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Sleep Meditation as Auditory Enrichment for Captive Chimpanzees (*Pan troglodytes*)

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Abstract

Studies suggest that the welfare of captive chimpanzees can be improved by providing different kinds of enrichments. Sensory enrichment has gotten more attention lately, by e.g. using sounds and images. The purpose of this study was to examine the differences in behavior, using asleep meditationpodcast asenrichment.An ethogram wasmade to categorizethe different behaviors. The difference between the medians of each behaviorwas then tested with a Mann-Whitney U test. Furthermore, the personalities of the chimpanzees were analyzed, byfirst plotting X-Y graphs of the median, kurtosis, skewness, and IQR.Afterward,χ^2 tests were performed on the slopes, todetermineif there were any significant differences in the chimpanzee's personalities.Additionally, behavioral diversity was calculated and compared with χ^2 tests. Based on these tests, it was not possible to conclude whether the sleep meditation causedachange in behavior in the enrichmenttestperiod. It is however possible to conclude that the study showed a significant difference in the personalities, between some of thechimpanzees.

Keywords: Chimpanzee, P. troglodytes, captive chimpanzees, sensory enrichment, auditory enrichment, sleep meditation behavioral diversity, behavioral reaction norms, Aalborg Zoo

Introduction

All over the world thousands of animals are housed in institutional settings, such as zoos, safari parks, sanctuaries, and laboratories. In recent times there has been more focus on the welfare of the animals in captivity, and how to improve their physical and social surroundings(Rampim and Oliva, 2016; Wells, 2009). This is often done by adding environmental enrichments to their habitat that simulates incentives, enabling them to experience a similar environment they otherwise would have experienced in the wild. This has been shown to improve the wellbeing of the captive animals, in this case, chimpanzees(*Pan troglodytes)*(Mellen and MacPhee, 2001; Newberry, 1995; Swaisgood and Shepherdson, 2006). Although this is a rather vague concept, it is widely agreed that the goal is to encourage natural behavior (Rampim and Oliva, 2016; Wells, 2009). These enrichments are often created by artificial or natural objects, scents, or sounds presented in a safe way so that the animals are not harmed (Bayne and Würbel, 2014; Hare et al., 2008). The objective is to increase physical activity, stimulate cognition, and promote natural behavior based on the current information from biological studies (Ross et al., 2010). Recently the use of sensory enrichment with a focus one.g. auditory, olfactory,or visuals, to stimulate behaviors, have gotten more attention (Mellen and MacPhee, 2001; Ross et al., 2010; Swaisgood et al., 2001).

This is likely because, an increase in the welfare of the chimpanzees can be measured by calculating the behavioral diversity(Miller et al., 2016a; Rabin, 2003; Sueur and Pelé, 2019).Wild chimpanzeesare exposed to a wide variety of environmental stimuli, which aredifficult to replicate in captivity and most of the stimuli used are repetitive(Wells, 2009).

Behavioral diversity is measured by comparing two different factors. The first is the number of behaviors, also called the richness of behavior, and the second being the frequency of the occurrence of each behavior, also called the evenness (Miller et al., 2016b).This is mostlydonewihout includingstereotypical/abnormal behavior. The reasoning behind this isthat multiplestudies have shown that stereotypical behavior is mostly linked to adecrease in welfare(Mason and Latham, 2004).

Multiple studies using auditory enrichment have been conducted, and concludes that it has the potential to improvethe wellbeing of animals living in institutional settings (Barcellos et al., 2018; Kogan et al., 2012; Robbins and Margulis, 2014). Awell known example is the increased milk production in dairy cowsthat are listening to classical music (Holden 2001). Studies have shown that the use of auditory stimuli reduced dominant or aggressive behavior and increased social affiliation in a group of captive chimpanzees, by playing music in the enclosure(Howell et al., 2003; Videan et al., 2007). The volume in the previous study was set relatively low, to allow human communication, but still loud enough to hear the melody and lyrics(Howell et al., 2003). There are some physiological differences between humans and chimpanzees when it comes to auditory sensitivity, which is why the choice of music must be taken into consideration(Howell et al., 2003; Kojima, 1990). Chimpanzees have an increased sensitivity to higher frequencies and are less sensitive to lower and middle frequencies than humans. This could result in different music experiences and consequently behavioral effects (Kojima, 1990).

When using traditional methodologies for behavioral studies there is a risk of misinterpreting the behavioral changes as random occurrences. This is sinceanimal behavior is unpredictable, which is known as behavioral instability(Linder et al., 2020; Pertoldi et al., 2020). Therefore, it is important to take behavioral instability into account when studying animal behavior(Pertoldi et al., 2020). The behavioral reaction patternof an individual is an indication of that individual'spersonality.By applying the concept of behavioral instability to the behavioral data,the personalitiesare taken into accountwhich makes it possible to replicate the result(Pertoldi et al., 2020).Behavioral instability is applied by observing the median, skewness, IQR (interquartile range), and kurtosis of the different behaviors observed.Skewness represents the asymmetry while IQR represents the variance, and kurtosis represents the predictability, of the specific behavior(Linder et al., 2020).

This paper aims to study and evaluate the behavioral effects of a sleep meditation podcast, on a group of chimpanzees in Aalborg Zoo, Denmark. The choice of this auditory enrichment was based on initialobservations of the chimpanzee's response to the communication with the zookeepers. The sleep meditation is expected to have a calming effect on the chimpanzees and reduce the dominant behavior, especially of the alpha male. Additionally, the enrichment is expected to show a higher behavioral diversity in the enrichment test period, than in the control withoutauditory enrichment.

Methods

Subjects and Settings

This study observed the behavior of four chimpanzees, one male, and three females, in Aalborg Zoo, Denmark. The oldest female, Jutta, was 46 years old and the mother of the three other chimpanzees. The male, Sebastian, was 13 years old and the two other females, Laura and Mywere 26and8years old, respectively. The chimpanzees had access to an indoor and an outdoor enclosure which they could move about freely during most of the day. Their diet consistsof vegetables, seeds, dry feed, and occasionally dried insects. The area of the enclosure observed for this study was 170 m^2 and includes the main indoor enclosure, without the smaller back areas(Appendix A).In the main enclosure two windows allow visitors to observe the chimpanzees.The area that was measured only include the floorand did therefore not include the heights of their climbing options.

