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Original Research Paper

The behavioral response of a captive female Bornean orangutan (*Pongo pygmaeus)* to mixed- species exhibition with two Asian small-clawed otters (*Aonyx cinereus*)

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Abstract

Recent years have seen a surge in the interest in improving the conditions of zoo-housed animals. Mixed-species enrichment interventions have the potential to improve animal welfare. This study examines the effects of two Asian small-clawed otters (*Aonyx cinereus*) on a captive female Bornean orangutan's (*Pongo pygmaeus*) behavior, as an intervention to enrich the environment with novel stimuli for improving the welfare of the orangutan. The orangutan's behaviors were recorded from 04:30 to 21:00 for 21 days. These days were split into a first period without otters and a second period with two otters in a shared enclosure. We found a significant increase in activity after the introduction of the otters. Given that lethargy is among the main indicators of distress in captive orangutans, our results suggest that this mixed species enrichment has the potential to improve the welfare of captive orangutans. However, more animals are needed in future studies.

Keywords: Primates; Zoo; Activity budget; Reaction norms; Enrichment; Surveillance; Environmental conditions; Translocation; Animal welfare.

Introduction

Bornean orangutans (*Pongo pygmaeus*) and other non-human primates face various welfare related problems in captivity (Perea-Garcia et al., 2020). Chronic stress responses are caused by the very different environment in captivity compared to their originating environment in the wild (Wright, 1996; Dalimun the et al., 2021). The native wild environment is complex and challenging, and these species' behavior and physiology have evolved to fit those conditions. This causes an incongruency between the species behavioral predisposition and the environment in captivity (Perea-Garcia et al., 2020). For instance, captive orangutans (*Pongo spp*.) tend to become inactive, predisposing them to obesity (Wright, 1996; Ting, 2011). Keeping orangutans in captivity results in changed behavior compared to those in the wild, caused by limited space, lack of interaction with other species, and abundance of food without the need to forage (Pearson et al., 2010; Abdullah et al., 2022). Wild orangutans spend approximately 44% of their time resting, 41% feeding, and 13% traveling (Knott, 1999). Another study found that captive and semi-captive orangutans spend 60% of their time resting, 13% feeding and 9% traveling (Kamaluddin et al., 2022). A study found that orangutans in the wild spend more time feeding than resting compared to their semi-wild counterparts who spend more time resting than feeding (Abdullah et al., 2022). To ensure the well-being of captive orangutans, enrichment in various forms such as toys and digital visual stimulations can contribute to the engagement of the orangutans' attention as well as cognitive skills. This can, in turn, result in fewer behaviors that indicate distress (Boere, 2001; Kim-McCormack et al., 2016; Perea-Garcia et al., 2020).

Multiple studies suggest that housing mixed-species in the same enclosure can lead to a more dynamic and wild-like captive environment for the inhabitants. This can have the potential to improve animal welfare by providing them with more stimulation and increasing activity. However, damaging, and even lethal consequences may occur between the species, therefore it is essential to consider the circumstances before introducing a new species (Shepherdson, 2003; Pearson et al., 2010; Buchanan- Smith, 2012; Daoudi et al., 2017). Buchanan-Smith (2012) suggested that positive interaction between species is not necessary to enhance

the environment, since the addition of a new species contributes to new smells, environmental manipulation or food dropping. This will enrich the environment with new stimulation, unpredictability, and opportunity for new activity. Species with this kind of indirect relationship might reap the benefits, while reducing the risk of fighting or similar problems (Buchanan-Smith, 2012). Multiple zoos in Europe report that orangutans and otters can co-exist in the same enclosure without complications and in some cases interact with each other (Abelló et al., 2018).

In this study, we investigated how the introduction of two Asian small-clawed otters (*Aonyx cinereus)* affected the behavior of a recently translocated orangutan female. It was hypothesized that the introduction of the otters would (1) increase the orangutan's time being active; (2) the predictability and stability of the orangutan's behavioral pattern will change; and (3) the orangutan's personality can be verified based on changes in activity budget and reaction norms.

Methods and materials

Animal and study design

This study examined a 9-year-old captive female Bornean orangutan. The participant was born in Sóstó Zoo in Hungary and transferred to Aalborg Zoo in Denmark on June 16th, 2022. The orangutan was observed for 21 days from 4:30 AM to 9:00 PM (16.5 hours a day and 346.5 hours in total). This period was divided into a baseline period (BL) which was before the introduction of the otters and a treatment period (TM) which was after the introduction of the otters. BL consisted of 10 selected days between June 20th and August 17th and TM consisted of 11 selected days between August 24th and October 17th. Two Asian small-clawed otters (*Aonyx cinereus)* were introduced to the orangutan's enclosure on August 24th and August 30th, respectively.

Housing and care

A male Bornean orangutan was later (June 23rd, 2022) introduced to Aalborg Zoo but was not included in this study. The two adjacent orangutan enclosures were separated with walls and metal wire allowing the two orangutans to see and interact with each other (Appendix A). Both orangutans were able to interact visually with zookeepers and visitors through the mesh wires as well as windows. The enclosures were divided into two indoor and one outdoor section. To clean and provide food, the zookeepers were able to close any part of the enclosure which resulted in limited space for the orangutan for a shorter period of time. Until July 8th the orangutan was only kept in the two indoor sections, D and E (Appendix A), but then the outdoor section became available. The otters had access to both outdoor sections through an artificial watercourse and a tube. Construction work was being done near the outdoor sections from September 5th to September 23rd, and during this period the female orangutan was transferred from the sections D, E, and F to A, B, and C (Appendix A). The observations from September 19th to October 23rd were made in the new enclosure. The zookeepers placed vegetables, fruits, hay, and branches with edible leaves in various spots in the indoor sections throughout the day, e.g. on the floor, hanging on the mesh wire doors, or in holes in the wall. The zookeepers also provided food on the roof of the outdoor enclosure which was outside the camera angle and was for this reason not registered as feeding, but rather as being out of view. Aalborg Zoo was not able to provide a time schedule for feeding and enrichment, as the relationship between the keepers and orangutans was not yet firmly established. The participant had access to plant material growing in the outdoor section. Water was accessible both in the indoor enclosure via water bowls and the outdoor enclosure via the watercourse. Objects for enrichment purposes were provided along with wood, wool, and blankets.

The indoor sections consisted of concrete floors and walls, ropes and tree trunks for climbing, and swings. The concrete floors and walls continued partially to the outdoor section (Appendix A). The rest of the outdoor section varied in type of ground surface: grass, rocks, and water. Trees, swings, and ropes were featured in this section.

Data collection

Prior to the observations an ethogram with selected behaviors was determined (Table 1).

Table 1 - Ethogram for division of animal behaviours. Modified from: Perea-Garcia et al. (2020) and yawning definition from: Massen & Gallup (2017).

Behaviour	Description
Locomotion	Walking, standing, crawling, or climbing
Inactive not covered	Sitting or lying down
Covered inactive	Sitting or lying down under a cover, e.g. blanket, hay, or plastic screens
Foraging/feeding	Searching for, manipulating or ingesting food or drinking
Positive social interaction	Interacting with the male orangutang or the zookeeper in a positive manner, e.g. looking, playing, or grooming.
Negative social interaction	Interacting with each other in a negative manner, e.g. fighting, or showing aggression
Self-directed behaviour	Cleaning or combing their hair or body parts with hands or mouth, scratching parts of their body using hands or feet, eating own feces, chewing on straws, licking on wall/door, or nesting
Interaction with enrichment	Using objects introduced to the environment for enrichment purposes, e.g activity toys, empty bottles, and bowls
Interaction with allospecific	Reacting to or interacting with the otters in the enclosure
Yawning	The action of opening the mouth widely and inhaling
Out of view	When it is not possible to see the individuals because of a lack of light or they are out of frame or when the camera night vision is activated
Other	Urinating, defecating, or vocalising

Seasonal changes in sunrise and sunset times caused inadequate quality of the surveillance, so not all hours of recordings were useful. Three cameras were provided; one in each of the three sections. Milesight AI 360° Panoramic Fisheye Network Cameras were used indoors and Milesight Mini PTZ dome 2.0 MP Starlight Camera was used outdoors. The cameras were installed before the arrival of the orangutan and hence did not disturb. The orangutan was unaffected by the presence of the surveillance system and was able to move freely outside of view of the camera. The observations of behaviors were registered as intervals with a start and end time point for each new behavior.

Data analysis

All data were tested for normal distribution with Shapiro-Wilk test (Zar, 2010). The data were non- normally distributed and therefore analyzed with non-parametric statistical methods. Data with <5 observations per day of a given behavior were not included in the statistical analysis. For both periods, BL and TM, respective activity budgets were modeled to display the percentage for each behavior. If a behavior made up less than 3% of the total amount of time, they were combined into a group called 'Other*'. Mann-Whitney U test was performed between the two periods for each behavior, testing for significance in time spent on each behavior. Furthermore, the same test was made within both periods to test for significance between time spent on the different behaviors respectively in BL and TM. Median, interquartile range (IQR), skewness, and kurtosis were calculated for each behavior for each day in the two periods and tested with Mann-Whitney U test (Zar, 2010). To visualize data tested with Mann-Whitney U test, the median was calculated for the medians, IQR, skewness, and kurtosis. Hereby only one value represents the median for medians in BL and one value for the median for medians in TM, etc. These data were plotted as a slope between BL and TM for each behavior

representing median, IQR, skewness, and kurtosis. Mann-Whitney U test was used to test for significant difference between the two periods for each behavior.

