

DISCUSSIONS

CASE WESTERN RESERVE UNIVERSITY UNDERGRADUATE RESEARCH JOURNAL

FEATURING:

Gharial (*Cavialis gangeticus*) Habitat
Use and Behavior Analysis in Response
to Repeated Aggression

Leslie Sadowski

The Natural History of Osteoarthritis

Ashley Quick

Art, Hallucination, and
Embodiment

Nick Davis

And More!

VOLUME 4
SPRING 2008

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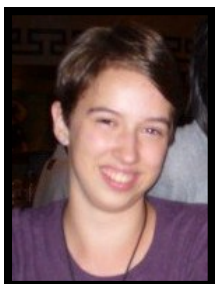
TABLE OF CONTENTS

- | | |
|------|---|
| [4] | Neuropsychological Functioning in Youth with Childhood-onset Schizophrenia
<i>Megan Carl</i> |
| [5] | <i>The Chronicles of Narnia</i> and <i>His Dark Materials</i> : The Bible and <i>Paradise Lost</i>
of Children's Literature
<i>Misia Yuhasz</i> |
| [6] | Gharial (<i>Gavialis gangeticus</i>) Habitat Use and Behavior Analysis in
Response to Repeated Aggression
<i>Leslie Sadowski</i> |
| [17] | The Natural History of Osteoarthritis
<i>Ashley Quick</i> |
| [25] | Art, Hallucination, and Embodiment
<i>Nick Davis</i> |
| [37] | How to Submit a Paper for Publication |
-

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Letter from the Editors:

The Spring 2008 (Volume 4) issue of *Discussions* marks the first time the journal has successfully published two issues in one year. We are proud of accomplishing this in only our third year, although Volume 4 is smaller than our previous issues. By increasing selectivity we hope to also maintain, if not increase, the integrity and quality of the articles published.

As we continue to develop the journal over time we have been able to incorporate new features into the publication. This semester we are printing an entirely color version, which allows us to better display the research chosen. Take a look at the excellent color images in *The Natural History of Osteoarthritis* and *Gharial (*Gavialis gangeticus*) Habitat Use and Behavior Analysis in Response to Repeated Aggression*, as well as the color rendition of the author's own artwork in *Art, Hallucination, and Embodiment*, and hopefully you too will enjoy the change. Additionally, we have been able to experiment a bit more with the cover, and currently feature an image from one of the articles published within the journal. We will also continue to produce CD versions of the journal, for the enjoyment of the more technologically inclined reader.

Our general reviewer body continues to grow, and we hope that many of these members will become future officers as they become more involved with the journal. Having new members join the group and add their unique viewpoint to our reviewing process keeps the journal fresh and alive, and certainly keeps the officers on their toes while trying to keep up with the flow of ideas.

Finally, *Discussions* is also happy to have gained some office space this semester! By next year we will have our very own computer, the addition of which will allow the journal to grow even more than it has already.

As usual, our articles this semester cover a variety of very different disciplines, and we hope that all readers are able to find something of interest within our pages. We encourage all undergraduates to submit their own research to the journal. Whether you are an engineer, anthropologist, future doctor, politician or economist, we look forward to reading your research next semester. The submission deadline for our Fall 2008 issue is September 7. Submission guidelines can be found on our website at www.case.edu/source/discussions.

We continue to welcome any students interested in becoming reviewers or otherwise involved in *Discussions*. As a student run organization, we rely completely on participation from the undergraduate student population at CWRU! The only skills or previous experience necessary to becoming a member of *Discussions* is the ability to read and form constructive criticism of the papers we review. Join us!

Thank you for picking up the Spring 2008 issue of *Discussions*. We hope you enjoy it.

Anna Wieser and Sean Yeldell
Editor-in-Chief and Managing Editor

Neuropsychological Functioning in Youth with Childhood-onset Schizophrenia



-Megan Carl-

Megan Carl is a second year Psychology major at Case Western Reserve University. She is a student Tour Guide in the Undergraduate Admissions Office, and a research assistant in the Department of Psychology. After graduation, she plans on pursuing a Ph.D. in Clinical Psychology.