Data Collection

The observations took place in November 2020, inthe weeks 45 and 46 during the zoo's off-season. Each week five observation sessions, spanning four hours each, were conducted. Three cameras (Kitvision Venture action camera) were used to film the indoor enclosure (AppendixA). The sessions spanned from 13:30 to 17:30 (UTC+1). The five sessions in week 45 were the control, which was used to estimate the baseline behavior of the chimpanzees under normal conditions. During the five sessions in week 46, sleep meditation was played by a speaker (Veho M6 360°) in the enclosure (AppendixA) for an hour, from 13:30 to14:30, as enrichment.The sleep meditation used was from a podcast called *"You Are Not Alone Guided Sleep Meditation"* by Tracks To Relax(Tracks To Relax, 2020).It consists ofcalming music, sounds, and a male voice designed to guidethe listener to sleep.

Analysis

When analyzing the filmed material, the observed behaviors of the chimpanzees were categorized in a behavioral ethogramas shown in Table 1. For all four chimpanzees, the duration of each behavior was noted and used for the analysis. The behavioral observations were used to determine if there was a difference in the medians of the behavior, of the chimpanzees between the control and the enrichment week. All statistical tests were made using the statistical software program *PAST* (Paleontological statistics software version 4.03, https://www.nhm.uio.no/english/research/infrastructure/past/).

Table 1: Behavioral ethogram.

Ethogram	
Passive behavior	Sleeping, resting, standing, sitting, limited movement, scratching behind, and sniffing fingers. If they shift from one passive position to another over less than 2 meters it is considered to be passive behavior.
Movement	Walking, running, swinging, climbing, playing alone, object handling.
Foraging	Collecting food, eating, drinking, interacting with food enrichments. Moving between food collecting and consumption may also be considered as foraging.
Interaction	Playing together, grooming, cuddling, submissive behavior, mating.
Dominant behavior	Chasing, throwing, dominant behavior, banging, hitting, shaking objects, aggressive screaming.
Stereotypical/abnormal behavior	Coprophagy, urophagia, rocking, smearing feces, scratching excessively.
Out of sight	When the chimpanzees move out of the camera frame.

Distributions

To test if enough data points had been collected for the data to be representative, the cumulated average of the time intervals was plotted for each behavior for all four chimpanzees in both weeks. Furthermore,summary statisticswerecalculated in PAST to obtain the median, skewness, kurtosis, and the25^{th,} and 75th percentiles. From the percentiles, the IQR was then calculated.Based on the kurtosis and skewness, it was determined whether the data were normally distributed or not.

The proportions of time spent on each behavior in a week were calculated by first subtracting the time spent "out of sight" from the total observation time. Then the percent spend on a given behavior was calculated using the adjusted observation time and the time spend on that behavior. This was done for all the observations in both weeks for all four chimpanzees. These data were used to illustrate the distribution of behaviors in the two weeks for each of the chimpanzees.To compare the weeks, a Mann-Whitney U test was performed on the medians, to determine whether there was a significant difference in the behaviors between the control week and the enrichment week, with a significance level of 0.05.

Differences in behavioral reaction norms

The difference in behavioral reaction norms for the chimpanzees was visualized by plotting the median, IQR, kurtosis, and skewness from the control and the enrichment weeks, in an X-Y plot, for a given behavior. Each plot contains either the median, IQR, kurtosis, or skewness for all four chimpanzees for a given behavior and the trendline between the plots for the individual. Additionally, the slopes of the trend lines were calculated and were used to analyze the personalities of the chimpanzees.If an individual displayed a positive slope for the IQR and a negative slope in kurtosis the data for that individual's behavior had a greater variance in the enrichment week than in the control week. A high variance makes it harder to predict the amount of time spent on a given behavior, and therefore it might not be possible to determine if there was a significant difference.If the skewness had a negative slope, it means that the individual might spend fewerseconds at a time on the specific behavior.χ^2 tests were performed on the slopes, to test for a significant difference in the personalities between the chimpanzees, with a significance level of 0.05.

Behavioral diversity

Shannon index was calculatedbased on the time intervals, to illustrate the behavioral diversity for each of the chimpanzees in the control and enrichment weeks. The indexes were tested with a χ^2 test for a significant difference in the behavioral diversity in the control and enrichment weeks. Furthermore,χ^2 tests were performed to determine whether there was a significant difference in thebehavioral diversity between the chimpanzees, in each week.In the test, the significance level was set to be 0.05.

Results

RCumulated average of the time intervals

The graphs showing the cumulated averages for each behavior in the control and the enrichment week (contact corresponding author for graphs) indicate that there was not collected enough data for it to be representative for any of the behaviors of the chimpanzees. Even though there is not enough data for most of the behaviors, there are some tendencies in the overall behaviour of the chimpanzees.

Distribution

Based on the summarystatistics (Appendix B), the skewness along with thekurtosis indicates that the data for the time intervalsare not normally distributed. This isdue tothe high skewness and that the kurtosisis not equal to 3,in all the datasets.Therefore, the median will be used as the measure of central tendency.Furthermore, the summary statistics showed a too small amount of data ($N<10$) in some of the behaviors, to perform any statistics on it.Therefore, only four of the behaviors; passive, movement, foraging, and interaction, are analyzed further.

The proportion of time spent on each behavior

The distribution of time spent on each behavior over a week for Sebastian, My, Jutta and Laura, in both the control and enrichment weeks, is illustrated in percent(Figure 1). For Sebastian there was almost no difference in overall passive behaviour between the control week and the enrichemtweek, while all three females showed an increase in passive bebavior in the enrichment week. All chimpanzees showed an increase or no change in movement behaviour. On the contrary all chimpanzees showed a decrease in fouragingbehaviour in the enrichment week. Only Sebastian showed an increase in interactions, while the three femalesspent less time on interactions in the enrichment week.