The total average sum of time spent on each behavior for both periods was calculated every 30 minutes and plotted as cumulative step graphs in the observed time interval (4:30-21:00) (Zar, 2010). Two step lines were plotted for each behavior representing each period, BL and TM, displaying the average sum per 30 minutes from 4:30 to 21:00.

Spearman Rank correlations (r_S) were made between the days in BL *versus* the days in TM to display the similarity between the two observed periods (Schober et al., 2018). Moreover, the same method was applied between groups of four days within each period, BL or TM, testing the correlation between the performed behaviors with sliding window technique (Datar et al., 2002; Schober et al., 2018). Four consecutive days for one behavior tested against four consecutive days for another behavior within the same period. The corresponding r_S-values between the same behaviors were tested with Mann-Whitney U test to determine significant differences between comparisons in BL and TM. All statistical analyses were made with RStudio version 2022.07.2 and Past4 version 4.11.

Results

Activity budget

The time spent on each behavior in BL and TM, is shown in Figure 1. 'Out of view' made up 22.7% in BL and 50.8% in TM of total time. In BL, most time was spent on 'Inactive covered' ($p < 0.01$). In TM, 'Locomotion' was significantly higher than the behaviors 'Inactive not covered' ($p < 0.01$) and 'Self-directed behavior' ($p < 0.01$) and significantly lower than 'Out of view' ($p < 0.001$). 'Inactive covered' was significantly higher than the behaviors 'Inactive not covered' ($p < 0.001$), 'Foraging/feeding' ($p < 0.05$), and 'Self-directed behavior' ($p < 0.01$). For the behavior 'Foraging/feeding' there was significantly higher than 'Inactive not covered' ($p < 0.01$) and 'Self- directed behavior' ($p < 0.05$) and significantly lower than 'Inactive covered' ($p < 0.05$) and 'Out of view' ($p < 0.001$). The behavior 'Inactive not covered' was significantly lower than all the behaviors ($p < 0.05$). Lastly, the behavior 'Self-directed behavior' was significantly higher than all behaviors ($p < 0.05$), except 'Inactive not covered' ($p < 0.05$). Furthermore, Mann-Whitney U tested between BL and TM for the same behaviors. 'Locomotion' ($p < 0.01$) and 'Out of view' ($p < 0.05$) were significantly lower in BL than TM. 'Inactive covered' ($p < 0.01$) was significantly higher in BL than in TM.

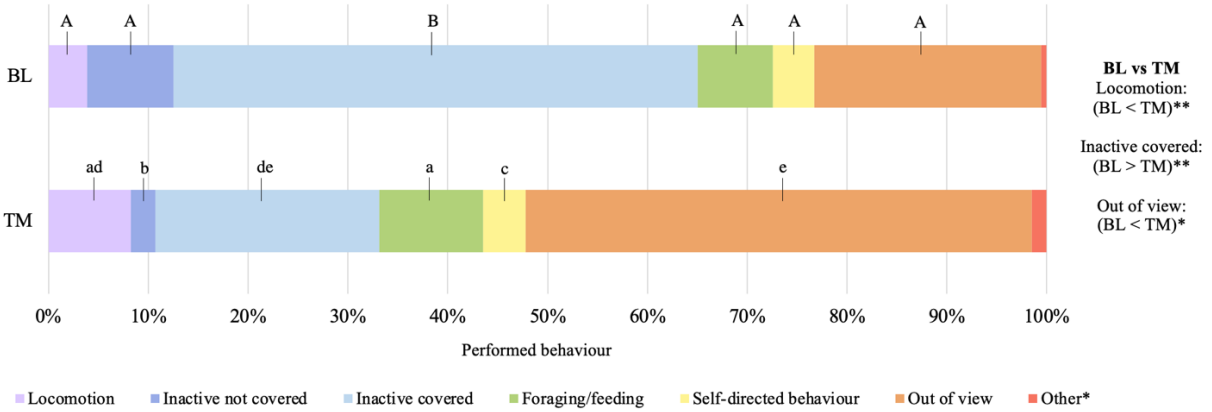
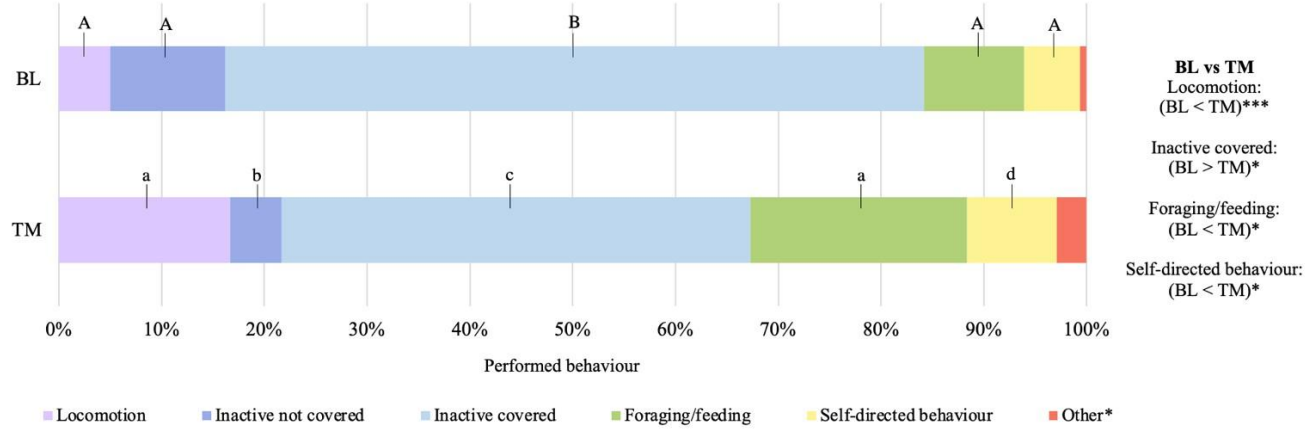


Figure 1 *- The two activity budgets with the percentage share of each behaviour in respectively baseline (BL) and treatment (TM). The behaviours are colour-coded. "Other*" is comprised of all behaviours that each had an accumulated time of <3%. Mann-Whitney U test of percentage share per day across behaviours of the activity budget for the specific treatment type is indicated by the letters above. Non-significance between behaviours shares letters. Significant results from Mann-Whitney U test for the same behaviour between BL and TM are indicated with asterisk, "*" when p < 0.05, "**" when p < 0.01 and "***" when p < 0.001.*

Data were subsequently analyzed after excluding 'Out of view' (Figure 2). In both periods, the longest time was spent on 'Inactive covered'. In BL, 'Inactive covered' was significantly higher than every other behavior ($p < 0.01$). In TM, 'Locomotion' was significantly higher than 'Inactive not covered' ($p < 0.001$) and 'Self-directed

behavior' ($p < 0.01$) and significantly lower than 'Inactive covered' ($p < 0.05$). 'Inactive not covered' was significantly lower than all other behaviors ($p < 0.05$). 'Inactive covered' was significantly higher than all other behaviors ($p < 0.05$) in TM. The behavior 'Foraging/feeding' there was significantly higher than 'Inactive not covered' ($p < 0.001$) and 'Self- directed behavior' ($p < 0.01$) and significantly lower than 'Inactive covered' ($p < 0.01$). Mann- Whitney U test between BL and TM for same behaviors. 'Locomotion' ($p < 0.001$), 'Foraging/feeding' ($p < 0.05$), and 'Self-directed behavior' ($p < 0.05$) were significantly lower in BL than in TM. 'Inactive covered' ($p < 0.05$) was significantly higher in BL than in TM.

Figure 2 *- The two activity budgets with the percentage share of each behaviour in respectively*



baseline (BL) and treatment (TM). The behaviours are colour-coded. "Other" is comprised of all behaviours that each had an accumulated time of <3%. Mann-Whitney U test of percentage share per day across behaviours of the activity budget for the specific treatment type is indicated by the letters above. Non-significance between behaviours shares letters. Significant results from Mann-Whitney U test for the same behaviour between BL and TM are indicated with asterisk, "*" when p < 0.05, "**" when p < 0.01 and "***" when p < 0.001.*

Reaction norms between periods

The slopes between medians from BL to TM for each behavior are shown in Figure 3. The largest difference between the two periods was seen for 'Inactive covered' which has a slope of -187.50 ($p< 0.05$).

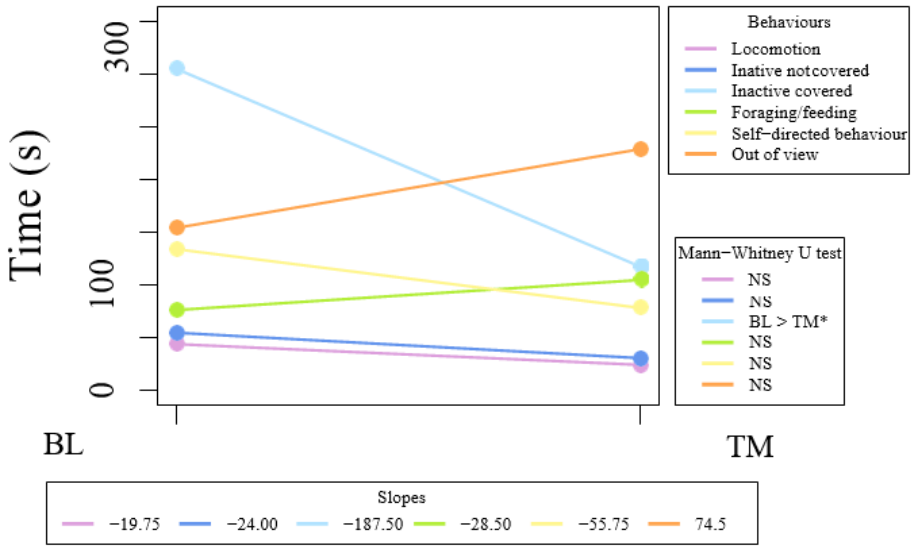


Figure 3 *- Comparison of median of medians between baseline (BL) and treatment (TM) for each behaviour. The different colours indicate different behaviours. Mann-Whitney U test results are listed for each behaviour. Significant test results are indicated with asterisk, "*" when p < 0.05, "**" when p < 0.01 and "***" when p < 0.001. Not significant results are indicated with "NS". Values of the slopes for each behaviour are presented.*

The difference in slopes between median IQR in BL and TM, respectively, for each behavior is shown in Figure 4. While 'Inactive covered' appears to have the largest slope of -540.75, no significant differences were found between the two periods.