-Acknowledgements-

I would like to thank Dr. Arin Connell Ph.D. for aiding me in narrowing down my research and encouraging me to research such a diverse topic. Also, I would like to thank Courtney Johnson for her insights, and encouragement throughout writing this paper. Finally, and most importantly, I would like to thank my parents for their support and witticism when I was on the brink of tearing my hair out.

ABSTRACT

Schizophrenia, in the general adult population, has an extremely low base rate. The American Psychiatric Association has not published population estimates for Childhood-onset Schizophrenia (COS) because the disorder is extremely uncommon. Adults and youth with Schizophrenia display characteristic impairments such as a loss of touch with reality and emotional difficulties. Typically, these emotional problems fall into one of two categories: having little or no emotion or displaying inappropriate emotions for the specific situation, such as laughing at a funeral. Individuals with COS, similarly to individuals with Adult-onset Schizophrenia (AOS), have impairments in functioning of their brain and central nervous system. Central nervous system deficits have been observed with measurements of weakened smooth-pursuit eye movements and jerky movements of limbs and other extremities. Individuals with both AOS and COS usually have an abnormality in a region of the brain specific to executive functioning, such as planning, or memory. If there is a lesion present in any of these locations, specific neuropsychological problems result. Neuropsychological difficulties normally found are in the domains of memory, IQ, and other neuropsychological functions, such as spatial and planning abilities.

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The Chronicles of Narnia and *His Dark Materials*: The Bible and *Paradise Lost* of Children's Literature

ABSTRACT

Ostensibly light and entertaining children's literature, *The Chronicles of Narnia* and *His Dark Materials* both engage in profound and mature moral and theological discussions. In creating their respective series', C.S. Lewis and Philip Pullman use themes and metaphors from traditional Christianity to construct reactions to the Christian faith and make arguments with respect to its validity. While C.S. Lewis depicts Christianity as the ultimate benevolent force of humanity, Philip Pullman portrays the church as an enslaving and stifling force that promotes conformity rather than free thought. Concentrating on the role of sin in post-lapsarian humanity, both C.S. Lewis and Philip Pullman use various facets of their series, such as the image of God, the role of the narrator, and the depiction of the serpent from the Garden of Eden, to construct reactions to the Christian faith. While Lewis follows traditional Biblical imagery, depicting his God as the almighty savior, the serpent as the bringer of all evil, and the Fall of Adam and Eve as the great downfall of mankind, Pullman reverses these notions: God as the definitive source of evil, the serpent as the only conscious and therefore intellectually acute being, and the Fall of Adam and Eve as the only means to an enlightened society. Using these themes and images among others, Lewis and Pullman create two contrary views of Christianity as it functions in relation to humanity: one as the benevolent society dedicated to providing eternal happiness, and one as the lying, manipulative institution concerned with enslaving its followers.

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-Misia Yuhasz-

Misia Yuhasz is a third year student at Case Western Reserve University pursuing a degree in English and a concentration in pre-medicine. Aside from academics, Misia is serving as president of the Ballroom Dance Society and is currently Assistant News Editor for *The Observer*. This spring, Misia is also working with other English majors and graduate students to organize an English honors society chapter of Sigma Tau Delta on campus. In addition, Misia is an active member of the Mortar Board Honor Society and the Golden Key International Honour Society and has served on the Jackson and Wittke Selection Committees. In her spare time, she volunteers at Rainbow Babies Children's Hospital.

-Acknowledgements-

I would like to thank my research advisor, Mary Grimm of the Department of English for all of her advice and support while writing this paper. Without her direction and constructive criticism, this paper would not have been possible. Special thanks are also in order for my mentor Brad Ricca of the Department of English. Professor Ricca's commitment to his students always exceeds expectations, and his support during this endeavor was crucial to its success.

Gharial (*Gavialis gangeticus*) Habitat Use and Behavior Analysis in Response to Repeated Aggression



-Leslie Sadowski -

Leslie graduated summa cum laude with honors in Biology in January 2008. She is an animal care and education volunteer at the North Chagrin Nature Center. She plans to attend graduate school in the fall and would like to study Conservation Biology, particularly the conservation of amphibians and reptiles. She is currently researching the antimicrobial peptides of Panamanian Golden Frogs at the Cleveland Metroparks Zoo.

