Gorillas and Orangutans, Hand in Hand: A Study of Woodland Park Zoo's Great Apes

In Memory of the Gentleman, Pete

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Abstract

Is the exhibited manipulation complexity of primarily terrestrial great apes at Woodland Park Zoo greater or lesser than the manipulation complexity of primarily arboreal great apes at Woodland Park Zoo during foraging activity? There is current support that complex manipulation of objects is more developed in terrestrial species of primates than arboreal species of primates due to the musculature and skeletal design of arboreal primate hands. All great apes involved in this study are cared for at Woodland Park Zoo in Seattle, WA. This study was conducted on five Western lowland gorillas, three Bornean-Sumatran orangutan hybrids, and one Sumatran orangutan. Manipulation complexity was considered on a scale of complexity divided into four considerations: number of hands used, number of items being manipulated, synchronicity of digits, and synchronicity of hands. Both terrestrial great apes and arboreal great apes exhibited the ability to perform at the highest level. Both species exhibited the ability to perform fine manipulation within the hand and a similarity of diversity of maneuvers employed in the manipulation of an object. Highest quality animal welfare practices should address the intelligence, emotions, curiosity, and physical abilities of these species as well as these individual primates. Exploration with one's hands is a vital element of primate perception and understanding of the world. Enrichment is an important tool to encourage this area of welfare and should be designed thoughtfully.

Introduction

In the beginning, primates were only to be found in the trees. There, hands were used to grasp branches, pinch off choice leaves, and pluck away ripe fruit. Slowly, over millennia, our ancestors and the ancestors of a few species of great apes left the relative safety and familiarity of an arboreal life for new opportunities down on the ground. The terrestrial lifestyle and its form of locomotion have long been purported to be the spur for primate tool use, and the increased use of tools is claimed to have driven a leap in cognitive ability and manual dexterity (Napier, 1956, 1962). Tool use is presumed to be inhibited by arboreal locomotion because the hands are in constant use as they grasp branches and grip for balance (Fragaszy & Visalberghi, 2004).

Regardless of the habitat, primates actively explore their environments, and the distinctive versatility of the primate hand encourages primates to conduct much of this exploration manually (Taffoni et al. 2017). Primate hands are capable of fine pincer grasps, such as pinching off leaves or plucking ticks from a companion's ear, as well as palm grips while holding heavy objects against the palm, such as lifting and holding heavy stones for

crushing nuts (Taffoni et al., 2017;Napier, 1962). Primate hands perform highly complex manipulations aided by precise sensory feedback and fine motor control (Taffoni et al. 2017).

Given the importance of the hand in primate evolution, high quality animal care in a captive environment requires careful consideration of this interplay between cognition and manual dexterity. This necessitates providing great apes with enrichment which allows captive great apes ample opportunities to exercise these faculties (Clark, 2011). Psychological well-being of managed animals is a vital aspect of animal husbandry, and allowing an animal to exert some control over their day, such as feeding and foraging, contributes to such well-being (AZA, 2017). Studies show that captive animals prefer to actively acquire their food in ways which are naturalistic and challenging (Kreger, Hutchins, & Fascione 1998). This study is designed to better understand the interplay of intellectual capacity and physicality in the manipulation complexity of a primarily terrestrial great ape species and a primarily arboreal great ape species.

Woodland Park Zoo is home to both terrestrial and arboreal great apes: Western lowland gorillas *(Gorilla gorilla gorilla)* and orangutans *(Pongo pygmaeus/abelii, Pongo abelii)*. As an Association of Zoos and Aquariums (AZA)-accredited institution with a high standard of animal welfare, Woodland Park Zoo's enrichment items would need to be intentionally designed so as to offer interesting challenges of manual dexterity. While the great apes at Woodland Park Zoo are given objects to encourage manual and digital manipulation, such as varied browse, it has not yet been measured how complex those manipulations are for these various individuals. Foraging for a favorite food item provides an opportunity to observe manipulation complexity because fine motor skills offer an advantage for extracting food, holding the food or manipulating the food with different objects (Heldstab et al., 2016).

