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Orangulas: effect of scheduled visual enrichment on behavioural and endocrine aspects of a captive orangutan (*Pongo pygmaeus*)

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Abstract
Captivity may have adverse effects on captive great apes, as they spend much more of their time engaged in foraging and other activities in the wild. Enrichment interventions have the potential to alleviate the adverse effects of captivity by introducing novel stimuli. In orangutans (*Pongo pygmaeus*), interactive digital enrichment has proven effective at engaging users out of their own free will, in exchange for nothing but the experience. This article reports the results of scheduled visual enrichment in the form of "orangulas"—one-hour long videos of footage consisting mainly of open spaces in different environments, with which the pongid participant could engage at free will. The efficacy of the orangulas were measured with both behavioural and endocrine measurements, concluding that scheduled visual enrichment has the potential to improve the welfare of captive orangutans by providing novel stimuli in the context of largely stable environments.

Background

Nonhuman primates face complex environments in the wild. Their behaviour and physiology have evolved to make them fit for such environments. In captivity, primates are therefore expected to exhibit a different behaviour than their wild counterparts. Unlike other primate species, orangutans are rarely noted as displaying abnormal behaviours (Valdovinos 2001). Instead, captive orangutans (*Pongo spp.*) tend to display obesity and lethargic behaviour (Wright 1995; Kaplan and Rogers 2002) or being hypersocial (Poole 1987; Tobach et al. 1989). Since these altered states are induced by the unchallenging environmental, feeding and social conditions imposed by captivity, enrichment aims at providing novel stimuli and tasks that will enable captive animals to engage their attention and cognitive skills (Lutz and Novak 2005). This expectation is confirmed by reports of reduced species-typical behaviours or increase of stereotypical behaviours (Swaisgood and Shepherdson 2005). In orangutans specifically, lethargic behaviour seems to be a marker of captive conditions (Kaplan and Rogers).

In orangutans, a variety of enrichment interventions have demonstrated the feasibility of increasing the complexity of their environment with beneficial effects. Valdovinos (2001) provides a brief review of studies on enrichment for captive orangutans until 1995. These include an increase in activity by the introduction of manipulable material (Tripp 1985), enlargement of enclosures (Perkins 1992), or novel items (Wright 1995). The positive effects of the vertical enlargement of enclosures on captive orangutans were also reported by Hebert and Bard (2000). Pizzuto et al. (2008) report a reduction of stereotypies (especially self-directed behaviour) after the introduction of environmental enrichment.

Currently, enrichment for orangutans is a lively field with many interesting proposals, particularly aimed at interactive enrichment (Wirman 2014). However, the results of the interventions are rarely reported, focusing more on challenges to design the enrichment (Jørgensen and Wirman 2016), or implications for human-animal interaction (Webber et al. 2017). Kim-McCormack et al. (2106) review the recent trend in enrichment studies in primates that primarily consist of the use of digital technologies. They define "digital technologies" as "digital touchscreen devices, projected visual stimulation, digital handheld device computer activities, embedded microchips that automates changes in environments" (Kim-McCormack et al. 2106). Of these enrichment studies, a handful are specifically designed for orangutans. Among them, Boostrom's (2013) bears interesting results. To begin with, her design restricts individuals from having unrestrained access to the digital device (a tablet), unlike a previous study that showed detrimental effects if this was the case. For example, in a setup without restrictions to access the devices, orangutans competed for access to it, resulting in aggressive behaviours, unequal access to enrichment and anxiety-related behaviours (Tarou et al. 2004). An increase in the number of devices, or supplying them only to individually caged animals (Mallavarapu et al. 2013) seemed to overcome these shortcomings. Boostrom's (2013) study also shows that the interest on the device depended on age and sex. The juveniles showed the most interest, regardless of the application that was being used. The adult males showed the least interest, and adult females showed interest but only on specific applications depending on individual differences. Separately to digital touchscreen devices, at least one study (Ritvo and McDonald 2016) showed that captive orangutans did not have a preference between music and scrambled sounds. They suggested that the effects of music as enrichment could be detrimental depending on the species of nonhuman primate in question.

