Human Visitation, Temperature, and Their Effects Upon Chimpanzee (*Pan troglodytes*) Spatial Distribution and Behavior at the Detroit Zoo

William Brown

Advisor: John Mitani

Introduction

Zoological institutions are constantly striving to improve the lives of their captive animals. Research on nonhuman primates has featured prominently in this attempt. For example, studies have examined how grooming interactions between individuals (Clark 2011; Kanngiesser et al. 2011), enclosure size (Judge & de Waal 1993; Bettinger et al. 1994; Videan & Fritz 2007; Ross et al. 2011), enrichment (Celli et al. 2003; Robins & Waitt 2011), and environmental complexity (Schapiro et al. 1997; Beisner et al. 2009) affect the well-being of captive animals. Additional research has investigated how human visitors influence the behavior of captive animals. Here prior studies have found that large crowds of zoo visitors led to an increase in the locomotor activity of primates (Hosey and Druck 1987; Mitchell et al. 1992). Alternatively, chimpanzees interact with human visitors to acquire food from them (Cook & Hosey 1995). Other primate species react to human presence in different ways, with human visitors generally adding to the stress experienced by the animals, and rarely, if ever, enriching their lives (Chamove et al. 1988). This potentially creates a problem as chronic stress poses many dangers to the long-term health of captive animals (Sapolsky et al. 1990; Sapolsky 1996).

If human visitors act as an added stressor to captive primates, then we should see an increase in stress-induced behavior, such as rough scratching, self-grooming, and yawning (Baker & Aureli 1997). In this context, a study of western lowland gorillas produced conflicting results. At one zoo, there was a positive correlation between visitor density and gorilla self-scratching frequency. At the second zoo, however, the presence of human visitors did not affect the amount of time gorillas self-scratched themselves (Carder & Semple 2008). Some studies have suggested that primates do not view humans as a source of stress, but instead view them with indifference or even as a source of potential enrichment. For instance, human visitors interact with captive chimpanzees over prolonged periods (Cook & Hosey 1995). One could argue that these interactions do not induce stress on the part of animals, and that exchanges between them are in fact beneficial insofar as they enrich the chimpanzees' lives.

These conflicting results highlight some of the problems associated with conducting research investigating the effects of human visitors on captive animals, as results vary even when studying the same species. What factors may have led to these disparate results? One possibility is that each zoo is unique and presents a different set of variables that affect matters. These include, but are not limited to, enclosure characteristics and the demographics of the animals who are on display. Another factor that can change daily and seasonally is temperature.

Previous research has investigated whether temperature influences the use of space by nonhuman primates. One study found that captive gorillas tended to spend more time near structures when it got hot (Stoinski et al. 2001). The implication was that the animals did so to maximize the amount of time they spent in the shade. Additional research used human participants, who spent one week living in an old outdoor orangutan enclosure (Litchfield et al. 2011). The universal complaint from all participants was heat discomfort. Many studies support the idea

that temperature plays a significant role in affecting not only how primates use space, but also their behavior. For example, chacma baboons increase their rates of grooming and resting and actively seek out shade in response to thermal stress (Hill 2006). Wild chimpanzees have also been observed to seek shade and increase their time spent resting during times of higher temperatures (Kosheleff & Anderson 2008). While these studies suggest that temperature affects the behavior of captive primates in important ways, other research has failed to show a relationship between temperature and habitat use (Ogden et al. 1990; Bettinger et al. 1994).

In this thesis, I build on the previous research outlined above and examine the effects of human visitors on the spatial distribution and behavior of captive chimpanzees. A second objective was to determine whether temperature influenced chimpanzee behavior and how they used their enclosure. Answers to these questions are important as they will help zoological institutions design effective plans to care for animals in captivity.

Methods

Subjects and Enclosure

This study was carried out on the chimpanzee colony at the Detroit Zoo in Royal Oak, Michigan, between June - September 2011. The group consisted of 11 chimpanzees. Each individual was easily recognizable by facial appearance and other anatomical features. Ten of the 11 chimpanzees were included in this study. I excluded one chimpanzee, a female infant who was born at the end this study in late August. Of the 10 study subjects, there were three males and seven females. One male was a three-year-old infant, while the remaining nine individuals were all adults, who ranged in age from 17-41 years old.

Human subjects were individuals who visited the zoo. For purposes of the following analyses, I did not record of the composition of human visitors.

The chimpanzee colony resided in a large outdoor, grass enclosure, separated from the public by a 20-foot high wall. The enclosure is meant to resemble a natural habitat, and thus contains multiple trees that are large enough for climbing, rocks, a pond, and artificial termite mound. A moat once surrounded the enclosure, but has since been drained. As a result, the areas adjacent to the surrounding wall are low and for the most part invisible to human visitors who stand outside the enclosure. These represent places that provide constant shade and are likely to be damp much of time due to runoff from rainfall that pools in the low-lying areas . During hot days, these locations provide appealing places for individuals who are trying to stay cool. The chimpanzees had unlimited access to the entire enclosure, but were kept indoors at night after public visiting hours.

Figures 1 and 2 depict the enclosure from two observation sites, while Figure 3 furnishes an aerial view of the enclosure.

Figure 1. View of the enclosure from observation site 3.

Figure 2. View of the enclosure from observation site 2.

Figure 3. Quadrant 1 is located in the top left, and Quadrant 14 is at the bottom right. Quadrant numbers are read top to bottom, then left to right.

The Quadrant System

Figure 3 shows the map used to record the location of chimpanzees during data collection. Fourteen zones or quadrants within the enclosure were defined (Figure 3). Because chimpanzees were known to spend large amounts of time in certain "hot spots," the quadrants were established, in part, to maintain the integrity of these areas. In addition, quadrants were divided based on landmarks to ensure that locations of chimpanzees were recorded accurately. Landmarks included the bottom and top of a central hill in the middle of the enclosure, the termite mound, corners of the surrounding wall, and identifiable trees. The 14 quadrants that I established represented a compromise between the need to record locations accurately and having a sufficient number of areas to evaluate how chimpanzees used the enclosure.

