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Assessment of Abnormal Behaviour and the Effect of Enrichment on Captive Chimpanzees at Aalborg Zoo

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Abstract

Studies have suggested that chimpanzees and other primates in captivity tend to develop abnormal behaviours if they are housed without proper enrichment. The purpose of this study was to get a better understanding of the behaviour of chimpanzees in captivity at Aalborg Zoo, Denmark. This was done by examining whether the individuals displayed abnormal behaviour and whether the enrichment provided would affect the display of abnormal behaviour and other examined behaviours. Furthermore, it was assessed whether the age of the chimpanzee would affect the amount of time spent on enrichment. The assessed behaviours were abnormal, passive, play, climbing, walking and/or running, foraging, food- and water ingestion, grooming another, receiving grooming, mutual grooming, and self-grooming, while enrichment included a mirror, televisions, toys, and balls. The chimpanzees were recorded for 20 hours over the course of 5 days in the control week, and 20 hours over the course of 5 days in the enrichment week in autumn 2019. The results showed that the enrichment provided did not lead to any significant change in the behaviours observed in the four chimpanzees. The results also showed that all chimpanzees displayed abnormal behaviour, but also that none of the observed chimpanzees interacted significantly more with the enrichment, based on age. It could be concluded that none of the four different types of enrichment had any significant effect on the observed behaviours. The study shows that it is important to evaluate the effects of new enrichments.
Keywords: chimpanzee; *Pan troglodytes*; behaviour; enrichment; captivity; behavioural instability

Introduction

Treatment and welfare of animals in captivity have become an increasingly relevant issue, which could affect zoos, as better animal-welfare could also lead to an increased interest from the public (Hosey, 2005). Furthermore, the quality of the educational properties as well as research carried out in zoos are affected by the welfare of the animals in question (Hosey, 2005; Honess & Marin, 2006). As welfare and stress are often considered opposites, stress is usually a factor that is minimized or avoided to increase the welfare of the captive animals (Veissier & Boissy 2007). A stressor to the animals could be environmental stress, which can be measured by the use of the concept of behavioural instability (Bech-Hansen et al., 2019; Pertoldi et al., 2016). To assess the welfare of captive chimpanzees, their behaviours are often compared to the behaviours observed in wild chimpanzees, because the behaviour displayed by wild chimpanzees is regarded as optimal (Yamanashi & Hayashi, 2011).

Abnormal behaviour is a type of behaviour observed in captive chimpanzees that is atypical from individuals living in the wild, meaning that it either rarely occurs or does not occur at all (Birkett & Newton-Fisher, 2011). When abnormal behaviour does occur in captivity it occurs at higher frequencies and longer durations (Payne et al., 2008; Birkett & Newton-Fisher, 2011). The presence of abnormal

behaviour in chimpanzees at zoos can partly be explained by a lack of fluid fission-fusion when forming their social groups, which would normally be available for wild chimpanzees (Khan, 2013). Fluid fission-fusion is a social system in which members and the composition of the group change over time according to resources (Aureli et al., 2008). An example of a common abnormal behaviour in chimpanzees at zoos is coprophagy (Khan, 2013; Birkett & Newton-Fisher, 2011).

One way to improve the chimpanzees' welfare is through enrichment, defined effective if it causes an increase in positive behaviour or a decrease in negative behaviour (de Groot & Cheyne, 2016; Wallace et al., 2017). Positive behaviour includes playing, affiliative behaviour, and being active, while negative behaviour includes submissive-, abnormal-, and aggressive behaviour (de Groot & Cheyne, 2016). Several studies have shown that enrichment either increase or decrease positive and/or negative behaviour in captive chimpanzees (Grunauer & Walguarnery, 2018; Paquette & Prescott, 1988; Fritz et al., 1992; Yamanashi & Hayashi, 2011; Honess & Marin, 2006). However, the effectiveness of enrichment could rely upon factors such as the chimpanzee's personality, as studies have shown that chimpanzees who are scored higher in terms of openness interact more with the enrichment provided (Hopper et al., 2014; Herrelko et al., 2012). Another factor that could influence the effectiveness of enrichment could be the age of the chimpanzee. Several studies have shown that younger chimpanzees have an increased tendency to interact with the enrichments presented to them when compared to older chimpanzees (Bloomsmith et al., 1990; Lambeth & Bloomsmith, 1992; Brent & Stone, 1996).

Aim of the Paper

This study was conducted with four chimpanzees at Aalborg Zoo. The aim was to better understand the behaviour of chimpanzees in captivity. To examine this, it was assessed whether the individuals displayed abnormal behaviour and whether the enrichment provided would affect the display of abnormal behaviour and other examined behaviours. Furthermore, it was assessed whether the amount of time spent on enrichment would vary depending on the age of the individual chimpanzee.

Methods

Study animals and site

In this study, all four chimpanzees located in Aalborg Zoo (Aalborg, Denmark) were studied. The group consisted of three females; Jutta (45 y/o), Laura (25 y/o) and My (7 y/o), and one male, Sebastian (12 y/o) (Appendix 1). All chimpanzees, except for Jutta, were born and raised in captivity at Aalborg Zoo. Jutta arrived at Aalborg Zoo from Africa in 1980 at the age of six.

The chimpanzees' enclosure consists of one indoor area (about 169 m^2) split in two, and an outdoor enclosure (about 475 m^2). The indoor area, facing the audience, had rocks, logs, and ropes for climbing, as well as five shelves for perching, nesting, and sleeping. This area also had a small artificial waterhole and three small food-wells on the walls, and the chimpanzees were provided daily with nesting material and blankets. The other part of the indoor area was out of view to the audience.

The outdoor area of the enclosure contained logs, ropes, hanging tires, and three big trees used for climbing and/or playing. Furthermore, the outdoor area included a shelter made of logs and two bigger food-wells. The indoor area, facing the audience, also had a glass wall separating the chimpanzees from the audience, while the outdoor area only had fencing.

Materials

Three Annox Outdoor Action cameras (Copenhagen, Denmark), two inside and one outside, were used along with two Y-cam Solutions Ltd. surveillance cameras (Wolverhampton, United Kingdom), placed outside, to record research sessions. The placements of the cameras can be seen on the floor plan (Appendix 2).