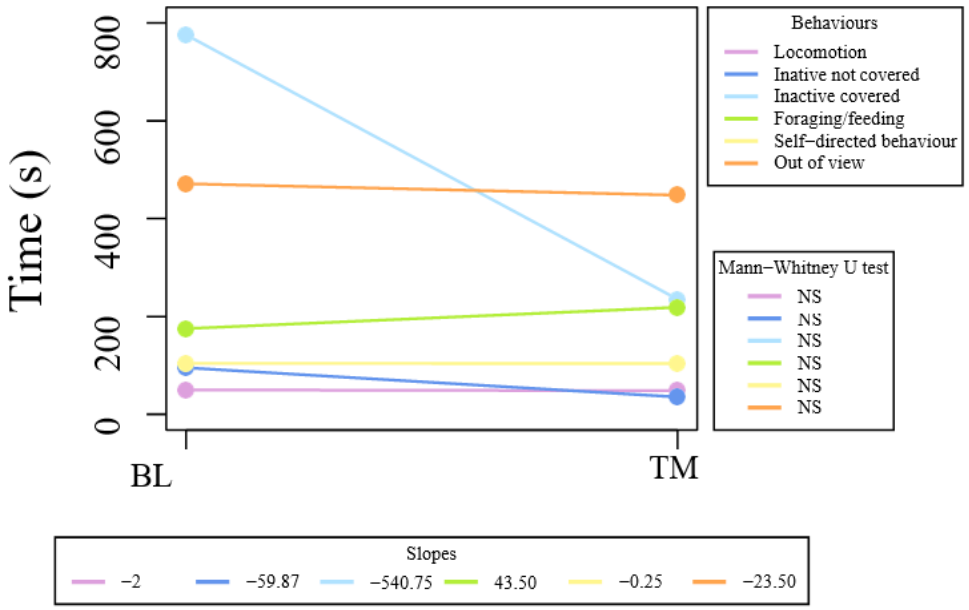


Figure 4 - *Comparison of median of IQR between baseline (BL) and treatment (TM) for each behaviour. The different colours indicate different behaviours. Mann-Whitney U test results are listed for each behaviour. Significant test results are indicated with asterisk, "*" when p < 0.05, "**" when p < 0.01 and "***" when p < 0.001. Not significant results are indicated with "NS". Values of the slopes for each behaviour are presented.*

The slopes for median skewness between the BL and TM periods are shown in Figure 5. Time spent 'Out of view' has the steepest slope of 2.54 and results from Mann-Whitney U test show a significantly higher median skewness in TM than in BL for this behavior ($p < 0.01$). Median skewness value for 'Out of view' in both periods shows a highly positive skewed distribution for the behavior. The same tendency can be seen for the rest of the behaviors since all median skewness values are >1.

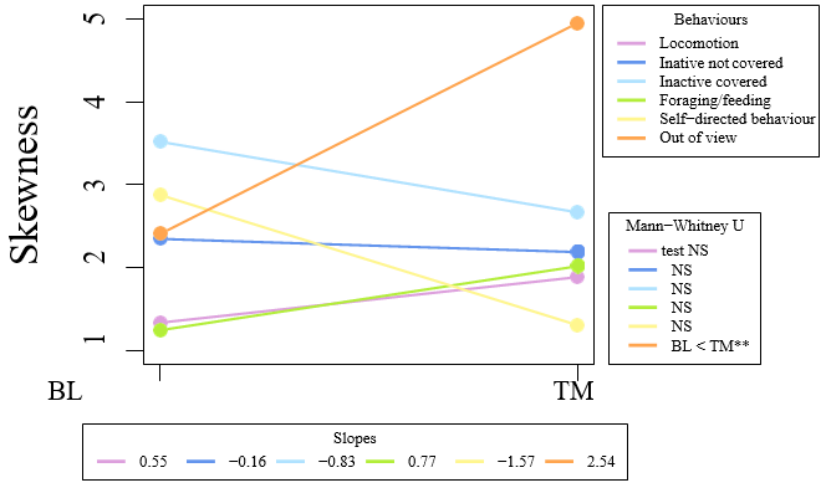


Figure 5 - Comparison of median of skewness between baseline (BL) and treatment (TM) for each behaviour. The different colours indicate different behaviours. Mann-Whitney U test results are listed for each behaviour. Significant test results are indicated with asterisk, "" when p < 0.05, "**" when p < 0.01 and "***" when p < 0.001. Not significant results are indicated with "NS". Values of the slopes for each behaviour are presented.*

The difference in slopes between median kurtosis in BL and TM, respectively, for each behavior is shown in Figure 6. Mann-Whitney U test showed significant difference between the periods for 'Out of view' ($p < 0.01$) and for the behavior 'Self-directed behavior' ($p < 0.05$).

Median kurtosis values for 'Inactive not covered', 'Inactive covered', 'Self-directed behavior', and 'Out of view' shows a leptokurtic distribution for the BL period. 'Locomotion' and 'Foraging/feeding' show a platykurtic distribution in BL. In TM, median kurtosis for all behaviors except 'Self-directed behavior' shows a leptokurtic distribution. Median kurtosis for 'Self-directed behavior' in TM shows a platykurtic distribution.

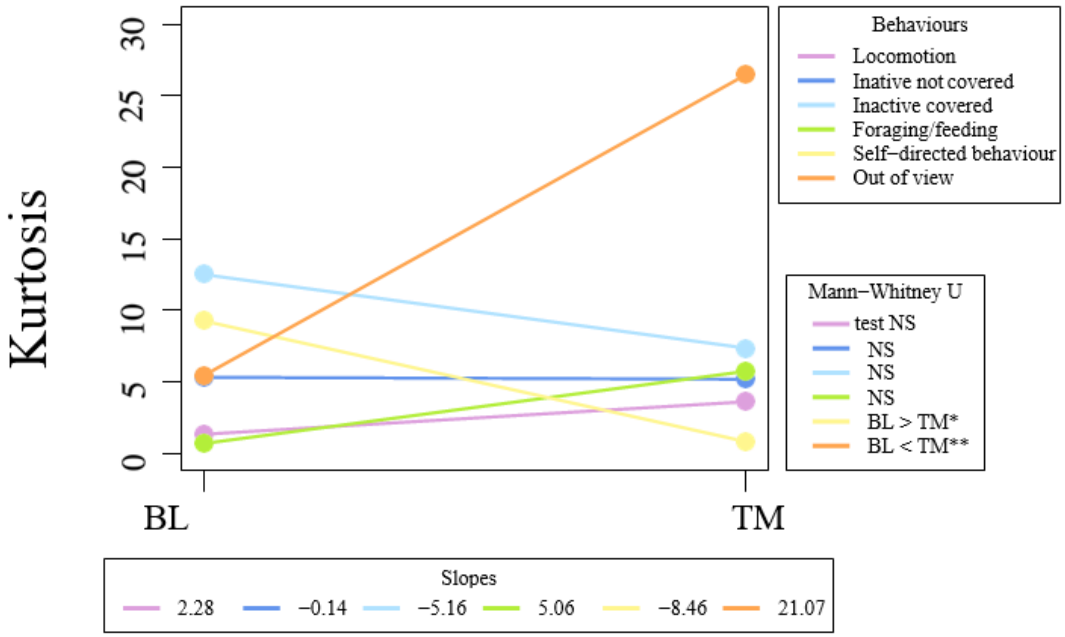


Figure 6 *- Comparison of median of kurtosis between baseline (BL) and treatment (TM) for each behaviour. The different colours indicate different behaviours. Mann-Whitney U test results are listed for each behaviour. Significant test results are indicated with asterisk, "*" when p < 0.05, "**" when p < 0.01 and "***" when p < 0.001. Not significant results are indicated with "NS". Values of the slopes for each behaviour are presented.*

Comparison of the temporal distribution of behavior in the two periods

The average cumulative sum of the behaviors 'Locomotion', 'Inactive not covered', 'Inactive covered', 'Foraging/feeding", "Positive social interaction", 'Self-directed behavior', 'Interaction with enrichment', and 'Out of view' throughout the day for both BL and TM is shown in Figure 7. In the second period, the participant starts and stops earlier on the day with the behavior 'Locomotion' than in BL. Overall, the participant spent more time on this behavior during the second period (Figure 7a). The participant evidently spent more time on the behavior 'Inactive not covered' during BL compared to TM throughout the whole day as displayed in Figure 7b. Furthermore, the orangutan has more varying average time spent on this behavior throughout the day in BL. During BL, the orangutan appears to spend more time on 'Inactive covered' throughout the entire day compared to TM, which can be seen in Figure 7c. From 4:30 to 8:30, the orangutan spent an equal amount of time on the behavior 'Foraging/feeding' during both periods after which TM gathered a higher rate of the behavior, as seen in Figure 7d. Overall, BL and TM appear to follow the same tendency for the behavior 'Foraging/feeding'. For 'Positive social interaction' as seen in Figure 7e, BL and TM appear to have a similar tendency, although there was a higher total sum of positive interactions during TM. The graphs for both periods follow a similar tendency for the behavior 'Self-directed behavior' as shown in Figure 7f, but the participant spent more time on this behavior during TM. Generally, more time was spent on the behavior 'Interaction with enrichment' during TM, which can be seen in Figure 7g. The majority of time spent on this behavior in BL occurred after 18:30. During both periods the orangutan appears to be out of view at a consistent average sum per 30

minutes, which can be seen in Figure 7h. However, in BL this tendency stops and the average sum at 17:00 appears much higher. Overall, the participant spent more time on this behavior in TM.