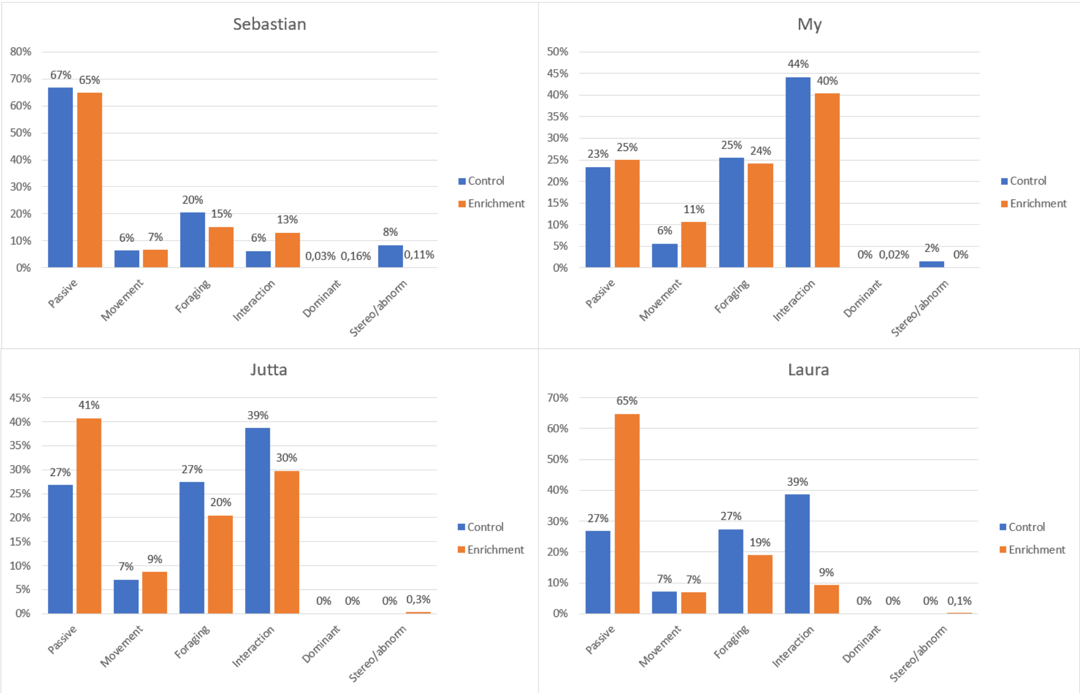

Figure 1:Illustrates the distribution of the percentage time the individual spent on the different behaviors, in the control and enrichment weeks, respectively. This is Illustrated for each of the four chimpanzees at Aalborg Zoo, with the behavior on the x-axis and the percentage on the y-axis.

Mann-Whitney U test

With a Mann-Whitney U test, the medians for four of the behaviors were tested for a significant difference, in the control week versus the enrichment week.The p-values of these tests only showed a significant difference inpassive behavior for Sebastian, whichhad a p-value of 0.037 (Table 2).

Table 2: P-values from the Man-Whitney U test on each behavior, tested for a significant difference in the medians between the control and enrichment week, for each of the four chimpanzees at Aalborg Zoo.

Mann-Whitney U test of medians

Sebastian		**My**	
	P-value		P-value
Passive	0.037	Passive	0.878
Movement	0.203	Movement	0.165
Foraging	0.886	Foraging	0.449
Interaction	0.160	Interaction	0.423
Jutta		**Laura**	
	P-value		P-value
Passive	0.248	Passive	0.329
Movement	0.153	Movement	0.244
Foraging	0.629	Foraging	0.063
Interaction	0.200	Interaction	0.070

Behavioral diversity

For each chimpanzee, the behavioral diversity was calculated, using the Shannon diversity index (Table 3). The indexes showed a slight difference between the control and enrichment weeks, for each individual, with a higher diversity after the enrichment.However, the $\chi 2$ tests showed that none of the diversity indexes were significantly different (Table 4).Additionally, none of the indexes were significantly different between each of the individuals, in neither the control nor the enrichment week, according to the performed χ2 tests (Table 5).

Table 3: Shows the behavioral diversity calculated with Shannon index, based on their time intervals, for all four chimpanzees at Aalborg Zoo.

	Shannon index	
	Control	Enrichment
Sebastian	0.954	1.032
My	1.273	1.294
Jutta	1.263	1.280
Laura	0.881	1.006

Table 4: Shows the p-values from the χ^2 tests performed on the Shannon index, tested for a significant difference in the behavioral diversity between the control and the enrichment weeks.

Behavioral diversity index, χ2 test p-values			
Sebastian	My	Jutta	Laura
0.964	1	1	0.938

Table 5: Shows the p-values from the χ^2 tests performed on the Shannon index. Tested for a significant difference in the behavioral diversity between each of the four individuals.

	Behavioral diversity index, χ2 test p-values					
	Sebastian x My	Sebastian x Jutta	Sebastian x Laura	My x Jutta	My x Laura	Jutta x Laura
Control	0.860	0.865	0.964	1.000	0.827	0.830
Enrichment	0.888	0.893	1.000	1.000	0.877	0.882

Differences in behavioral reaction norms

The slopes of the trendlines for the median, skewness, kurtosis, and IQR (Appendix C) for the behaviors expressed in the control and enrichment weeks were used to calculate whether there was a significant difference in the personalities between the individuals (Table 6).

Passive

There was a significant difference in the medianfor Sebastian x My ($p<0.05$) and for Sebastian x Laura and Jutta x Laura ($p<0.01$)(Table 6).All four had positive slopes for the medians(Appendix C).For skewness, there was only a significant difference for Sebastian x My and Sebastian x Jutta ($p<0.05$)(Table 6).Sebastian had a negative slope, where the othershad a positive slope(Appendix C). For kurtosis,there was a significant difference forSebastian x Laura ($p<0.01$) and between the rest of the individuals ($p<0.001$)(Table 6).Sebastian had a negative slope, where the others had positive slopes(Appendix C). For the slopes of IQR there wasa significant difference for Jutta x Laura ($p<0.05$) and between the rest of the individuals ($p<0.001$)(Table 6). My had a negative slope, where the others had positive slopes (Appendix C).

