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Abstract:

Suboptimal housing conditions in zoos can cause animals to develop negative behaviors associated with excessive stress levels. Environmental enrichment and the use of natural substrates can decrease stereotypy and increase species-specific behaviors of captive animals (Gibbons et al, 1994). This study observed two pairs of gibbons (*Nomascus leucogenys leucogenys)* at the Oregon Zoo for 40 hours from July 5th through August 7th in order to analyze the effect that increased environmental enrichment and natural substrates had on the behavior of captive white-cheeked gibbons. One of the gibbon pairs (Phyllis and Duffy) had been housed in the new Red Ape Reserve for 10 months prior to this study. The experimental pair of gibbons (Nancy and Gunther) had access to the outdoor portion of the exhibit for two hours every morning beginning ten days prior to the start observations. The behaviors of the two pairs of gibbons were compared with the intention of determining the extent to which access to a larger, more natural environment with improved enrichment strategies promoted the species-specific behaviors of arboreality and brachiation. Activity levels were also analyzed to determine the extent to which the enrichment techniques have affected the cognitive health of the subjects. After all observation hours were completed, it was determined that within the experimental group, instances of brachiation, arboreality and activity levels increased significantly and the amount of time the subjects spent on or close to the ground decreased throughout the course of this study. It was concluded that access to natural substrates and increased environmental enrichment did increase species-specific behaviors of the captive white-cheeked gibbons at the Oregon Zoo.

Introduction:

Environmental enrichment can be defined as modifications to an animal's environment that increase their biological functioning (Newberry, 1995). Zoos in the United States have been implementing environmental enrichment for several decades in an attempt to mitigate the amount of stress captive animals experience (Swaisgood and Shepherdson, 2005). Stereotypic behaviors, defined as repetitive movements that do not serve an immediate function, are common in captive animals due to a lack of physical and psychological stimulation (Mason, 1991). A reduction of species-specific behaviors is also very common among animals housed in suboptimal conditions due to the inability of the animal to interact with its environment in a natural way (Gibbons et al, 1994). Environmental enrichment research aims to increase the amount of stimulation in the captive animals' enclosure. This is accomplished through a myriad of different methods such as recreating natural environments, placing food into puzzle boxes, and hiding scents and treats throughout an enclosure. Enrichment programs have been associated with a 53% decrease in stereotypy (Swaisgood and Shepherdson, 2005). With increased research on the success rates of each type of enrichment strategy for specific animals, the living conditions of captive animals will greatly improve.

The Hylobatid apes, also called lesser apes because of their small stature in comparison to the great apes, are highly arboreal primates endemic to the tropical and subtropical forests of South, East, and South-East Asia (Geissman, 1995). There are four genera of gibbon in the family Hylobatidae that are distinguished from each other by the number of diploid-chromosomes they each have; *Hylobates* (dwarf gibbons) 44 chromosomes, *Hoolock* (hoolock gibbons) 38

chromosomes, *Symphalangus* (Siamangs) 50 chromosomes, and *Nomascus* (crested gibbons) 52 chromosomes (Tuttle, 1986). Northern white-cheeked gibbons, *Nomascus leucogenys leucogenys*, are endemic to southern Yunnan, North-Western Vietnam and Laos (Geissman, 1995). The populations of northern white-cheeked gibbons in the Yunnan province are thought to be extinct as China has not reported any sightings of this species to the International Union for the Conservation of Nature (IUCN) since 1990 (University of Wisconsin, 2010). Currently the population in Vietnam is critically endangered and the population in Laos is quickly diminishing due primarily to habitat loss (Gibbon Conservation Center, 2010).

Subjects: The Oregon Zoo currently has four individuals of the species *N. leucogenys leucogenys* that are housed in separate adjacent enclosures in mated pairs. Phyllis (female) was the first gibbon that was obtained by the Oregon Zoo in September of 1975. Her estimated birth date is in 1970; however the exact date is unknown because she was not born in captivity. Gunther (male), the oldest of the four, was born in the wild in approximately 1964 and acquired by the Oregon Zoo in October of 1975 (Oregon Zoo, 2011). These two gibbons formed a very successful mated pair and produced many offspring over the next twenty years (Thomas, 2011). In 1995, the Oregon Zoo acquired another white-cheeked gibbon, Nancy, a wild born female gibbon approximately the same age as Phyllis (Oregon Zoo, 2011). After her arrival, Nancy was paired with Gunther (Thomas, 2011). In 2000, the zoo obtained their last gibbon, Duffy, a five year old captive born male, by far the youngest of the group (Oregon Zoo, 2011). With this new addition, the keepers decided to pair Phyllis and Gunther back together and pair Duffy with Nancy. This situation worked until Duffy reached puberty, at which time he became overly aggressive towards Nancy. It was decided to pair Duffy with Phyllis, a more dominant female. Nancy and Gunther were paired together because they were both more submissive. There have been no problems between the animals since they have been paired in this way.

Prior to the opening of The Red Ape Reserve in September of 2010, the last significant renovation of the primate exhibit at the Oregon Zoo occurred in 1981 (Oregon Zoo, 2011). The older enclosures consisted of concrete walls and floors, logs and metal bars for climbing, sparse access to natural substrates such as dirt and grass, or toys (balls, magazines, old t-shirts, dog toys, etc). While being housed in these exhibits, the white-cheeked gibbons had shown a marked decrease in species-specific behaviors such as brachiation and arboreality. In order to decrease abnormal behaviors in both the gibbons and orangutans, The Red Ape Reserve was constructed. It includes two 410 ft^2 indoor enclosures, one built to suit the pair of orangutans (Kutai and Inje) and one to suit a pair of gibbons, with a 5,400 ft^2 outdoor enclosure to which both the orangutans and gibbons have access during zoo operating hours. Due to the highly territorial nature of gibbons, and lack of funding for an additional indoor gibbon habitat, only one pair of the pairs of gibbons (Phyllis and Duffy) were able to move into the new Red Ape Reserve's indoor gibbon enclosure (Thomas, 2011).