Endocrinological and observational evidence has shown enrichment to be efficient at enhancing the well-being of captive orangutans, however most of the studies above rely on observations of the effects of the intervention in animals' behaviour. An exception is Pizzuto et al. (2008), who include an assessment of the subject's faecal metabolites, finding an acute increase in cortisol relative to the baseline during the habituation period, followed by an overall reduction of cortisol during the enrichment period. Cortisol has been extensively studied in relation to stress in vertebrates (Lane 2006). The co-occurring drop in self-directed behaviours with the aforementioned habituation pattern observed in Pizzuto et al.'s (2008) study provide strong evidence that cortisol measurements are a good indicator of well-being in orangutans.

Taking this body of work into consideration, as well as the observation that perceived naturalism of provisioned enrichment has no effect on the level of engagement, or overall beneficial effects of enrichment in orangutans (Goshert 2011; Crosby 2015) it was decided to provide scheduled visual enrichment in the form of "orangulas"—one-hour long videos of different kinds of footage featuring landscapes. The hypothesis was that scheduled visual stimuli can improve the well-being of captive orangutans. For the endocrinological measurements, a habituation pattern similar to the one in Pizzuto et al.'s (2008) study was expected. Because the habituation pattern exhibits an initial increase in cortisol, an increase in activity during the scheduled administration of the stimuli was also expected. The results show promise in this kind of enrichment intervention, which is easy to set up in most zoo enclosures and, if implemented properly, can provide orangutans (and perhaps other ape species) with alternative activities with which they can voluntarily engage.

Action

Participant

The participant was a 13-year-old male orangutan housed since birth at Aalborg Zoo, Denmark. Following increased animosity with other orangutans, he was kept in a separate enclosure since July 2016, about a year before data collection began. He has visual access to a family unit composed of a flanged male, a female adult and a female infant. He was also able to interact with the zoo staff through mesh wire.

Figure 1. Still frame extracted from the footage used by the coders.

Table 1. Ethogram used for coding the behavioral observations, adapted from Pizzuto et al. (2008).

Category	Behaviour
Locomotion	Walking or running
Stationary (passive)	Standing still, lying down, or sleeping without handing objects
Feeding	Manipulating and/or ingesting food.
Self-grooming (self-directed) or scratching	Cleaning the hair free of parasites, combing and cleaning the hair with fingers or mouth. Also scratching parts of the body using hands or feet (including masturbating)
Interaction	Reacting to the caretakers or other orangutans through the mesh wire
Manipulation of objects	Handling objects (e.g., plastic, paper) or any item introduced in the enclosure (ropes, wood, plants and stimulating items that are not edible)
Others	Vocalising, drinking water, urinating and defecating

Table 2. Behavioural coding for both control and experimental condition. Each row specifies observations of the subject engaged in specific behaviours for each condition (percentages are calculated over the summation of behaviour observed in each condition).

	Control	Experimental	Changes	P (χ^2)
Locomotion	83 9.36%	190 14.49%	+128.92%	< 0.0001
Stationary	507 57.16%	552 42.11%	+8.88%	= 0.167
Feeding	71 8.00%	179 13.65%	+152.11%	< 0.0001
Interaction	86 9.70%	167 12.74%	+94.19%	< 0.0001
Manipulation	122 13.75%	181 13.81%	+48.36%	< 0.01
Scratching	1 0.11%	35 2.67%	+3400%	< 0.0001
Others	17 1.92%	7 0.53%	-58.82%	< 0.05

Setting

The participant's enclosure is connected with an open enclosure (see Figure 1 above); the orangutan of this study spent all recorded time in these enclosures. During the experimental condition, the zoo staff placed the computer playing the stimuli in the service corridor from which they fed the orangutans. A schematic representation of the enclosure is presented in Figure 2. The screen was 19 inches, and it was placed 40 cm from the mesh wire. The participant could look at the stimuli whenever he wished to, through the mesh wire (see Figure 3 below). He could