Data collection

Data was collected five days a week for two weeks (Control week: 30/09-, 02/10-, 03/10-, 05/10-, 06/10/2019. Enrichment week: 22/10-, 23/10-, 24/10-, 26/10-, 27/10/2019) from 12 pm to 4 pm. The first week was used as a control week and had no additional interference, while the second week was used for enriching the chimpanzees. During both weeks, the chimpanzees were provided with their usual enrichments from the zookeepers, such as clothing, blankets and supplementary food packages. The data was collected in the form of video recordings from the cameras, and the footage was later viewed. A concordance test was performed, in which the recorded behaviours were placed into 11 predetermined behavioural categories. A 12th behavioural category was added during the enrichment week to account for the time spent interacting with the enrichment (Table 1). The time of the beginning and end of each behaviour was noted along with the duration of a behaviour.

Table 1: Modified after table 1 from Wallace at al. (2017).

Observed behaviours	**Definition of observed behaviours**
Passive	Sitting, lying down, sleeping, standing still.
Walking and/or running	Walking or running on a horizontal plane.
Climbing	Climbing up and down using arms or jumping.
Foraging	Search for and collection of food.
Food- and water ingestion	Eating, drinking, use of sticks to eat from food-wells.
Play	Interaction with object or another individual in a playful manner.
Grooming another	Observed individual manipulating the fur of another individual.
Receiving grooming	Another individual manipulating the fur of the observed individual.
Mutual grooming	Observed individual and another individual manipulating each other´s fur simultaneously.
Self-grooming	Observed individual manipulating own fur.
Abnormal	Regurgitation and reingestion, plucking of hair, urophagia, coprophagy, scratching excessively, rocking, smearing faeces on surface.
Enrichment	Interaction with enrichment by looking or manipulation.

Enrichment

Four kinds of enrichment were used in this study over the course of the enrichment week. A new enrichment was provided each day with each enrichment being given inside the indoor enclosure or shown from outside the glass of the indoor enclosure approximately at the time of feeding. Enrichment shown outside the enclosure was removed shortly after 4 pm when filming stopped, while enrichment given inside the enclosure was removed the next morning during cleaning. The first day (Tuesday), the chimpanzees were shown a 50 x 100 cm mirror placed on the outside of the glass. The second day (Wednesday), they were shown recordings of

feline predators and psychedelic videos on two separate 25 inch screens placed outside, 40 cm away from the glass. The third day (Thursday), they were given two toy snakes and a teddy chimpanzee, inside the enclosure. The fourth day (Saturday), they were given a soccer- and volleyball, inside the enclosure, and on the final day (Sunday), they were shown recordings of rainforests and other chimpanzees on the same screens used Wednesday, also placed outside, 40 cm from the glass.

Data analysis

The statistical analyses used in this study were conducted with Excel (Microsoft Office 365 ProPlus, versions 1902 & 1910) and Past (Version 3.26b) (raw data available from the corresponding author on request).

To determine whether the data was normally distributed, the skewness and kurtosis were analysed. As the skewness was different from 0 and the kurtosis was different from 3, the data was therefore not-normally distributed, and non-parametric methods were then used throughout the rest of the data.

Effect of enrichment on abnormal behaviour and other examined behaviours

To determine whether the days were significantly different from one another, a Mann-Whitney U test was performed, pairwise comparing the duration spent on a behaviour throughout a day compared to another day, in and between the two weeks, for each chimpanzee (See Appendix 3). To determine whether the changes observed in each behaviour between weeks were significant, a Mann-Whitney U test was performed separately on the pooled medians, interquartile range (IQR), skewness, and kurtosis of the two individual weeks for each chimpanzee.

Effect of enrichment based on the age of the chimpanzee

To determine whether there were any significant differences between the chimpanzees regarding the durations of time spent on enrichment, a Mann-Whitney U test was performed, using the pooled medians of the durations of time spent on enrichment.

Assessment of the behaviour of the chimpanzees

Using pairwise comparison of all data; the median, IQR, skewness and kurtosis were analysed using Mann-Whitney U tests, Levene's tests and D'Agostino's tests respectively, at a significance level of 0.05. This data was pooled for the four aforementioned parameters for each week (control and enrichment) and then plotted separately for each behaviour. This resulted in four plots per behaviour; one for each of the parameters, with each plot containing data for all four chimpanzees. These plots were used to evaluate the duration of each behaviour, and the distribution of the data. To assess whether the behaviour of the observed chimpanzees differed between the individuals, a χ^2-test was performed to determine whether the slopes (Figures 1a-7d) were significantly different from one another.

Results

Effect of enrichment on abnormal behaviour and other examined behaviours

All four chimpanzees displayed the assessed behaviours, including abnormal behaviour, at varying levels during the observations, except My and Sebastian, who did not take part in mutual grooming. Additionally, Sebastian was not observed to groom himself. The most prevalent type of abnormal behaviour was coprophagy, which was observed in all individuals. Furthermore, rocking, which is an abnormal behaviour, was only performed by Jutta. Smearing of faeces onto a surface was only displayed by Sebastian. All assessed behaviours were used when performing the various tests, except all grooming-related behaviour, as none of the assessed behaviours pertaining grooming occurred enough times, and therefore it was not possible to perform any tests on them. The results show that some of the behaviours displayed were significantly different between days (See Appendix 3). Furthermore, it was found that there was no statistically significant difference

between the duration of behaviours displayed for all assessed behaviours for each chimpanzee between the control- and enrichment week ($p > 0.05$).

Effect of enrichment based on the age of the chimpanzee

Based on a significance level of 0.05, none of the chimpanzees interacted significantly more with the enrichment compared to one another.

Assessment of the behaviour of the chimpanzees

The results of the χ^2-tests showed that there were some significant differences between the slopes of the medians, IQRs, skewnesses and kurtosises respectively, for each chimpanzee when compared to one another (Figure 1a-7d). For all the χ^2-values see appendix 4.