Recording Procedure

In this study, scan samples of chimpanzee locations and behavior were made over four hour observation periods. Scans were conducted at 15 minute intervals. Data were collected twice per week, once on a weekday and once on the weekend. Observations were made in this fashion to attain variation in visitors over the course of the study, as larger crowds visit on the weekends.

Observations were made from one of nine locations outside of the chimpanzee enclosure (Figure 3) by two teams of observers. Two data sheets (Figures 4a and 4b) were used during each observation session. One was used by one team that covered the north side of the yard (observation sites 1-4), while another sheet was employed by a second team that made observations from the south side of enclosure (observation sites 5-9).

Time, cloud score, and temperature were recorded at the beginning of observation session. The primary purpose of recording cloud cover was to evaluate whether chimpanzees were in the shade. Cloud scores ranged from 0 to 2, with 0 being no cloud cover, 1 being partial cloud cover, and 2 being full cloud cover. Full cloud cover indicated that all chimpanzees were in the shade during the observation session regardless of their location in the enclosure. Temperature was recorded using a thermometer at the enclosure.

After recording enclosure climate conditions, data collection proceeded in the following manner. First, the number of visitors, excluding the observer, and disruption scores were recorded. Disruption scores ranged from 0 to 2, with 0 representing complete silence, 1 representing quiet to normal noise levels, and 2 representing normal to excessive noise levels. Disruption scores were recorded based on the assumption that the noise created by visitors may have impacted the behavior of chimpanzees more than the number of visitors. During scan samples, observers recorded the number, identities, activities, and quadrant locations of each visible chimpanzee. In addition, we scored whether chimpanzees were located in the shade or not. We randomized observations from each of the nine observation sites to minimize bias. In addition, observers made themselves as unobtrusive as possible and did not attempt to interact with the chimpanzees nor human visitors.

When chimpanzees were not visible from any site, they were scored as "unseen" for purposes of the following analyses.

Following data collection, observations were entered in an excel spreadsheet and later analyzed in MATLAB. In some cases, recording errors occurred. These primarily involved double sightings of the same individual during scan samples. In these situations, observations made during scans were excluded from analysis.

Behavior Categories

For the purposes of the following analyses, nine behavior categories were defined to describe the behavior of chimpanzees (Table 1). Definitions are adapted from an ethogram developed by Nishida and colleagues (Nishida et al. 1999).

1. Feeding:	Remove foodstuff (leaves and so on.) and liquid from the substrate, process, put into mouth, bite and chew, wodge and swallow it .
2. Grooming:	Using both hands, pushing the hair back with the thumb or index finger of one hand and holding it back while picking at the exposed skin with the nail of the thumb or index finger of the other. The chimpanzee can also use one hand, parting the hair in the same way and holding it back with the lower lip. Grooming may occur in bipedal, quadrupedal, sitting or lying posture.
3. Self-grooming:	Grooming (2) conducted on oneself.
4. Contact aggression:	Aggressive physical contact between two, or more, individuals.
5. Non-contact aggression:	The chimpanzee may move in a slow rhythmic cantering gait, run at a moderate speed or very fast. Display patterns include scrubbing, throwing, dragging branch, swaying branch, slapping, stamping, slap-stamping, flailing, drumming, raking, and chest beating. The display may also incorporate hair erection, compressed lips and face, or pant hoots. It can be bipedal, quadrupedal, or tripedal, and is typically a male display.
6. Resting:	Remaining immobile.
7. Playing:	There can be self or social play, and there is a facial expression connected with play, the play face, a type of locomotion that is seen only in the play context, the play walk, and a vocalization, laughing. There are many behaviors associated with play that include, but are not limited to: dangling, leaping, somersaulting, climbing, swinging, dragging, flailing, slapping, tickling, chasing, and wrestling.
8. Moving into an area	Entering into an area adjacent to the observation site.
9. Moving out of an area	Leaving an area adjacent to the observation site.
10. Unseen	Chimpanzee was not in view from any observation site.

Table 1. Chimpanzee behaviors recorded in this study.

Data Analysis

Number of Human Visitors vs. Number of Visible Chimpanzees

The primary purpose of this study was to determine whether human visitors affected how chimpanzee used space within their outdoor enclosure. To address this question, I performed a correlation analysis to examine the relationship between the number of human visitors and the number of chimpanzees who were visible at each moment in time. A positive correlation would suggest that visitors acted as a possible source of enrichment at this institution, with chimpanzees attracted to humans. A negative correlation would suggest that visitors stressed the chimpanzees, who hid as crowd size increased. No relationship would indicate that human visitors did not affect chimpanzee spatial distribution.

Number of Human Visitors vs. Behavior Frequency

Another goal of this study was to determine if human visitors affected chimpanzee behavior in other ways besides their use of space. To investigate this question, I plotted how frequently chimpanzees engaged in different behaviors with varying crowd sizes (Figure 6). These graphs provide an easy way to visualize how chimpanzee behavior changed as a function of visitor densities.

Number of Human Visitors vs. Temperature

I examined the relationship between the two independent variables of interest in this study to determine whether there was a potential interaction between them.

Distribution of Chimpanzee Behaviors

I plotted the frequencies of each of the nine behaviors recorded during this study plus the behavior of "unseen" to provide readers a sense of what the chimpanzees actually did during the course of a normal day.

Temperature vs. Number of Visible Chimpanzees

To what extent did increasing temperature influence the activity levels and hence visibility of chimpanzees to the viewing public? I investigated this question by conducting a correlation analysis examining the relationship between temperature and the number of visible chimpanzees.

Temperature vs. Behavior Frequency

In this study I also examined whether temperature affected chimpanzee behavior. Here I plotted how the frequencies of behaviors displayed by chimpanzees changed at varying temperatures.

Usage of the Enclosure

To evaluate how chimpanzees used the total area within the enclosure and to identify locations that were particularly favored, I constructed a graph displaying how frequently chimpanzees used each of the fourteen quadrants defined in this study.

Results

Number of Human Visitors vs. Number of Visible Chimpanzees

Figure 5 shows the correlation between the number of human visitors and the number of visible chimpanzees. Results indicate no relationship between these two variables ($r = 0.09$, $P > 0.25$). This result suggests that human visitors did not affect how chimpanzees used their enclosure.