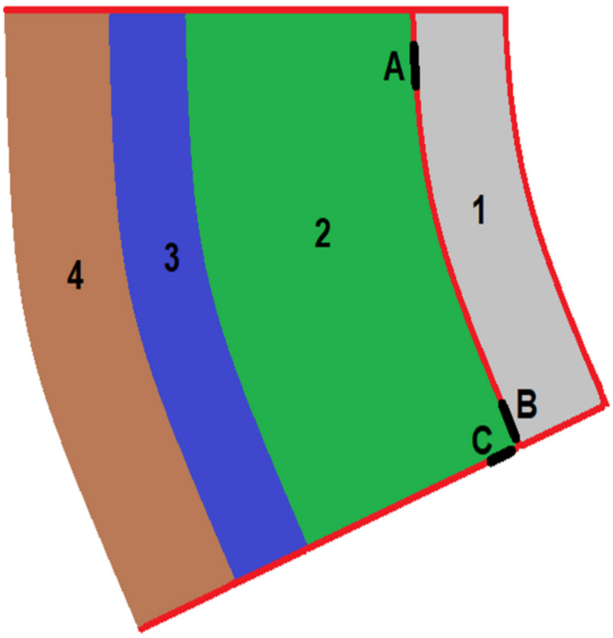

Figure 2. Schematic representation of the orangutan's outer enclosure, where the study took place. Black bar B represents mesh wire through which the subject could watch the stimuli. Area 1 is the inner corridor that zoo staff can use to interact with the orangutans, and it is here that the computer was placed. Area 2 represents the outer enclosure. Area 3 is a water barrier that separates the orangutan from visitors. Area 4 is the area that the public can access to see the orangutans.

Figure 3. The orangutan peeks into the service corridor where the computer is playing one of the "movies".