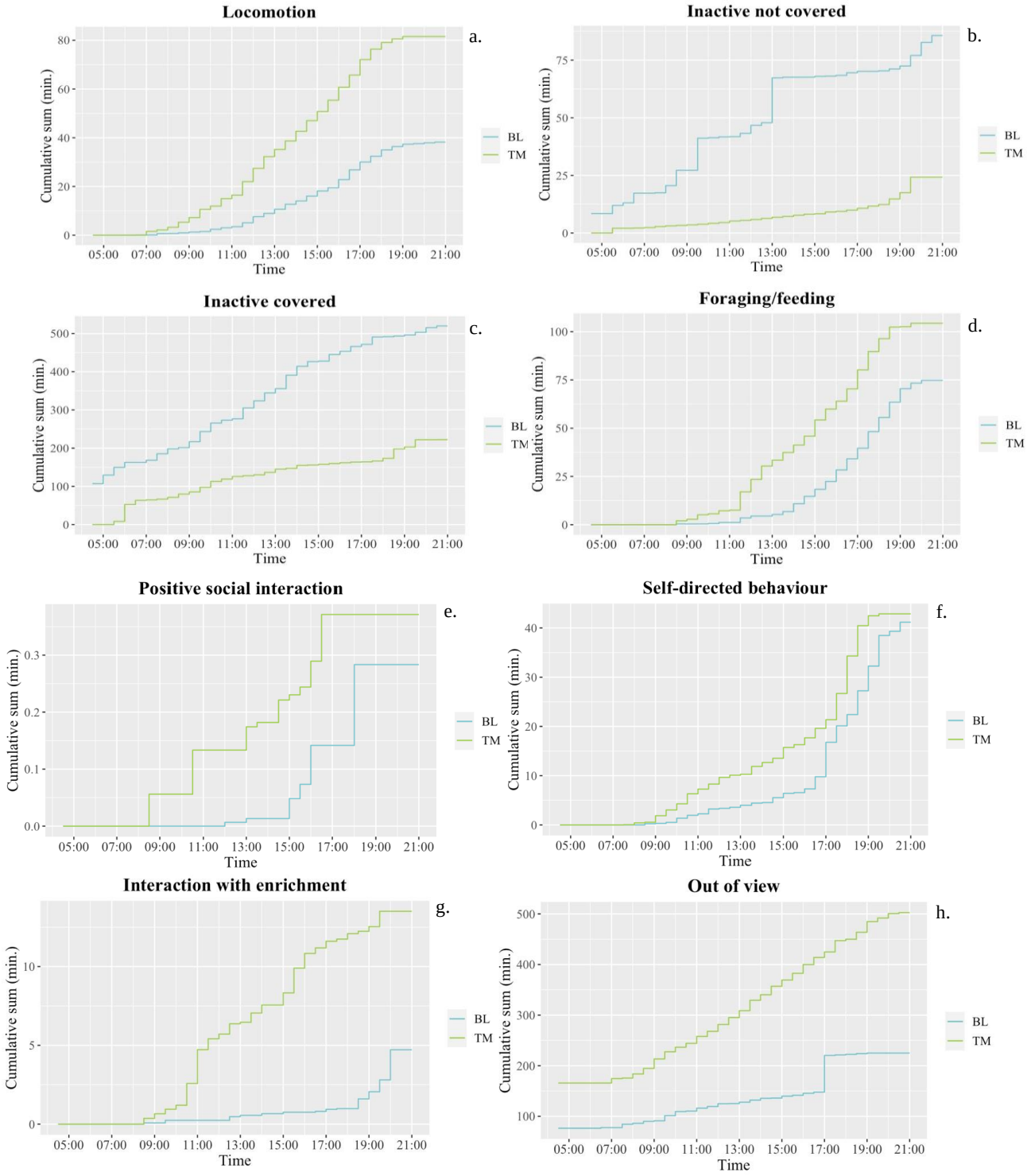


Figure 7 - Step lines of the average cumulative sum per every half hour from 4:30-21:00 measured in minutes for the behaviour *(a) 'Locomotion', (b) 'Inactive not covered, (c) 'Inactive covered, (d) 'Foraging/feeding', (e) 'Positive social interaction', (f) 'Self-directed behaviour', (g) 'Interaction with enrichment', and (h) 'Out of view' measured in minutes. The blue line represents the baseline period (BL), and the green line represents the treatment period (TM).*

Correlation between observed days for each behavior

Seven correlation matrixes are shown in one matrix for each behavior with Spearman Correlation applied

between each day of the two periods. This is used to compare behavioral patterns between BL and TM. A positive correlation between the two periods indicates that when time spent on a given behavior in one of the periods increases, time spent on the same behavior likewise increases in the other period. A negative correlation between the two periods indicates that when time spent on a given behavior in one of the periods increases, time spent on the same behavior decreases in the other period. This will allow us to determine whether a behavior follows the same tendency in the two periods.

For the behavior 'Locomotion' the *r*s-values were between -0.11 and 0.87. Two correlations were negative and the rest were positive. For 'Inactive not covered' the *r*s -values range between -0.36 and 0.62. The *r*s-values for the behavior 'Inactive covered' vary from -0.29 to 0.45. Correlation results for 'Foraging/feeding' show *r*s-values between -0.08 to 0.68. The behavior 'Self-directed behavior' has *r*s-values ranging between -0.26 to 0.74. For 'Interaction with enrichment' the results show *r*s- values between -0.20 to 0.60. The last tested behavior, 'Out of view' has *r*s -values from -0.20 to 0.70.

Sliding window correlations between behaviors in groups of four days

Correlations between behaviors calculated with sliding window technique are shown in Figure 9 and Figure 10. This is used to compare the correlation between two behaviors within the same period. A positive correlation between the two behaviors indicates that when time spent on a given behavior increases, time spent on the other behavior likewise increases. A negative correlation between the two behaviors indicates that when time spent on a given behavior increases, time spent on the other behavior decreases. This will allow us to determine whether two behaviors influence each other through the observation periods, BL and TM. The first plots, Figure 9a and Figure 10a show the correlation between 'Locomotion' and all the other behaviors. Correlation between the behavior 'Inactive not covered' and the rest of the behaviors can be seen in Figure 9b and Figure 10b. The correlation between 'Inactive covered' and the rest of the behaviors can be seen in Figure 9c and Figure 10c. The correlation between 'Foraging/feeding' and the rest of the behaviors is presented in Figure 9d and Figure 10d. Correlations between the behavior 'Self-directed behavior' and the rest of the behaviors are shown in Figure 9e and Figure 10e. The last plots, Figure 9f and Figure 10f show a correlation between 'Interaction with enrichment' and the only behavior left, 'Out of view'. Mann-Whitney U test was performed between the two periods, e.g. correlation between 'Locomotion' and 'Inactive not covered' in BL *versus* TM. No significant results from the tests between the two periods were found. Testing the sliding window correlations with Mann-Whitney U test showed a significant difference between BL and TM for the correlations of the behaviors 'Locomotion' and 'Inactive covered' ($p < 0.05$). A majority of negative correlations were seen in BL whereas in TM the correlations were moderately positive to not correlated