Number of Human Visitors vs. Behavior Frequency

Figure 6 shows how chimpanzee behavior varied as a function of varying crowd sizes. No obvious trends emerge from these data. Chimpanzees rested for the most part regardless of the number of visitors. The data reveal that chimpanzees were frequently out of view from the public.

Number of Human Visitors vs. Temperature

Figure 7 shows the relationship between the number of human visitors and temperature. There was no relationship between these variables ($r = 0.04$, $P > 0.60$). As a result, the two independent variables of interest in this study did not interact in any obvious way.

Distribution of Chimpanzee Behaviors

Figure 8 shows the number of times chimpanzees engaged in various behaviors during the entire study. Chimpanzees rested a considerable amount of time, and were hidden from the viewing public in over half of all observations.

Temperature vs. Number of Visible Chimpanzees

Figure 9 shows the relationship between temperature and the total number of chimpanzees visible at any given time. There was a weak, but nonetheless, significant relationship between these variables ($r = 0.38$, $P < .001$). As temperature increased, fewer chimpanzees were visible to the public.

Temperature vs. Behavior Frequency

Figure 10 shows the variations in behavior frequencies between different temperature ranges. The chimpanzees began to hide more frequently from the viewing public with rising temperature. Similarly, most behaviors dropped in the frequencies they were displayed as temperature increased. Resting in particular decreased with increasing temperature.

Total Enclosure Usage

Figure 11 shows how often the chimpanzees spent in different locations or quadrants during this study. Chimpanzees spent most of the time in two quadrants when they were visible: quadrant 11 (11% of the time), and quadrant 7 (12% of the time). Only minimal amounts of time were spent in the other 12 quadrants.

Discussion

Results of this study indicate that chimpanzees hid from the viewing public most of the time (Figure 8). Nonetheless, temperature appeared to influence how they used space within their enclosure and their behavior. In contrast, the number of human visitors had little to no impact on what they did.

In this study, I documented a negative relationship between temperature and the number of visible chimpanzees. Chimpanzees started to hide with increasing temperature. They did so in areas that were near the wall of the enclosure. The ground in these areas is significantly lower and is therefore likely to be more damp than other sites that were exposed to the sun. In addition, the height of the wall surrounding the enclosure provides almost unlimited access to shade. These two factors provide for an ideal environment for chimpanzees to escape the sun and hot temperatures that they typically experience during the summer months.

As temperature rose, most behaviors decreased in frequency, but resting showed the most pronounced drop. This result is surprising because other studies have found that high temperatures lead to more resting by captive animals (Stelzner 1988; Hill 2006; Kosheleff & Anderson 2009). One complicating factor to consider is that chimpanzees were hidden from view most of the time. In these hidden areas there is no enrichment nor are chimpanzees fed, all of which suggests had they been visible, they would have been observed resting. If this were the case, then resting would account for an overwhelming amount of the total time spent by these captive chimpanzees. As a consequence, this would have been more in line with the findings of past research.

The fact that the subjects were hidden from view over 50% of the time is troubling, especially from the perspective of the zoo which presumably wants the chimpanzees to be seen by the public. Despite the large size of the enclosure, the chimpanzees were rarely seen outside a few select areas. A study of captive gorillas suggested that they frequent areas that provide the most functionality (Stoinski et al. 2002), and there is no reason to suspect that this doesn't apply to the chimpanzees observed in this research.

Figure 11 shows that, apart from the unseen condition, quadrants 7 and 11 were the most commonly utilized. Quadrant 7 includes a group of trees that provide a large shaded area, and quadrant 11 is located next to a building and overhang, also providing shade. These observations support the findings of Stoinski and colleagues who showed that captive gorillas spent significantly more time in close proximity to buildings and walls as temperatures increased (Stoinski et al. 2001). The benefits of the unseen areas have been noted above, and in this regard, the amount of time chimpanzees spent in these areas and in the two favored quadrants may not be surprising. This seems to be the biggest problem facing the Detroit Zoo with respect to keeping its chimpanzees on full view to the public.

One possible solution lies with research conducted in Senegal, which examined the use of caves by chimpanzees during high temperatures (Pruetz 2007). This study found that chimpanzees sought the shelter of caves when it got hot. Cave use is not a unique occurrence and has been observed in many primate species to

protect against high and low temperatures (Huang et al. 2003; Barrett et al. 2004).

Man-made caves in the enclosure would provide the chimpanzees with permanently shaded areas and concrete surfaces that would remain cool. Adding a water spring would provide another reason for chimpanzees to use the cave, as it would provide another added benefit to the chimpanzees in relation to overheating. Furthermore, it would reduce the amount of time that the chimpanzees spent in unseen areas and increase the number of times the public can actually see the chimpanzees.

Resting makes up the majority if the chimpanzees' daily activity. Wild chimpanzees spend roughly half of their time feeding and travelling (Matsumoto-Oda 2002). In captivity, the enclosure prevents significant amounts of travelling, and searching for food is unnecessary because the zoo provides it. This results in the chimpanzees having a lot of spare time that they allocate to resting.

Chimpanzees are highly intelligent animals and thus need constant stimulation. Varying feeding times has been found to decrease the amount of inactivity (Bloomsmith & Lambeth 1995). A second, more costly possibility would be to undertake something similar to the National Zoo in Washington D.C., which established a "think-tank" for its orangutans (Gilbert 1996). In the "think-tank," orangutans are given tasks, and are rewarded for their participation. The public is allowed to observe the animals as they perform, and therefore gain first-hand knowledge of an orangutan's mental capabilities. Installing something similar to the "think-tank" would be advantageous for both the Detroit chimpanzees and members of the public who visit them.

In conclusion, results of this study suggest that human visitation does not impact chimpanzee spatial distribution or behavior adversely. Instead, temperature seems to influence both. The effects of temperature shown here can be addressed relatively easily. The Detroit Zoo could utilize results of this study to create an environment that is stimulating for its chimpanzees and provides more opportunities for human visitors to actually see them.