Wild orangutans live a much more arboreal lifestyle than wild gorillas, and the morphology of the orangutan hand would suggest difficulty in using thumbs during in-hand maneuvers due to its low thumb-forefinger index (Bardo, 2017). A physical determinist would suggest that this low thumb-forefinger index limits manipulation complexity. However, one who is willing to acknowledge the intellectual capacity of orangutans would note their propensity to innovate. Captive, well-managed orangutans living in groups innovate at a higher

rate than wild orangutans, supported by the theory of the "Captivity Effect" in which orangutans in captivity are less neophobic and more willing to innovate with novel items, in part because of their trust in their human caretakers (Van Schaik et al. 2016). Due to this increased potential to innovate, it was predicted that gorillas and orangutans would exhibit similar manipulation complexities despite the orangutan's low thumb-forefinger index.

Methods

All great apes involved in this study are cared for at Woodland Park Zoo in Seattle, Washington. Individuals studied included nine Western lowland gorillas (*Gorilla gorilla gorilla)*, four Bornean-Sumatran (*Pongo pygmaeus/Pongo abelii)* orangutan hybrids, and one Sumatran orangutan (*Pongo abelii*). These individuals are housed in 5 separate groups with one dominant male in each troop (see Appx. 1).

Data was collected using all occurrences behavioral sampling. The observed behavior was defined as making physical contact with browse, dietary items, or enrichment items filled with food (such as a puzzle, Kong, etc) so as to feed. Only manipulation of objects during foraging activity was recorded. Recorded contact was limited to manual interactions (interactions with hands) of the forelimbs only. Hind limb manipulation and holding items in the mouth did not constitute an observable behavior. These behaviors were observed in events, and events began once an individual began to manually manipulate objects. The event ended once physical contact with the object ended. This end was either a result of ingesting the object or discarding the object once its use was over.

We utilized the methodology created by Heldstab et al. (2016). Manipulation complexity was considered on a scale of complexity divided into four considerations: number of hands used, number of items being manipulated, synchronicity of digits, and synchronicity

Level 1	*Level 2*	*Level 3*	*Level 4*	*Level 5*	*Level 6*	*Level 7*
						
Single Hand Palm Grip Digits synchronized	Single Hand Precision Grip Digits asynchronized	1 Object Bimanual Hold Digits synchronized	1 Object Bimanual Hold Synchronized hands Digits synchronized	1 Object Bimanual Hold Digits asynchronized	2 objects Bimanual manipulation Digits synchronized	2 objects Bimanual manipulation Digits asynchronized

Figure 1: Cumulatively Ranked Levels of Manipulation Complexity

of hands (Fig. 1). Synchronicity of digits was determined if all digits (no thumb) were in the same position and direction. Asynchronicity involved the use of the thumb and/or digits in different positions and manipulating the object in varied ways. Hands were positioned in the same direction for synchronicity of hands and in different degrees from each other in asynchronicity of hands. If an object was held between the majority of the digits and the palm the interaction was defined as palm grip. If the object was held between the thumb and 1-2 digits it was determined to be a precision grip. One additional interaction was added upon discovery during observations; fine manipulation within the hand (See Fig. 2). This action results in each individual digit (thumb could be included) manipulating the object or objects independent of the other digits (Heldstab et al., 2016).

Figure 2: Fine manipulation within the hand

It was intended to record five minutes of footage for each individual. When an event ended due to ingestion of the object or the subject moving out of sight, recording ended. Data was recorded with video so as to allow for both observers to record the events and to accommodate the occasional long-distance viewing required due to exhibit design. Recording with video also allowed for observers to more accurately record data as many manual maneuvers can be quick, subtle, and difficult to see the first time you observe an event. Due to the complexities of the definitions of our manipulation events, the ethogram contains photos of the categories (see Appx. 2).

Data was analyzed based on three parameters: greatest diversity of levels used while manipulating a single object for each individual, highest level of complexity observed for each individual, and an aggregate of "manipulation within the hand" events for each individual. Species-specific averages were calculated for both greatest diversity of maneuvers used and highest level of manipulation complexity. Percentage of individuals within a species who manipulated objects within the hand at least once was then calculated. T-Tests provided the p value for each parameter measured.