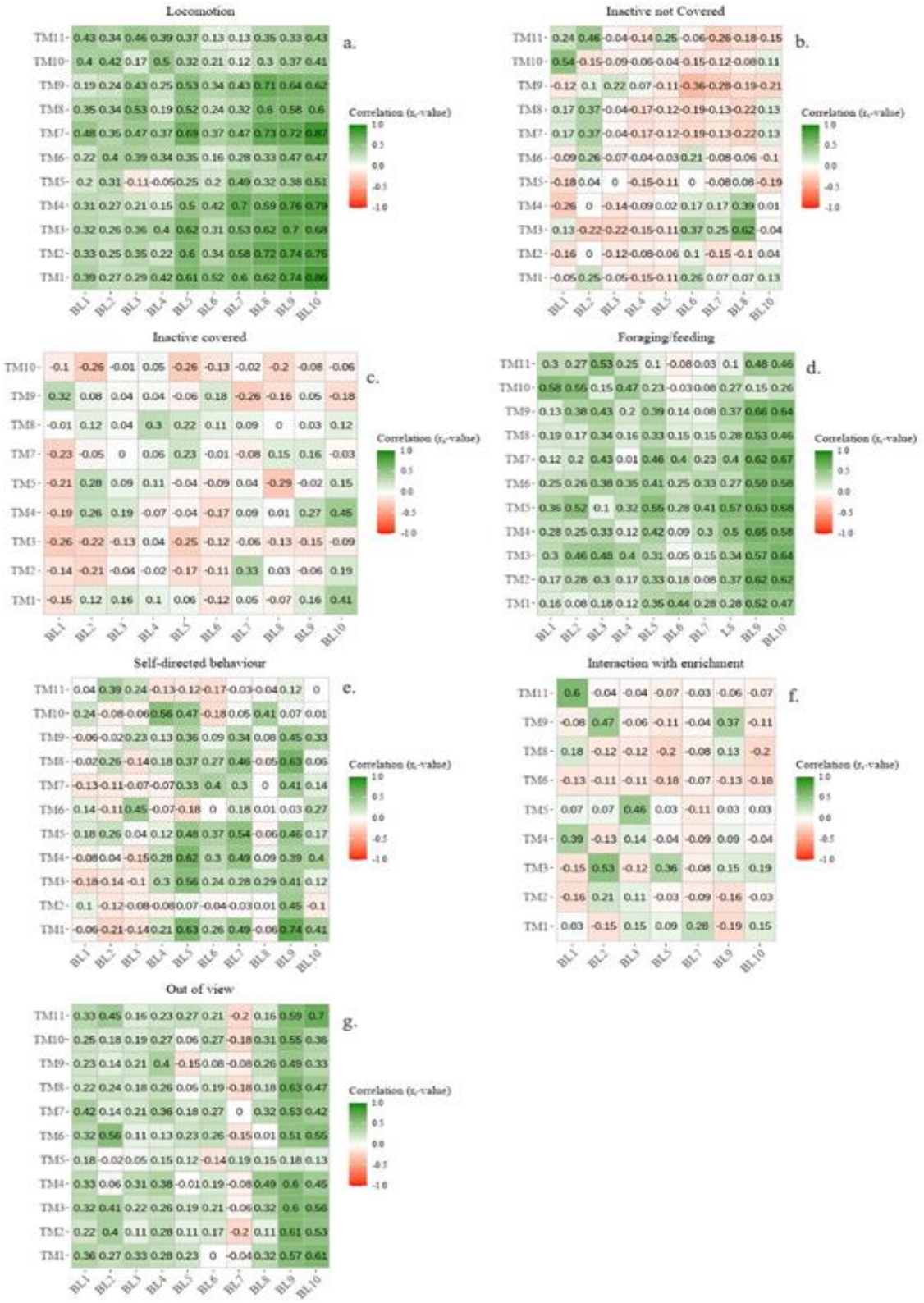


Figure 8 *- Spearman Correlation matrix for (a) Locomotion, (b) Inactive not covered, (c) Inactive covered, (d) Foraging/feeding, (e) Self-directed behaviour, (f) Interaction with enrichment, and (g) Out of view for the days of the two periods baseline (BL) on the x-axis and treatment (TM) on the y-axis. This is displayed by the axis point followed by the consecutive observation day number of each period. Spearman correlation coefficient (rs) across the days is shown in each box as a matrix. The colour gradient also indicates the correlation, as' shown on the legend to the righ*

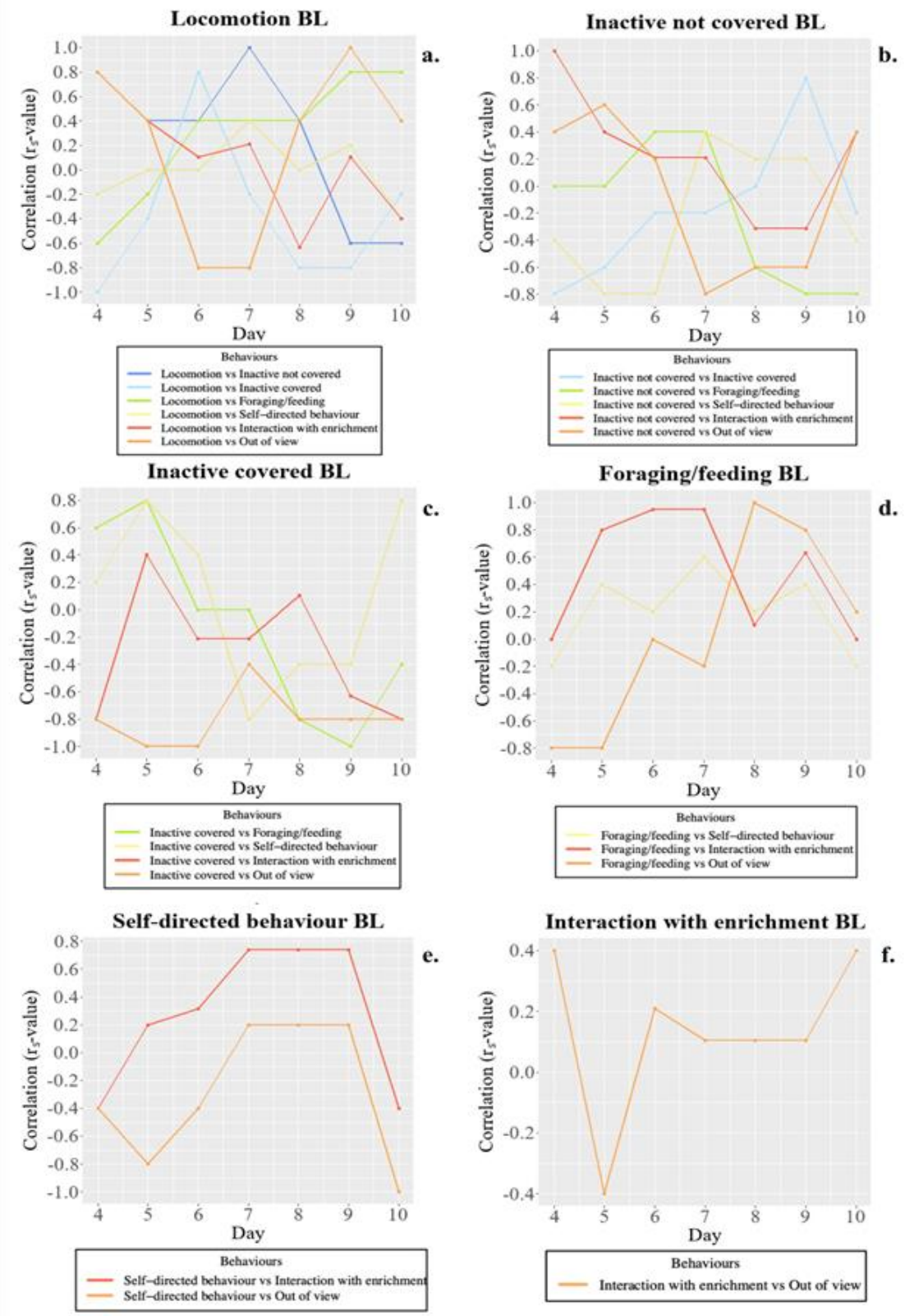


Figure 9 *- Spearman correlation test with sliding window technique (four days) between the behaviours in the baseline period (BL). All comparisons are indicated with different colours. In plot a) 'Locomotion' was tested against all other behaviours, b) 'Inactive not covered' was tested against all the remaining behaviours, c) 'Inactive covered' was tested against all the remaining behaviours, d) 'Foraging/feeding' was tested against all the remaining behaviours, e) 'Self-directed behaviour' was tested against all the remaining behaviours, and f) 'Interaction with enrichment' was tasted against all the remaining behaviours*