References

Baker, K., Aureli, F. 1997. Behavioural Indicators of Anxiety: An Empirical Test in Chimpanzees. *Behaviour* 134: 1031-1050

Barrett, L., Gaynor, D., Rendall, D., Mitchell, D., Henzi, S. 2004. Habitual cave use and thermoregulation in chacma baboons (*Papio hamadryas ursinus*). *Journal of Human Evolution* 46: 215-222

Beisner, B., Isbell, L. 2009. Movement ecology in a captive environment: the effects of ground substrate on movement paths of captive rhesus macaques, Macaca mulatta. *Animal Behaviour* 78: 1269-1277

Bettinger, T., Wallis, J., Carter, T. 1994. Spatial Selection in Captive Adult Female Chimpanzees. *Zoo Biology* 13: 167-176

Bloomsmith, M., Lambeth, S. 1995. Effects of predicatble versus unpredictable feeding schedules on chimpanzee behavior. *Applied Animal Behavioural Science* 44: 65-74

Carder, G., Semple, S. 2008. Visitor effects on anxiety in two captive groups of western lowland gorillas. *Applied Animal Behaviour Science* 115: 211-220

Celli, M., Tomonaga, M., Udono, T., Teramoto, M., Nagano, K. 2003. Tool use task as environmental enrichment for captive chimpanzees. *Applied Animal Behavior Science* 81: 171-182

Chamove, A., Hosey, G., Schaetzel, P. 1988. Visitors excite primates in zoos. *Zoo Biology* 7: 359-369

Clark, F. 2011. Space to Choose: Network Analysis of Social Preferences in a Captive Chimpanzee Community, and Implications for Management. *American Journal of Primatology* 73: 748-757

Cook, S., Hosey, G. 1995. Interaction sequences between chimpanzees and human visitors at the zoo. *Zoo Biology* 14: 431-440

Gilbert, B. 1996. New ideas in the air at the National Zoo. *Smithsonian* 27: 32-8+

Hill, R. 2006. Thermal constraints on activity scheduling and habitat choice in baboons. *American Journal of Primatology* 129: 242-249

Hosey, G., Druck, P. 1987. The influence of zoo visitors on the behaviour of captive primates. *Applied Animal Behaviour Science* 18: 19-29

Huang, C., Wei, F., Li, M., Li, Y., Sun, R. 2003. Sleeping cave selection, activity pattern and time budget of white-headed langurs. *International Journal of Primatology* 24: 813-824

Judge, P., de Waal, F. 1993. Conflict avoidance among rhesus monkeys: coping with short-term crowding. *Animal Behavior* 46: 221-232

Kanngiesser, P., Sueuer, C., Riedl, K., Grossmann, J., Call, J. 2011. Grooming Network Cohesion and the Role of Individauls in a Captive Chimpanzee Group. *American Journal of Primatology* 73: 758-767

Kosheleff, V., Anderson, C. 2009. Temperature's Influence on the Activity Budget, Terrestriality, and Sun Exposure of Chimpanzees in the Budongo Forest, Uganda. *American Journal of Physical Anthropology* 139: 172-181

Litchfield, C., Dorrian, J., Davis, J., Lushington, K., Dawson, D. 2011. Lessons in primate heat tolerance: A commentary based on the "Human Zoo" experience. *Journal of Applied Animal Welfare Science* 14: 162-169

Matsumoto-Oda, A. 2002. Behavioral seasonality in mahale chimpanzees. *Primates* 43: 103-117

Mitchell, G., Tromborg, C., Kaufman, J., Bargabus, S., Simoni, R., Geissler, V. 1992. More in the 'influence' of zoo visitors on the behaviour of captive primates. *Applied Animal Behaviour Science* 35: 189-198

Nishida, T., Kano, T., Goodall, J., McGrew, W., Nakamura, M. 1999. Ethogram and ethonography of Mahale chimpanzees. *Anthropol. Sci.* 107: 141-188

Ogden, J., Finlay, T., Maple, T. 1990. Gorilla Adaptations to Naturalistic Environments. *Zoo Biology* 9: 107-121

Pruetz, J. 2007. Evidence of cave use by savanna chimpanzees (Pan troglodytes verus) at Fongoli, Senegal: implications for thermoregulatory behavior. *Primates* 48: 316-319

Robins, J., Waitt, C. 2011. Improving the Welfare of Captive Macaques (Macaca sp.) Through the Use of Water as Enrichment. *Journal of Applied Animal Welfare Science* 14: 75-84

Ross, S., Calcutt, S., Schapiro, S., Hau, J. 2011. Space Use Selectivity by Chimpanzees in an Indoor-Outdoor Enclosure. *American Journal of Primatology* 73: 197-208

Sapolsky, R. 1996. Stress, glucocorticoids, and damage to the nervous system: the current state of confusion. *Stress* 1: 1-19

Sapolsky, R., Uno, H., Rebert, C., Finch, C. 1990 Hippocampal damage associated with prolonged glucocorticoid exposure in primates. *The Journal of Neuroscience* 10: 2897-2902

Schapiro, S., Boomsmith, M., Suarez, S., Porter, L. 1997. A omparison of the effects of simple versus complex environmental enrichment on the behaviour of group-housed, subadult rhesus macaques. *Animal Welfare* 6: 17-28

Stelzner, J. 1988. Thermal effects on movement patterns of yellow baboons. *Primates* 29: 91-105

Stoinski, T., Hoff, M., Maple, T. 2001. Habitat Use and Structural Preferences of Captive Western Lowland Gorillas (*Gorilla gorilla gorilla*): Effects of Environmental and Social Variables. *International Journal of Primatology* 22: 431-447

Stoinski, T., Hoff, M., Maple, T. 2002. The Effect of Structural Preferences, Temperature, and Social Factors on Visibility in Western Lowland Gorillas. *Environment and Behavior* 34: 493-507

Videan, E., Fritz, J. 2007. Effects of short- and long-term changes in spatial density on the social behavior of captive chimpanzees (*Pan troglodytes*). *Applied Animal Behavioural Science* 102: 95-105

Wood, W. 1998. Interactions Among Environmental Enrichment, Visiting Crowds, and Zoo Chimpanzees (*Pan troglodytes*). *Zoo Biology* 17: 211-230

Figures 4a and 4b were the tables used to record at the 9 observation sites surrounding the enclosure. The numbers at the top of each grid indicate the observation site. Q represented the quadrant, or area, in which the chimpanzee is located within the enclosure; A represented the activity, or behavior, that chimpanzee is exhibiting; C was that chimpanzee's companion (if applicable); and S represented whether that chimpanzee was in the shade or not.