The outdoor habitat is exposed to the weather and equipped with natural foliage, vines, soil, water. No species of primate in this exhibit has had the opportunity to experience any of these features in its previous habitat. The zoo also created a hollow "enrichment tree" in the shape of a large buttress tree that keepers can enter through an underground tunnel. The tree has various holes and in which keepers hide toys, treats and puzzle boxes in order to give the animals opportunities to search for food and enrichment stimulation. The indoor portion of the habitat has a variety of trees and vines on which the primates can play and was also designed to utilize 100% of the vertical space to increase the area that is accessible to the primates. This was done to increase the amount of time that the apes spent above ground, a natural behavior of both gibbons and orangutans. The side of the indoor habitat that is adjacent to the outdoor enclosure is lined completely with glass so the animals have a visual connection to the outdoors at all times. The glass wall coupled with skylights provides plenty of natural light for the primates even when

indoors (Oregon Zoo, 2011). All of this was accomplished with the hope of increasing psychological and physical stimulation within the primates' environment and thereby encouraging species-specific behaviors of the primates (Lewis, 2011). Gibbons are naturally a highly arboreal species that spend the vast majority of their time above ground. Nancy and Gunther's indoor enclosure has not been remodeled.

As of June 25th, 2011, Nancy and Gunther have been given access to the outdoor portion of The Red Ape Reserve from 9:00 am to approximately 10:45 am daily. While Nancy and Gunther are in this area of the exhibit, Phyllis, Duffy and the orangutans are restricted to their indoor enclosures. Nancy and Gunther do not share the outdoor enclosure with the other gibbons or the orangutans at any time. After 10:45 am, Nancy and Gunther are taken back to their indoor enclosure for the remainder of the day. Phyllis, Duffy and the two orangutans (Inje and Kutai) have access to the outdoor portion of the Red Ape Reserve immediately after Nancy and Gunther have been taken back inside. At the time of this study, the keepers have no intention of allowing Nancy and Gunther to share the outdoor portion of the exhibit with the orangutans (Thomas, 2011). Phyllis, Duffy and the orangutans have access to the outdoor exhibit from approximately 10:45 am to 6:00 pm, when the zoo closes to the public.

It is hypothesized that Phyllis and Duffy's behavior will stay fairly consistent throughout the course of this study because they have been housed in The Red Ape Reserve for a longer time frame and therefore have had time for their behaviors to adjust to their newer environment. However, there may be an increase in the territorial behavior of this pair because this is the first time that these animals have had to share a portion of their enclosure. Nancy and Gunther's behavior, however, is expected to change significantly throughout the course of this study. It is presumed that their activity levels, arboreality and instances of brachiation will increase due to increased environmental enrichment and access to natural substrates and that the amount of time that these animals spend on or near the ground will decrease by the end of the study.

Methods:

Scan sampling occurred at 60 second intervals over the course of 33 observation periods. A total of 20 hours was spent observing each pair of gibbons. Observation hours varied from 9:00 AM to 6:00 PM in order to capture all hours the gibbons were on exhibit at the Oregon Zoo. Behaviors of the gibbons were observed on all days of the week. A stop watch set to 60 seconds was used to determine when to record the behavioral data. The behavior of the gibbons was recorded on the ethogram that had been created for this study (Appendix 1). This ethogram was based on a pilot study of the four gibbons' behavior prior to the construction of the Red Ape Reserve and was expanded to reflect the aims of this study (Davis, 2011).

During each scan the following data points were recorded for each individual gibbon: their location (indoor or outdoor and where exactly in those exhibits the subjects were), elevation from the ground, proximity to their partner, proximity to each orangutan, their posture or mode of locomotion, and the activity they were engaged in at the time of the scan. The codes for these parameters are defined in Appendix II. The possible locations for the animals were broken down into five sections due to the large area of the exhibits: the orangutans' indoor enclosure (Indoor I), Phyllis and Duffy's indoor enclosure (Indoor II), Nancy and Gunther's indoor enclosure (Indoor III), the area of the outdoor enclosure to the east of the tree tunnel entrance where the gibbons have their access chutes (Zone 1), and the area of the outdoor enclosure to the west of the tree tunnel where the orangutans have their access door (Zone 2) (Fig. 1). Every instance of an interspecies social interaction was also recorded and described in order to quantify the interspecies relationships between Phyllis and Duffy and the orangutans. If a subject was engaging in multiple activities at once (such as eating and receiving allogrooming) activities that were of a more social

and dynamic nature (allogrooming, social interactions, play) were given preference over behaviors that could be considered solitary activities (feeding, foraging, or looking around enclosure).

A) **B)**

Figure 1. A) Picture of Nancy in the portion of the outdoor enclosure of The Red Ape Reserve labeled Zone 1. B) Picture of Kutai in the portion of the outdoor enclosure of The Red Ape Reserve labeled

Results:

Location: While in sight, Phyllis and Duffy spent the majority of their time (52% and 66% respectively) in the outdoor portion of the Red Ape Reserve labeled Zone 1. Phyllis was the only gibbon to enter the Orangutans' indoor enclosure, despite constant access. This event happened only once while both orangutans were outdoors and lasted a total of two minutes. Nancy and Gunther spent nearly an even amount of time within the outdoor and indoor enclosures. Gunther was the only gibbon to spend slightly more of the time he was in view within his indoor enclosure (53%). Nancy spent slightly more time outdoors (52% of her in sight time). Nancy only spent a total of two minutes in the portion of the outdoor enclosure labeled Zone 2 (less than any other gibbon).

Elevation: Elevation of the gibbons did not differ greatly within the two pairs; however it did differ greatly between the pair that had been given greater access to the remodeled environment and the pair that had recently been introduced to the outdoor portion of the Red Ape Reserve (Table 1). Phyllis and Duffy spent the least amount of their time below two meters from the ground; both gibbons only spent 11 minutes on the ground throughout all hours of observations, approximately 2% of the total time they spent in sight of the researcher. The amount of time spent above four meters from the ground was used as a positive indicator of the arboreality of the animals during this study. Duffy spent on average 73.09% of his time above four meters from the ground, the most of any of the gibbons. Phyllis spent a similar 71% of her time above four meters. Nancy and Gunther, however, spent much more of their time (over 55%) on the ground instead of at a significant elevation. Nancy spent the shortest amount of time above four meters from the ground at only 135 minutes or 14.35% of her in sight time. The average amount of time Gunther spent above four meters was only slightly more at 155 minutes (16.68%).

Table 1. Time (in minutes) each gibbon spent at certain elevations

	Phyllis	Duffy	Nancy	Gunther
Ground	11 min	11min	469 min	454 min
0- 2 meters	3 min	28 min	105 min	69 min
2-4 meters	142 min	123 min	118 min	137 min
Over 4 meters	385 min	440 min	135 min	155 min
Total in sight	**541 min**	**602 min**	**941 min**	**929 min**

During weeks four to six, Nancy and Gunther did decrease the amount of time they spent on the ground by 24.65% and 12.34% respectively (Fig. 2A). Throughout these weeks, the disparity between the two groups decreased significantly, however Phyllis and Duffy still spent between 0.81% and 6.17% more time above four meters from the ground (Fig. 2B).