-Acknowledgements-

I would like to thank Dr. Kristen Lukas for allowing me to do this project at the Cleveland Metroparks Zoo, keeper Brad Poytner for his assistance and knowledge, and the rest of the Cleveland Metroparks Zoo staff who aided me in this project.

ABSTRACT

Gavialis gangeticus, the Indian gharial, is the only extant gharial species in the world. The gharial is a large crocodylian in the family *Gavialidae* and is characterized by a long snout. Due to its sparse numbers and increased habitat destruction, its behavior as compared to other living crocodylians remains relatively unknown. This particular specimen, located at the Cleveland Metroparks Zoo, was a female of approximately 28 years. The study was done in order to determine causes for aggression towards certain species of fish in the gharial's enclosure. These species of fish were too large for the gharial to consume and thus would not represent a prey item to the gharial. It was hypothesized that limited enclosure space led to increased aggression in the gharial. However, throughout the course of the study no attacks on fish were recorded, but stereotyped swimming by the gharial was seen. It was noted that the gharial displayed less stereotypical swimming when the public was present than when people were not observing the enclosure. These results suggest that the public could be a source of stimulation for the gharial and thus could reduce negative behaviors in the captive gharial.

INTRODUCTION

The Indian gharial, *Gavialis gangeticus*, is the only extant species of gharial left in the world (Vliet 2001). The gharial is a member of the order Crocodylia, which also includes crocodiles, alligators, and caimans. It is in the family *Gavialidae* and is characterized by its long, narrow snout. The males are distinguished by the large, bulbous

“ghara” on the tip, hence the common name “gharial” (Whitaker 1982). This adaptation is due to the fact that its main diet is the fish that inhabit these rivers, such as tilapia, and that the gharial tends to dwell in fast flowing river systems, although it is often found in out-crops of these rivers where the water flow is slower (Whitaker 1982). It is well adapted for this aquatic environment since the long, narrow snout allows for less water resistance when catching fish. Therefore, the gharial is the most aquatic member of the crocodilians, and also the only member whose diet is mainly characterized by fish (Whitaker 1982).

The only natural populations of gharial are found in India, specifically in the river systems of the Indus (Pakistan), the Ganges (India and Bangladesh), the Brahmaputra (Bhutan), and Mahanandi (Orissa) (Whitaker 1982). The population was nearly decimated in the 1970s, but local organizations were then formed, and are still heavily in existence, in order to breed these animals in captivity and release them back into the wild (Whitaker 1982). Due to the specificity of its habitat and the rather small population, the gharial remains a mystery in terms of its behaviors, and even most basic life characteristics. Captive populations in the United States are minimal, with single specimens at the Cleveland Metroparks Zoo (female), San Diego Zoo, National Zoo, and the largest population at St. Augustine Alligator Farm in Florida. There are many complications in forming a breeding population within the United States, including the difficulty of transporting adults within the country and the necessity of shipping only juveniles from overseas due to the fragility of their snouts. Therefore, there is not currently a breeding couple in the country.

Gharial life spans are thought to be similar to other crocodilians of large size and late maturity and tend to be upwards of 100 years (Whitaker 1982). Their reproductive status is also like other crocodilians, in that size, not age, determines when they become reproductively active. This generally happens upon reaching over 3 m in length for females and 4 m for males, although there have been exceptions to the rule in smaller individuals in India (Whitaker 1982). The average adult size ranges from 3.5 m to 4.5 m (Brazaitis 2001), but males are known to reach 6-7 m (Whitaker 1982). They are believed to be the most timid and least aggressive and territorial of the known crocodilians, however it is to be emphasized again that very few have been studied.

The gharial’s social displays are similar to those of the other members of the crocodilian order. These displays include the dominance display (head and tail emerging erect out of the water or merely a snout lift out of water, and acoustic signals, including subaudible vibrations and grunts/bellows) and other dominance displays such as headslaps and jawclaps (Vliet 2001). Many of these displays are also associated with reproduction, mainly used by males to attract females. Territoriality is also seen amongst males, as is demonstrated by dominance displays, bellows and headslaps/jawclaps. However, the gharial is not believed to be as territorial as other crocodilians. In general, unless finding territory, attracting a mate, or acquiring food, crocodilians conserve energy either in the water, the primary home of the gharial, or by basking on the sandy banks.