Name: Date: Time:

Cloud score (0-2): Crowd Size (H/L): Temp:

Site	1				2				3				4			
Number of Visitors																
Disruption Score																
	Q	A	C	S	Q	A	C	S	Q	A	C	S	Q	A	C	S
Abby																
Akati																
Bubbles																
Chiana																
Nyani																
Tanya																
Trixi																
Ajua																
Bahati																
Imara																
Unknown F																
Unknown M																
Unknown X																

Activity

1. Feeding 2. Grooming 3. Self-grooming 4. Aggression (w/ contact)
5. Aggression (no contact) 6. Resting 7. Playing 8. Relocating (T=toward, A= away from)

Other notes:

Should I use this data: YES / NO

Figure 4a. North side of yard.

Name: Date: Time:

Cloud score (0-2): Crowd Size (H/L): Temp:

Site	5				6				7				8				9			
Number of Visitors																				
Disruption Score																				
	Q	A	C	S	Q	A	C	S	Q	A	C	S	Q	A	C	S	Q	A	C	S
Abby																				
Akati																				
Bubbles																				
Chiana																				
Nyani																				
Tanya																				
Trixi																				
Ajua																				
Bahati																				
Imara																				
Unknown F																				
Unknown M																				
Unknown X																				

Activity

1. Feeding 2. Grooming 3. Self-grooming 4. Aggression (w/ contact)
5. Aggression (no contact) 6. Resting 7. Playing 8. Relocating (T=toward, A= away from)

Other notes:

Should I use this data: YES / NO

Figure 4b. South side of yard.

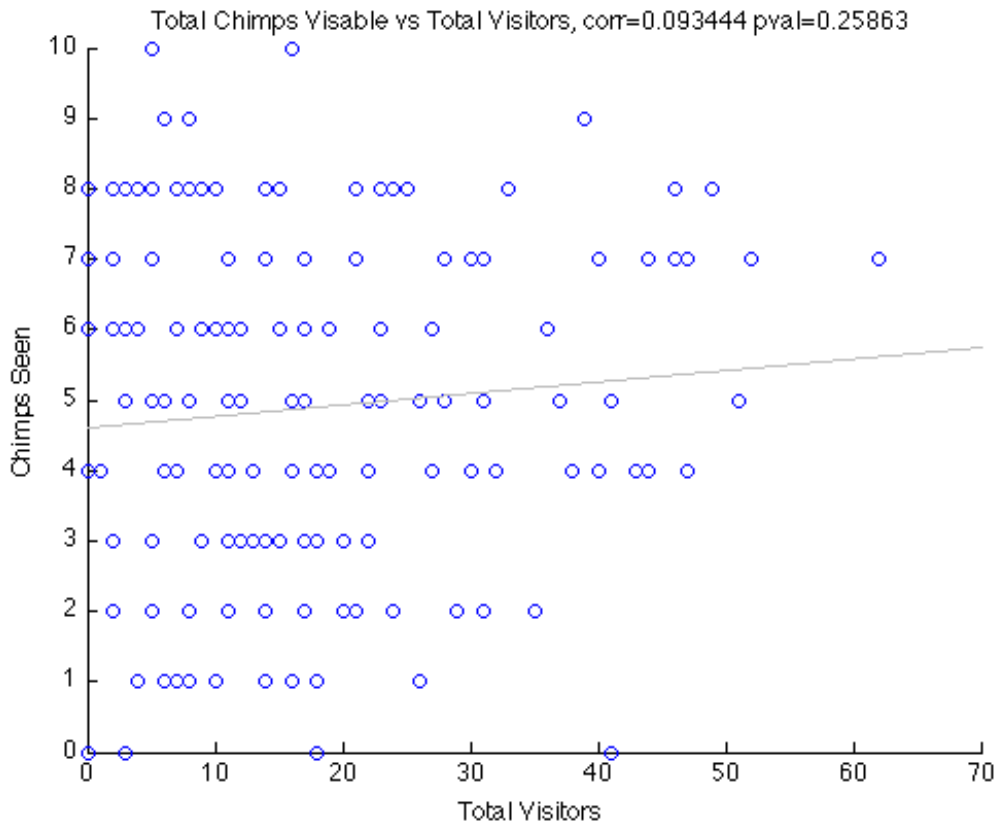

Figure 5. The total number of visible chimpanzees versus the total number of human visitors at any given time. There was no relationship between these two variables (r = 0.09, P > 0.25).