A) **B)**

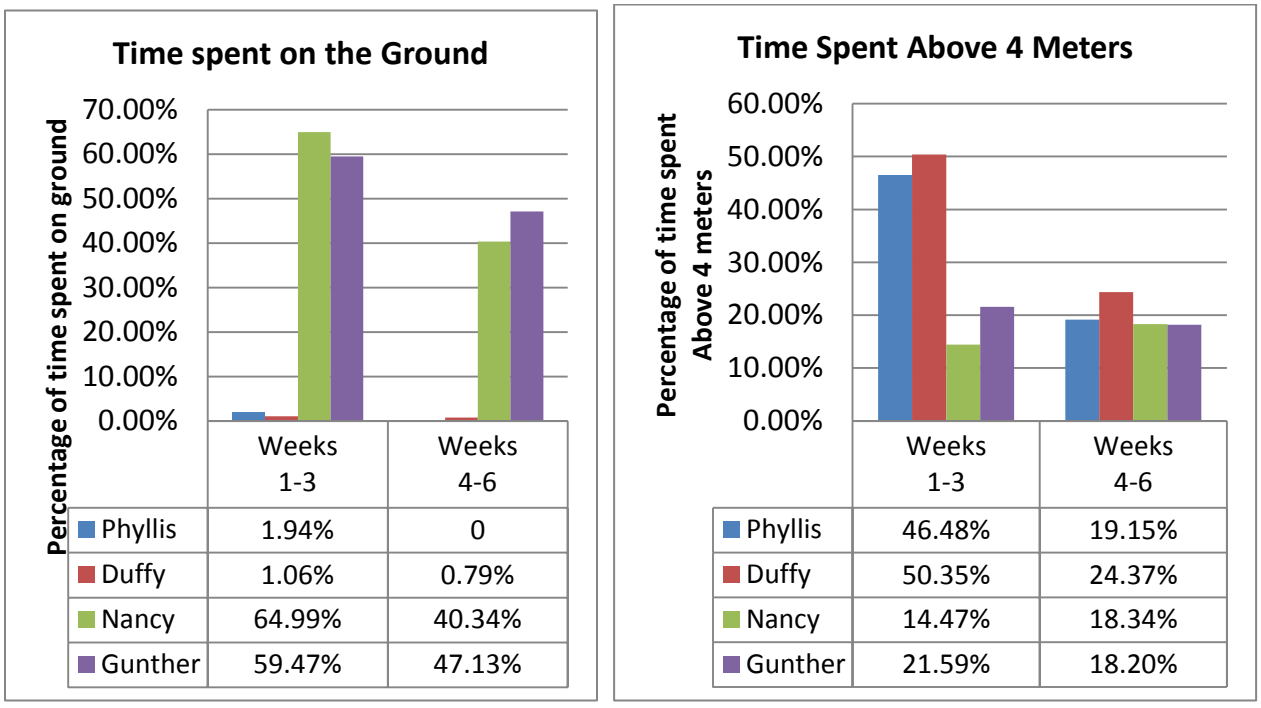


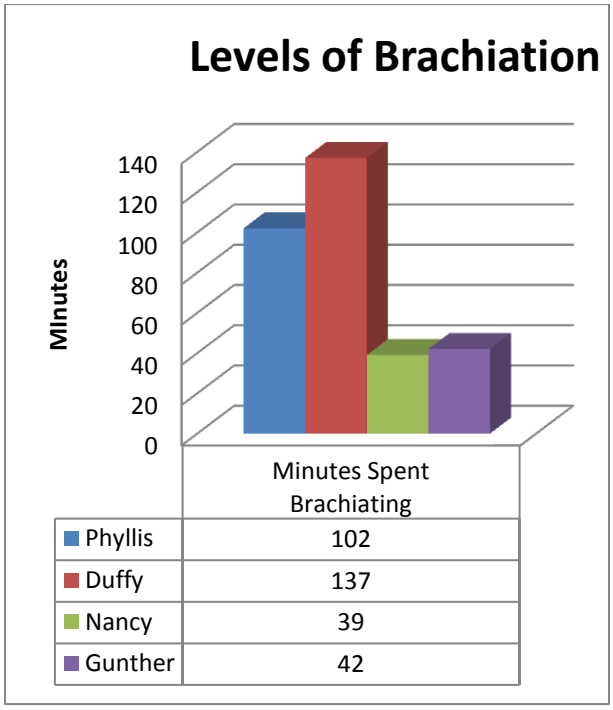
Figure 2. A) Comparison of the percentage of total time each gibbon spent on the ground during weeks one-three and weeks four-six. B) Comparison of the percentage of time each gibbon spent above four meters from the ground during weeks one-three and weeks four-six.

Brachiation: Duffy showed the most instances of brachiation, he spent 137 minutes of total observation hours brachiating. Nancy and Gunther used brachiation less frequently, only 39 and 42 minutes, respectively, throughout all hours of observation. To account for the difference in activity levels of the four gibbons as a reason for the large disparity in these numbers, the amount of time spent brachiating was divided by the amount of time each animal spent active throughout the study. These percentages can be seen in Table 2. Phyllis and Duffy spent significantly more of their active time brachiating than did Nancy and Gunther (Fig. 4).

Table 2. Percentage of active time each animal spent brachiating

	Phyllis	**Duffy**	**Nancy**	**Gunther**
Percent	**77%**	**88%**	**16%**	**23%**

A)



B)