Movement

For the median,Myhadno slope, whilethe rest of the individuals had negative slopes (Appendix C). For skewness, Sebastian had a negative slope, whereas the others had positive slopes(Appendix C).For kurtosis,there was a significant difference for Sebastian x Jutta ($p<0.05$), My x Laura ($p<0.01$), and between the rest of the individuals ($p<0.001$)(Table 6).Sebastian had a negative slope, where the others had positive slopes(Appendix C). For IQR there were significant differences for Sebastian x Jutta and Sebastian x Laura ($p<0.01$) and between the rest of the individuals ($p<0.001$) (Table 6).My and Sebastian hadpositive slopes, Jutta and Laura on the other hand hadnegative slopes (Appendix C).

Foraging

For the behavior foraging,there was a significant difference in the median for Jutta x Laura ($p<0.05$) and between the rest of the individuals ($p<0.001$)(Table 6).Sebastian had a negative slope, where the others had positive slopes(Appendix C).For skewness, there were no significant differences between any of the chimpanzees ($p>0.05$)(Table 6).For kurtosis,there wereno significant differencesforMy x Jutta, My x Jutta, and Jutta x Laura ($p>0.05$), but there were significant differences between the rest of the individuals ($p<0.001$)(Table 6).Sebastian had a positive slope, whereas the others had negative slopes(Appendix C). For IQR there was no significant difference for Sebastian x My ($p>0.05$) but there were significant differences between the rest of the individuals ($p<0.001$) (Table 6).Laura had a positive slope, where the others had negative slopes (Appendix C).

Interaction

For the behavior interaction,there was a significant difference forSebastian x Laura ($p<0.05$) and between the rest of the individuals ($p<0.001$)(Table 6).Juttahad a positive slope, where the others had negative slopes (Appendix C).For skewness, there were no significant differences between any of the chimpanzees ($p>0.05$) (Table 6).For kurtosis,there was a significant difference forJutta x Laura ($p<0.001$) and for Sebastian x Jutta and My x Laura ($p<0.01$)(Table 6).All four hadpositive slopes(Appendix C). For IQR there was no significant difference for Sebastian x My ($p>0.05$), but there were significant differences between the restof the individuals ($p<0.001$) (Table 6). Jutta had apositive slope, whereas the others had negative slopes (Appendix C).

Table6: Shows the p-values from the χ^2 tests performed on the slopes of the trendlines for the median, skewness, kurtosis, and IQR (Appendix C), to test for a significant difference. This is tested on each behavior, for all four chimpanzees at Aalborg Zoo.The notation n.s. stand for nonsignificant and indicates $p>0.05$, * indicates $p<0.05$, ** indicates $p<0.01$, and *** indicates $p<0.001$.

Median, χ2 test p-values of X-Y-plot slopes

	Sebastian x My	Sebastian x Jutta	Sebastian x Laura	My x Jutta	My x Laura	Jutta x Laura
Passive	*	n.s.	**	n.s.	n.s.	**
Movement	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Foraging	***	***	***	***	***	*
Interaction	n.s.	***	*	***	n.s.	***

Skewness, χ2 test p-values of X-Y-plot slopes

	Sebastian x My	Sebastian x Jutta	Sebastian x Laura	My x Jutta	My x Laura	Jutta x Laura
Passive	*	*	n.s.	n.s.	n.s.	n.s.
Movement	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Foraging	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Interaction	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

Kurtosis, χ2 test p-values of X-Y-plot slopes

	Sebastian x My	Sebastian x Jutta	Sebastian x Laura	My x Jutta	My x Laura	Jutta x Laura
Passive	***	***	**	n.s.	***	***
Movement	***	*	***	***	**	***
Foraging	***	***	***	n.s.	n.s.	n.s.
Interaction	n.s.	**	n.s.	n.s.	**	***

IQR, χ2 test p-values of X-Y-plot slopes

	Sebastian x My	Sebastian x Jutta	Sebastian x Laura	My x Jutta	My x Laura	Jutta x Laura
Passive	***	n.s.	n.s.	***	***	*
Movement	n.s.	**	**	***	***	n.s.
Foraging	n.s.	***	***	***	***	***
Interaction	n.s.	***	***	***	***	***

<0.05 **<0.01 *<0.001 n.s.>0.05*

Discussion

distribution

There weretendencies but no significant differences in the overall behaviour of the chimpanzees between the control week and the enrichment week. The females seemed to react different than Sebastian on enrichment. Females in general showed an increase in passive behaviour and interactions, and a decrease in time spent onfouraging.The different behavior by Sebastian may be due to his status as alpha male. In a study thatexamined radio music as enrichment for four single caged baboons showed nodifferences in behaviors of the individuals,yet heartrates of the baboons decreased when they listened to the music(Brent and Weaver, 1996).A slowed heartrate could be the reason for an increase in passive behavior for the female chimpanzees.Lack of significant difference in the medians, may be due to the small sample size.However, the data showed significant differences in behavioral reaction norms, between thechimpanzees.

Differences in behavioral reaction norms

The discussion about the differences in behavioral reaction normsis based on the slopes of the trend lines in the graphs(Appendix C) and the calculated χ^2 tests on those(Table 6).

Heteroscedasticity

The fact that Jutta had a significantly different slope for the median in interaction, compared to the other chimpanzees,could be explained by the IQR and kurtosis.Juttahad a steep positive slope for IQR, and a negative slopefor kurtosis, which indicates a greater variance and less predictability in behavior. This could be an indication of heteroscedasticity which describes a difference in variability of the variance between the control and enrichment weeks (Sin and Lee, 2020). Consequently,this could have affected the results of the Mann-Whitney U tests, where homoscedasticity is expected.

Sebastian

Sebastian´s slopes for passive behavior for the median and IQR weresignificantly different from My. This could be because My is younger than Sebastian which can influence their way of reacting to the enrichment. This is explained more thoroughly when discussing My'sbehavioral reaction norms. It could also be caused byheteroscedasticity.In foraging, there was a significant difference in the kurtosis slopes between Sebastian and the females. This makes the behavior more unpredictablefor the femalechimpanzees, andcould therefore mean that there might not have been a difference at all, due to possible heteroscedasticity. Significant differenceswas found between the median slopes for interaction between Sebastian andthe two adult females Jutta and Laura, but there was not found anydifference between Sebastian and My. This is likely due to all the play that was observed between My and Sebastian, where the adult females did not play much. Another study found out that male chimpanzees played more than female chimpanzees at all age stages (Bloomsmith et al., 1994), this explains the playful behavior expressed by Sebastianeven though he is considered an adult (Hamada et al., 1996).