Results

The results of this study did not support the postulation that Heldstab et al.'s manipulation categories follow a cumulative ranking (Heldstab et al. 2016). Individuals capable of performing Level 4 did not always display the ability to also perform Levels 1 through 3, for example (See Appx. 2). Individuals who performed a high level of manipulation complexity did not necessarily also perform a high diversity of maneuvers with single objects with the exception of the juvenile gorilla, Yola, and the orangutan without two digits on her left hand, Melati (See Appx. 3). Performance of the highest degree of manipulation complexity did not differ between species. Both terrestrial great apes and arboreal great apes exhibited the ability to perform at the highest level (Level 7). The average level attained by gorillas was 5.8 and the average level attained by orangutans was 5.5 (See Fig.3). A statistical T-Test of species averages for manipulation complexity in Woodland Park Zoo's gorillas and orangutans resulted in a p-value of .8. This p-value supports the null hypothesis that there is no significant difference between the degree of manipulation complexity of gorillas and orangutans.

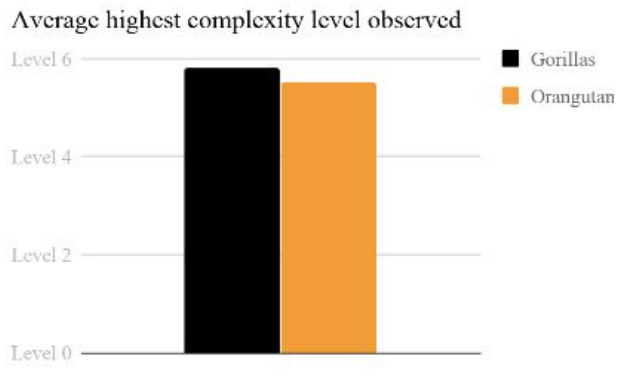


Figure 3: Species Average of Highest Complexity Level Observed

Both species exhibited the ability to perform fine manipulation within the hand, however while 100% of gorillas studied performed fine manipulation within the hand, only 25% (Melati) of orangutans performed fine manipulation within the hand (See Fig. 4).

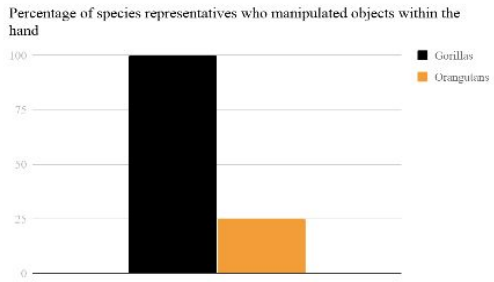


Figure 4: Percentage of Individuals who Performed Fine Manipulation within the Hand

A statistical T-Test of observed events of Level 7 manipulation complexity in Woodland Park Zoo's gorillas and orangutans resulted in a p-value of .2. This p-value further supports the null hypothesis that there is no significant difference in

the observed manipulation complexity of Woodland Park Zoo's great apes. Our prediction aligned with the null hypothesis: Woodland Park Zoo's terrestrial great apes and their arboreal great apes exhibit similar degrees of manipulation complexity.

Discussion

Both gorillas and orangutans at Woodland Park Zoo can manipulate objects with a sophisticated degree of complexity. This study suggested an intriguing difference in the two groups, however: while more individual orangutans exhibited high complexity levels, gorillas exhibited a stronger tendency to manipulate objects with fine dexterity within the hand. Perhaps orangutans are more deliberate in their choice of maneuvers employed while gorillas are more experimental and/or exploratory. Every individual gorilla was observed performing fine manipulation of objects within the hand.

Orangutans were observed with a greater variety of enrichment, which may have influenced the results. For example, orangutans were provided with peel-on citrus fruits, paper towels, and lettuce placed within the mesh (See Fig. 5) rather than deposited onto the ground of their exhibits as was done in the gorilla exhibit. These items may have encouraged greater levels of manipulation than the browse and food items placed within the gorilla exhibits.

Figure 5: Orangutans Godek (rear) and Chinta (forefront) with Citrus and Lettuce Items

Yola, a juvenile, is a significantly more active gorilla than the rest of her troop. She actively explores her habitat, and much of her exploration is guided by touch and manipulation of items. Sensorimotor theory proposes that the consciousness and perceptions of a sensory experience are not merely generated within the brain but are also constituted by the objective capacities of an environment (O'Regan & Noë 2001). This process of understanding the capacities of the environment around you begins when you first become aware of your own body and how you may control your body to produce desired movement, thus affecting the surrounding environment (Taffoni et al. 2017).