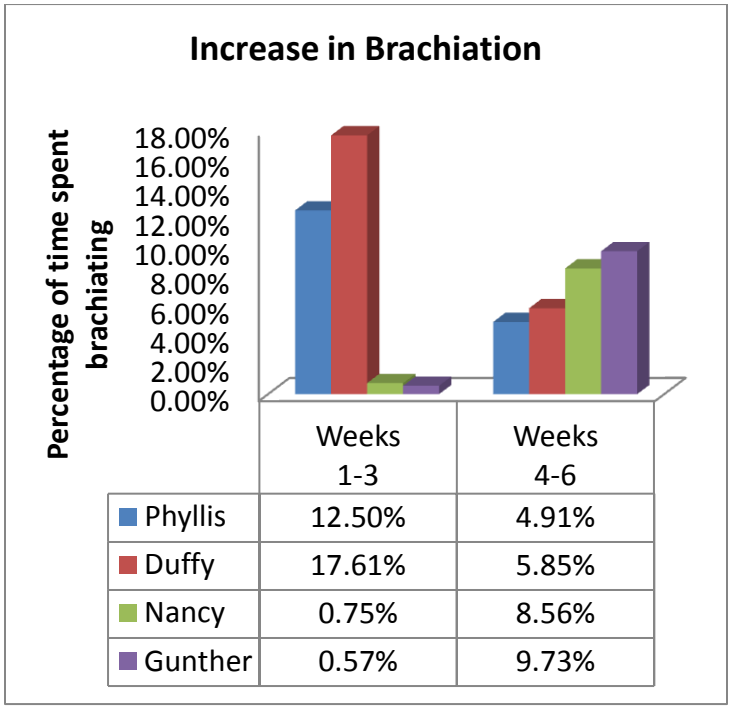
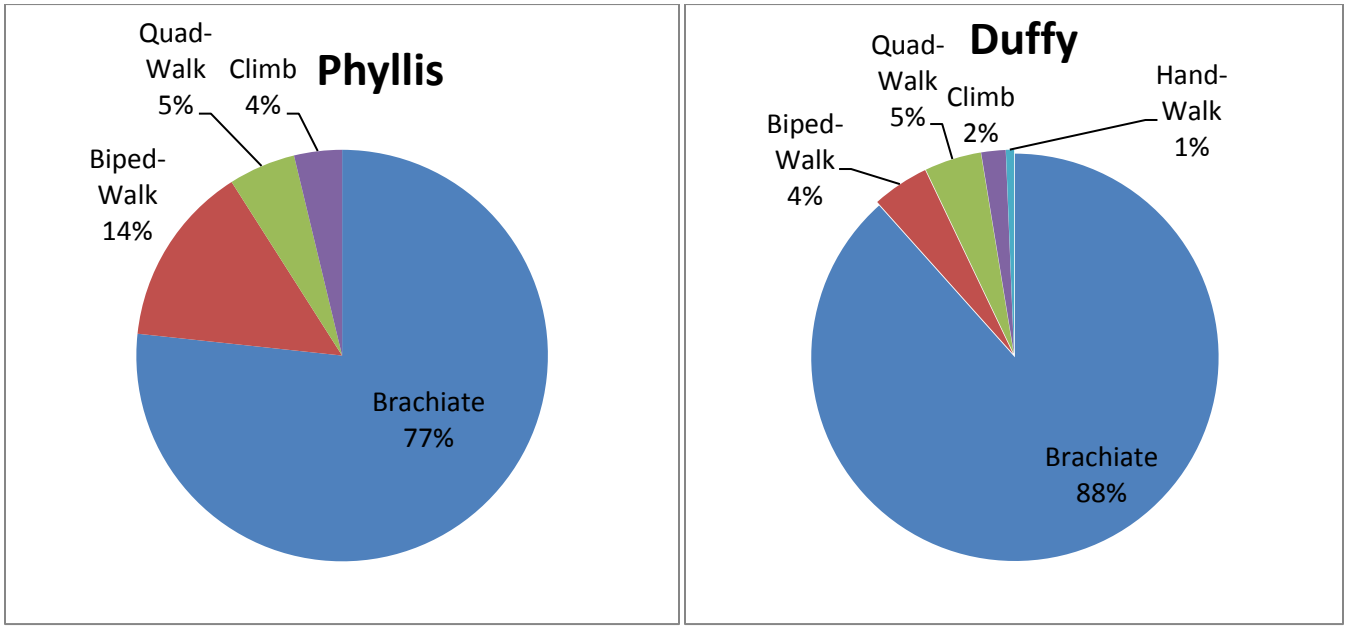


Figure 4. A) Total minutes each gibbon spent brachiating during all observation hours (1200 minutes/each gibbon) B) Comparison of the percentage of time each gibbon spent brachiating during weeks one-three and weeks four-six.

During the first three weeks of the study, Nancy and Gunther spent less than 1% of their time brachiating, compared to the 12.5% and 17.51% of time Phyllis and Duffy spent brachiating over the same period (Fig. 5). During the last three weeks of this study however, both Nancy and Gunther increased brachiation by over ten fold. This is a considerable increase, especially when the control group (Phyllis and Duffy) decreased their instances of brachiation by 7.59% and 11.76%.

Mode of Locomotion: Both Phyllis and Duffy's primary form of locomotion was brachiation, which made up 77% and 88% of their movements, respectively (Fig. 6A). Nancy and Gunther had a more even distribution of locomotive movements, and much fewer instances of brachiation (Fig. 6B). Instead, bipedal walking tended to be the primary form of locomotion for Nancy and Gunther, followed by climbing.

A)



B)

