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The Effects of Enclosure Type on Aggressive Behavior in Captive Chimpanzees

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THE EFFECTS OF ENCLOSURE TYPE ON AGGRESSIVE BEHAVIOR IN CAPTIVE CHIMPANZEES

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Abstract:

Male chimpanzees are known to be aggressively territorial in the wild. It is expected that the limited enclosures of captivity would make them even more aggressive. The Kansas City Zoo was chosen as an ideal venue to explore this assumption because it boasts the largest outdoor enclosure of its kind, and the apes alternate between this and much smaller indoor housing.

Quantitative data on crowd size, time of day, temperature, and frequency/intensity/duration of aggressive behaviors were recorded for the alpha male in both enclosures during 300 hours of observation. These data were used to test the following hypotheses: as measured by frequency/intensity/duration, aggression will increase 1) inside relative to outside, 2) with number of visitors, 3) with temperature, and 4) during the middle of the day.

Statistical tests and graphical analysis showed that the frequency and duration of aggressive events did, in fact, increase inside, while the intensity decreased. The number of visitors, temperature, and time of day showed little relationship to aggressive interaction, although a few patterns were seen. These conclusions not only aid in the understanding of captive chimpanzee aggression, but also can be used to improve conditions for chimpanzees in zoological parks throughout the United States.

Introduction:

Endangered species are kept in captivity for research and protection from extinction. To maintain animal well-being, zoological facilities must design living areas to limit possible sources of stress. Stress leads to aggression, which can have serious health consequences for the animals. This project examines the effects of enclosure size and type on aggressive behavior in chimpanzees at the Kansas City Zoological Park.

The Problem:

Aggression is a normal part of life for wild chimpanzees. Such behaviors are associated mostly with social excitement, territorial defense, competition for food and mates, and the protection of offspring and social allies (Goodall, 1986). Still, levels of hostility between group members may well be higher in captivity than in the wild, especially where movement is restricted, and crowding a problem. A study by Boyce and coauthors (1998) provides a good example of this for other primates. These authors found that rhesus macaques crowded together showed a five-fold increase in severe injuries. Other researchers echo these concerns, noting that abnormally high levels of aggression occur among animals reared in grossly restricted environments (Davenpport and Berkson, 1963; and particularly Walsh et al., 1982). Given the severe consequences of increased levels of aggression, it is important to see whether these patterns hold true for other primates, such as *Pan troglodytes*, the common chimpanzees. The Kansas City Zoo is an ideal place to test these assumptions. The outdoor enclosure is the largest of its kind in the United States (approximately 3.5 acres in size), and the apes alternate between this and smaller indoor housing.

Justification For Research:

This study concentrates on levels of aggression—the primary concern when dealing with animal welfare. According to Hinde (1983), studies of animal and human behavior have shown that opportunities to behave aggressively may make further aggression more likely on a future occasion. Further, if aggression is to be controlled, the external conditions responsible must be removed. Unfortunately, the principles involved in the evolution of increasingly complex behavior and the role that it has played in shaping the direction of evolution are still not well understood (Martin and Bateson, 1993; and Wrangham et al., 1994). Therefore, this project has considerable implications for understanding the effects of enclosure size, crowd size, temperature extremes, and time of day on levels of chimpanzee aggression. Results could therefore help define better management techniques for captive chimpanzees. Finally, by contributing to a growing body of information, these data can be used to reconstruct captive environments and improve conditions for chimpanzees in zoological parks throughout the United States.

Model:

This study predicts that in a larger, outdoor habitat, less aggression will be seen. However, as disturbances and discomforts occur, such as increased visitor number and temperature, the frequency/intensity/duration of aggressive events will increase. The following hypotheses were generated to test these assumptions.

Hypothesis 1:

Aggression will be greater in the more restrictive indoor enclosure, as opposed to the larger outdoor enclosure, as measured by frequency, intensity, and duration.

Hypothesis 2:

Aggression will increase with number of visitors as measured by frequency, intensity, and duration.

Hypothesis 3:

Aggression will increase with temperature as measured by frequency, intensity, and duration.

Hypothesis 4:

Aggression will increase midday (time of day 2) as measured by frequency, intensity, and duration.

Materials and Methods:

Housing:

The two habitats have very different immediate physical environments. The outdoor enclosure spreads across 3.5 acres of land, is scattered with trees, and presents little visual or auditory contact with visitors to the zoo. Visitors are enclosed in a small building, separated from the chimpanzees by large, tinted panes of glass. Three small, open-aired, viewing areas exist, but are separated from the enclosure by a walled ditch approximately six meters deep and three meters across.