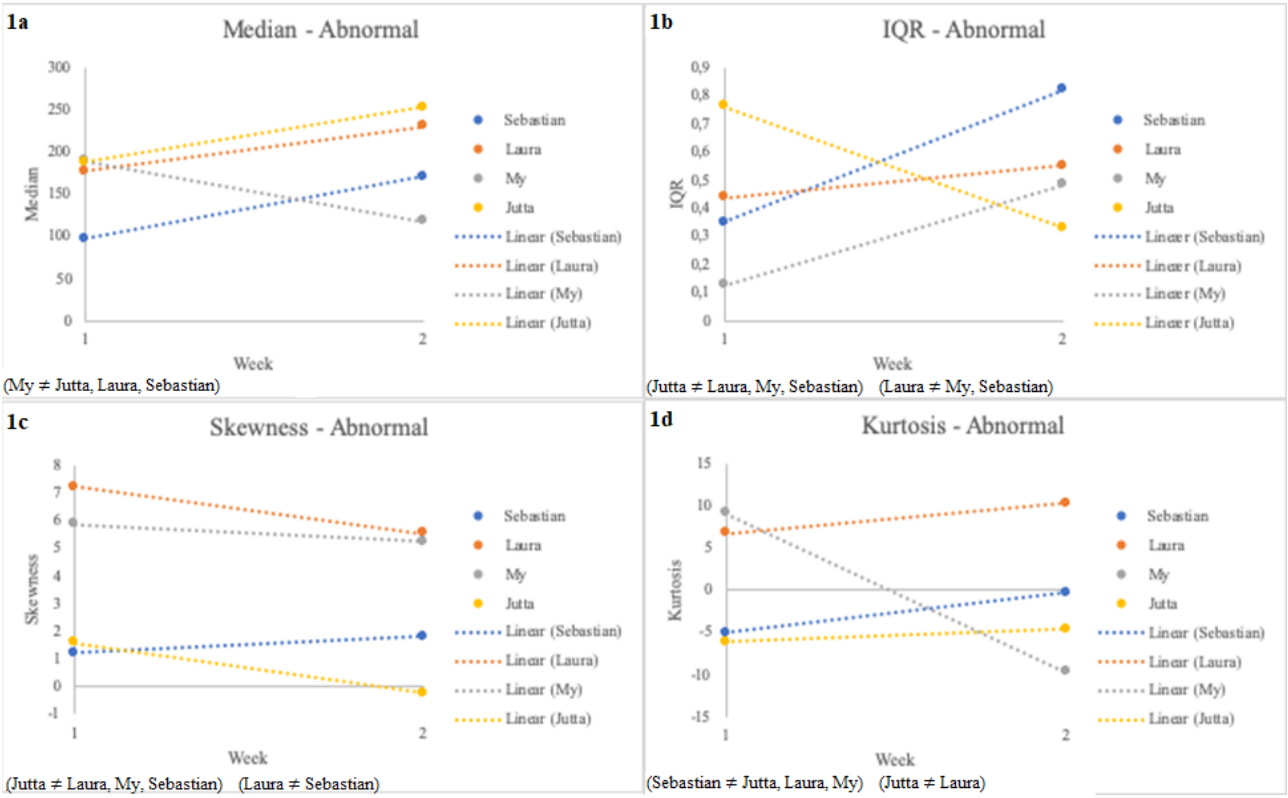
For the medians, the results of the χ^2-tests showed that there was a significant difference between the slopes of the medians of My and Jutta, the slopes of the medians of My and Laura, and the slopes of the medians of My and Sebastian regarding abnormal behaviour (Figure 1a). Furthermore, there was a significant difference between the slopes of the medians of My and Laura, and the slopes of the medians of My and Sebastian regarding passive behaviour (Figure 2a). Lastly, there was a significant difference between the slopes of the medians of Jutta and Sebastian regarding food- and water ingestion (Figure 7a).

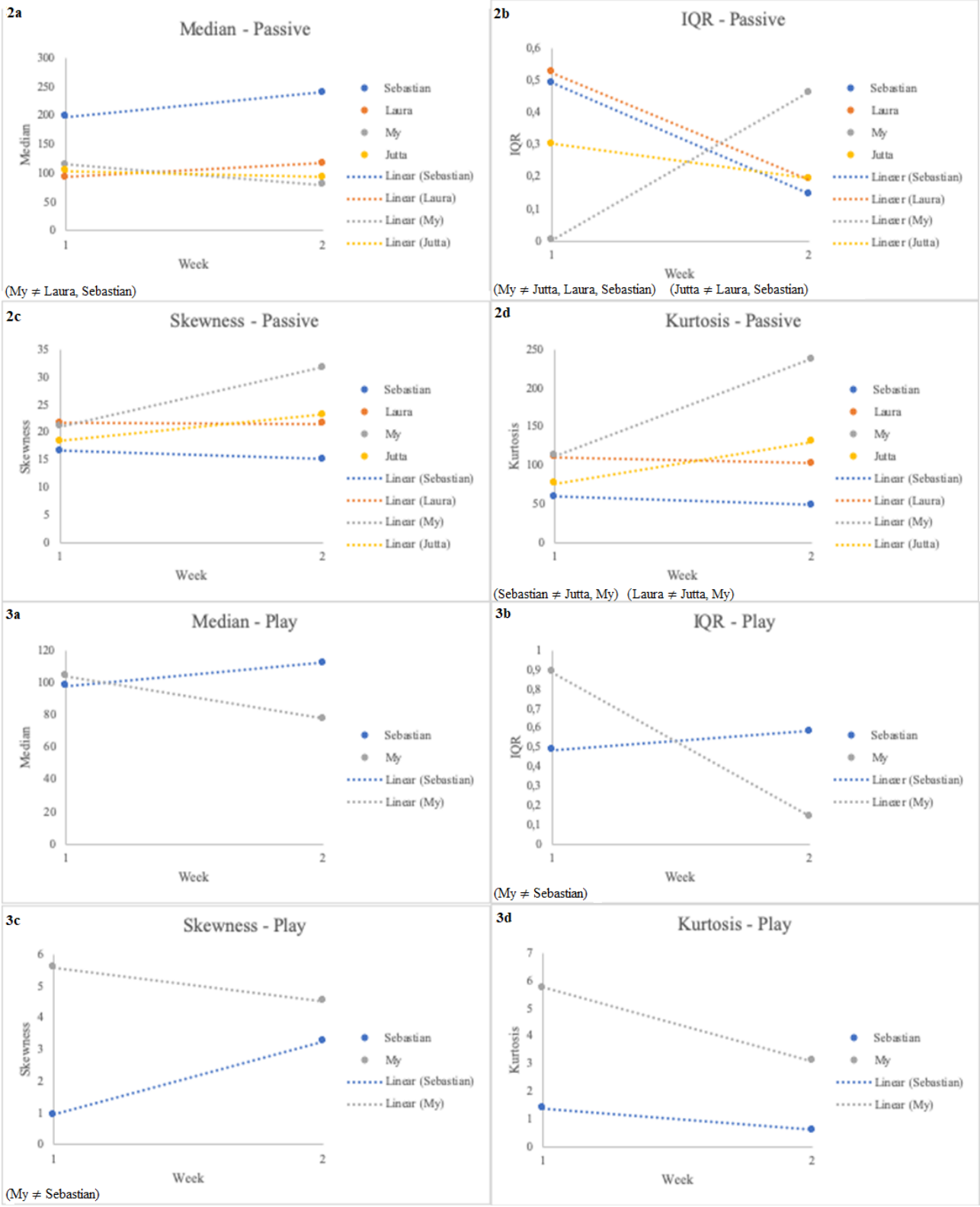
For the IQRs, the results of the χ^2-test showed that there was a significant difference in regard to abnormal behaviour between the slopes of the IQRs of Jutta and Laura, Jutta and My, Jutta and Sebastian, Laura and My, and between Laura and Sebastian (Figure 1b). The results also showed that there was a significant difference between the slopes of the IQRs of My and Jutta, My and Laura, My and Sebastian, Jutta and Laura and of Jutta and Sebastian in regard to passive behaviour (Figure 2b). In regard to play behaviour, there was a significant difference between the slopes of the IQRs of My and Sebastian (Figure 3b). Furthermore, in regard to the slopes of the IQRs, there was a significant difference between the slopes of Laura and Jutta, Laura and My, Laura and Sebastian, My and Jutta, and of My and Sebastian in regards to climbing (Figure 4b). In regard to walking and/or running the results showed that there was a significant difference between the slopes of the IQRs of all the chimpanzees (Figure 5b). There was also a significant difference between the slopes of the IQRs of Sebastian and Jutta, Sebastian and Laura, Sebastian and My, My and Jutta, and between My and Laura in regard to foraging (Figure 6b). Lastly, in regard to food- and water ingestion, there was a significant difference between the slopes of the IQRs of My and Jutta, My and Laura, My and Sebastian, Jutta and Laura, and between Jutta and Sebastian