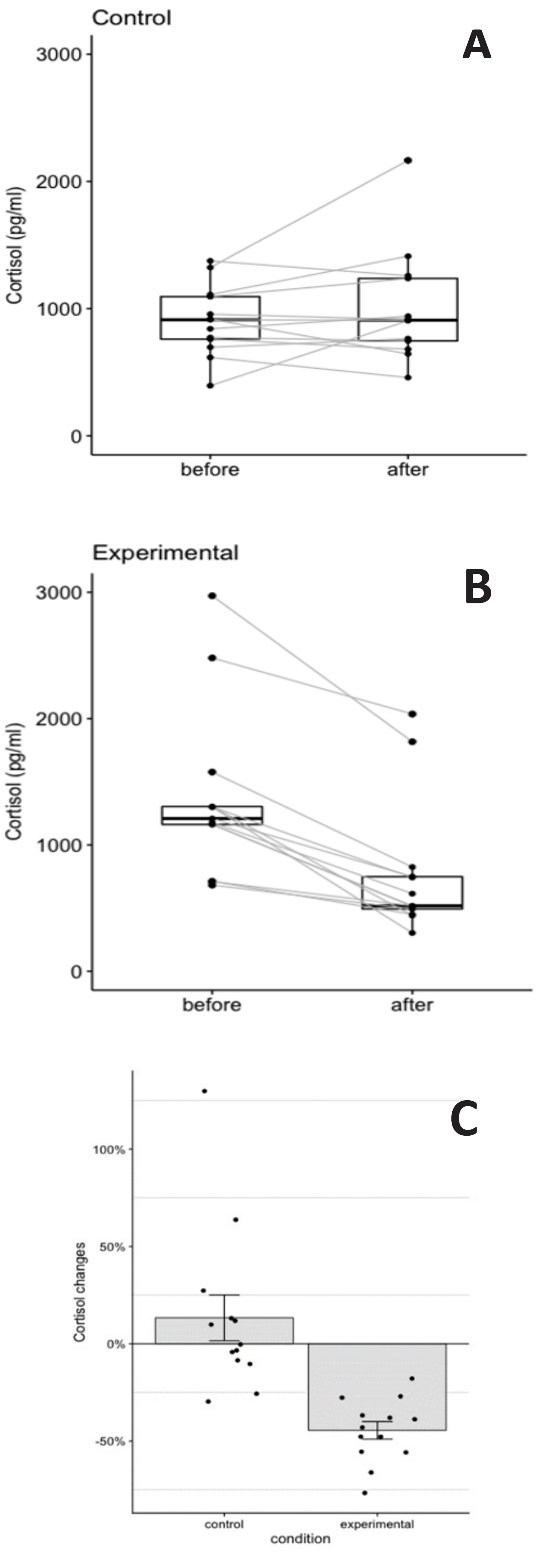

Figure 4. (A and B) Cortisol levels under control and experimental conditions (median and interquartile ranges are displayed). (C) Percentages of cortisol changes in control and experimental conditions (bar represents the standard error of the mean).

also move around freely and choose not to see the stimuli.

Stimuli

The stimuli were dubbed "orangulas", a portmanteau of "orangutan" and "película" (the Spanish word for "film" or "movie"). Each of the six orangulas lasted one hour. Orangulas showed either footage of a) the rainforest canopy; b) desert and savannah; c) outer space; d) marine underwater; e) mountains; or f) abstract art. Because captive orangutans are exposed to plenty of anthropomorphic stimuli during the day, face-like stimuli were avoided in all footage, which consisted instead mostly of natural environments. To avoid confounders and to make sure that the effect was entirely due to visual stimuli, the sound was edited out of the movies.

Procedure

The experimental procedure was prepared in accordance to the policy relating to animal ethics and complies with the ethical guidelines set out by Sherwin, Christiansen et al. (2003). The Danish Animal Experiment Committee does not consider salivary measurements to be invasive nature and hence no license was obtained. THJ and AKOA, who are licensed according to the Federation of Laboratory Animal Science Association (FELASA C) were part of the study and approved the salivary measurements in line with normal medical training performed with the orangutans. Importantly, the subject could disengage from the stimuli out of his own free will at any time, like with other training procedures. Baseline measurements were taken on weekdays from June 6th to July 6th, 2017, and the experimental condition was carried out on weekdays from July 7th to August 5th. These two months were chosen because of the relative stability of weather conditions in Denmark during this period. Salivary measurements were collected with Sarstedt salivettes by the primate caretakers, since the subject had already been trained to open its mouth for dental inspection.

The only difference in the procedure between the baseline and experimental condition was a computer playing the stimuli from 8:30 to 9:30 am, with no other changes to subjects' regular schedule during this period. The different kind of stimuli ("outer space", "marine"...) were played in a fixed order, and the zoo staff was instructed not to reward the subject or to attract them to the stimuli. The orangutan was filmed for one hour a day (roughly from 8:30 to 9:30 am, before any visitors were allowed in the zoo) with a GoPro4 digital camera. Two salivary samples were taken, approximately at 8:30 and 9:30 am. Salivary samples were stored in Sarstedt cortisol salivettes (Sarstedt, Rommelsdorf, Germany) at −18C immediately after their collection.

Analysis

Behavioural observations were performed on the filmed material. The recordings were coded using focal sampling by interval (Altmann 1974). For this study, the ethogram used by Pizzuto et al. (2008) was adapted as detailed in Table 1. Coders were made blind to the condition they were coding. They inspected the recordings for 10 sec every 60 sec in sessions of 60 min. This totalled 10 hours of coded material, consisting of a third of the recorded material over the two-month period during which the study took place (amounting to 2,198 data points before and during enrichment). Differences in frequencies of behaviours between conditions were tested with the Pearson's chi-square test. Cortisol concentrations were assessed at the Behavior and Stress Biology lab (Aalborg University) with a commercial EIA-assay, DetextX, Cortisol, Arbor Assays, MI 48108-3284, USA. The intra-assay and inter-assay variation were 3.1% and 4.1%, respectively. Differences in cortisol levels between conditions as well as between pre- and post-treatment were tested with the Student's t-test (two tails).