Aggression in captivity is seen more often than in the wild due to the restraints on the animal’s territory and habitat. Categories in which environments can negatively affect the captive animal include, but are not

limited to, inconsistencies in substrate, temperature, auditory ranges (specifically infrasonic with respect to crocodylians), lighting conditions, diet, isolation from conspecifics, and cage size (Vliet 2001). The effect of restricted movement due to limited space has frequently been studied, and has been found to be a major contributor to stress and stereotyped behavior (Morgan 2006). Stereotyped behavior consists of any behavior that is uncommon or absent in wild populations or is detrimental to the animal's health. It is also common for animals under a certain type of stress, such as excess noise from humans, to respond to this stressor in a seemingly unrelated manner, like lack of movement. Therefore, it is important to explore all aspects of an animal's environment in order to understand why a negative behavior is being elicited (Morgan 2006). Over the period of 45 days, the gharial at the Cleveland Metroparks Zoo killed a giant gourami, a knifefish, a tinfoil barb, and on two separate occasions bit two giant gouramis. In each of these instances, the fish was not eaten. Thus, the basis of the study was to better understand the basis of the attacks by analyzing the gharial's habitat use, time management, and social behavior.

METHODS AND MATERIALS

The study was done at the Cleveland Metroparks Zoo in Cleveland, Ohio. One female gharial, *Gavialis gangeticus*, inhabited the exhibit (Fig 1).

The subject was obtained in 2003 from Silver Springs after having been in several zoos in the United States. The subject was approximately 28 years old and 2.98 m long from snout to tip of tail; it was believed that the female had not yet reached reproductive status, and most likely will never reach this status due to the size of



Figure 1. Female gharial located at Cleveland Metroparks Zoo.

its enclosure. It was also blind in one eye, which the keepers at the zoo believed was due to an injury at a previous zoo. This disorder, however, had been proven to not affect the captive gharial's ability to consume food or to interact with other specimens in a shared exhibit (Singh 1981). The specimen at the Cleveland Metroparks Zoo had never been heard making any of the audible signals. In fact, gharials in general do not vocalize (Vliet 2001). The gharial had rarely shown dominance displays, one of which was witnessed during observation, allowing accurate descriptions of the specimen's behavior. The exhibit was shared with two female Batagur turtles (also known as Giant River Terrapins), one female and one unknown Callagur turtles (also known as Painted River Terrapins), one Hamilton's Pond Turtle, one female New Guinea Snapping Turtle, one male and one female Orlitas (Giant Malyasian Turtles), one clown knifefish, and fifteen tinfoil barb (though during the experiment one of these was eaten by the gharial).

The habitat was divided into sections. The front of the exhibit consisted of clear glass and the remaining

walls were covered with artificial foliage. The water portion was 9m x 3.5m and approximately 9000 gallons (Fig. 2a-c). The left portion of the land, left of the log

(Fig. 2d) was about 2m x 2m and the right portion was approximately 4.5m x 1.5m (Figs. 2e, f). The land was composed of artificial tan-colored sand. Underwater



Figure 2. Photographs of the gharial exhibit. (a) left water=LW (b) middle water=MW (c) right water= RW (d) left land=LL (e) middle land=ML (f) right land=RL

were various logs and sticks. In the left front corner of the exhibit was a source of flowing water, which often caused bubbles in the water (Fig. 2a). It was noted that the subject was only fed on Thursday mornings, during which no observation occurred. However, one Friday morning feeding was observed to take baseline information about the feeding behavior of this particular specimen.