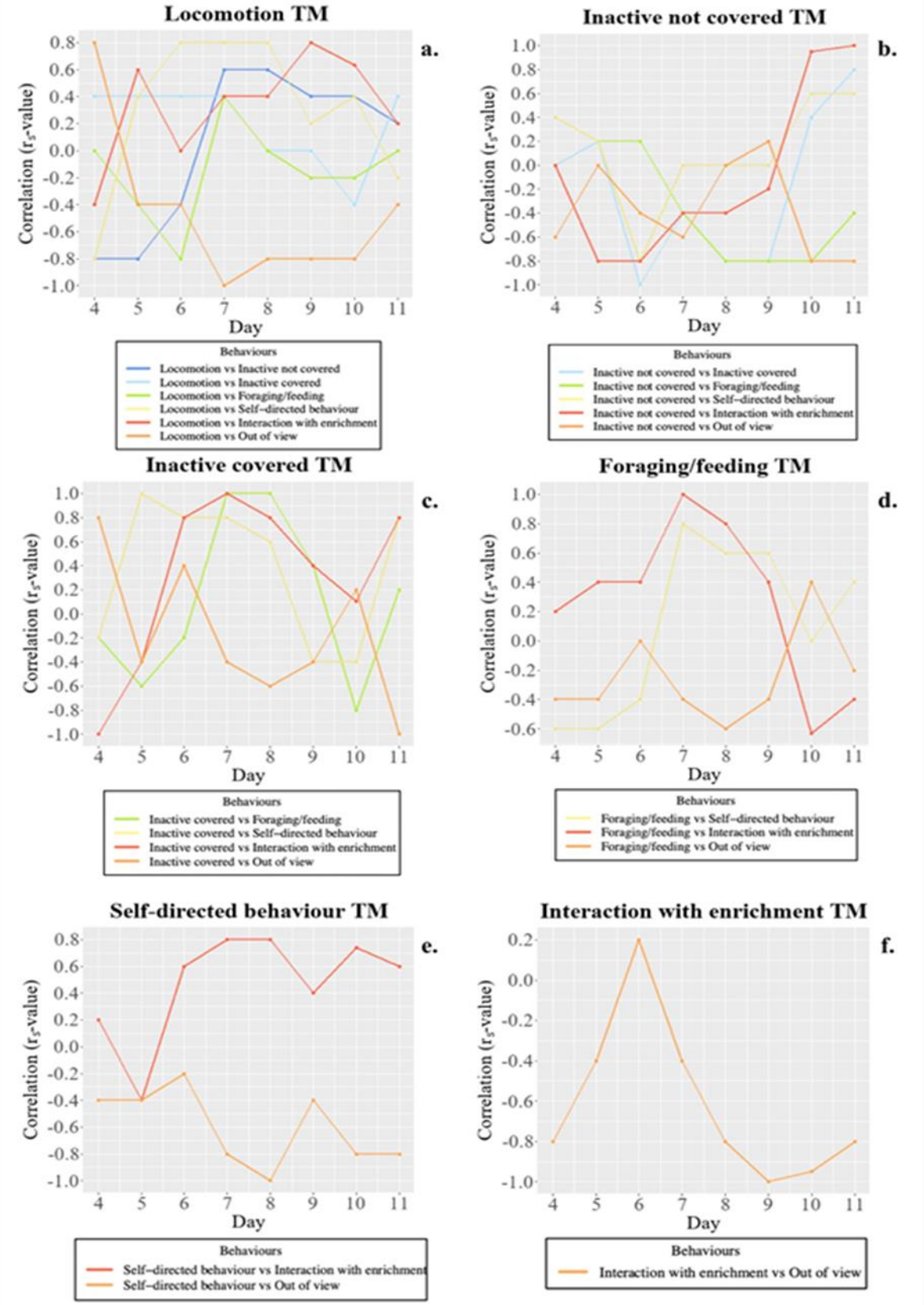


Figure 10 *- Spearman correlation test with sliding window technique (four days) between the behaviours in the treatment period (TM). All comparisons are indicated with different colours. In plot a) 'Locomotion' was tested against all other behaviours, b) 'Inactive not covered' was tested against all the remaining behaviours, c) 'Inactive covered' was tested against all the remaining behaviours, d) 'Foraging/feeding' was tested against all the remaining behaviours, e) 'Self- directed behaviour' was tested against all the remaining behaviours, and f) 'Interaction with enrichment' was tested*

against all the remaining behaviours

Discussion

In this study we assessed the impact that the introduction of two otters (*Aonyx cinereus*) had on the behavior of a captive female orangutan. By comparing time spent on specific behaviors, we found an increase in activity after the introduction of the otters, which suggests that this mixed species enrichment has the potential to improve the animal welfare of captive orangutans. The results from this study strengthen the findings from previous studies by Abelló et al., 2018 and Pearson et al., 2010.

Activity budget

The behavior of the orangutan was changed after the introduction of the otters. This is in agreement with Daoudi et al. (2017), who found improved animal welfare by mixed-species enrichment with two captive groups of tufted capuchins (*Sapajus apella*) and squirrel monkeys (*Saimiri sciureus*). They concluded that the mixed-species were cognitively challenging and therefore had improved welfare for both species (Daoudi et al., 2017).

We only focused on one species, and we found a significant increase in orangutan activity after introduction of the otters which suggests that this mixed species enrichment has the potential to improve the animal welfare of captive orangutans. This is in accordance with another study conducted by Finch et al. (2022) in which four species, including a Sumatran orangutan were observed pre- and post-translocation: Their orangutan spent 6.8% of the time being inactive pre-translocation which increased to 19.6% post-translocation. The orangutan in our study spent 79.2% being inactive in BL which could be caused by the post-translocation from Sóstó Zoo to Aalborg Zoo (no data exist for the pre-translocation). Hence, it is assumed that the orangutan was more accustomed in the second period (TM). Here, the orangutan spent 50.6% being inactive which was significantly lower than in BL. Finch et al. (2022) found a decrease in locomotion from 12.5% pre-translocation to 0.1% post- translocation. In our study, the orangutan had a significantly lower time spent on 'Locomotion' in BL, post-translocation, than in TM, pre-translocation; a decrease from 16.7% pre-translocation to 5.0% post-translocation which also is in accordance with Finch et al. (2022). A study by Knott (1999) on wild orangutans found that they spent 13% on 'Locomotion' and a study from Basalamah (2018) investigated captive-bred orangutans in the wild which resulted in 14.4% spent on this behavior. This indicates a higher similarity between TM and the wild compared to BL for the behavior 'Locomotion'. The activity budget which includes 'Out of view' shows a similar tendency between the periods.

The first hypothesis stated that time spent on being active will increase from BL to TM, which is supported by the significant increase in 'Locomotion' and decrease in 'Inactive covered' from BL to TM.

Reaction norms between periods

Only few significant results were found for median IQR and median, displaying a high predictability for all behaviors when comparing the two periods. However, the result showed a significant decrease in the median of the time spent on the behavior 'Inactive covered' from BL to TM. This result supports hypothesis (3) that the orangutan's personality can be verified by the significant change in activity budget and reaction norms. Thus, indicating less time spent on resting behaviors, which may be a result of more access to the outdoor section of the enclosure and enrichment from the introduction of the two otters (Hebert & Bard, 2000; Pearson et al., 2010). Reaction norms are used to keep the determination of personality quantitative rather than qualitative. However, it is a simplified method, and a complete description of the individual personality should include the entire behavioral repertoire across all the possible environments in which the individual is experiencing. Furthermore, a significant alteration in the pattern of 'Out of view' was seen from BL to TM. The results display shorter and more fluctuating intervals during TM compared to BL. The alteration could be a response to the different environmental conditions between the two periods (Dingemanse et al., 2010). A possible explanation is the limited access to the outdoor section in parts of the BL period, meaning less time 'Out of view' when more time was spent in the indoor section where there was full camera coverage. This is opposite to TM, where free access to the outdoor section is granted anytime of the day through the entire period where camera coverage was limited. The camera coverage was further decreased when the orangutan swapped enclosures. Furthermore, the alteration in 'Out of view' can possibly be a result of the presence of the otters, who are located out of view. Their presence may contribute to the enrichment of the environment and encourage the orangutan to explore the enclosure out of the camera angles (Buchanan-Smith, 2012)

Additionally, most climbing facilities were located out of view in the outdoor section and since orangutans are largely arboreal primates it can be assumed that the orangutan would spend time climbing out of view (Ashbury et al., 2015).

Lastly, significant differences in median kurtosis were found between BL and TM, when comparing 'Self-directed behavior', indicating a shift in behavioral pattern. 'Self-directed behavior' went from a fluctuating to a homogenous behavioral pattern, which may be a result of the different environmental conditions, e.g. access to the outdoor section (Hebert & Bard, 2000). These results are in accordance with hypothesis (2) and (3). Adequate space may improve the orangutan's welfare since a more homogenous behavioral pattern was observed.

Generally, most behaviors were found to be non-significant for behavioral reaction norms between BL and TM implying predictability and stability for most behaviors.

Comparison of the temporal distribution of behavior in the two periods

On average, the orangutan starts performing 'Locomotion' at an earlier time in TM compared to BL, and it spends more time on this behavior in TM. However, the behavior also stops later throughout the day during BL. The increased time spent on locomotion in TM might be caused by the different circumstances in BL, as there were no otters present, the orangutan had just been translocated and was limited to the indoor section for the first couple of days. It is assumed that the lack of enrichment caused by the otters and smaller space limits the movement, need to forage, and the ability to play with the environment. It was also observed that more time was spent on 'Inactive covered' during BL which may be due to longer daytimes in this observation period. This may have led the orangutan to perform this behavior or being able to be observed at later times because of sleeping schedule, camera view, etc. However, the absence of otters may also have contributed to this inactive behavior. 'Foraging/feeding' looks most consistent out of all behaviors on average, which indicates that time spent on feeding and the time of the day is similar throughout the entire observation period. The different start and end times could be explained by daytime length as discussed above.

The pattern for 'Positive social interaction' seems to be unreliable which may be explained by some of the same reasons as above, while the inconsistency is assumed to be a consequence of few observations of this behavior.

In TM, the orangutan spent more time performing 'Interaction with enrichment' and 'Out of view' than in BL. The reason for the difference in 'Interaction with enrichment' between BL and TM can potentially be explained by the lack of habituation of the orangutan due to the translocation, where there was more inactivity observed in BL.

Correlations between observed days for each behavior

Positive correlations between the two periods were mostly observed in the behaviors 'Locomotion', 'Foraging/feeding', 'Self-directed behavior' and 'Out of view'. Therefore, the interpretation of these correlations is a tendency for longer intervals later in the day for both tested days. The reason for this change throughout the day may be due to an increase in general activity, caused by visitors, daylight, and sleeping schedule. The strongest correlations were observed between BL and TM for 'Locomotion' and 'Foraging/feeding', respectively. This is sensible considering the orangutan must eat every day and hereby travel to obtain food. Therefore, these behaviors were expected to not vary a lot between the periods. Moreover, a general increase in activity may lead to greater metabolic costs which can result in an increased need for 'Foraging/feeding'. Furthermore, the strongest correlations are mainly between the last observed days in BL and the earliest observed days in TM for a given behavior. Perhaps this can be explained by a behavioral pattern, when the orangutan does a behavior in a given amount of time, she tends to follow the same patterns the following days. This may be explained by similar conditions and possibilities in the last observed days in BL and the first observed days in TM since these days were followed by each other. These conditions include access to the same sections, approximately the same day length and before swapping enclosures with the male orangutang. Therefore, the increase in 'Locomotion' in TM may be caused by a behavioral pattern rather than the introduction of the otters. Many of the tested days showed a weak or no correlation and therefore a possible predicted pattern would be unreliable.