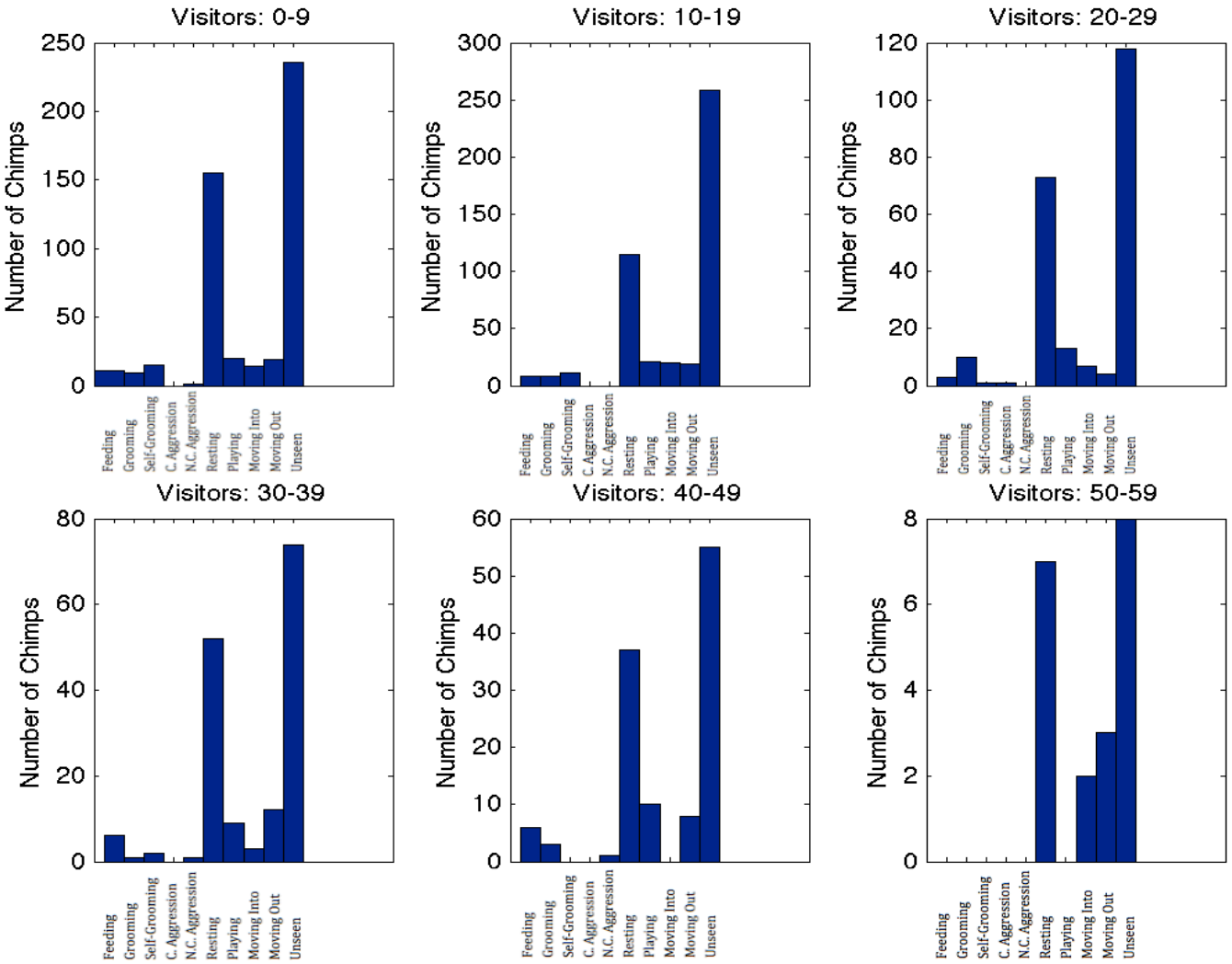

Figure 6. The behavior of chimpanzees at varying crowd sizes.

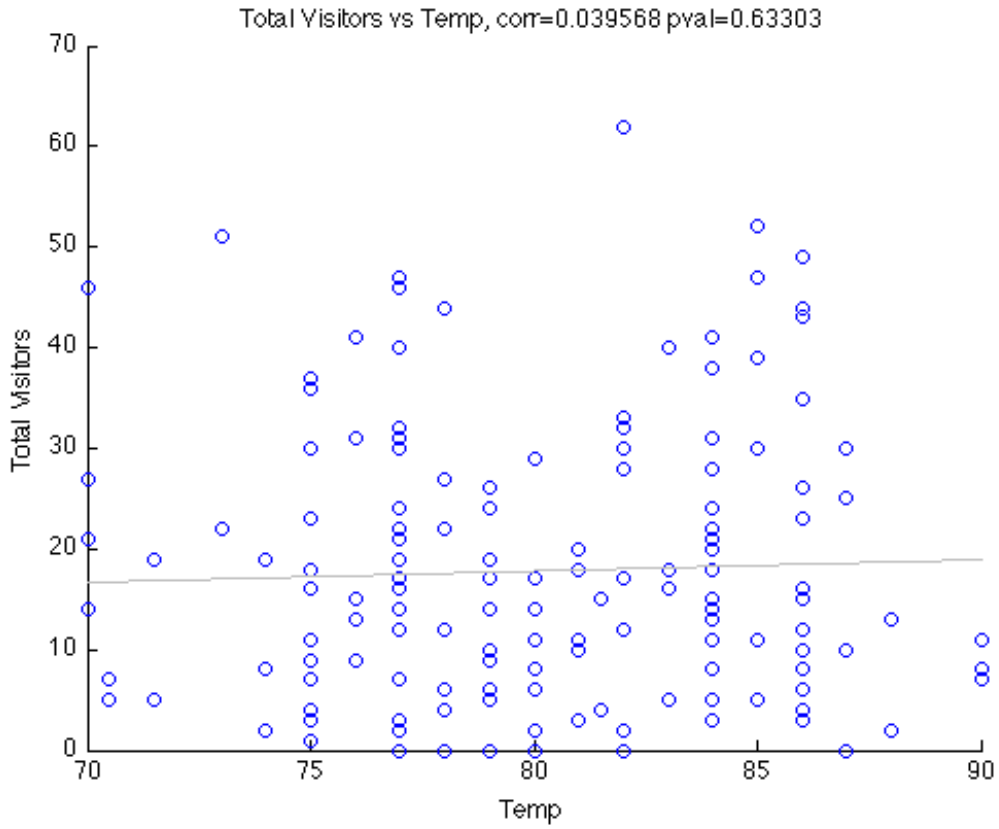

Figure 7. The total number of visitors at the chimpanzee enclosure versus temperature. There was no relationship between these two variables (r = 0.04, P > 0.60).