Figure 6: Gorilla Yola with Browse Enrichment Item

Yola is actively engaged in building her understanding of distance, color, space and other properties which our brains consciously and unconsciously perceive. Her hands, like the hands of all primates, are an essential component of this exploration (See Fig. 6).

Manual dexterity is a distinctive feature of primate species (Napier 1962; Fragaszy & Crast 2016; Taffoni et al. 2017). Navigating complex, three-dimensional environments often composed of variable obstacles oriented in unpredictable ways is greatly aided by the dexterity of primate hands (Patel et al. 2015). Perhaps our primate ancestors hastened their manufacture of tools after they left the trees because they were bored from having so little to do with their hands down on the ground. We write in jest, but the research still suggests that apes, no matter their thumb-forefinger index, are prone to innovating and exploring actively with their hands and can accommodate physical limitations, as the high scoring and dexterous three-fingered Melati displayed (See Appx. 2).

Conclusion

Is the exhibited manipulation complexity of primarily terrestrial great apes at Woodland Park Zoo greater or lesser than the manipulation complexity of primarily arboreal great apes at Woodland Park Zoo during foraging activity? Performance of the highest degree of the manipulation complexity scale did not differ between species. Both terrestrial great apes and arboreal great apes exhibited the ability to perform at the highest level (Level 7). Both species exhibited the ability to perform fine manipulation within the hand. Individuals who performed a high level of manipulation complexity did not necessarily also perform a high diversity of maneuvers with single objects with the exception of the juvenile gorilla, Yola, and the orangutan, Melati.

Further qualitative and quantitative studies could potentially increase our understanding of the high degree of manual and digital complexity which these species are more accurately capable of. These studies would benefit from being controlled experiments in which subjects are each provided identical objects to manipulate so as to decrease the confounding variable of each group in this study being provided very different enrichment items.

To increase the level of animal welfare, there is also the potential for further study. Such studies could include: how can enrichment at Woodland Park Zoo increase the repertoire of complexity? How do gorillas and orangutans differ in their exploration of space and pursuit of understanding? Which forms of enrichment encourage such forms of physical and intellectual exercise? And, finally, how do our biases of the species-specific behavior indexes affect our ability to differentiate traits from states? By better understanding the traits of individuals, their distinguishing qualities, we can learn to recognize states, which are specific conditions during a set period of time.

Literature suggests that the highest quality of animal welfare practices should address the intelligence, emotions, curiosity, and physical abilities of species as well as individuals (Kreger, Hutchins, & Fascione 1998; Grandin, 2018;Clark, 2011). Exploration with one's hands is a vital element of primate perception and understanding of the world. Enrichment can be an important tool in the promotion of this cognitive and physical exploration of captive habitats, thus enrichment should be carefully considered and intentional.

REFERENCES

AZA Ape Taxon Advisory Group. (2017). Orangutan *(Pongo)* Care Manual. Silver Spring, MD: Association of Zoos and Aquariums.

Bardo, A., Cornette, R., Borel, A., & Pouydebat, E. (2017). Manual function and performance in humans, gorillas, and orangutans during the same tool use task. *American Journal of Physical Anthropology,*164, 821–836

Barrett, B., McElreath, R., & Perry, S.E. (2017). Pay-off-biased social learning underlies the diffusion of novel extractive foraging traditions in a wild primate. *Proceedings of the Royal Society B,* 284.

Clark, F. E. (2011). Great ape cognition and captive care: Can cognitive challenges enhance well-being? *Applied Animal Behaviour Science*, 135, 1–12.

Heldstab, S. A., Kosonen, Z. K., Koski, S. E., Burkart, J. M., van Schaik, C. P., & Isler, K. (2016). Manipulation complexity in primates coevolved with brain size and terrestriality. *Scientific Reports*

Kreger, M. D., Hutchins, M., & Fascione, N. (1998). Context, ethics, and environmental enrichment in zoos and aquariums. In D. J. Shepherdson, J. D. Mellen, & M. Hutchins (Eds.), *Second Nature: Environmental Enrichment for Captive Animals* 59–82.

Fragaszy, D. & Crast, J. (2016). Functions of the hand in Primates. In *The evolution of the primate hand: Anatomical, developmental, functional, and paleontological evidence* 313-344.