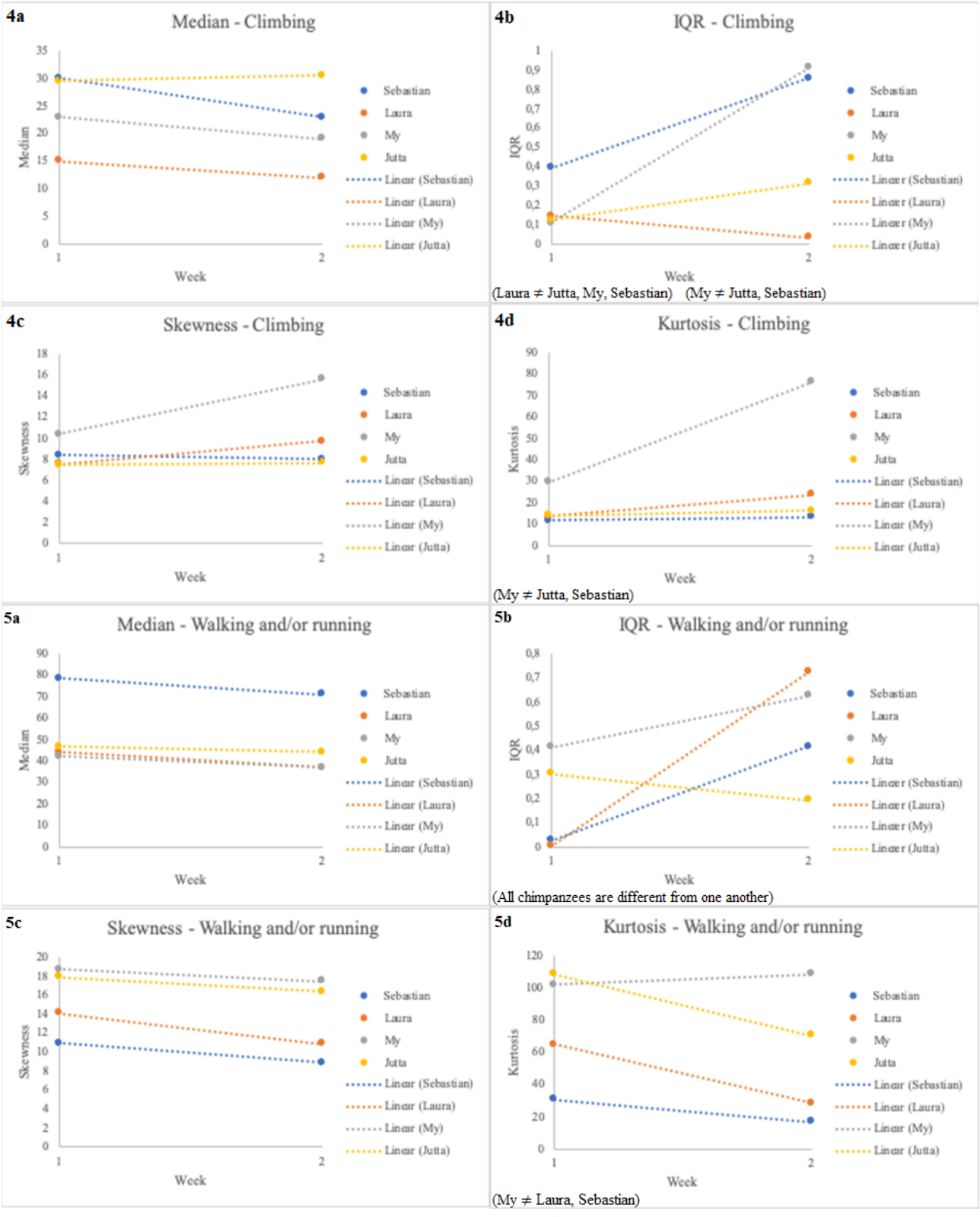
For the skewnesses, the results of the χ^2-test showed that there was a significant difference between the slopes of the skewnesses of Jutta and Laura, Jutta and My, Jutta and Sebastian, and between Laura and Sebastian in regard to abnormal behaviour (Figure 1c). The results also showed that there was a significant difference between the slopes of the skewnesses of My and Sebastian in regard to play behaviour (Figure 3c). Furthermore, the slopes of the skewnesses were significantly different between Jutta and Sebastian for foraging (Figure 6c).

