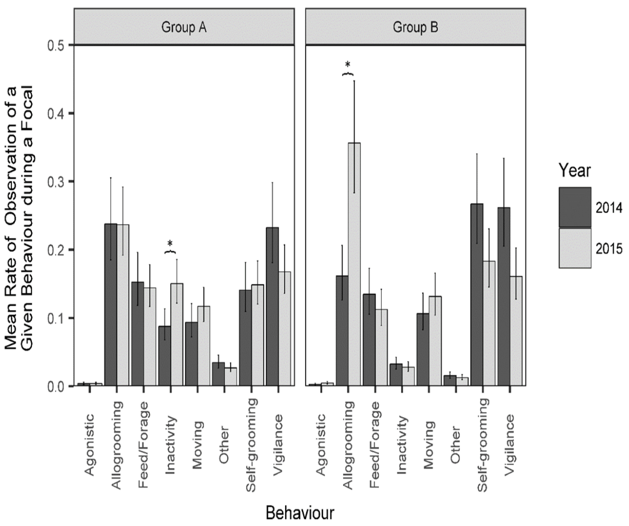

Figure 4. Mean rate of observations and 95% confidence interval bars for each behaviour type for individuals in group A (left) and group B (right) during late August to October 2014 in the old exhibit/social group and during late August to September 2015 in the new exhibit/social group. Means and confidence intervals were generated from the least squares means of the model. Asterisks represent statistically significant differences between years.

Results

Habituation

The rate of the behaviours in the new exhibit varied between the early week and late week ($F(7, 2170)=9.11$, $P<0.001$; Figure 3). There was significantly less inactivity ($t(2309)=-4.08$, $P=0.005$), less occurrence of other behaviours ($t(2503)=-3.94$, $P=0.008$) and more vigilance ($t(1613)=3.63$, $P=0.026$) in the early week compared to the late week, as indicated by the post hoc analysis. The descriptive statistics for the "Other" behaviours of interest are presented in Table 3.

Year-to-year comparison

There was a significant interaction between behaviour and year for group A ($F(7, 3549)=3.04$, $P=0.004$; Figure 4) and group B ($F(7, 3723)=7.07$, $P<0.001$; Figure 4). Post hoc analysis indicated that individuals from group A were more inactive in 2015 than in 2014 (A2014 vs. A2015: $t(3026)=-3.50$, $P=0.040$). In 2015, individuals from group B allogroomed more than in 2014 (B2014 vs. B2015: $t(2735)=-5.08$, $P<0.001$). The descriptive statistics for the "Other" behaviours of interest are presented in Table 4.

Discussion

During the first week that the Japanese macaques were fully introduced to the new outdoor exhibit, the group was significantly less inactive and performed more vigilance than during the late week (four months later). Both behavioural changes may suggest habituation as they could be indicative of increased visual and physical exploration of the novel environment in the early week. Vigilance in primates can also be often directed towards group members (Treves 2000). Therefore, the decrease in vigilance over time could be indicative of not only habituation to the new environment but also to the new social group. Contrary to our expectations, there was significantly more "other" behaviour in the late week and, based on the descriptive statistics, this was likely driven by "object manipulation". Ogden et al. (1990) also observed low levels of object manipulation when gorillas were introduced to a new exhibit and suggested it could be due to a lack of preferred objects to manipulate, species-typical exploratory tendencies or the age of the animals.

Though there did appear to be some degree of habituation to the new enclosure, the effect of the change of social group and exhibit on behaviour and, by proxy, welfare was not so clear-cut. Our results indicated that individuals from both groups experienced only a small behavioural change from 2014, in the old Japanese macaque exhibit as two separate groups, to 2015, in the new exhibit as a combined group. Specifically, group A was significantly more inactive in the new enclosure and social group than in the old enclosure and social group. Group B, on the other hand, performed significantly more allogrooming in the new exhibit and social group compared to the old exhibit and social group.

The increase in inactivity by members of group A from 2014 to 2015 was unexpected considering that the new exhibit was bigger and more complex; there was more space to move, more objects in the environment with which to interact and even more individuals with which they could interact. As there was also a non-significant trend towards increased movement in the new exhibit, the increased inactivity of the macaques in the new exhibit was likely enabled by a decrease in behaviours other than movement. Vigilance, for example, showed a non-significant decreasing trend. Vigilance can be considered an indication of stress or anxiety in animals (Mason and Veasey 2010; Larsen et al. 2014). A decrease in vigilance in favour of rest may indicate that an animal is more "relaxed" (Owczarczak-Garstecka and Burman 2016). The increase in inactivity could therefore be interpreted as a sign of increased welfare for the individuals of group A, but it is not strongly support. Overall, behaviour exhibited across 2014 and 2015 for group A was very similar, especially for social behaviours such as allogrooming, agonistic and affiliative behaviours.