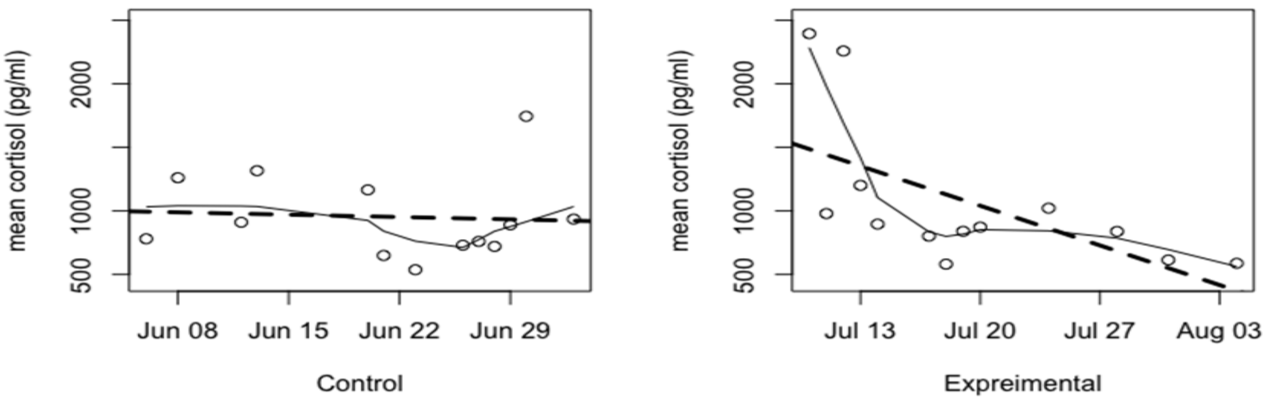

Figure 5. Progression of cortisol levels in both conditions.

Cortisol changes over time were tested with linear regression analysis. An F-test of equality of variances has been used to test cortisol variance between conditions. All statistical analyses were conducted using R version 3.3.2 (R Core Team 2016).

Consequences

The focal sampling observations on the filmed material showed that, while stationary behaviour did not change across conditions $\chi^2(1)=1.91$, P>0.05, there was a significant increase in locomotion $\chi^2(1)=41.94$, P<0.0001, feeding $\chi^2(1)=46.66$, P<0.0001, interactions with both other orangutans and zoo staff χ2(1)=25.93, P<0.0001, manipulation of objects $\chi^2(1)=11.49$, P<0.01, and self-directed behaviour (self-grooming and scratching) $\chi^2(1)=32.11$, P<0.0001 in the experimental, relative to the control condition. Other behaviours were significantly reduced $\chi^2(1)=4.17$, P<0.05. See Table 2 for details.

Cortisol concentrations in the two conditions were not significantly different (Mc=953.8, SD_c=362.7, Me=1068.04, SD_e=665.5; t(38.65)=0.77, P=0.45). The first measures of cortisol across conditions were significantly different (Mc=905.2, SD_c=274.9, Me=1365.4, SD_e=667.5, t(12)=2.30, P<0.05). In the second measures, cortisol levels were not significantly different (Mc=1002.6, SD_c=439.7, Me=770.7, SD_e=534.3, t(12)=1.20, P=0.24). When the coefficient of variance (CV = sd/mean*100) for the two conditions was calculated as a parameter representing variability in cortisol concentrations, this was higher in the experimental (CV=62.31) compared to the control condition (CV=38.02), *F*(25,25)=0.30, P<0.01. Two two-tailed paired Student's t-tests showed that cortisol concentrations in the second measurement were significantly reduced (i.e., different from zero) in the experimental condition (M=-594.69, SD=297, t(12)=7.22, P<0.0001), but not in the control condition (M=97.46, SD=302.01, t(12)=1.16, P=0.267), and both changes were significantly different from each other (t(24)=5.89, P<0.0001), suggesting that the orangulas had an effect in reducing endogenous cortisol release. See Figure 3 for details.