Sliding window correlations between behaviors in groups of four days

No strong correlations were found between any two behaviors through both periods, meaning that it is not possible to assume causation or strong correlation between any behaviors. With this in mind, there might be more consistency in some cases, e.g. strong positive correlation between the behaviors 'Foraging/feeding' and 'Interaction with enrichment' in some of the observed days in BL. This indicates that the orangutan is more likely to interact with enrichment, when more food is consumed or *vice versa*. Interaction with enrichment requires energy which leads to a higher need for food. On the contrary, when more food is consumed, the orangutan may have more energy to interact with enrichment. Moreover, moderate to strong positive correlations in several observed days in TM between the behaviors 'Self-directed behavior' and 'Interaction with enrichment' were found. This indicates that the orangutan is more likely to perform 'Self-directed behavior', when more time is spent interacting with enrichment or *vice versa*. This correlation suggests that an excessive interaction with enrichment could be detrimental since 'Self-directed behavior', which includes stereotypes, could be a sign of stress. However, in this study 'Self-directed behavior' is not solely negative and for this reason it is not an adequate indicator of stress. Additionally, the time spent on 'Interaction with enrichment' made up < 3% of the total time which means that the behavior was not performed excessively and was likely not enough to cause a detrimental effect in the form of 'Self-directed behavior'.

Lastly, the Mann-Whitney U test showed a significant difference in the correlations of 'Locomotion' *versus* 'Inactive covered' between BL and TM. The correlation between the two behaviors in BL indicates that when 'Locomotion' increases then 'Inactive covered' decreases and *vice versa*. The correlation between the two behaviors in TM had no clear pattern. This is in accordance with the activity budgets where the orangutan spent significantly more time on 'Inactive covered' than 'Locomotion' in BL and no significant difference between these behaviors in TM.

Limitations

The study has several major limitations. Only one female orangutan was observed for a limited amount of time, which limits the reliability of the data. This increases the risk of type I and II errors where a true hypothesis will be rejected, or a false hypothesis will be accepted. Furthermore, some behavior definitions in the ethogram could have been more specific, as 'Self-directed behavior' includes both the negative stereotypes and the positive nesting behavior. Moreover, several other factors than just mixed-species enrichment could influence the results. Since the observations were made shortly after the translocation from another zoo, the results could have been influenced by a habituation period, as well as the introduction of a male orangutan in the adjoining enclosure. In addition, unfortunately, construction work was place in the zoo. Also, the blind angles on the camera limited the observations of the behaviors.

Conclusion

This study found significant differences in some of the behaviors exhibited by the female captive orangutan between the two periods. Results suggest that otters as enrichment may increase the captive orangutan's activity and hereby improve the welfare. Mixed species should not replace the use of other types of enrichment but can be used as an addition. Other factors that our study could not account for, such as a habituation period after being translocated from another zoo, may have also contributed to our results.

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Conflict of interest

The authors declare no conflicts of interest.

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Appendix A

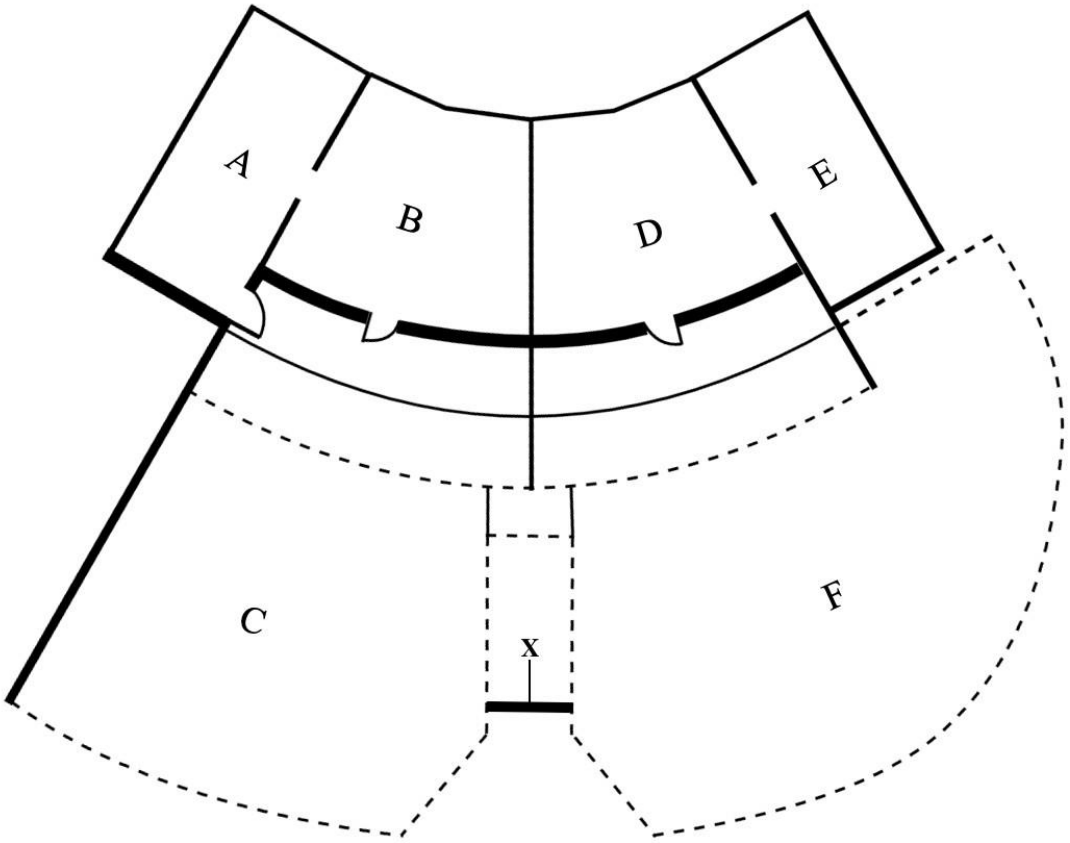


Figure 11 *- Outline of the enclosures. A, B and C were three enclosures for one orangutang. D, E and F were three enclosures for another orangutang. X indicates the passage for the otters between the two outdoor enclosures.*

Appendix B

Cumulative graphs for all 21 observed days

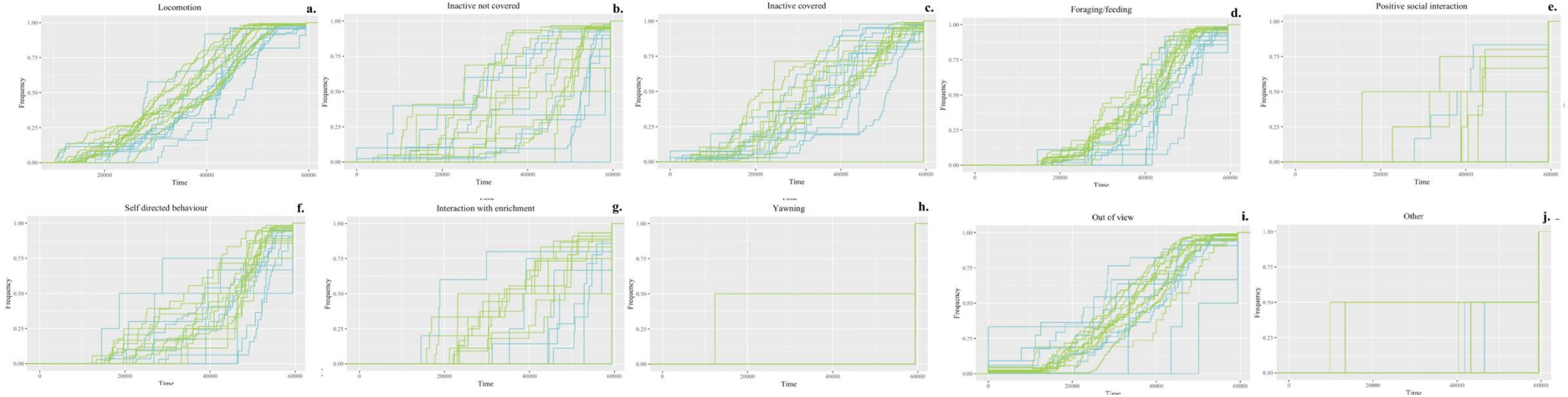


Figure 12 *- The cumulative frequency measured from 4:30-21:00 for the behaviour (a) 'Locomotion', (b) 'Inactive not covered, (c) 'Inactive covered, (d) 'Foraging/feeding', (e) 'Positive social interaction', (f) 'Self-directed behaviour', (g) 'Interaction with enrichment', (h) 'Yawning', (i) 'Out of view', and (j) 'Other' measured in minutes. Every blue line represents a day in the baseline period (BL) and every green line represents a day in the treatment period (TM).*

Appendix C

Cumulative graphs (average relative frequency per 30 minutes)