Fragaszy, D. & Visalberghi, E. (2004). Socially biased learning in monkeys. *Animal Learning and Behavior.* 32, 24–35

Grandin, T. (2018) My Reflections on Understanding Animal Emotions for Improving the Life of Animals in Zoos, *Journal of Applied Animal Welfare Science*, 21:sup1, 12-22,

Marzke, M. (1997). Precision grips, hand morphology, and tools. *American Journal of Physical Anthropology.* 102(1):91-110.

Napier, J.R. (1956) The prehensile movements of the human hand. *Journal of Bone and Joint Surgery*. 38B:902–913

Napier, J (1962) The Evolution of the Hand. *Scientific American* Vol. 207, No. 6, 56-65

O'Regan, J.K. & Noë, A. (2001). A sensorimotor account of vision and visual consciousness. *Behavioral and Brain Sciences,* 24 (05), 939-973

Patel, B., Wallace, I., Boyer, D., Granatosky, M., Larson, S., Stern, J. (2015). Distinct functional roles of primate grasping hands and feet during arboreal quadrupedal locomotion. *Journal of Human Evolution.* 88 (2015). 79-84

Taffoni, F., Polizzi di Sorrentino, E., Sabbatini, G., Formica, D., Truppa, V. (2017) Primates' Propensity to Explore Objects: How Manual Actions Affect Learning in Children and Capuchin Monkeys. In: Bertolaso M., Di Stefano N. (eds) The Hand. *Studies in Applied Philosophy, Epistemology and Rational Ethics*. vol 38. Springer, Cham

Van Schaik, C.P., Van Noordwijk, M.A., Wich, S.A. (2006). Innovation in wild Bornean orangutans (*Pongo pygmaeus). Behavior!* 43, 839-876

Van Schaik, C.P., Burkart, J., Damerius L., Forss, S.I.F., Koops, K., Van Noordwijk, M.A., & Schuppli, C. (2016). The reluctant innovator: orangutans and the phylogeny of creativity. *Philosophical Transactions of the Royal Society B.* 371: 20150183

Appendix 1

Appendix 1: General Information of subjects based on grouping/Troop

Troop	Name	Age	Sex	Birth Place	Species
1	Pierrot "Pete"	50	male	wild born, Cameroon	*Gorilla gorilla gorilla*
1	Amanda	48	female	wild born, Cameroon	*Gorilla gorilla gorilla*
2	Vip	39	male	Wassenaar Zoo	*Gorilla gorilla gorilla*
2	Jumoke	13	female	Woodland Park Zoo	*Gorilla gorilla gorilla*
3	Kwame	19	male	Smithsonian National Zoo	*Gorilla gorilla gorilla*
3	Nadiri	22	female	Woodland Park Zoo	*Gorilla gorilla gorilla*
3	Akenji	17	female	Woodland Park Zoo	*Gorilla gorilla gorilla*
3	Uzumma	11	female	Woodland Park Zoo	*Gorilla gorilla gorilla*
3	Yola	3	female	Woodland Park Zoo	*Gorilla gorilla gorilla*
4	Chinta	50	female	Woodland Park Zoo	hybrid *Pongo pygmaeus/Pongo abelii*
4	Melati	46	female	Smithsonian National Zoo	hybrid *Pongo pygmaeus/Pongo abelii*
4	Godek	9	male	Cheyenne Mt. Zoo	*Pongo abelii*
5	Heran	29	male	Woodland Park Zoo	hybrid *Pongo pygmaeus/Pongo abelii*
5	Belawan	37	female	Woodland Park Zoo	hybrid *Pongo pygmaeus/Pongo abelii*