The indoor enclosure, on the other hand, consists of five pairs of adjacent cages, each approximately five meters long and three meters wide, separated from one another by a long hallway. Each cage consists of three concrete walls and one wall of bars facing the hallway. Although much smaller than the outdoor habitat, the indoor enclosures are isolated entirely from visitors and have a much more controlled environment, with temperatures averaging between 75 and 80 degrees Fahrenheit year-round.

Subjects:

The subjects of this study included 12 chimpanzees total: three adult males, four adult females, one adolescent male, two adolescent females, and two baby females.

As numerous studies have shown that the 'alpha' male is most prone to engage in aggressive interactions (Martin and Bateson, 1993), this project focused on Joshua. Using the focal animal sampling technique, data on other individuals were not recorded.

Observations:

Data on aggressive and affiliative behaviors were recorded in both enclosures, between 8:30 AM and 4:45 PM, five days a week, for eight weeks and approximately three hundred hours of observation. Daily observations at both sites began with a record of temperature (temp). Subsequent temperature readings were taken every hour throughout the day. Outside, the number of visitors was recorded every ten minutes and during aggressive and affiliative encounters. Time of day (time) was subdivided into three categories: 8:30 to 11:15 for Time of Day 1, 11:16 to 2:00 for Time of Day 2, and 2:01 to 4:45 for Time of Day 3. Using the definitions below, the following data were collected:

Time was recorded at the beginning (begin) and end (end) of each behavior.

Total duration (total) was calculated by subtracting 'begin' from 'end'.

Location (in/out) was labeled 'I' for indoor enclosure and 'O' for outdoor enclosure.

Contact type was subdivided into two categories—affiliative (af) and aggressive (A).

Affiliative behaviors were divided into four categories: grooming (G), being groomed (GB), playing (P), and copulation (C)

Aggressive and affiliative activities were divided into two categories—vocalizations (voc) and facial expressions (face). The vocalizations recorded were pant hoot (ph), loud bark (lb), scream (s), and chirp (ch), while facial expressions included play face (pf), display face (df), and compressed lips (cl).

Aggressive actions (action) were subdivided into the following categories: bite (b), hair bristle (hb), throw (th), chase (ch), rock (r), sway (s), jump (j), take (t), foot stomp (st), displacement (d), bang (bg), drag (dr), and bipedalism (bp).

Measurements Made After Data Collection:

Frequency of aggressive and affiliative behaviors was compiled both overall and during each time of day interval.

Intensity of each aggressive behavior was subdivided into three categories: Intensity 1 consisting of one or two behaviors (vocalizations, facial expressions, or actions); Intensity 2, either three behaviors or just a bite, hit, drag, throw, or bipedal movement; and Intensity 3, more than three behaviors, or any one behavior combined with bite, hit, drag, throw, or bipedal movement.

Duration of each behavior (both aggressive and affiliative) was subdivided into three categories: Duration 1 defining behaviors with total time between 1-10 seconds; Duration 2, 11 seconds to 1 minute; and Duration 3, greater than 1 minute.

Discussion:

This study examines how possible sources of stress in relation to enclosure type affect levels of aggression in captive chimpanzees. By looking at the frequency, intensity, and duration of aggressive behaviors demonstrated by the focal animal in each enclosure, and comparing these to the possible sources of stress, base lines were established and variables isolated for significance.

Enclosure Type (Outside vs. Inside):

Results of this study indicated that there was a significant difference between the frequency, intensity, and duration of aggressive interactions outside as compared to those inside (Table 3). As shown by Figure 1, aggressive interactions were significantly more frequent inside than outside. As shown by Figure 2, events of each intensity were also more frequent in the smaller enclosure. When comparing the ratios of intensities in each enclosure, however, the majority of events inside were of intensity 1, while the majority of events outside were of intensity 3. Thus, although the frequency of aggressive interactions of each intensity was significantly greater inside, the overall intensity actually increased outside. This inconsistency can be explained in terms of boredom. Because the chimpanzees had less to do in the smaller, more restrictive enclosure, they tended to become bored and picked small fights with one another (de Waal, 1989). By allowing the chimpanzees more space, the small skirmishes of boredom were eliminated, and only those interactions necessary to maintain social structure were displayed. It follows that these interactions would be of greater intensity considering they were acts of dominance and display. Thus, the majority of aggressive interactions outside would be of greater intensity.