Jutta

The trendline slopes of the IQR for foraging, were significantly different between Jutta and Laura. This means that for Laura, it might be necessary to take heteroscedasticity into consideration. For the median, Jutta's slope was significantly different from My, Laura and Sebastian's.This difference in personalities of foraging might be sinceJutta has adifferentrearing history than the other chimpanzees. Sebastian, Laura, and My are all born in Aalborg Zoo, but Jutta is wild-bornin Africa. She was captured and taken from her mother at a very young age, and later brought to Aalborg Zoo at an age of approximately 6 years old.Studies of chimpanzees using social information from conspecifics to solve the experimental task have shown that a chimpanzee's sex, rearing history, and age are three factors that appear to influence optimal learning behavior (Watson et al., 2018). Chimpanzees may be more sensitive to social information, during their early life (Biro et al., 2003; Lonsdorf, 2005). An example of this is, that in an experiment it was found that wild-born captive chimpanzees were more likely to successfully use a tool in a food-raking task than captive-born individuals (Brent et al., 1995). Furthermore, an experiment showed that chimpanzees have a critical period, between the age of 3 and 5 years old, where they socially learn the challenging skill of nut-cracking behavior (Biro et al., 2003).Based on these studies, Jutta's rearing might be the reason that she reacts differently than the other chimpanzees, in her foraging behavior, while presented to anunknown stimulus.Since she was taken from her mother at a very young age, she might not have received social learning to be adaptive, in her early years.Besides the possible effect of early-life sensitivity to social information, another study(Lacreuse et al., 2014)found that younger chimpanzeesperformed better on social cognition tasks than olderfemales. Since Jutta is both an old female chimpanzee,in the aspect of the lifespan for chimpanzees in captivity(Wood et al., 2017), and is at least 20 years older than the other chimpanzees at Aalborg Zoo, this might also be a reason for the difference in personalities between her and her peers. It was likewise found that Jutta differed in interaction, from the other chimpanzees. She, as the only one, had a positive slope, which might also be due to her rearing history. However, since her kurtosis was decreasing and the IQR was increasing, this could as well be due to heteroscedasticity.

My

There was only a significant difference in themedian slopes for interaction between Myand Jutta. This might be sinceMy is still considered a juvenile, and therefore is still playing more, in this case with Sebastian.My willnotbe considered mature untilaround the age of 12.5 years if she follows the same pattern as the chimpanzees from the Sanwa Laboratory (Hamada et al., 1996). Chimpanzees tend to groom more and play less,the older they get. In this experiment, we did not seemuch groomingoccurringregularly, by any of the chimpanzees,which also could be a reason why My and Jutta had adifferencein the slopes of the median. However, the IQR for Jutta's slope of interaction was increasing, and therefore the difference could be due to heteroscedasticity.There was no significant difference between Myand Sebastian. This might be sinceSebastian was observed playing a lot with My, which contributes to his median slope for interaction.

Laura

Laura and My had similar slopes for passive behavior but different to the other chimpanzees. This might be since they both are placed in the lower half of the hierarchy. However, it islikely caused by heteroscedasticity, sinceLauras IQR was increasing while My's was decreasing. Laurawas significantly different from Sebastian when comparing the medianslopes for foraging. In a study, it is explained that male chimpanzees need to consume more calories than females(Hamada et al., 1996).In the Sanwa laboratory, the male chimpanzee'saverage weight was 53 kg and the average chimpanzee female weight was 45 kg(Hamada et al., 1996).This will make a difference in the nutrition consummation because the intake is calculated by the individual´s weight(Hamada et al., 1996).Based on the information from the study by Hamada et al. (1996), Sebastian would likely have had more foraging behavior than Laura. However, this study showed the opposite which might be causedbyheteroscedasticity, since Lauras IQR is steeply increasing.

Observationsof the different behaviors of the chimpanzees

The hypothesis was that the use of the sleep meditation would decrease the dominant behavior especially of the alpha male Sebastian. This tendency has been proved in two other studies(Howell et al., 2003; Videan et al., 2007). Based on our observations the enrichment failed to do this and had the exact opposite effect on him. In fact, in a comparison between the weeks, Sebastian showed a tendency to increase in dominant behavior from 0.03% to 0.16% (Figure 1). Another study of wild chimpanzees from the Tai National Park, found that the chimpanzees produce more cortisol, and is therefore, more stressed when the social hierarchy is unstable. When the hierarchy was stable, they were less stressed but showed an increase in dominant behavior(Preis et al., 2019). On that note, the more frequent observations of dominant behavior could be an indicator that the chimpanzees are less stressed.

Multiple studies show that music has a decreasing effect on stereotypical/abnormal behavior (Miller et al., 2016a; Wells and Irwin, 2008). This study, with the chimpanzees at Aalborg Zoo, as well showed a tendency towards a decrease in stereotypical/abnormal behavior for Sebastian and My, from 8% to

0.11% and 2% to 0% (Figure 1). Even though this is not a direct sign of better welfare, it is still likely a sign of an improvement(Mason and Latham, 2004).

The χ^2 testson the slopes for foraging, showed a difference in personality between all the chimpanzees. The reason for this might lie in the differences in how they react when they are given food. This was observed when the chimpanzees were given food enrichment in different objects,as a task. Laura often avoided the other chimpanzees while interacting with the enrichment, which might have been to avoid anyone stealing it from her, since she is at the lower half of the hierarchy. Jutta always spent more time with the food enrichment, than the other chimpanzees. Sebastian often stole the enrichment from My, which likely is because he is the alpha male, and therefore used his dominance as an advantage to get more food. My would often go to the other chimpanzees, where she would plead for food, and collect what the other dropped. This difference in their way of reacting to the food enrichment might have hadaninfluence on the slopes for foraging, in both the medians and the predictability, since even though their reaction seems somewhat predictable, the amount of time they spent on the enrichment is different from both each other and from one day to another.