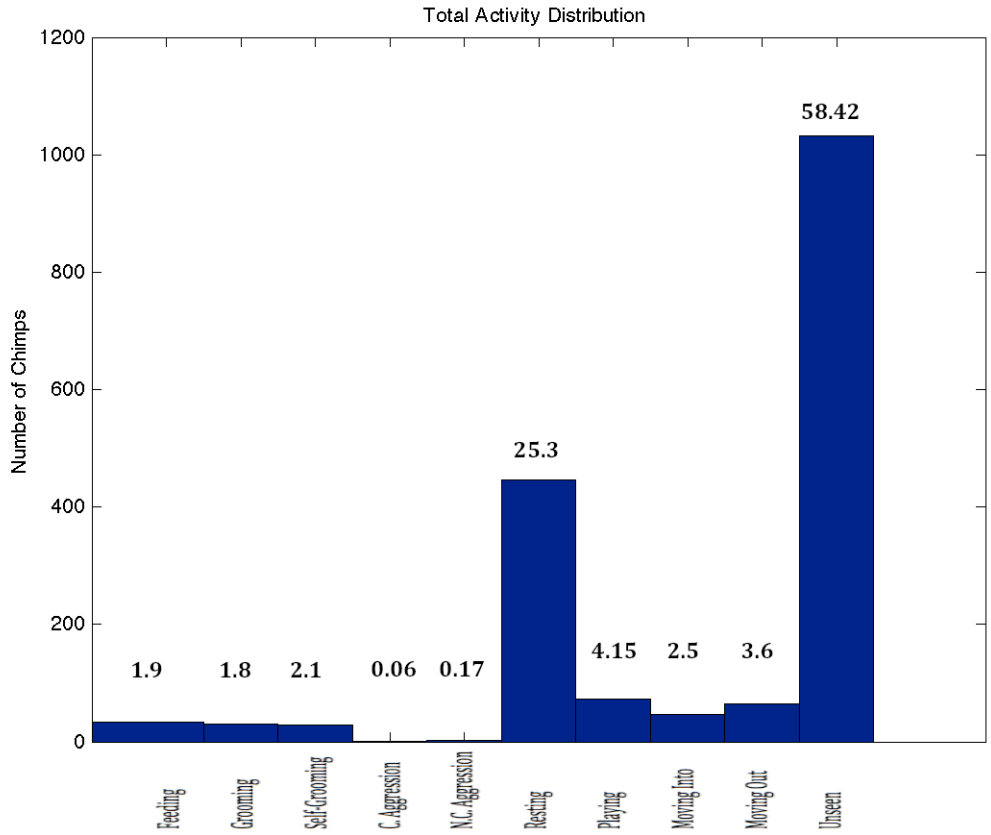

Figure 8. Distribution of observed chimpanzee behaviors. Percentage of total observed behaviors are listed at the top of each bar.

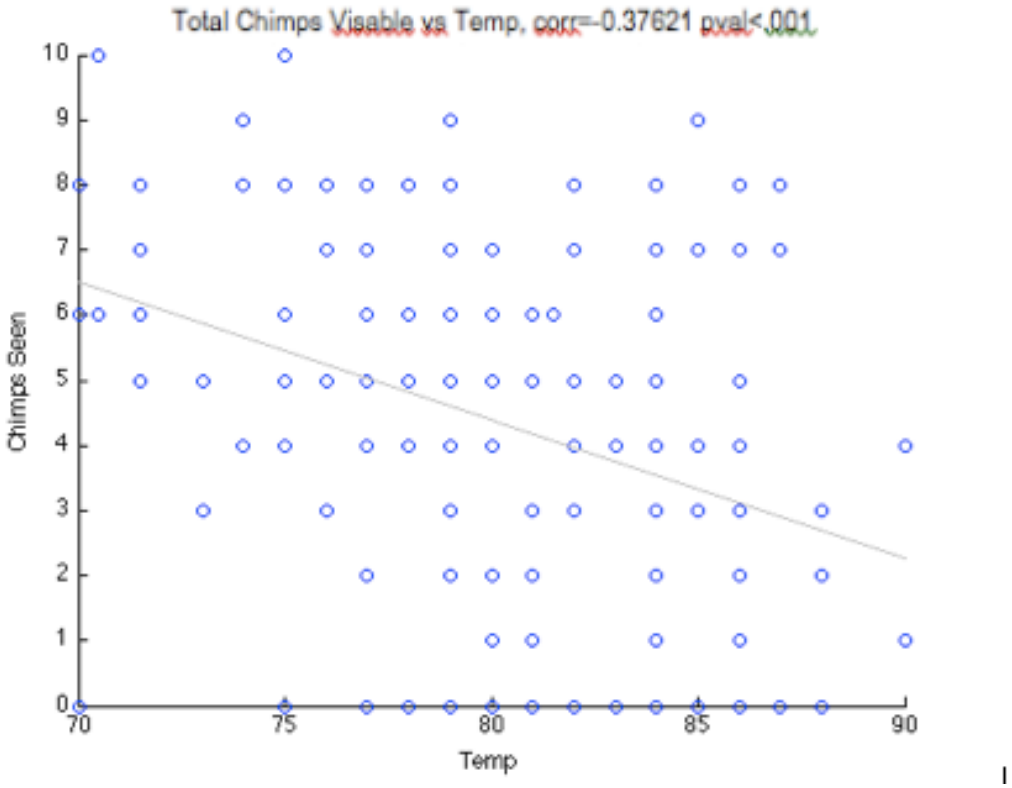

Figure 9. The total number of visible chimpanzees versus temperature. There was negative relationship between these two variables (r = - 0.38, P < .001).