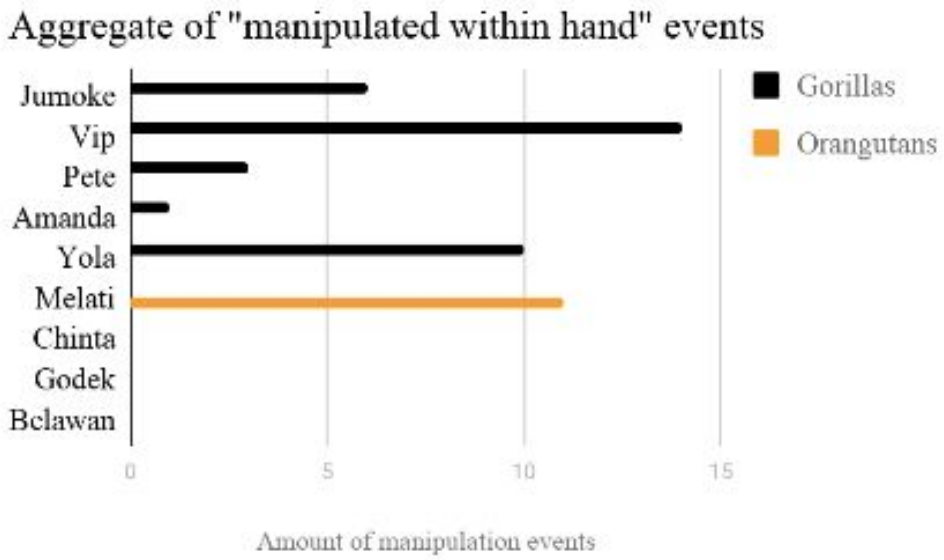
Appendix 2

Ethogram containing amount of every event recorded

									**NOTES**
PETE	*4*	*6*		*1*				*3*	*Passed away 11/4/18*
AMANDA	*5*			*2*		*1*		*1*	
VIP	*10*	*21*			*2*	*2*		*14*	*Inflamed surgery site/limited movement*
JUMOKE	*13*	*18*			*1*	*1*		*6*	*Rolls celery between fingers. Shakes off lettuce*
***KWAME**									*No data*
***NADIRI**									*No data*
***AKENJI**									*No data*
***UZUMMA**									*No data*
YOLA	*20*	*67*	*4*	*3*	*5*	*7*	*2*	*10*	*Returned to exhibit 11/7/18*
CHINTA	*1*	*50*		*2*			*8*		*1 hand, 2 objects*
MELATI	*12*	*9*		*2*	*6*		*12*	*11*	*Missing last 2 digits on left hand*
GODEK	*10*	*7*	*3*	*4*	*3*	*2*			*Often unable to record manipulation due to the fact he was handling "non-foraging" item*
***HERAN**									*No data*
BELAWAN	*3*	*7*							*Often difficult to locate within exhibit*

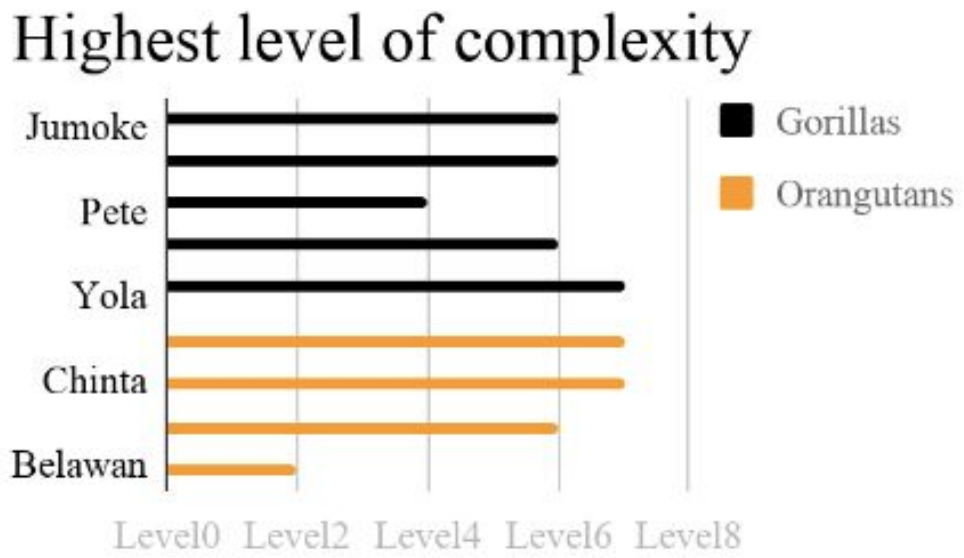
* No data collected due to visibility, time constraints, off exhibit, food availability, or other

Appendix 3



Appendix 3: Aggregate of "Fine Manipulation within Hand" Events per Species Representative

Appendix 4



Appendix 4: Highest Level of Complexity Observed for each Subject