Experimental Design. An ethogram was developed based upon previous knowledge of the gharial (Appendix I). Reproductive, social, and territorial displays were kept to a minimum and combined in the categories given in the ethogram due to the lack of other animals. The possibility of these displays shown to human observers was considered, and therefore these measures were not completely left out of the ethogram, however only those that keepers had seen (the dominance displays and general swimming, basking, and passive activities) were developed in the ethogram. Five-minute behavior scans were taken for a period of 120 minutes each day; this was done three days a week, two in the afternoon and one in the morning, from February 5 through April 13, 2007. There were a total of 1260 morning minutes and 2220 minutes of scans in the afternoon. The behaviors studied for the scanning behavior were swimming, basking, feeding, walking (this can be on land or on the ground underwater), interacting with other exhibit-mates, and passivity (which includes any lack of movement). It was decided that interaction with exhibit-mates would be eliminated from further calculations since it never occurred. The position in the habitat was noted: left water (LW) (Fig. 2a), middle water (MW) (Fig. 2b), right water (RW) (Fig. 2c), left land

(LL) (Fig. 2d), middle land (ML) (Fig. 2e), and right land (RL) (Fig. 2f). Also recorded was if the subject was distant ($>1\text{m}$), close ($<1\text{m}$), or touching another species in the exhibit. These three groupings were calculated separately. Each category within the grouping was taken as a percentage of time by dividing the amount of times it was recorded by the total number of scans. These were then averaged, and standard error was calculated.

The all-occurrence behaviors recorded were dominance display, which consists of an erect tail and head (Vliet, 2001) emerging from the water, a grunt, a headslap on the water, and a snap at another animal in the exhibit. The all-occurrence behaviors were simply tallied as a total. The subject was also observed by its keepers to seem to gravitate towards the public presence. Therefore each scan period it was noted if the public was present, and if the subject oriented its body, specifically its snout, toward the visitors.

RESULTS

Very little all-occurrence behavior was seen. The gharial carried out one dominance display immediately after visitors walked by on one afternoon. The only other all-occurrence behavior was a jaw snap at a turtle after it had been swimming around the gharial's snout.

In terms of overall activity, the gharial spent most of its time, about 64%, passive. However, 25% of its time was spent swimming (Fig. 3a). The gharial also spent some amount of its morning and afternoons walking in its enclosure and/or basking on the sand. Approximately 95% of its time was spent in water, which was consistent with the description of the species (Fig. 3b). Also, over half of the gharial's time was spent

close to another species in the exhibit (Fig. 3c). It was noted that this was predominantly near the turtles, as they did not show any aversive behavior towards its presence. Time spent physically touching another ani-

mal was rare, usually observed when the gharial was resting on the bottom of the water and the turtle was either on top of the gharial or touching next to it, usually near the tail.

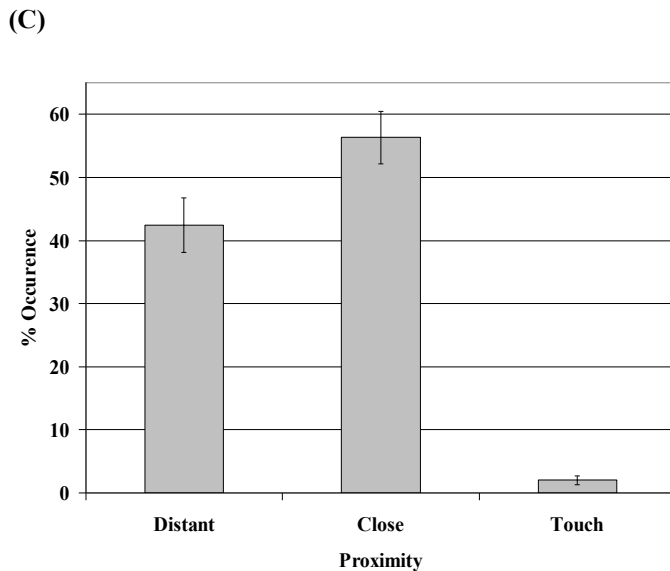
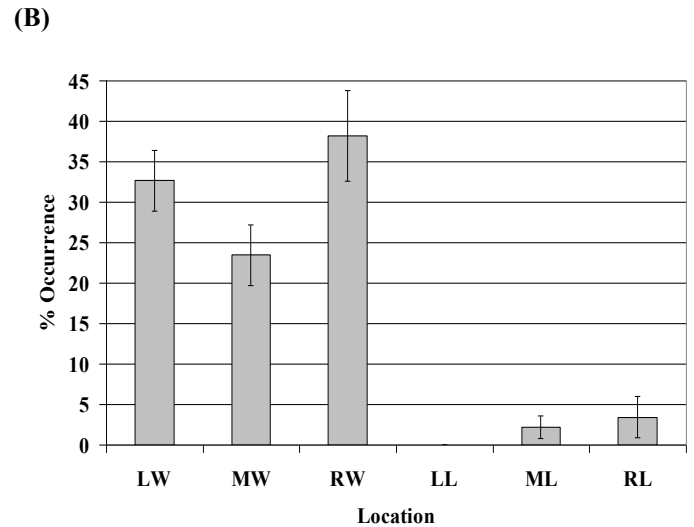
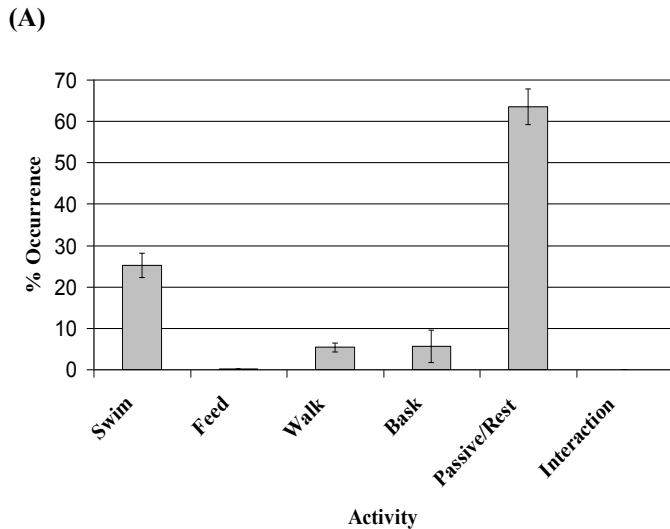