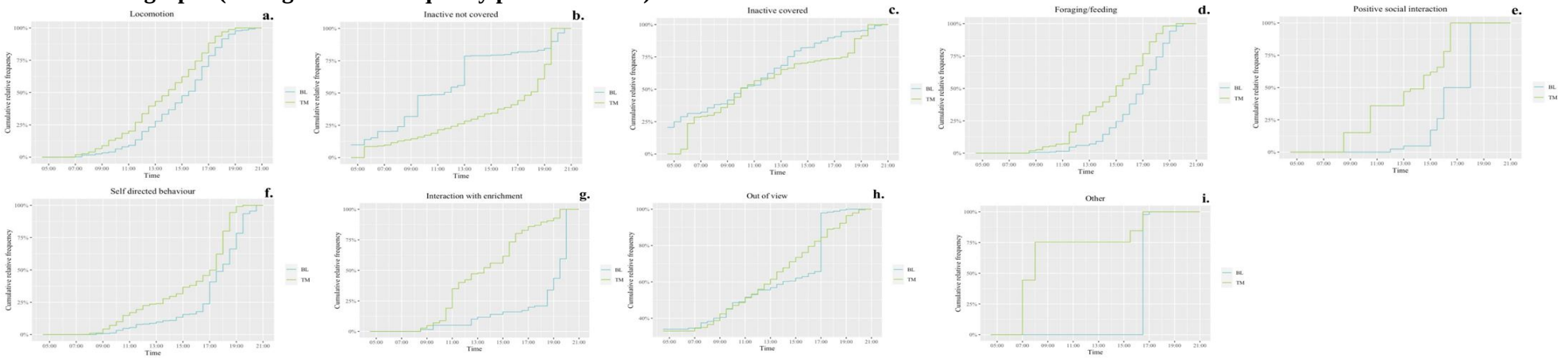
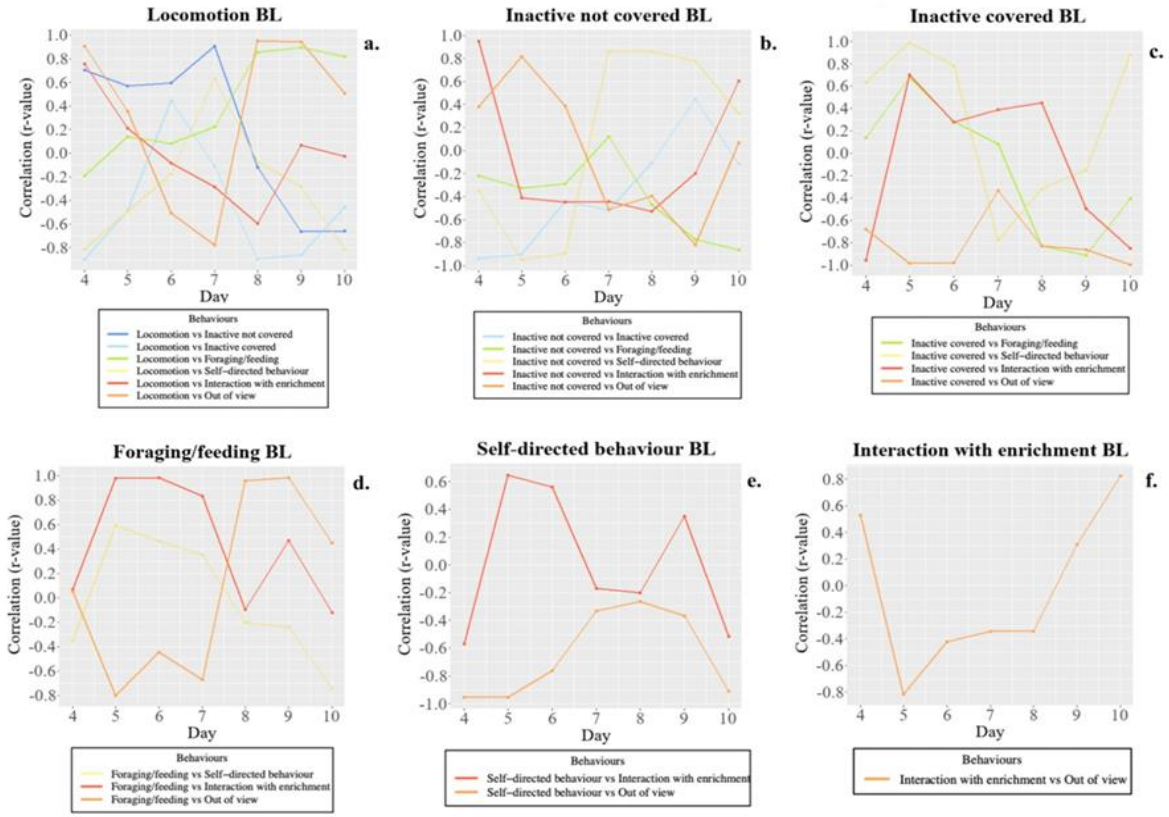


Figure 13. The average cumulative relative frequency per every half hour from 4:30-21:00 for the behaviour (a) 'Locomotion', (b) 'Inactive not covered, (c) 'Inactive covered, (d) 'Foraging/feeding', (e) 'Positive social interaction', (f) 'Self-directed behaviour', (g) 'Interaction with enrichment', (h) 'Out of view', and (i) 'Other' measured in minutes. The blue line

represents the baseline period (BL) and the green line represents the treatment period (TM).

Appendix D



Pearson correlation for Sliding Window

Figure 14 - Pearson correlation test with sliding window technique (four days) between the behaviours in BL. All comparisons are indicated with different colours. In plot a) 'Locomotion' was tested against all other behaviours, b) 'Inactive not covered' was tested against all the remaining behaviours, c) 'Inactive covered' was tested against all the remaining behaviours, d) 'Foraging/feeding' was tested against all the remaining behaviours, e) 'Self-directed behaviour' was tested against all the remaining behaviours, and f) 'Interaction with enrichment' was tested against all the remaining behaviours

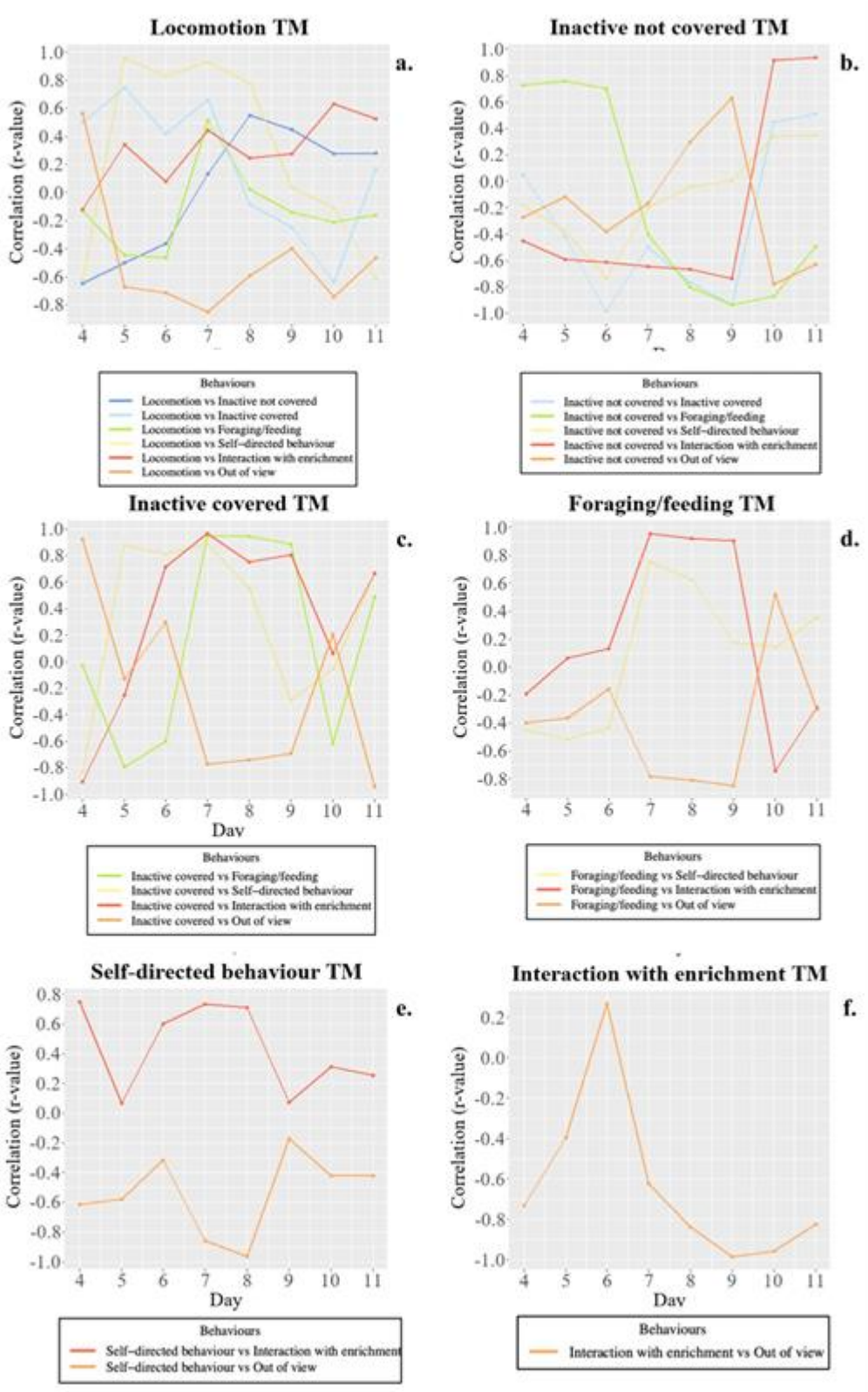


Figure 15 - *Pearson correlation test with sliding window technique (four days) between the behaviours in TM. All comparisons are indicated with different colours. In plot a) 'Locomotion' was tested against all other behaviours, b) 'Inactive not covered' was tested against all the remaining behaviours, c) 'Inactive covered' was tested against all the remaining behaviours, d) 'Foraging/feeding' was tested against all the remaining behaviours, e) 'Self-directed behaviour' was tested against all the remaining behaviours, and f) 'Interaction with enrichment' was tested against all the remaining behaviours.*