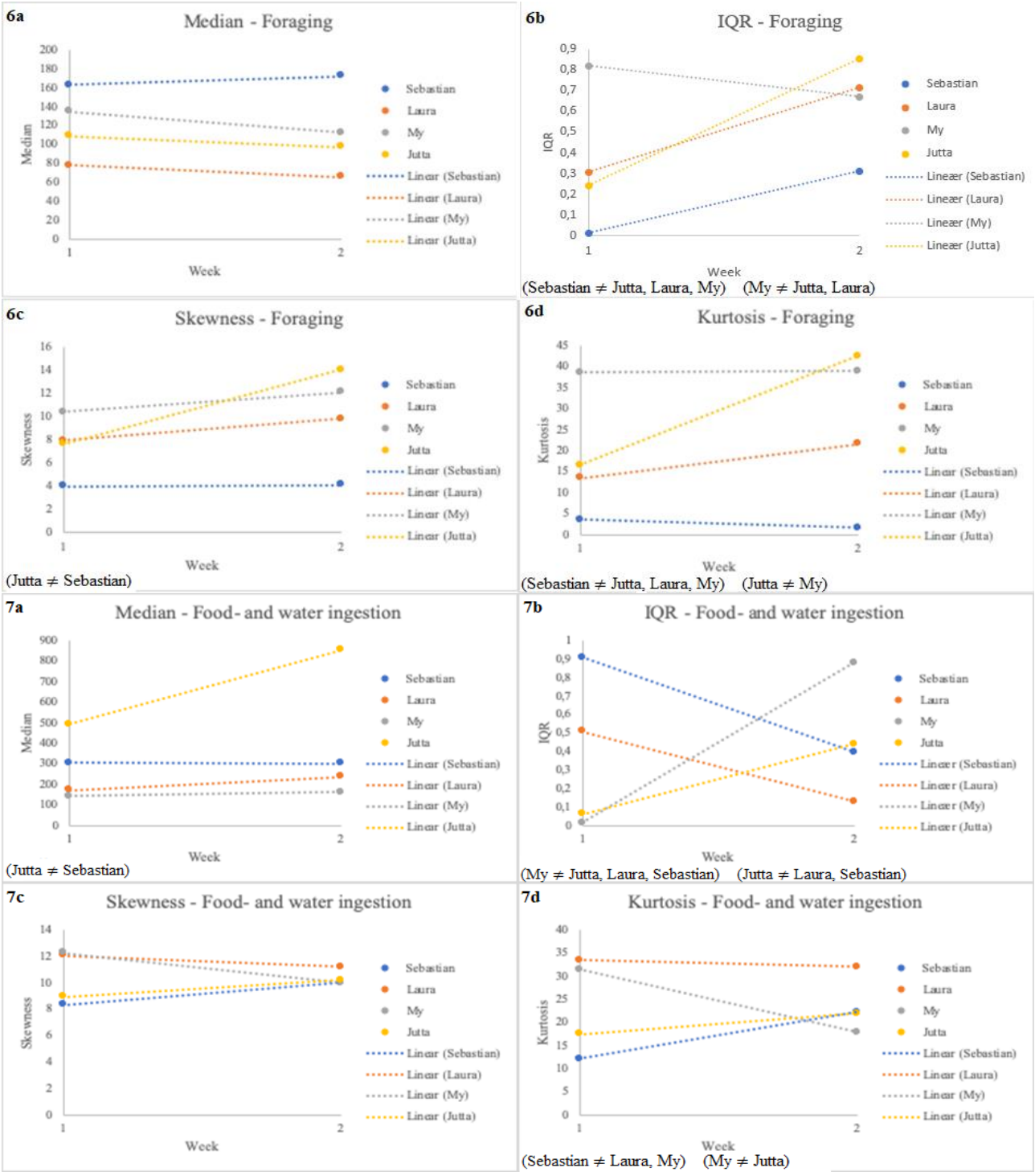
For the kurtosises, the results of the χ^2-test showed that there was a significant difference between the slopes of the kurtosises of Sebastian and Jutta, Sebastian and Laura, Sebastian and My, and between Jutta and Laura in regard to abnormal behaviour (Figure 1d). There was also a significant difference between the slopes of the kurtosises of Sebastian and Jutta, Sebastian and My, Laura and Jutta, and between Laura and My in regard to passive behaviour (Figure 2d). Furthermore, there was a significant difference between the slopes of the kurtosises of My and Jutta, and between My and Sebastian in regard to climbing (Figure 4d). In regard to walking and/or running there was a significant difference between the slopes of the kurtosises of My and Laura, and between My and Sebastian (Figure 5d). There was also a significant difference between the slopes of the kurtosises of Sebastian and Jutta, Sebastian and Laura, Sebastian and My, and between Jutta and My in

regard to foraging (Figure 6d). Lastly there was a significant difference between the slopes of the kurtosises of Sebastian and Laura, Sebastian and My, and between My and Laura in regard to food- and water ingestion (Figure 7d).




2a
Median - Passive
Median
Week
Sebastian
Laura
My
Jutta
Linear (Sebastian)
Linear (Laura)
Linear (My)
Linear (Jutta)
(My ≠ Laura, Sebastian)
2b
IQR - Passive
IQR
Week
(My ≠ Jutta, Laura, Sebastian) (Jutta ≠ Laura, Sebastian)
2c
Skewness - Passive
Skewness
Week
(Sebastian ≠ Jutta, My) (Laura ≠ Jutta, My)
2d
Kurtosis - Passive
Kurtosis
Week
3a
Median - Play
Median
Week
(My ≠ Sebastian)
3b
IQR - Play
IQR
Week
3c
Skewness - Play
Skewness
Week
(My ≠ Sebastian)
3d
Kurtosis - Play
Kurtosis
Week


4a
Median - Climbing
Median
Week
Sebastian
Laura
My
Jutta
Linear (Sebastian)
Linear (Laura)
Linear (My)
Linear (Jutta)
4b
IQR - Climbing
IQR
Week
(Laura ≠ Jutta, My, Sebastian) (My ≠ Jutta, Sebastian)
4c
Skewness - Climbing
Skewness
Week
4d
Kurtosis - Climbing
Kurtosis
Week
(My ≠ Jutta, Sebastian)
5a
Median - Walking and/or running
Median
Week
5b
IQR - Walking and/or running
IQR
Week
(All chimpanzees are different from one another)
5c
Skewness - Walking and/or running
Skewness
Week
5d
Kurtosis - Walking and/or running
Kurtosis
Week
(My ≠ Laura, Sebastian)