Figure 3. Daily activity budget, location of gharial in exhibit, and proximity to other species in exhibit. (a) % Occurrence \pm SE vs. Activity. Values were determined by dividing the number of times the gharial was observed to be participating in the particular activity divided by the total amount of scans for each day observed and standard error was calculated. (b) % Occurrence \pm SE vs. Location. LW=left water, MW=middle water, RW=right water, LL=left land, ML=middle land, RL=right land. Values were determined by dividing the number of times the gharial was at the particular location divided by the total amount of scans for each day observed and standard error was calculated. (c) % Occurrence \pm SE vs. Proximity. Distant=less than 1m, Close=up to 1m without touching, and Touch=touching another animal. Values were determined by dividing the number of times the gharial was at the particular proximity divided by the total amount of scans for each day observed and standard error was calculated.

A point of interest is that its activity differed on days when the public was present and when it was not (Fig. 4a). From the graph one can see that less time was spent at rest when there were people present, which was also the only time in which the gharial was basking. Due to large standard error values, no conclusions can be made about its swimming and walking behavior, and statistics were not feasible due to small sample size. Both days with public present and days without shows that the gharial spent the previously mentioned majority of time in water (Fig. 4b); based purely upon

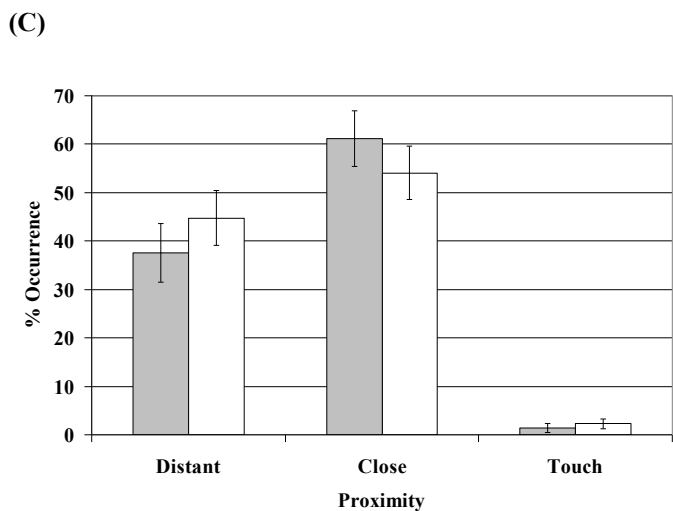
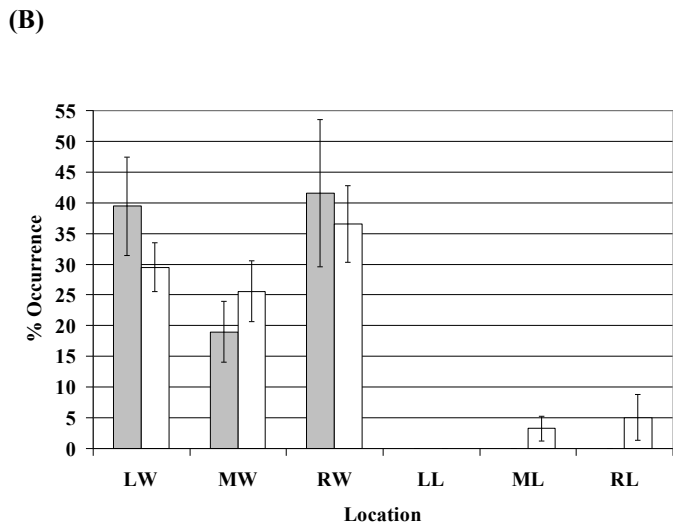
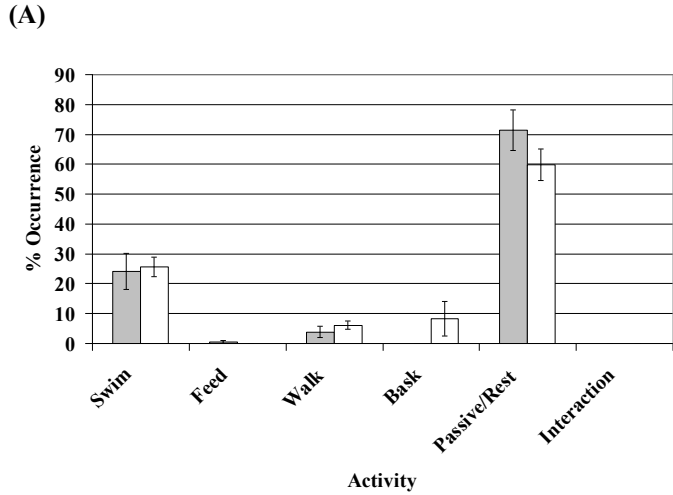


Figure 4. Activity budget, location of gharial in exhibit, and proximity to other species in exhibit on days with no public present (Filled bars) vs. days with public present (Open bars). (a) % Occurrence \pm SE vs. Activity. Values were determined by dividing the number of times the gharial was observed to be participating in the particular activity divided by the total