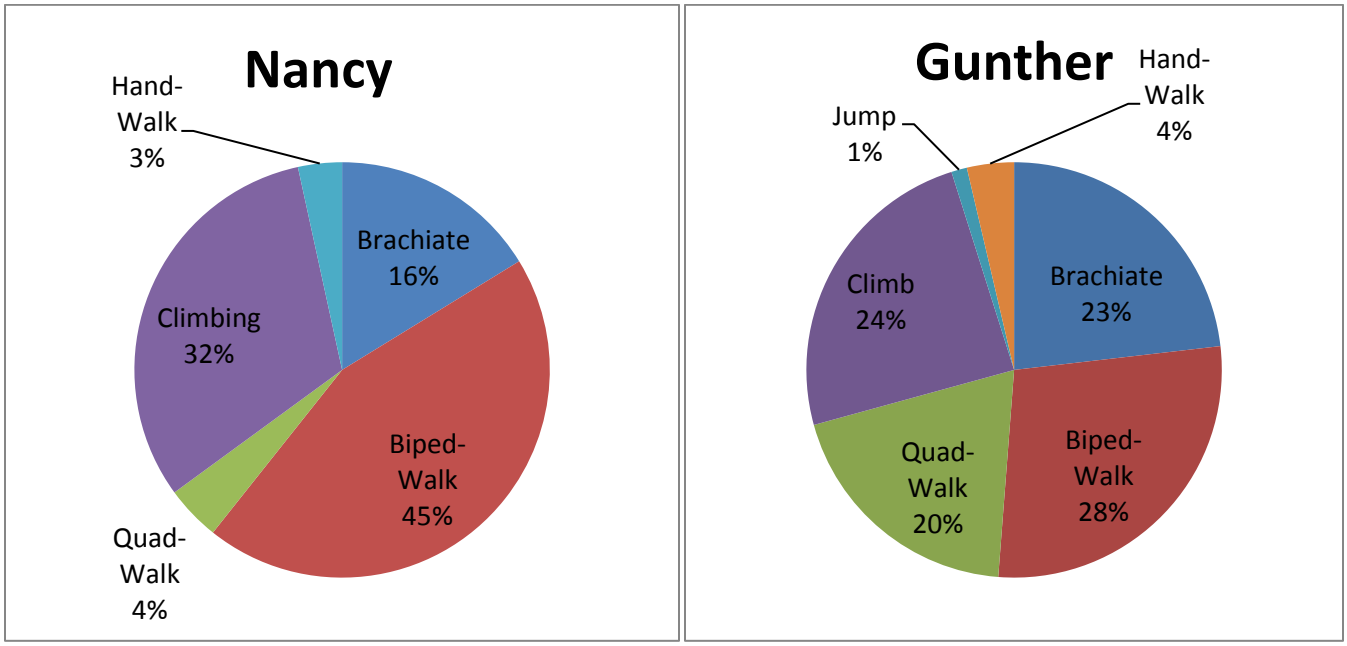


Figure 6. A) Modes of locomotion used by Phyllis and Duffy throughout total in-sight observation time. B) Modes of locomotion used by Nancy and Gunther throughout total in-sight observation time.

Activity Levels: Active was defined as engaging in any kind of locomotive behavior (brachiation, bi-pedal walking, quadrupedal walking, hand-walking, climbing, and jumping). Non- active was defined as any non-locomotive postures (hanging, sitting and lying). There were very similar results within the pairs of gibbons. Phyllis and Duffy spent approximately 25% of their time active and 75% inactive. Nancy and Gunther spent more time inactive than did the other pair. They spent approximately 15% of their time active and 85% inactive (Table 3).

Table 3: Minutes each gibbon spent active and non active during total observation hours (1200 min/each gibbon).

	Phyllis	Duffy	Nancy	Gunther
Active	133 min	154 min	155 min	140 min
Non- Active	408 min	447 min	786 min	789 min
Total in-sight min	541 min	601 min	941 min	929 min

The behavioral data collected on all four gibbons were separated into week's one through three and weeks four through six to ascertain any change in behavior following introduction into the new exhibit. Nancy and Gunther's activity levels increased markedly throughout the course of the study. Gunther increased the time he spent active by nearly eight times (3.79% to 29.9%) and Nancy almost doubled her activity (12.97% to 21.03%). During this time, Phyllis and Duffy decreased the amount of time spent active by 7.7% and 10.59% (Fig. 7).

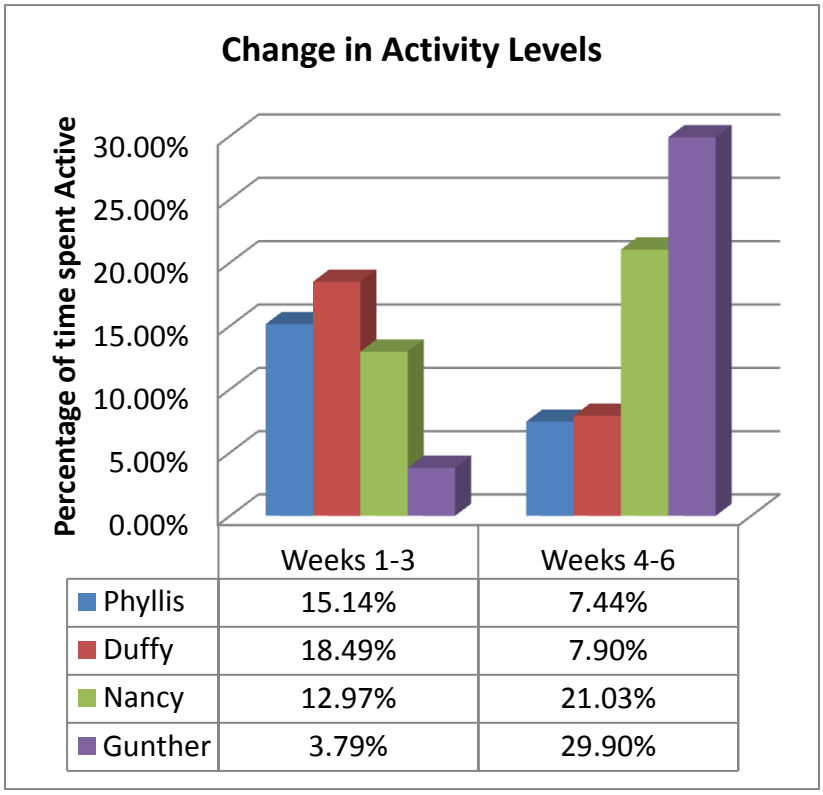


Figure 7. Comparison of the amount of time each gibbon spent active during weeks one-three and weeks four-six of the study.

Interspecies Relationship: There was a lack of evidence to support the existence of an interspecies relationship between Phyllis and Duffy and the two orangutans, Inje and Kutai. The gibbons did not spend a significant amount of time in close proximity to either orangutan and every time that this occurred, the orangutans were the ones that came within two meters of the gibbons, never the other way around. When the orangutans would get close to the gibbons both Phyllis and Duffy would stare at the orangutan for a short while before brachiating away. On one occasion, Kutai came within one meter of Phyllis. Duffy was about 6 meters away when this occurred. Phyllis backed up into the chute that connects their indoor enclosure with the outdoor enclosure while staring at Kutai's face. Duffy then brachiated towards the two of them. Kutai saw him coming and started moving back towards Zone 2 of the outdoor enclosure. Duffy followed him a little ways into Zone 2 but then brachiated back towards Phyllis. This was the extent of the observed interspecies interactions between the gibbons and the orangutans.

Comparison of Nancy and Gunther's behavior indoors and outdoors: To determine whether there was a difference in key behaviors when Nancy and Gunther were located in their indoor enclosure that had not been renovated, compared to when they were given access to the highly enriched outdoor enclosure of the Red Ape Reserve, Nancy and Gunther's behavioral data from the two enclosures was analyzed separately. Both Nancy and Gunther's activity levels were higher indoors than outdoors. Gunther's activity level was nearly four times as high indoors. Time spent on ground level and brachiating followed the same unexpected pattern as Nancy and Gunther's

indoor and outdoor activity levels; both gibbons showed more positive results indoors rather than outdoors. See Fig. 11 A-D for more detail. The only parameter that had results which followed the hypothesis that the subjects would show increased species-specific behavior outdoors was that Nancy spent more time above four meters from the ground outdoors rather than in her indoor enclosure.