Figures 1-7: The figures 1a, 2a, 3a, 4a, 5a, 6a & 7a show the sums of the medians of the duration of assessed behaviours for week 1 and 2 compared to one another. The figures 1b, 2b, 3b, 4b, 5b, 6b & 7b show the sums of the IQRs of the duration of assessed behaviours for week 1 and 2 compared to one another. The figures 1c, 2c, 3c, 4c, 5c, 6c & 7c show the sums of the skewnesses of the duration of assessed behaviours for week 1 and 2 compared to one another. The figures 1d, 2d, 3d, 4d, 5d, 6d & 7d show the sums of the kurtosises of the

duration of assessed behaviours for week 1 and 2 compared to one another. Additionally, it is written whether a chimpanzee has a significantly higher slope than one or more chimpanzees on each figure.

Discussion

Effect of enrichment on abnormal behaviour and other examined behaviours

Abnormal behaviour was observed in all individuals, but except for coprophagy, the types displayed by each individual varied. The fact that all chimpanzees performed coprophagy could be linked to boredom in the enclosure or management, and less likely the types of food they were provided. Studies have shown or speculated that coprophagy is linked to the amount of "wadge-making" materials (e.g. such as leaves, nuts and vegetables) provided or the amount of nutrients in the food that the chimpanzees are presented with (Fritz et al., 1992; Payne et al., 2008). The chimpanzees get a balanced fibrous diet. Sebastian was the only one who also smeared faeces on the walls of the enclosure, but as Hopper et al. (2016) categorised this as part of coprophagy, it could also be a result of similar causes as the aforementioned (Hopper et al., 2016, Table 1). Rocking, which was performed only by Jutta, could be related to her being hand-reared, but as she arrived at the zoo at the age of six, it is not possible to determine if this actually could be the reason (Clay et al.,2015; Nash et al.,1999). Rocking could be an indication of negative welfare (Hopper et al., 2016). Abnormal behaviour, such as aggression, was only observed in My and Sebastian. Primarily, My showed aggression when dogs were visible to her, which, according to the zookeepers, could indicate that this was done in relation to territorial behaviour. Meanwhile, it was observed that Sebastian primarily displayed aggressive behaviour after failed attempts at acquiring the attention of the three female chimpanzees. The abnormal behaviour, which was displayed by all chimpanzees, could also be a result of the enclosure not meeting certain requirements, such as the chimpanzees' need to spend a large amount of time foraging, as chimpanzees in natural habitats spend up to 56 % of their daily time foraging (Yamanashi & Hayashi, 2011; Khan, 2013). While this study did not find any statistical difference between the duration of any of the assessed behaviours between the control- and enrichment week for the observed chimpanzees, other studies, such as Grunauer & Walguarnery (2018), Paquette & Prescott (1988), Fritz et al. (1992), Yamanashi & Hayashi (2011), and Honess & Marin (2006), found that enrichment either increase or decrease positive and/or negative behaviour in captive chimpanzees (Grunauer & Walguarnery, 2018; Paquette & Prescott, 1988; Fritz et al., 1992; Yamanashi & Hayashi, 2011; Honess & Marin, 2006). For example, a study by Paquette and Prescott (1988) found that providing the chimpanzees with different quantities of objects they could manipulate, would decrease time spent being inactive, self-grooming, and the abnormal behaviours displayed (Paquette & Prescott, 1988). The reason why their behaviour did not change between the weeks, specifically in regards to the mirror, could be explained by the brain structures (the anatomy of superior longitudinal fasciculus), also affected by task training by humans, which was found to influence the chimpanzees ability to do self-recognition in a mirror (Hecht et al. 2017). In other studies, chimpanzees had access to e.g. the mirror in ten days before the test or the duration of the test lasted for more than four months (Lambeth & Bloomsmith, 1992; Povinelli et al., 1997). Other explanations regarding the lack of change in behaviour of the chimpanzees when provided with enrichment could be already significant differences in behaviour between the days in the control week not caused by enrichment but other factors (See Appendix 3). Factors with impact on the behaviour of the chimpanzees other than enrichment could include sounds, lights, dogs, weather, types of food provided, and visitors. The type of enclosure may also have some significance, with a more naturalistic setting being more optimal when it comes to reducing the amount of abnormal behaviours displayed (Khan, 2013), as uncontrollable and barren enclosures lead to abnormal behaviour (Brüne et al., 2006). Furthermore, although all chimpanzees showed abnormal behaviour, lack of behavioural response to new enrichments could also be due to an existing wide enrichment-program at Aalborg Zoo, meaning that they had already been provided with a wide variety of types of enrichment such as providing feed in many different ways. This could mean that any further enrichment could have been redundant and thus did not yield any results.

Effect of enrichment based on the age of the chimpanzee

This study found no significant connection between the age of the observed adult chimpanzees and the time spent interacting with enrichment. This could be explained by the fact that the chimpanzees in this study were more than 7 years old, which may have influenced their exploratory interest in new enrichment objects negatively. Another reason for why the chimpanzees did not show an increased interest in the enrichment with age, could be explained by the fact that the enrichment was not presented for sufficient time to make an interest for adult chimpanzees not accustomed to the provided enrichment beforehand. Similarly, a study by Brent & Stone (1998) found that age and the use of toys were not significantly correlated. In the study of Brent & Stone (1998) they examined nine chimpanzees between the ages of 4.5 and 34 years (Brent & Stone, 1998), and similarly, three of the four chimpanzees in the present study were between the age of 7 and 25, while the last one was 45 years old. The opposite was found in studies from Bloomsmith et al. (1990), Lambeth & Bloomsmith (1992) and Brent & Stone (1996), where all found that younger chimpanzees would interact with enrichment for a longer time compared to older chimpanzees (Bloomsmith et al., 1990; Lambeth & Bloomsmith, 1992; Brent & Stone, 1996).