Aggressive events of the highest duration, on the other hand, increased inside relative to outside. As shown by Figure 3, the majority of events outside were of durations 1 and 2. Therefore, only a small minority of events lasted longer than a minute (duration 3). Inside, on the other hand, almost a third of aggressive events were of the longest duration. Once again, this can be explained in terms of boredom. Because Joshua had less to occupy his time inside, his displays tended to increase in duration. The superior acoustics inside also allowed a much louder, intimidating display, which caused the other chimpanzees to become more excited, further encouraging Joshua's prolonged aggression. In the open-air enclosure, however, displays could not be as spectacular and would therefore not last as long.

Visitors Number:

Results of this study showed that crowd size had no significant impact on frequency or duration of aggressive events, but did have an effect on the intensity of aggressive interaction (Table 4). It follows that the frequency and duration of aggressive behaviors would not be impacted by crowd size because the layout of the outdoor enclosure minimizes both visual and auditory interaction. However, Figure 4 shows that intensity level did increase significantly with visitor number. This suggests that although the glass limited noise, large numbers of visitors created enough disturbance to instigate displays of greater intensity.

Temperature:

Temperature had no significant impact on frequency, intensity, or duration of aggressive behavior in either enclosure (Table 6). This was expected for the indoor enclosure, considering temperature was controlled, but because outside temperature remained mild throughout the course of this study, it follows that little impact would be seen in either enclosure.

Time of Day:

Time of day had no significant impact on duration of aggressive interactions outside or frequency/intensity of aggressive behavior in either enclosure (Table 7). The duration of events inside, however, did show a significant difference in relation to time of day, although it did not increase midday as predicted. Instead, events of duration 1 decreased in frequency throughout the day, and events of longer duration decreased in frequency midday (Figure 5). This decrease could be related to the fact that the keepers left for an extended period of time midday. Thus, the disturbances created by the keepers in the morning and late afternoon could have influenced Joshua to display for prolonged periods of time in comparison to those while the keepers were away.

Implications:

In short, a large, outdoor enclosure can effectively reduce abnormal levels of aggression if the visitors are sufficiently separated from the animals and the temperatures remain mild. It is important for zoological facilities to keep these parameters in mind when designing captive environments. For example, visitors should always be separated by glass—not only to keep them from throwing foreign objects into the enclosure, but also to minimize pheromone disturbance and visual/auditory contact. Secondly, climate must be considered. Enclosures built in areas with highly variable weather patterns should either contain transfers between indoor and outdoor facilities, or indoor housing that maximizes vertical and horizontal space.

Works Cited:

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Erica Findley

RESULTS

Definitions (Tables 1 and 2)

Intensity 1	1 or 2 behaviors
Intensity 2	3 behaviors, or just b, h, dr, th, or bp
Intensity 3	> 3 behaviors, or 1 behavior and b, h, dr, th, bp

Duration 1	1-10 sec
Duration 2	11-60 sec
Duration 3	>60 sec

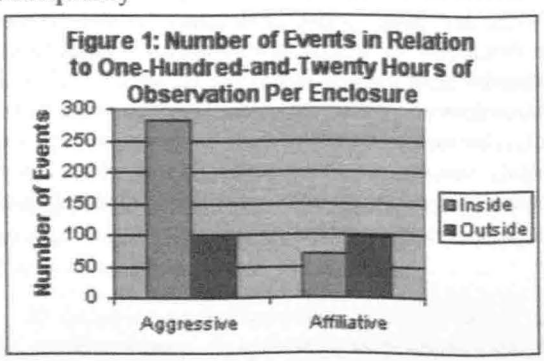
Enclosure Type (Outside vs. Inside)

Hypothesis 1: Aggression will be greater inside than outside as measured by frequency, intensity, and duration.

Table 3

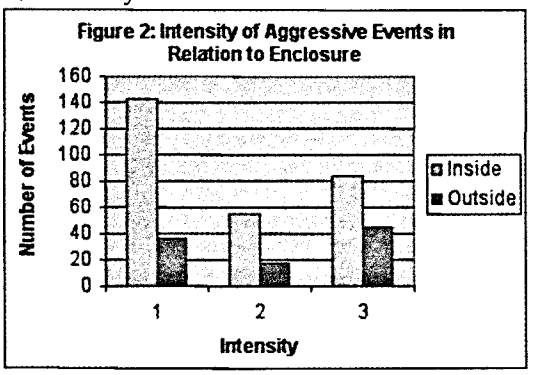
Variable	Chi-Square	Degrees of Freedom	Probability	Significance
A) Frequency	51.212	1	0.000	Yes
B) Intensity	8.589	2	0.014	Yes
C) Duration	16.987	2	0.000	Yes