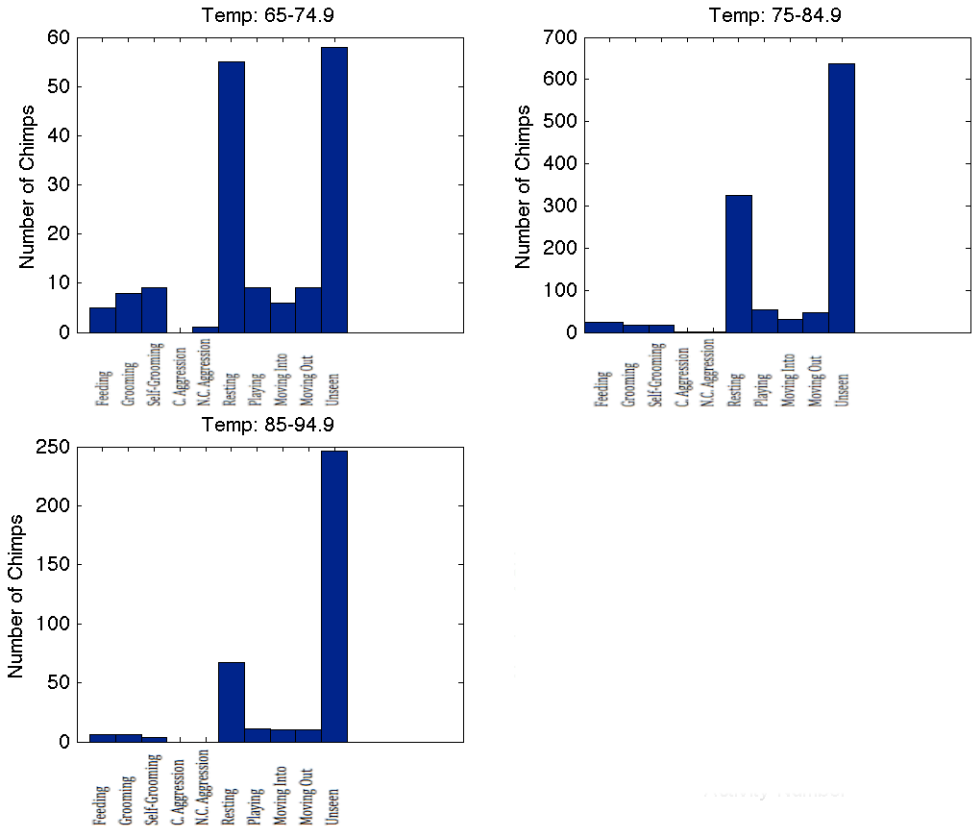

Figure 10. Variation in chimpanzee behavior at different temperatures.

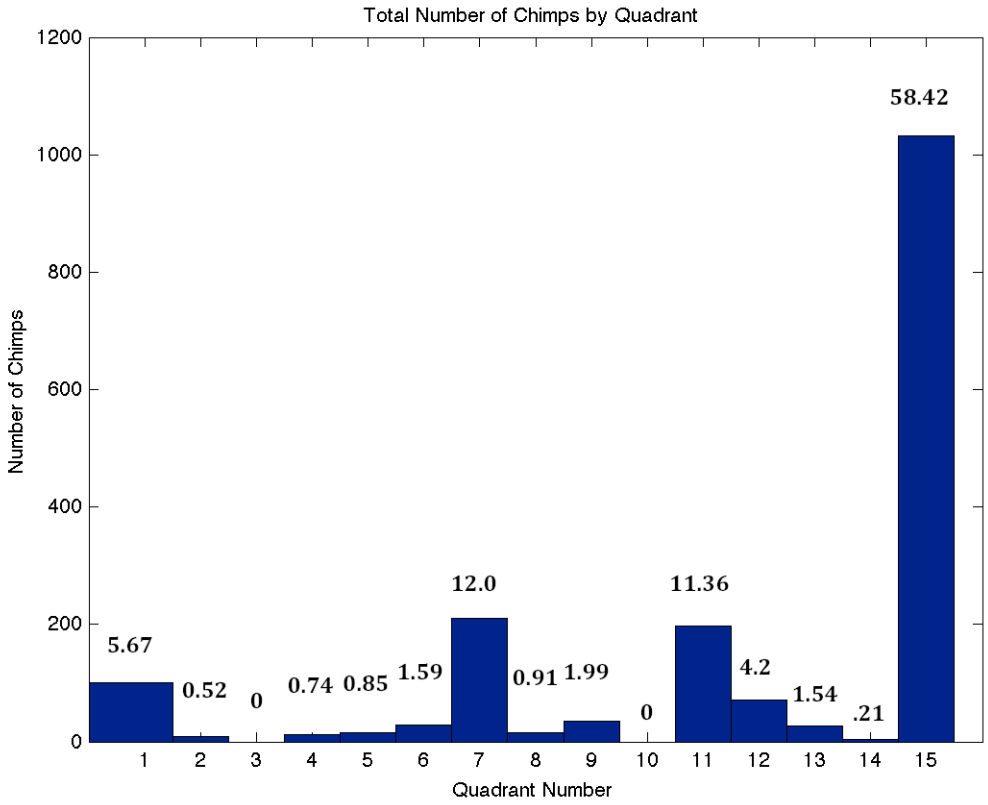

Figure 11. Distribution of time spent in different quadrants in the enclosure. Percentage of total observed quadrant locations are listed at the top of each bar.

Acknowledgements

I would first like to thank the University of Michigan Department of Anthropology, and the Honors Program for its support and dedication to its students. Specifically, I would like to thank Dr. Thomas Chivens for his unending support and advisement during my undergraduate career.

I would next like to thank the Detroit Zoo, and Mary Wulf in particular, for their cooperation and contributions to this study. Without their endless assistance and accommodations none of this would have been possible.

I am thankful for the efforts of Carol Bresnay, Tom Roy, Carrie McIntyre, and Nick Malzahn. Their assistance with both the design and execution of my research was crucial to its success and allowed it to take on the scope that it did. Additionally, I wish for them to know that they helped make what could have been painfully slow data collection a truly fun experience. I will always value their friendships.

I am thankful to all those who have supported me emotionally along the way: my parents, and close friends who had to deal with me when I was sometimes too frustrated for words. Your support made some difficult times much easier.

I wish to especially thank my brother, Robert Brown, who was a never-ending source of input and guidance in regards to the statistical challenges of my study. Making yourself available so often over the course of this past year could not have been convenient, but I will not forget it.

Lastly, and most importantly, I wish to thank Dr. John Mitani, to whom I will forever be grateful. He has worked with me from the beginning of this project and had a constant hand in shaping the finished product. His patience and assistance made this thesis possible. From its inception, he encouraged me to explore for myself, but was always present as a guiding hand and never let me go astray. More than that, his unmatched passion for primatology was what first sparked my interest in the field, and turned what was once a mild interest into an insatiable curiosity. For that, I am forever indebted.