Assessment of the behaviour of the chimpanzees

Lack of response to enrichment in this study may be due to chimpanzees having different personality types (Weiss et al., 2009; Herrelko et al., 2012). The results of this study (Figures 1a, 2a, 3a, 4a, 5a, 6a & 7a) support that the behaviour displayed by the observed chimpanzees, although not all were significant, differed between individuals. According to Herrelko et al. (2012), personality can be used to determine the appropriate enrichment for increasing welfare (Herrelko et al., 2012). As the enrichments did not have any significant effect on either of the observed chimpanzees' behaviours, it could indicate that the enrichment offered did not match the personalities of the chimpanzees. Additionally, the results show no clear overall trend regarding whether the medians increased or decreased, which means that the duration neither decreased nor increased for any examined behaviour, when the chimpanzees were provided with enrichment (Figure 1a, 2a, 3a, 4a, 5a, 6a & 7a). The results show a slight trend regarding an increase in the IQRs, meaning that for four out of seven examined behaviours, most of the IQRs increase when the chimpanzees are provided with enrichment (Figure 1b, 2b 3b, 4b, 5b, 6b & 7b). This indicated that the duration of the behaviours had a tendency to become more unpredictable for each individual, and an increased unpredictability could indicate an increased behavioural instability. Furthermore, based on our results, it can be observed that the skewness and kurtosis varied for each individual and behaviour, which in turn indicates that the predictability of the behaviour displayed by each individual also varies. As the variation increases, so does unpredictability (Figure 1c, 1d, 2c, 2d, 3c, 3d, 4c, 4d, 5c, 5d, 6c, 6d, 7c & 7d). This variation is by Bech-Hansen et al. (2019) defined as an estimation of the behavioural instability (Bech-Hansen et al., 2019), thus this suggests that the behavioural instability increases as the variation of skewness and kurtosis increases.

Conclusion

Based on our data, it is suggested that there is no significant change in the duration of the assessed behaviours, neither positively nor negatively, as a result of the provided new enrichments. As only adult chimpanzees, more than 7 years old, were used in this study, the age and lack of previous adjustment to object enrichment (mirror, video, toys like plastic snakes, teddy and balls) may have influenced the results. Additionally, abnormal behaviour was present in all chimpanzees at Aalborg Zoo. However, the enrichments provided in this study did not affect the behaviours of the observed chimpanzees. In future studies, behavioural instability, the personality of the chimpanzees, their age and needs for adjustment to new objects should be considered in the experimental setup, as well as other types of enrichments, such as food or music, and a structural change of the enclosures. The study emphasizes the importance of evaluating the effects of new enrichment.

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Author's Contributions

All authors have contributed equally.

Ethics

The authors declare no ethical issues after the publication of this manuscript.

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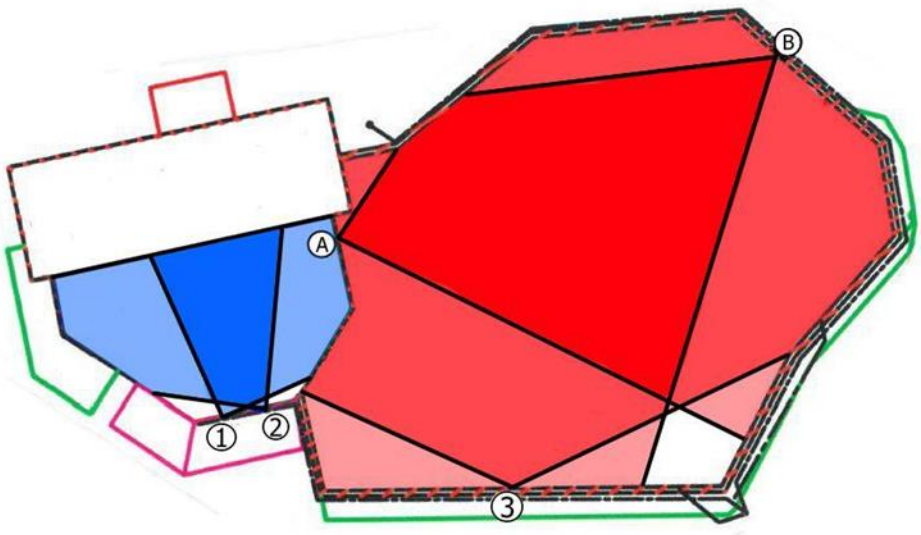
Appendix

Appendix 1

All of the chimpanzees at Aalborg Zoo. 1) Jutta, 2) Laura, 3) My, and 4) Sebastian.

Appendix 2

Floor plan of the chimpanzees' enclosure. The indoor enclosure had two Annox cameras (1 & 2), while the outdoor enclosure had one Annox camera (3) and two y-cams (A & B). The blue (indoor) and red (outdoor) colours indicate where the cameras placed indoors and outdoors filmed, and where they overlapped.



Appendix 3

The table shows the percentage of days in a given week that had a p-value lower than 0.05 for each chimpanzee according to every behavioural category.

Mann Whitney U test			
Behaviour	Chimpanzee	Control	Enrichment
Passive	Jutta	30%	10%
	My	30%	0%
	Sebastian	20%	40%
	Laura	20%	0%
Walking and/or running	Jutta	0%	20%
	My	10%	20%
	Sebastian	40%	0%
	Laura	40%	10%
Climbing	Jutta	0%	0%
	My	0%	60%
	Sebastian	20%	0%
	Laura	20%	40%
Foraging	Jutta	0%	0%
	My	0%	0%
	Sebastian	0%	10%
	Laura	30%	30%
Food and water ingestion	Jutta	10%	20%
	My	40%	10%
	Sebastian	30%	10%
	Laura	10%	0%
Play	Jutta		
	My	0%	0%
	Sebastian	0%	40%
	Laura		
Abnormal	Jutta	0%	0%
	My	67%	0%
	Sebastian	0%	0%
	Laura	20%	0%

Appendix 4

The table shows the values from a $\chi 2$-test on the data derived from the chimpanzees´ behaviours medians in both the control and enrichment week, and furthermore a ratio between the two weeks. A ratio value over 1.7 shows a significant difference between the chimpanzees.