Conclusion

It was possible to observe some changes in the distribution of behaviors for each individual between the control and enrichment weeks. However, based on the Mann-Whitney U test it can be concluded that it was only Sebastian that had a significant difference in the median for the passive behavior. The rest of the differences in medians for the chimpanzees were not significant, in any of the behaviors.Based on the graphs of the cumulated averages it can be concluded that we did not collect enough data for it to be representative for the behaviors observed in the chimpanzees, which might be why no differences in the medians were observed.However, when analyzing the differences in personalities, between the chimpanzees, some differences were shown.

Based on the results of the Shannon index it can be concluded that even though we did observe some differences in the behavioral diversity between the control and enrichment week, these were not significant. The test also showed that there were no significant differences between the individuals' behavioral diversity in neither the control week nor the enrichment week.Therefore, it is not possible to confirm the hypothesis that sleep meditation results in more diverse behavior.

It was observed that Sebastian had an increase in dominant behavior which disproves the hypothesis that sleep meditation reduces dominant behavior. However, based on Preis et al.(2019) the increase in dominant behavior couldsupport the hypothesisthat sleep meditation has a calming effect since dominant behavior can be an indication of a less stressful environment.

It is not possible to conclude wether the sleep meditation resulted inthe change in behavior of the four chimpanzees, as observed. This might be due to lack of statistical power. Since some of the graphs for cumulate average indicates that more data should have been collected(contact corresponding author for graphs), an improvement of this study could be a bigger sample size. In a future experiment it should be considered wether to observe the chimpanzees for longer time increaments or a longer period collecting data.

Based on the behavioral reaction norms it can be concluded that the study has shown a significant difference in the personalities between the chimpanzees. The trend lines in the X-Y plots (Appendix C), and the χ^2 tests of the slopes (Table 2) showed that there were some significant differences between some of the chimpanzee's slopes. This is an indicator of the different behavioral reaction norms that the individuals display. Therefore, it can be concluded that the individuals have different personalities that result in different behavioral reactions when exposed to the sleep meditation. The personalities might thereforeeffect the results of the auditory enrichment. In order to take the personalities into consideration when dicussing the result it would be neccesary to observe their behavior for as long as months or years.

Acknowledgements

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Appendix

Appendix A

Appendix A: Picture of the chimpanzee enclosure at Aalborg Zoo, which was the setting of this experiment. The rings indicate where the three cameras and the speaker used were placed, during the experiment.It should be taken into account, that the picture does not coverall angles of the enclosure, and therefore is not representing the total space available.

APPENDIX C

Sebastian, Control	Passive	Movement	Foraging	Interaction	Dominant	Stereo/abnorm
N	142	207	83	45	2	1
Median	23	12	60	18	8.5	46
25 prcntil	9	7	11	5.5	3	46
75 prcntil	81.75	20	187	43	14	46
Skewness	5.39	2.31	2.62	4.32	0.00	0
Kurtosis	30.42	7.37	8.53	21.90	-2.75	0
IQR	72.75	13	176	37.5	11	0

Sebastian, Enrichment	Passive	Movement	Foraging	Interaction	Dominant	Stereo/abnorm
N	91	191	67	45	8	3
Median	39	11	46	8	8.5	9
25 prcntil	15	6	16	4.5	8	6
75 prcntil	130	21	148	27.5	11.5	36
Skewness	4.67	2.28	4.69	4.84	0.28	1.67
Kurtosis	22.38	5.61	29.09	23.30	-0.72	-2.33
IQR	115	15	132	23	3.5	30

My, Control	Passive	Movement	Foraging	Interaction	Dominant	Stereo/abnorm
N	112	195	85	68	0	7
Median	22.5	11	47	26.5	-	83
25 prcntil	9	6	11.5	5	-	45
75 prcntil	65.75	18	241.5	88.25	-	202
Skewness	3.73	1.99	1.64	4.03	-	0.87
Kurtosis	14.55	4.74	1.97	17.28	-	-0.71
IQR	56.75	12	230	83.25	-	157

My, Enrichment	Passive	Movement	Foraging	Interaction	Dominant	Stereo/abnorm
N	111	228	78	56	1	0
Median	27	11	52.5	11.5	7	-
25 prcntil	11	6.25	16	6	7	-
75 prcntil	57	23	205.25	52	7	-
Skewness	9.77	7.48	1.35	3.44	0	-
Kurtosis	99.82	68.07	0.61	11.64	0	-
IQR	46	16.75	189.25	46	0	-

Jutta, Control	Passive	Movement	Foraging	Interaction	Dominant	Stereo/abnorm
N	74	107	53	48	0	0
Median	30	15	78	12.5	-	-
25 prcntil	11.75	8	25	5	-	-
75 prcntil	108.25	38	399.5	85.25	-	-
Skewness	2.75	3.66	2.40	3.37	-	-
Kurtosis	6.87	15.66	6.84	11.67	-	-
IQR	96.5	30	374.5	80.25	-	-

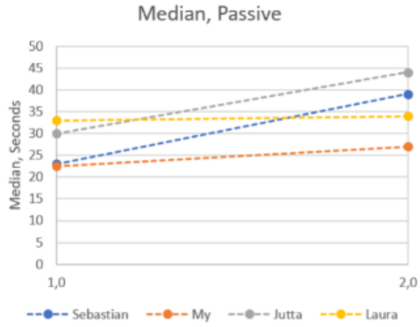
Jutta, Enrichment	Passive	Movement	Foraging	Interaction	Dominant	Stereo/abnorm
N	135	181	47	18	0	2
Median	44	14	145	64	-	74.5
25 prcntil	16	8	36	5.75	-	60
75 prcntil	170	24	323	1437.75	-	89
Skewness	7.89	3.94	1.60	1.67	-	0
Kurtosis	72.08	19.43	1.85	1.73	-	-2.75
IQR	154	16	287	1432	-	29