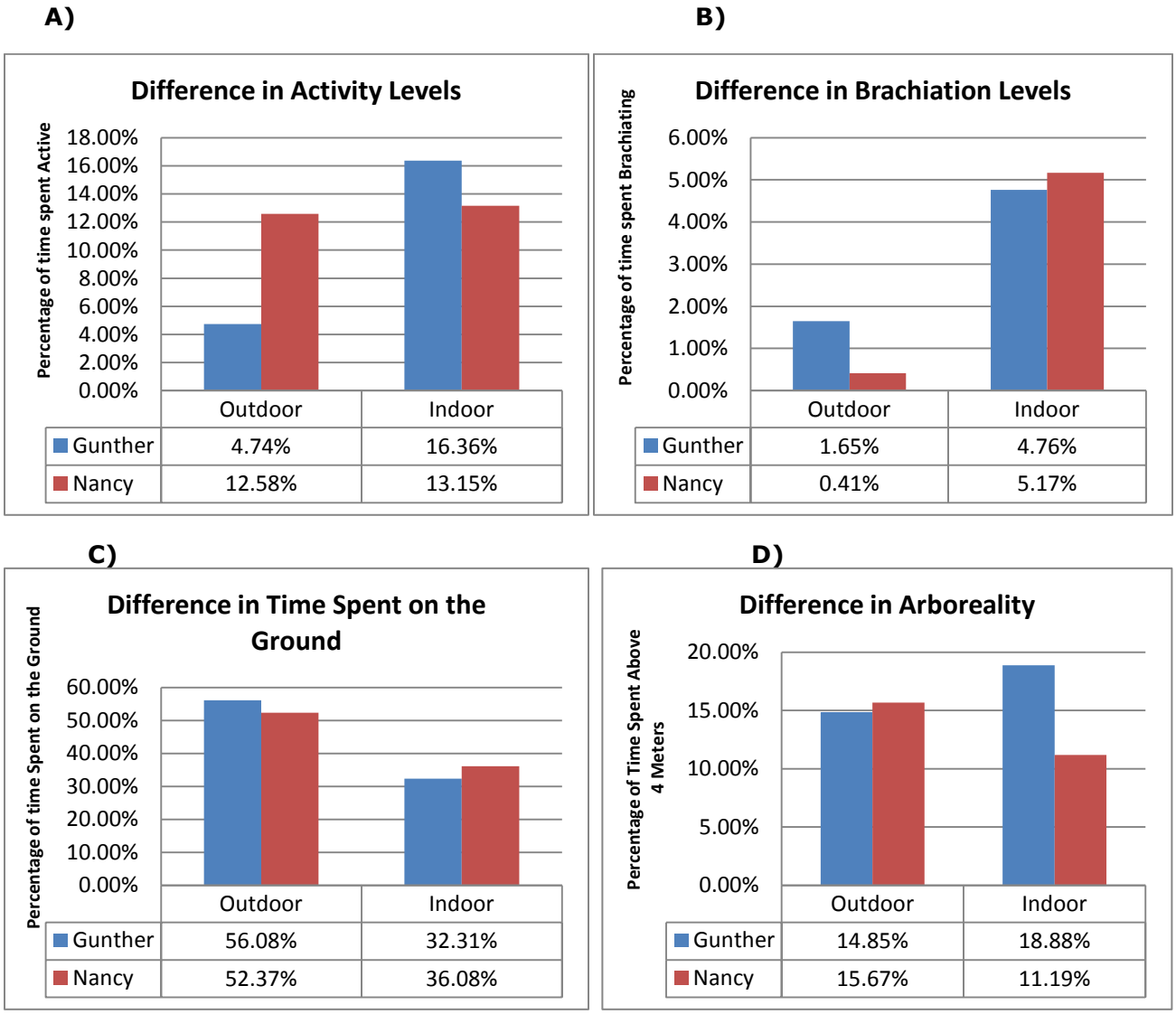


Figure 11. Comparison of Nancy and Gunther's behavior in their un-remodeled indoor enclosure and in the outdoor portion of the red ape reserve. A) Activity levels B) Percentage of time spent brachiating C) Percentage of time spent on the ground D) Percentage of time spent above four meters from the ground

Occurrences of stereotypies: Throughout all observation hours, there was no indication of stereotypies in any of the four gibbons.

Discussion:

There were distinct differences between the pair of gibbons with longer access to the enriched enclosures and the pair of gibbons that had been recently introduced to the outdoor portion of the reserve. This study focused on the species-specific behaviors of brachiation and arboreality (measured by the amount of time spent above four meters from the ground) and also

activity levels, which is usually indicative of cognitively healthier animals in enriched environments (Gibbons et al, 1994). An increase in these behaviors in Nancy or Gunther would indicate that the introduction of natural substrates and increased environmental enrichment were having a positive effect. Because Phyllis and Duffy had been housed in the Red Ape Reserve for roughly one year before the beginning of this study, it was assumed that their behavior would not change dramatically. Their behavior was used as a control when analyzing a change in Nancy and Gunther's behavior throughout the course of this study.

As predicted, Phyllis and Duffy had higher activity levels and spent considerably more time brachiating and at higher elevations than Nancy and Gunther had. The large disparity in these numbers may have been influenced by the personalities of the individual gibbons. Phyllis and Duffy are the dominant animals of the four gibbons, this is one of the reasons the keepers decided to give them access to the new enclosure initially. Duffy is also only 16 years old, making him by far the youngest gibbon at the Oregon zoo which may increase his likelihood to be more active. The marked decrease in brachiation events in the control group during weeks four through six may be explained by the weather. It was perceptibly warmer during the weeks four through six of this study, reaching up to nearly 90 degrees Fahrenheit in the afternoons, about 10 degrees higher than weeks one through three. Nancy and Gunther did increase their activity levels and arboreality and also greatly increased the amount of time spent brachiating during weeks four through six of this study, even in their older enclosure. This suggests that as little as two hours a day in a highly enriched environment filled with natural substrates can perceptibly increase the species-specific behavior of arboreality and brachiation in captive northern white-cheeked gibbons.

Nancy and Gunther increased their activity levels, time spent brachiating and also decreased the amount of time they spent on the ground while in their indoor habitats. This was not necessarily expected because the indoor enclosure had not been renovated. Beginning in August, Nancy and Gunther's schedule for use of the Red Ape Reserve changed from morning access to over-night access. During this time, researchers were not able to observe the animals outdoors due to the zoo's operating hours. Most of the outdoor observations occurred during the first four weeks of the study, when the animals could have still been warming up to the new the exhibit and the positive effects of the enrichment had not taken full effect yet. Access into the Red Ape Reserve could have increased the activity of these animals, however due to the lack of ability to observe these animals outdoors, this was not recorded. Having access to the enriched environment could also have increased species-specific behaviors and positive behaviors in the un-remodeled environment due to an increase in cognitive health overall. The animals may have spent more time foraging and eating indoors due to boredom while in their indoor enclosure. These results may also have been influenced by the change in schedule midway through this study.