$\chi 2$ test - Median						
	Sebastian-Laura	Sebastian-My	Sebastian-Jutta	Laura-My	Laura-Jutta	My-Jutta
Passive						
Control week	2.12	1.72	1.91	0.81	0.89	1.11
Enrichment	2.06	3.02	2.59	1.46	1.25	0.85
Ratio	1.02	1.76	1.35	1.81	1.39	1.30
Walking and/or running						
Control week	1.78	1.87	1.69	1.05	0.95	0.90
Enrichment	1.92	1.92	1.61	1.00	0.84	0.84
Ratio	1.07	1.03	1.05	1.05	1.12	1.07
Climbing						
Control week	2.00	1.30	1.02	0.65	0.51	0.78
Enrichment	1.92	1.21	0.75	0.63	0.39	0.62
Ratio	1.04	1.08	1.35	1.03	1.29	1.25
Foraging						
Control week	2.10	1.21	1.50	0.57	0.71	1.24
Enrichment	2.62	1.52	1.77	0.58	0.67	1.15
Ratio	1.25	1.26	1.18	1.01	1.05	1.07
Food and water ingestion						
Control week	1.78	2.15	0.61	1.20	0.34	0.28
Enrichment	1.26	1.85	0.35	1.46	0.27	0.19
Ratio	1.41	1.16	1.75	1.21	1.24	1.50
Play						
Control week		0.94				
Enrichment		1.44				
Ratio		1.53				
Abnormal						
Control week	0.54	0.51	0.51	0.93	0.94	1.00
Enrichment	0.73	1.44	0.67	1.95	0.91	0.46
Ratio	1.35	2.82	1.30	2.08	1.03	2.15

$\chi 2$ test - IQR						
	Sebastian-Laura	Sebastian-My	Sebastian-Jutta	Laura-My	Laura-Jutta	My-Jutta
Passive						
Control week	0.94	861.75	1.63	919.92	1.74	1.89E-03
Enrichment	0.77	0.32	0.76	0.41	0.99	2.39
Ratio	1.21	2705.52	2.13	2228.40	1.76	1267.84
Walking and/or running						
Control week	6.95	0.06	0.09	8.5E-3	0.01	1.51
Enrichment	0.58	0.66	31.68	1.15	55.07	47.73
Ratio	12.09	11.20	354.29	135.37	4282.24	31.63
Climbing						
Control week	2.74	3.70	3.24	1.35	1.18	0.88
Enrichment	27.69	0.94	2.75	0.03	0.10	2.93
Ratio	10.10	3.94	1.18	39.80	11.90	3.34
Foraging						
Control week	0.04	0.01	0.05	0.37	1.26	3.39
Enrichment	0.43	0.46	0.36	1.07	0.84	0.78
Ratio	11.11	31.84	7.36	2.87	1.51	4.33
Food and water ingestion						
Control week	1.79	70.15	15.01	39.13	8.37	0.21
Enrichment	3.04	0.45	0.90	0.15	0.30	2.00
Ratio	1.69	1.56.21	16.71	265.02	28.36	9.35
Play						
Control week		0.54				
Enrichment		4.11				
Ratio		7.54				
Abnormal						
Control week	0.80	2.74	0.46	3.43	0.57	0.17
Enrichment	1.49	1.70	2.48	1.14	1.67	1.46
Ratio	1.86	1.61	5.42	3.00	2.91	8.73

$\chi 2$ test - Skewness						
	Sebastian-Laura	Sebastian-My	Sebastian-Jutta	Laura-My	Laura-Jutta	My-Jutta
Passive						
Control week	0.77	0.79	0.90	1.03	1.18	1.14
Enrichment	0.70	0.48	0.65	0.68	0.93	1.37
Ratio	1.09	1.66	1.38	1.52	1.27	1.20
Walking and/or running						
Control week	0.77	0.58	0.61	0.75	0.79	1.04
Enrichment	0.81	0.51	0.54	0.62	0.67	1.07
Ratio	1.05	1.15	1.12	1.21	1.18	1.02
Climbing						
Control week	1.12	0.81	1.12	0.72	1.01	1.39
Enrichment	0.82	0.51	1.04	0.62	1.27	2.03
Ratio	1.36	1.58	1.08	1.16	1.26	1.47
Foraging						
Control week	0.50	0.39	0.52	0.77	1.04	1.36
Enrichment	0.42	0.34	0.29	0.81	0.70	0.86
Ratio	1.20	1.13	1.78	1.06	1.49	1.58
Food and water ingestion						
Control week	0.69	0.68	0.93	0.98	1.35	1.37
Enrichment	0.90	1.00	0.98	1.12	1.10	0.98
Ratio	1.29	1.47	1.06	1.14	1.23	1.39
Play						
Control week		0.17				
Enrichment		0.72				
Ratio		4.27				
Abnormal						
Control week	0.17	0.21	0.76	1.23	4.56	3.70
Enrichment	0.32	0.34	-7.95	1.06	-24.52	-23.17
Ratio	1.94	1.67	-10.43	1.16	-5.37	-6.25

$\chi 2$ test - Kurtosis						
	Sebastian-Laura	Sebastian-My	Sebastian-Jutta	Laura-My	Laura-Jutta	My-Jutta
Passive						
Control week	0.54	0.53	0.77	0.98	1.44	1.47
Enrichment	0.47	0.21	0.37	0.43	0.79	1.82
Ratio	1.14	2.58	2.08	2.26	1.83	1.24
Walking and/or running						
Control week	0.48	0.30	0.28	0.63	0.60	0.94
Enrichment	0.58	0.15	0.24	0.26	0.40	1.55
Ratio	1.22	1.97	1.20	2.42	1.47	1.63
Climbing						
Control week	0.85	0.39	0.82	0.46	0.97	2.10
Enrichment	0.56	0.17	0.83	0.31	1.47	4.74
Ratio	1.52	2.26	1.00	1.49	1.52	2.26
Foraging						
Control week	0.26	0.09	0.21	0.35	0.81	2.34
Enrichment	0.07	0.04	0.04	0.55	0.51	0.92
Ratio	3.75	2.35	6.00	1.60	1.60	2.55
Food and water ingestion						
Control week	0.36	.38	0.69	1.07	1.92	1.80
Enrichment	0.69	1.24	1.01	1.80	1.47	0.82
Ratio	1.92	3.23	1.47	1.69	1.31	2.20
Play						
Control week		0.24				
Enrichment		0.19				
Ratio		1.25				
Abnormal						
Control week	-0.75	-0.56	0.83	0.74	-1.11	-1.49
Enrichment	-0.03	0.03	0.06	-1.06	-2.21	2.08
Ratio	27.87	-19.45	13.94	-1.43	1.99	-1.40