Laura, Control	Passive	Movement	Foraging	Interaction	Dominant	Stereo/abnorm
N	132	172	66	38	0	8
Median	33	13.5	73	26.5	-	59
25 prcntil	13	7	15.75	9	-	49
75 prcntil	96.75	30.5	202.25	218.5	-	84.5
Skewness	4.72	3.21	2.04	2.17	-	0.84
Kurtosis	22.83	9.48	4.60	3.23	-	0.90
IQR	83.75	23.5	186.5	209.5	-	35.5

Laura, Enrichment	Passive	Movement	Foraging	Interaction	Dominant	Stereo/abnorm
N	130	161	55	21	0	0
Median	34	12	112	10	-	-
25 prcntil	17	7	35	5.5	-	-
75 prcntil	126.75	21.5	349	67.5	-	-
Skewness	4.95	5.93	0.76	3.75	-	-
Kurtosis	26.19	41.07	-0.67	14.83	-	-
IQR	109.75	9.5	314	62	-	-

Appendix C: Statistic summary of each chimpanzee, on each behavior in the control and enrichment weeks. Shows the numbers of observations (N), median, $25^{th,}$ and 75^{th} percentile, skewness, kurtosis, and IQR, all based on the time intervals.

APPENDIX B


Median, Passive
Median, Seconds
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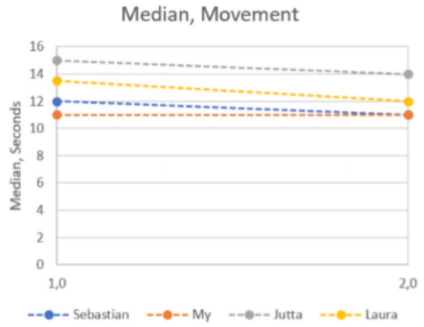
Sebastian My Jutta Laura


Median, Movement
Median, Seconds
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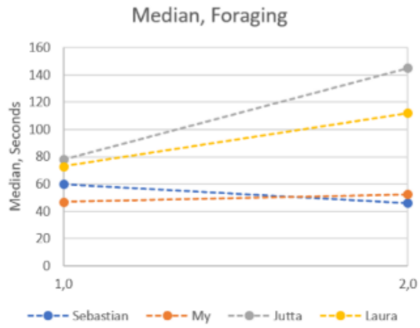
1,0 2,0
Sebastian My Jutta Laura


Median, Foraging
Median, Seconds
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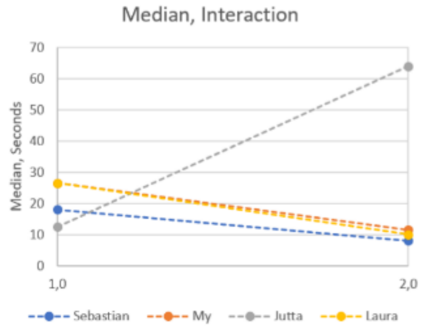
Sebastian My Jutta Laura


Median, Interaction
Median, Seconds
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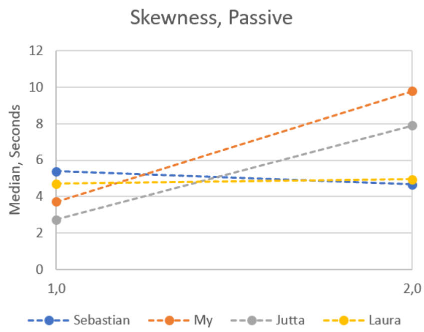
Sebastian My Jutta Laura


Skewness, Passive
Median, Seconds
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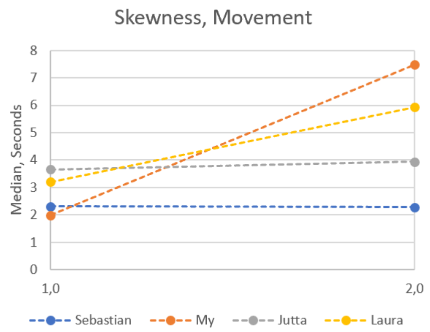
Sebastian My Jutta Laura


Skewness, Movement
Median, Seconds
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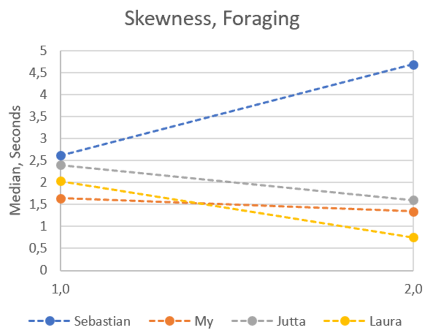
Sebastian My Jutta Laura


Skewness, Foraging
Median, Seconds
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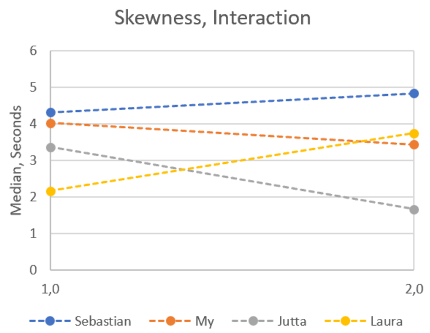
1,0 2,0
Sebastian My Jutta Laura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Median, Seconds
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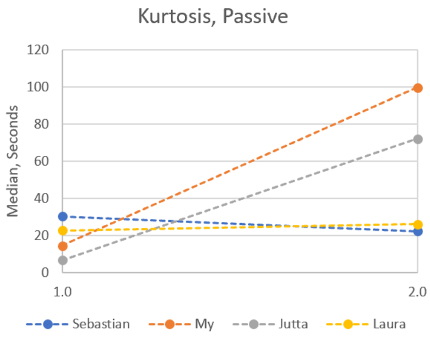
Sebastian My Jutta Laura


Kurtosis, Passive
Median, Seconds
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100
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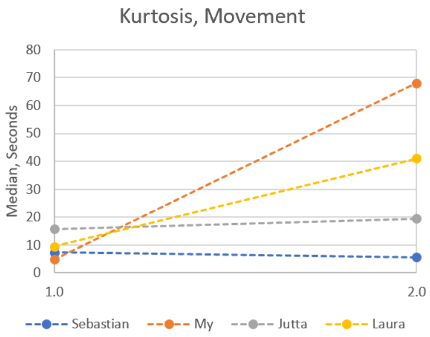
Sebastian
My
Jutta
Laura