A) Frequency



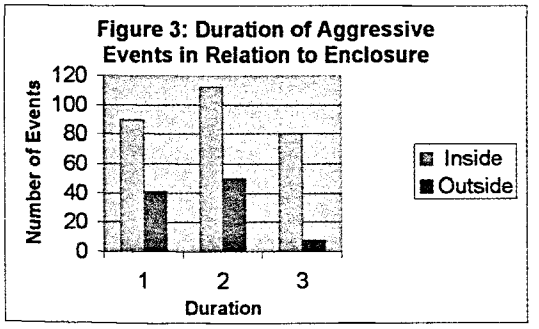
This figure shows that aggressive relative to affiliative events were more frequent inside than outside. Because the frequency of affiliative events does not differ greatly between the two enclosure types, it is the difference in aggressive events that drives the significant

B) Intensity



This figure shows that although events of each intensity were more frequent inside than outside, the majority of events outside were of higher intensity. Note also that the number of events was compiled for one-hundred-and-twenty hours of observation in each enclosure.

C) Duration



This figure shows that aggressive interactions of each duration were more frequent inside than outside. Inside, events of duration 1 and 3 happened at relatively the same frequency, while outside, events of duration 3 occurred much less than those of duration 1. This suggests that overall duration did increase inside relative to outside.

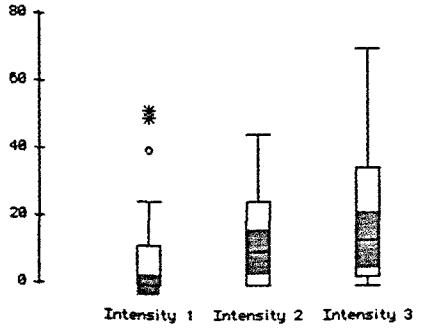
Visitor Number (Outside Only)

Hypothesis 2: Aggression will increase with number of visitors as measured by frequency, intensity, and duration.

Table 4

Variable	MWU or KW Test Statistic	Degrees of Freedom	Probability	Significance
A) Frequency	4518	1	0.466	No
B) Intensity	10.563	2	0.005	Yes
C) Duration	1.898	2	0.387	No

Figure 4 – Intensity of Aggressive Events in Relation to Visitor #



Note: On this boxplot and subsequent—the median for each dataset is indicated by the center line, the first and third quartiles are the edges of the box, which is known as the inter-quartile range (IQR), and the extreme values are the ends of the extended lines. Points at a greater distance from the median than 1.5 times the IQR are plotted individually as circles and asterisks. These points represent outside values and far outside values.

This figure shows that intensity level did increase with visitor number, as shown by the increase in visitor mean and median from intensity 1 to intensity 3.

Table 5

Intensity	Minimum Vis	Maximum Vis	Mean Vis	Median Vis	St Deviation
1	0	50	7.139	0	12.079
2	0	45	14.222	10	15.180
3	0	70	20.578	13	21.165

Temperature (Outside vs. Inside)

Hypothesis 3: Aggression will increase with temperature as measured by frequency, duration, and intensity.

Table 6

Variable	Enclosure	MWU or KW	DF	Probability	Significance
A) Frequency	Outside	4496	1	0.44	No
	Inside	9226.5	1	0.301	No
B) Intensity	Outside	0.234	2	0.89	No
	Inside	0.697	2	0.706	No
C) Duration	Outside	1.775	2	0.412	No
	Inside	2.901	2	0.234	No

Time of Day (Outside vs. Inside)

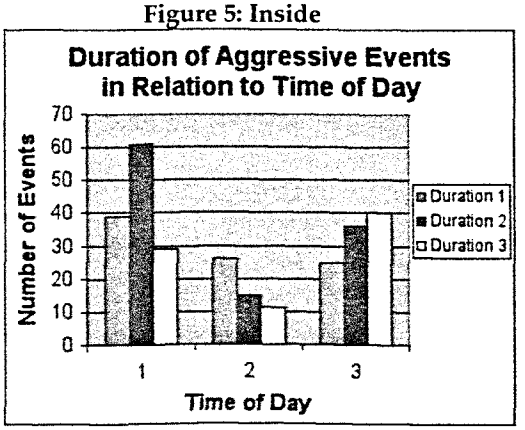
Hypothesis 4: Aggression outside will increase midday (time of day 2) as measured by frequency, intensity, and duration.