In addition to using Phyllis and Duffy's behavior as a control, their behavior during observation periods in which Nancy and Gunther had recently had access to the outdoor portion of the Red Ape Reserve (when the observation period occurred less than one hour since a pair-switching event) was analyzed in order to determine whether or not Nancy and Gunther's presence in the territory influenced Phyllis and Duffy's behavior. A pair- switching event was defined as the several minutes where Nancy and Gunther were brought indoors and Phyllis and Duffy were given access to the outdoor enclosure for the remainder of the day. This has been the first time that these animals have shared any part of their habitat with others of the same species. White-cheeked gibbons, like all gibbon species, are highly territorial, therefore the possibility of the expression of territorial behaviors could not be ignored. Solo and duet vocalizations are the primary method gibbons use to defend their territories (Tuttle, 1986). During the course of this study, vocalizations occurred only once directly following a pair-switching event. On this day, Phyllis engaged in duet vocalizations with her partner Duffy for three minutes. During these duets, Phyllis always initiated the calls

which were followed several seconds later by Duffy joining the duet. Throughout the entire study, Phyllis was not heard solo vocalizing.
On the same morning, Duffy was also heard vocalizing. He engaged in solo and duet vocalizations for a total of three minutes each. Just after each of Duffy's solo vocalizations, Gunther was heard vocalizing in his indoor enclosure. During this time, Duffy and Gunther stared at each other the entire time through the glass and wire enclosure gates. The occurrences of vocalizations do support a territorial dispute, however, these were only heard on one morning throughout the six week study. This does not give adequate support to the hypothesis that Nancy and Gunther's presence in the outdoor portion of the Red Ape Reserve significantly affected vocalization territorial behaviors of Phyllis and Duffy or vice versa; more trials would be needed in order to make that conclusion.

Another territorial behavior that was elicited by both Phyllis and Duffy was staring at the other pair of gibbons (labeled LOOP in the ethogram). Duffy engaged in this behavior more often than Phyllis did, which is consistent with the male of this species possessing a more territorial nature. During observations that began within one hour of a pair-switching event, Phyllis spent 11 minutes or 5.31% of her time exhibiting this behavior and Duffy spent a total of 34 minutes or 14.78%. During observations that began at least one hour after a switching event, Phyllis spent 18 minutes or 5.39% and Duffy spent 17.74% of their time engaging in this behavior (an increase in frequency by 0.08% and 2.96% respectively). Phyllis' change in frequency was not great; however, the frequency of Duffy eliciting this behavior did increase during observations occurring at least an hour after a switching event. These results again do not show conclusive evidence to support a change in behavior due to territorial disputes. Using observations that began over an hour after a pair-switch might not have been an adequate control.

Additional Observations: During one observation period, Duffy was recorded engaging in self-directed behavior (grooming) with the use of a reflective surface to see areas of his body he otherwise would not have been able to view (his backside and buttocks) (Fig. 12). This is a remarkable observation because there are a multitude of studies that indicate that gibbons, or lesser apes, are incapable of recognizing their reflection in the mirror as themselves (Suddendorf & Collier-Baker, 2009; Hyatt, 1998). There have only been two studies that indicate the possibility of self-recognition in two genera of gibbon; Symphalangus and Hylobates (Ujhelyi et al, 2000; Heschl & Fuchsbichler, 2009). During these studies individual gibbons were seen engaging in self-directed behaviors in front of a mirror; however in both studies all the gibbons failed a Gallup mark test. The standard Gallup mark test involves marking an animal on the cheek or forehead and allowing it access to a mirror. To pass the test, the animal must notice the mark and attempt to remove it, thereby showing clear evidence of self-recognition. Duffy's behavior is a good indication that the individual is self aware; however there is debate to whether using a mirror for self-directed behaviors is enough evidence to imply an animal's ability of self-recognition (Bard et al, 2006). Conducting a version of the mirror mark test would provide an objective measure of visual self-recognition (Suddendorf & Collier-Baker, 2009) and is recommended for future studies on these gibbons.

Figure 12. Duffy engaging in self-directed grooming with the aid of a reflective surface

The phylogeny of the Hylobatid family is still under debate (Geissmann, 2003; Suddendorf & Collier-Baker, 2009). However, several theories have arisen as a result of the use of molecular, morphological, and vocal data comparisons using Bayesian analysis (Geissmann, 2003; Roos & Geissmann, 2001; Wildman et al, 2003). One theory held by Thomas Geissmann and Christian Roos, is that *Nomascus* is the most basal genus of the Hylobatid family (Roos and Geissmann, 2001). Based on this theory, conducting a mirror mark test on a member of the genus *Nomascus* would greatly benefit the body of knowledge on gibbon cognition and the evolution of hominoid visual self-recognition.

Limitations: There were several limitations to this study, some of which have already been mentioned. To cover all of the observation hours needed for this study, observation periods varied throughout each day. This can cause variations within the data sets due to differences in behavior during different periods of the day. The temperature and weather were not consistent throughout the course of the study. Temperatures ranged from approximately 60° to 90° Fahrenheit. The weather included sunny, cloudy, and rainy days during the study. While temperatures were high, the animals spent more time out of sight and inactive. The number of people that attended the zoo also changed daily and throughout each day. The number of people viewing the subjects and the noise level of the viewers seemed to have some effect on the behavior of the animals, especially while the animals were in their indoor enclosures. During periods when there was a high volume of visitors, the animals tended to spend more time out of sight. Duffy's age differed greatly from the rest of the subjects; this may have greatly contributed to his higher brachiation and activity levels. This study also used a small sample size of four subjects, leading to a possibility that these results may not be universally true among captive white-cheeked gibbons. Individual personalities may have a large effect on the behavior of animals and can account for some of the variation of behavior between the subjects. Beginning in August, the primate keepers modified Nancy and Gunther's schedule of use of the Red Ape Reserve. Instead of access to the outdoors for two hours every morning, Nancy and Gunther had access to the entire outdoor enclosure overnight. The keepers would let them out after zoo hours and bring them back indoors in the morning just before the zoo would open. This happened without prior notification to the researchers. This may have affected data collection during the latter half of this study because the animals had longer access to the enriched area, access occurred at different times and when zoo patrons were not in the area. The researcher was also unable to observe these animals in their outdoor habitat during this time.