Kurtosis, Movement
Median, Seconds
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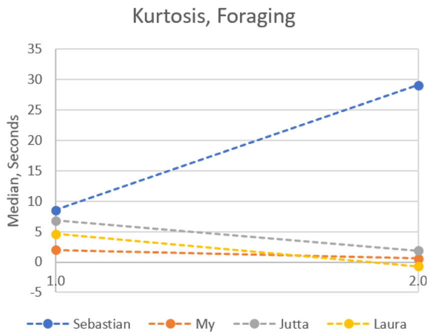
Jutta
Laura


Kurtosis, Foraging
Median, Seconds
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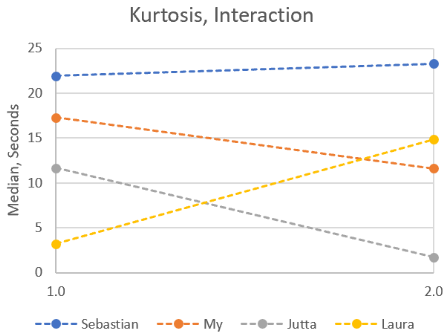
Sebastian
My
Jutta
Laura


Kurtosis, Interaction
Median, Seconds
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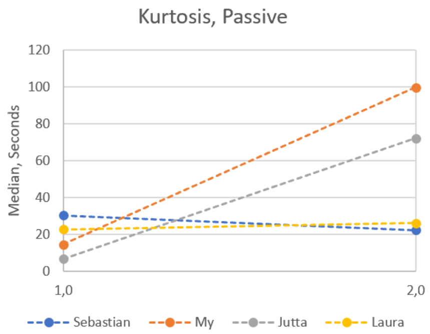
Laura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Median, Seconds
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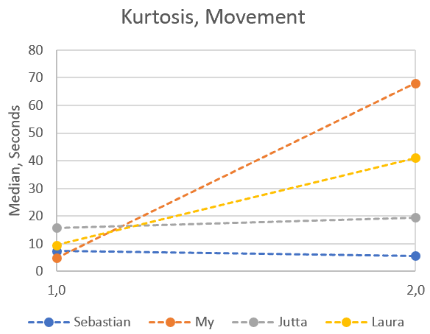
Sebastian
My
Jutta
Laura


Kurtosis, Movement
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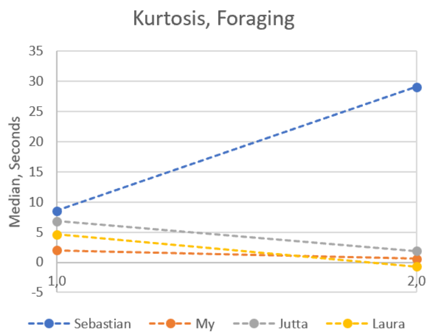
Kurtosis, Foraging
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Sebastian
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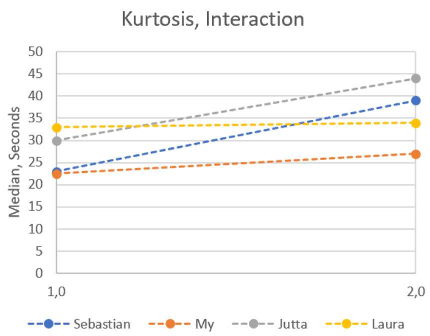
Kurtosis, Interaction
Median, Seconds
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Sebastian
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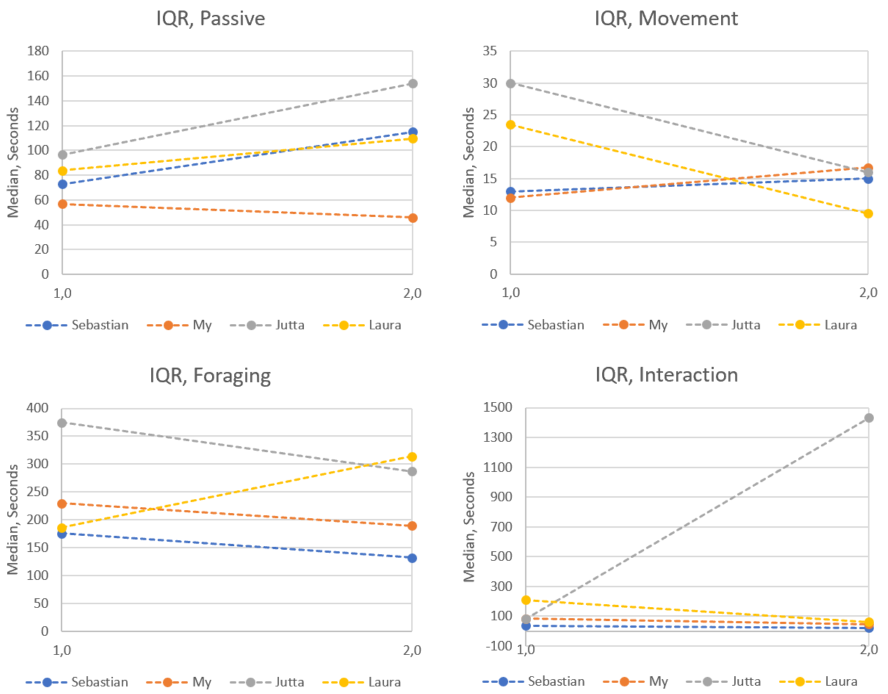
Jutta
Laura



Appendix B: Illustrates the behavioral reaction norms, as an X-Y plot. Shows the median, skewness, kurtosis, and IQR of the time intervals, in the control and enrichment weeks, for each of the four individuals.This is shownforeach of the behaviors; passive, movement, foraging, and interaction, with a trend line between the medians, skewness, kurtosis, and IQR, respectively,of the two weeks for the same individual.The skewness represents the asymmetry while the IQR represents the variance. χ^2 tests were performed on each slope, to compare the individuals' personalities (Table 6).