Table 7

Variable	Enclosure	Chi-Square	DF	Probability	Significance
A) Frequency	Outside	2.997	2	0.223	No
	Inside	0.808	2	0.668	No
B) Intensity	Outside	5.133	4	0.274	No
	Inside	2.163	4	0.706	No
C) Duration	Outside	5.599	4	0.231	No
	Inside	17.922	4	0.001	Yes

C) Duration

Figure 5: Inside



This figure shows that the duration of events did not increase midday as predicted. Instead, events of duration 1 decreased in frequency throughout the day, and events of longer duration decreased in frequency midday.

Faculty Comments:

Ms. Findley's faculty mentor had the following things to say about her:

> Ms. Findley is among the best and brightest students I have known during my six years at the University of Arkansas. She maintains an extremely high GPA, is active in student organizations, and has real-life experience working in the field of study she wishes to pursue. Ms. Findley is a senior and took my course in Primate Adaptation and Evolution last year. Despite the fact that this was a graduate level course, Ms. Findley held her own with M.A.- and Ph.D.-level students very well, and received a grade of A. Ms. Findley's academic goal is to earn a doctorate with a focus in primate behavioral ecology. She takes this goal very seriously. For example, she has supplemented her education here at the University of Arkansas with courses in animal ecology at the University of Canterbury, New Zealand.
>
> Her research aptitude is evidenced both by her class work and by her work done at the Kansas City Zoological Park. There, she served as researcher, interpreter and educator. She has excelled in classes emphasizing research and quantitative methods. Also, she won a prestigious State of Arkansas Information Liaison Office undergraduate grant under my direction to conduct behavioral research on captive chimpanzee aggression, which is the subject of this article.
>
> Ms. Findley is also very well rounded. She is a motivated, enthusiastic student leader. She serves as Vice President of the Outdoor Recreational Club for the University, is Treasurer for the Student Sierra Coalition, and recently raised funds as Financial Coordinator to send University of Arkansas students to the Environmental Conference at the University of Pennsylvania. She clearly has the ability to meet her goals and commitments. In sum, Erica Findley is a bright, energetic, enthusiastic, motivated student who has clearly defined goals and a great future in academia ahead of her.

Another of her teachers, Loredana Lanzani, is very complimentary about Ms. Findley's abilities. She says:

> I have known Ms. Findley since August 2000, when she enrolled in my advanced undergraduate mathematics course on Differential Equations. Even though all the 37 students in the class had been carefully selected and proved to be very talented and dedicated, it became clear from the very beginning that Ms. Findley would define the top of the class. I like to compare my teaching experience at the University of Arkansas with my experience as an instructor at Purdue University, where I have had extensive contacts with many science or engineering majors. None of the students I had known at Purdue could even remotely compare to Ms. Findley in terms of mathematical ability and rigor, intuition, enthusiasm and curiosity. Not one lecture went by without Erica being with me or, more often, ahead of me in the presentation. She showed equal enthusiasm both for the theoretical aspects of the subject (in fact, I could tell from her remarks that she was able all the time to pin down the details that I had left out in the proofs) and for the many applications to biology, physics and engineering that were covered throughout the course. It goes without saying that Ms. Findley's written work was spotless, and she earned the best score in the class (and I should add that, based on my five-year experience at the University of Arkansas, the number of talented students in Ms. Findley's class was unusually large). In short, she was, by all measures, the very best in the class. There is no doubt that Erica R. Findley ranks in the top 1% among the over 400 students I have so far had the good fortune to assist in their intellectual growth. I am confident that she will succeed in any career she may choose to pursue.
>
> Although I am best qualified to assess Erica R. Findley's scientific merits, I feel that her deep and genuine concern for the social issues that are related to her research area, primate evolutionary biology, cannot be left unmentioned. She is perfectly aware that her research in the branch of primatology dealing with the dysfunctional behavior of captive primates may bring invaluable insight to the analysis of human behavior under stressful circumstances. This awareness has fueled Ms. Findley's exceptional drive in pursuing exhausting fieldwork as a zoo intern, and has given her a crystal-clear vision of her goals and long-term objectives. Indeed, the continuity between her current and past research and her plans for future work are one of the aspects of her personality that I find most appealing: I feel that the determination and consistency she has demonstrated so far show a great deal of promise toward the successful completion of her ultimate goal, to become a professor of primate evolutionary biology. To find an individual, in particular a woman, that is as clearly driven, talented and motivated at such a young age is so rare an event that all efforts must be made to support that individual in the pursuit of her career plans and her vision.