When the percentage cortisol change from the first to the second measurement was computed, a significant reduction was found for the experimental condition M=-45%, SD=16.35, t(12)=9.82, P<0.0001, compared to the control one M=+13.29%, SD=42.30, t(12)=1.32, P=0.028. To investigate whether cortisol levels decreased over time, the first and second measures were aggregated, and a linear regression was run to investigate differences in cortisol levels. Results showed that while cortisol was stable in the control condition *F*(1,11)=0.05, p=.82, R2=.00, it significantly decreased over time in the experimental condition *F*(1,11)=6.43, p<.05, R2=.37 (see Figure 4).

Discussion

Many aspects of the participant's behaviour changed significantly during the period of scheduled enrichment relative to his baseline behaviour. These changes can be evaluated as beneficial, assuming that a general increase in activity is desirable in captive orangutans (Wright 1995; Kaplan and Rogers 2002). For example, increased locomotion was observed (from 9.36 to 14.49%). The participant was also observed feeding more often than before, from 8 to 13.65%, closer to the 18% that has been observed as typical in captive orangutans (Rodman and Mitani 1987). Likewise, a significant increase in his interactions with the zoo staff and other orangutans through the mesh wire was observed (from 9.70 to 12.74%). The increase in manipulation of objects was also significant (from 13.75 to 13.81%). However, a significant increase in self-directed behaviours was also observed, comprising self-grooming and scratching (from 0.11 to 2.67%) which can be deemed as signs of stress or restlessness. Because of its novelty value, an increase in activity is expected after the introduction of enrichment, before habituation begins. The present observations of an overall increase in activity are in accordance with this expectation and, considering that lethargy is a hallmark of captivity in orangutan behaviour (Kaplan and Rogers 2002), the overall increase in activity is considered as beneficial in this context.

The endocrinological data lend support to the hypothesis that scheduled visual enrichment can be beneficial for captive orangutans, as demonstrated by the reduction in the second measurement of the experimental condition. Animals who are exposed to novel situations see an increased activity in their hypothalamic-pituitary-adrenal (HPA) axis, as evidenced by an increase in the secretion of glucocorticoids (Moberg 2000). The stimulation provided by the enrichment resulted in an overall increase in the secretion of glucocorticoids at the beginning of the experimental period (Figure 4). This increase corresponds with the process of habituation observed at the beginning of interventions (e.g., Pizzuto et al. 2008). However, the participant consistently showed a decrease in cortisol after exposure to the stimuli (Figures 3 A and B), and an overall tendency for his cortisol to decrease (Figure 4).

There was a lack of resources to continue observation following enrichment, but early reports from long-term use of televisions as enrichment for chimpanzees (Brent and Stone 1996) suggest that an interest in visual stimuli can be sustained over long periods of times, albeit with a certain degree of habituation. An important difference with this study, however, is that the present setup did not allow the participant to watch the stimuli outside of schedule, nor to choose the kind of stimulus (i.e., "outer space", "mountains", "deserts"...) as these were played sequentially. Future work building on this design might also look at the specific contribution of different kinds of video, which were not investigated here. Affluency of visitors was not controlled for, nor was the specific contribution of each of the types of videos to the behaviour or cortisol levels of the subject. Follow-ups to the present study would benefit greatly from including this kind of data.

Conclusion

The present results indicate that scheduled visual enrichment can improve the well-being of captive orangutans by increasing their activity and reducing their cortisol levels. Despite these promising results, it should be noted that this study does not endorse the substitution of scheduled visual enrichment at the expense of other forms of enrichment. Rather, it suggests that this can be a beneficial addition to other kinds of enrichment, particularly since it can be relatively easy to set up and maintain. It is also proposed that the enrichment be administered on a schedule and that attention should be paid to cohabitation with other captive animals in the same enclosure, etc. This seems to be the crucial difference between the present method and previous attempts at enrichment with digital technologies that showed mixed results (Boostrom 2013; Tarou et al. 2004; Mallavarapu et al. 2013). This method may be of special interest in cases when vertical enrichment is hard to implement for logistic, spatial, or monetary reasons.

Declarations

Competing interests
The authors declare that they have no competing interest.

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