Future Studies: Further observations should be conducted for more conclusive evidence to support the evidence of a decrease in abnormal behaviors in the gibbons from this study and an increase in species-specific behaviors. These studies should include a way to measure the effectiveness of the enrichment techniques implemented in order to better comprehend how to encourage positive behaviors in the animals. Additional studies including animals from other zoos and in other habitats would provide a better understanding of captive white-cheeked gibbon behavior as well. When constructing new habitats in the future, observations of the animals' behavior before introduction into the new habitat should be completed to provide a control to measure changes in behavior associated with the animals' move into the newer enclosure.

Conclusion:

Captive animals housed in substandard habitats may begin to show abnormal behaviors due to excessive stress. One way to mitigate these behaviors and to promote species-specific behaviors is through environmental enrichment and the use of natural substrates throughout the captive animal's enclosure. The construction of The Red Ape Reserve at the Oregon Zoo has implemented many enrichment techniques with the aim of increasing the species-specific behaviors of arboreality and brachiation in their captive northern white cheeked gibbons (*Nomascus leucogneys*

leucogneys). These renovations substantially increased these behaviors in the experimental pair of gibbon. Access to the enclosures with increased enrichment for short periods of time (two hours) daily also increased the activity levels of the experimental pair of white cheeked gibbons. More observations will need to be conducted on a larger sample size in order to universalize these results. Additional observations on these four gibbons at the Oregon Zoo will also be helpful in creating supplementary data points to ensure accurate results.

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Appendix I: Sample White-Cheeked Gibbon Ethogram

Start Time	Stop Time	Duration of Scan	Observer	Male	Female	Weather	Time Since Pair Switch

Time	Sex	Out of Sight	Location	Elevation	Proximity to Partner	Proximity to Inje	Proximity to Kutai	Locomotion / Posture	Activity
1	M								
	F								
2	M								
	F								
3	M								
	F								
4	M								
	F								
5	M								
	F								
6	M								
	F								
7	M								
	F								
8	M								
	F								
9	M								
	F								

Appendix II: Code Sheet and Definitions

Out of Sight

- The gibbon is not visible

Location

- Indoor one (I1): Orangutan Exhibit. This zone is defined as the room that the orangutans have access to. It is the first indoor enclosure of the Red Ape Reserve. The following are areas that the Gibbons may be found in this zone:
  - The ground: G
  - Log bridges (1 & 2): LB
  - Wooden pillar (1-7): WP
  - Far logs (1 & 2): FL
  - Close logs (1-7): CL
  - Ropes: R
  - Metal platform: M
  - Back wall: BW
  - Viewing window: W
- Indoor 2 (I2): Phyllis and Duffy's Enclosure. This zone encompasses the second indoor enclosure of the Red Ape Reserve that Phyllis and Duffy have access to. The following areas are possible areas the gibbons may inhabit:
  - Middle Tree: (T)
  - Branches of the middle tree: TB
  - Rock in the far right corner: WRK
  - Log: L
  - Small tree in the back of enclosure: ST
  - Tree built into the back wall: TW
  - Ropes: R
  - Plastic platform: PP
  - Rocks on the left side of the enclosure: RB
  - Ground: G
  - Viewing window: VW
  - Bamboo: BM
  - Middle Tree: T
- Indoor 3 (I3): Nancy and Gunther's Enclosure. This zone consists of the gibbon enclosure that had not been remodeled to increase species-specific behavior. It is adjacent to Phyllis and Duffy's enclosure. This zone includes the following possible areas to spot Nancy and Gunther:
  - Logs: L
  - Viewing Gate: VG
  - Ground: G
  - Platform on wall: P1-P7
  - Hammock: HMK
  - Ropes: R
  - Metal ladder: ML
- Zone 1 (Z1): This zone includes the entire outdoor exhibit to the east of the tree tunnel entrance to the indoor portion of to the Red Ape Reserve. It can be viewed from the outdoor walkway or through a glass window in the indoor portion of the exhibit. Areas to find gibbons in this zone include:
  - Outdoor viewer platform: VP
  - Ceiling: CL

  - Back gate (looking from the outside viewing area): BG
  - Side Gate: SG
  - Front gate (looking from the outside viewing area): FG
  - Large wooden pillars: WP
  - Ropes: R
  - Rock platform near indoor viewing area: RPF
  - Back cages: BC1(Nancy and Gunther's access chute), BC2 (Phyllis and Duffy's access chute)
  - Ground: G
  - Metal Platform: MP
  - Tree branch: TB
  - Logs: L
  - Rock bed surrounding the small waterfall (near indoor viewing area): FRK
- Zone 2 (Z2): This zone is comprised of the entire outdoor area to the west of the tree tunnel entrance. It can be viewed from two outside viewing areas and an indoor viewing window adjacent to the orangutan indoor enclosure. The gibbons can be found in/on the following areas in this zone:
  - Enrichment tree: ET
  - Log: L
  - Side gate: SG
  - Tree tunnel: TT
  - Ceiling: CL
  - Rock pile: RP
  - Viewing window: VW
  - Ropes: R
  - Ground: G
  - Keeper door that looks like a rock: RD

Elevation

- 0: On the ground
- 1: Less than 2 meters
- 2: Between 2 and 4 meters
- 3: Over 4 meters

Proximity to Partner

- - : less than 2 meters away
- + : more than 2 meters away

Proximity to Inje

- - : less than 2 meters away
- + : more than 2 meters away

Proximity to Kutai

- - : less than 2 meters away
- + : more than 2 meters away

Locomotion and Posture

- BR: Brachiating
- HA: Hanging
- S: Sitting

- BW: Bipedal walking
- QW: Quadrupedal walking
- L: Laying
- CL: Climbing
- J: Jumping
- HW: Hold walking (when the animal is walking bipedally while holding on to an object with their hands for support)

Activity

- E: Eating
- P: Playing
- VS: Solo Vocalization
- VD: Vocalizing in a duet
- G: Self grooming
- GAI: Initiate allogrooming
- GAR: Receive allogrooming
- F: Foraging
- SI: Social interaction
- LOE: Looking around enclosure
- LOV: Looking at viewers
- LOP: Looking at partner
- LOOP: Looking at other pair of gibbon
- LOO: Looking at an Orangutan – when occurs specify which orangutan
- R: Rest
- M: In movement
- SX: Sexual behavior