The significantly higher amount of allogrooming observed in group B from 2014 to 2015 is also not in accordance with many other studies (Hogan et al. 1988; Little and Sommer 2002); these studies found fewer social interactions, both positive and negative, in bigger exhibits and attributed it to the increased distance between individuals. In social primates, however, allogrooming is often used to ease social tension and strengthen alliances (Schino et al. 1988; Dunbar 2010). Hemelrijk (1994) found that long-tailed macaques (*Macaca fascicularis*) were more likely to support an individual in an aggressive interaction if they had been recently groomed by them. This would be especially important in a relatively new group where social bonds are still being formed. Alternately, Lehman et al. (2007), found that, in the wild, the amount of time a primate group spends grooming increased with group size until the group exceeded 40 individuals. Therefore, the increase in allogrooming could have been due purely to the increased group size and not due to the stress of group formation. Either way, it is suggested that the increase in allogrooming in the new exhibit was more related to the change in social environment than to the change in physical environment. Otherwise, the individuals of group B showed trends towards decreased self-grooming and vigilance in 2015 compared to 2014, but the difference was not significant.

Studies have found that primates may display significant differences in behaviours when moved to a new exhibit, or relatively conservative differences (Little and Sommer 2002; Ross et al. 2011). Transferring animals from an exhibit that is small but still relatively complex to a bigger, more complex exhibit might not always elicit a great change in behaviour. This was observed in great apes at the Lincoln Park Zoo (Ross et al. 2011). The results for both groups A and B could, therefore, have been due to the nature of the exhibits; both were relatively naturalistic and complex but differed mainly in size and species-specificity. The time-frame of the study may also have been an issue. Studies suggest that primates may require a relatively long time, perhaps a year or longer, to habituate to a novel environment (Ogden et al. 1990; Ross et al. 2011). Though some degree of habituation did occur, this study may have been too short for all the animals to fully habituate and experience the welfare benefits of the new enclosure.

What may have been more influential was the merging of members from the original two macaque groups to form a new group immediately prior to the introduction to the exhibit; it incorporated an important social component to the study that made a direct comparison between the enclosures impossible, caused complications in the statistical analysis and interpretation, and likely added additional stress for the animals. Group formation and social instability have been shown to have negative effects on the physical health of primates, causing increased cortisol, decreased immune function and even increased plaque build up in arteries (Kaplan et al. 1983; Gust et al. 1991). It can also result in increased aggression and changes in the rate of affiliative behaviours such as allogrooming (Shively et al. 1986; Kaburu and Newton-Fisher 2013). In the Zoo de Granby Japanese macaques, hair loss in several individuals increased after the new group was formed and again after a major hierarchy restructure occurred in mid-August 2015, suggesting that this was a stressful experience (Anderson et al. 2016). If the macaques were indeed experiencing stress from group formation and the social instability, it may have negated any positive effects of the new enclosure at the time of the study. For example, it is possible that agonistic behaviours would have decreased in the new enclosure with its increased size, as in the previously mentioned studies if not for the social instability (Hogan et al. 1988; Little and Sommer 2002). Unfortunately, it was not possible to differentiate between the effect of physical versus social environments.

Conclusions

It is clear from these observations that studying behaviour in a novel environment is not necessarily a clear-cut process. There are many factors that need to be considered, such as the duration of the study, the nature of the two environments, and perhaps most important of all, the social implications of the move. In order to measure changes in welfare due to physical environment alone, transfers to new exhibits should be done in a way that minimises the effects on group social dynamics, for example by minimising the amount of time animals spend separated from their social group. Even if there is no plan to intentionally manipulate the social group, it may be beneficial to collect detailed data on dyadic interactions for a time before and after transfers are made to determine whether groups were stable in their old environment, whether they maintain their group structure and stability after transfer to a new environment and, if not, how long after the transfer was stability re-established. This could help guide zoo management and future researchers wishing to evaluate the welfare benefit of new exhibits by helping them plan the timeframe of their study and prepare for this issue caused by social dynamics.

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