amount of scans for each day observed and standard error was calculated. (b) % Occurrence \pm SE vs. Location. LW=left water, MW=middle water, RW=right water, LL=left land, ML=middle land, RL=right land. Values were determined by dividing the number of times the gharial was at the particular location divided by the total amount of scans for each day observed and standard error was calculated. (c) % Occurrence \pm SE vs. Proximity. Distant=less than 1m, Close=up to 1m without touching, and Touch=touching another animal. Values were determined by dividing the number of times the gharial was at the particular proximity divided by the total amount of scans for each day observed and standard error was calculated.

observation, the gharial was viewed basking on land more often when the public was present (in the afternoon only) than when it was not. When the public was present the gharial spent slightly more time distant, but also more time in contact with the other species, though no large difference was noted (Fig. 4c).

It was observed that the knifefish spent the majority of its time under the log, which was also under shadow, and the tinfoil barb frequently migrated to the opposite side of the exhibit that the gharial was on. On the days of observation when the zoo was open to the public, the gharial oriented itself towards the public 41% of the time.

The subject was also observed to have performed less stereotypic behaviors when the public was present. When initial observations were taken and no visitors were present, it was noticed that the gharial had a patterned swim route. It was passive for a period of time in the right corner of the water, and then swam along the front-bottom portion of the water. It would then rest in the corner that bordered the left and middle

water conditions explained previously, and then swim to where the bubbles emanated in the very left corner of the water and rest there. Afterwards it would return to the right side of the exhibit and begin again. Based on observation, this patterned swimming was seen less when the public was present.

DISCUSSION

The gharial has been stated as being the most timid of crocodylians (Brazaitis 2001). However this may not be the most accurate description. It may be the least aggressive, but not necessarily the most timid due to the fact that the gharial would often orient itself toward the public and continuously swim directly in front of the glass where the visitors stood to watch. One can see this visitor interaction by the results, in which the gharial spent less time resting in the afternoon when the public was present rather than in the morning when there is very little human interaction (Fig. 4a). In fact, very few instances about gharial attacks on humans are recorded in literature. According to minimal research on this topic, the gharials have all been either defending territory or eggs; the gharial has been known to mistakenly take small humans for prey by grabbing an extremity, but the person was then quickly released. There are no recorded deaths due to gharial attacks (Bustard & Singh 1981). This could either be due to lack of information from native people, lack of interaction between gharials and native people, or that the gharial is truly the least aggressive crocodylian. According to keepers and minimal experience in the exhibit during the study, the gharial at the Cleveland Metroparks Zoo is not prone to attacks and can even be hesitant to approach a new person. From the data and the results of this study, and by

the fact that stereotyped swimming was reduced, we can see that this particular gharial was stimulated by the presence of people (Fig. 4). The gharial often left what it was doing to swim in front of the glass in the exhibit.

One keeper related a story that in the morning when the first large group of people came up to the exhibit, the gharial, previously basking, opened one eye, turned its head toward the public and walked into the water and began swimming in front of the glass. The results of the days with public present versus not present are essentially the afternoon versus morning scans, respectively. The differences could be due to either time of day or presence of visitors. However, based upon the main keeper's and observer's observations of the gharial, the correlation strongly points towards the presence of people and not to time of day. There are also anecdotes from the keepers in which the gharial stayed active late at night, when the exhibit lights were already off, due to a large party. This would suggest that although it is the time of day in which the gharial is not normally active at the front of the exhibit, the presence of people changed this routine. These pure observational results must be studied further in a more scientific fashion in order to determine the complete significance of these observed behaviors.

The only basking that was seen was in the afternoon (Fig. 4a). This is difficult to interpret due to the artificial surroundings. During the winter, gharials are seen basking during all times of the day to maintain their higher body temperatures. In warm months, they are only seen basking in the early morning and retreat to water once early afternoon hits with the warm sun (Whitaker 1982). In a habitat in which artificial lighting and heat are emitted, it is difficult to determine the rea-

son why basking was seen in the afternoon due to the lack of thermometers in the exhibit itself. Therefore, the basking may only be seen once the gharial is more active and able to heave itself onto the land in order to keep itself warm for a portion of the day, but these results are inconclusive. Also, the gharial was never seen basking on the left side of the land. This is most likely due to two things: first, the small size of this portion of land would not provide enough room for the gharial to pull itself onto the land; second, this is also where the gharial is fed, and the keepers noticed that the gharial has only been seen in this section when it is fed.

The study began with the intent to determine what in its environment was causing the gharial to attack and kill, but not eat, the fish in its exhibit. During the study, the gharial only killed one tinfoil barb, and it was most likely due to the fact that it was not fed on its proper day since the keepers were waiting to feed it for a television crew that was coming four days after the usual feeding time to use the gharial for education purposes. The day before this was to happen a tinfoil barb was killed, and for the most part eaten. Therefore, no correlations were able to be drawn regarding the gharial's interspecific aggression. However, any studies on this species are valuable due to the lack of literature on the gharial.

The implications of the study may very well show a social nature of the gharial. They are known to be communal nesters (Rao & Singh 1993), meaning that females may live in social groups. Further research on their behavior in the wild is needed. Due to the dwin-

ding populations, this may not be a possibility, but as the captive-reared specimens are released into the wild it may allow us to discover aspects to their behavior not yet known. The aggression previously noted in this individual may be due to a lack of social stimulation, or even overstimulation due to the amount of other turtle and fish species in the exhibit. In the wild the gharial may choose its location based on water velocity and the relative amount of other animals and availability of a niche. The large volume of turtles in such a limited exhibit may be causing stress. A Callagur turtle was observed biting the tail of the gharial during an observation. Therefore, these constant stressors may be causing the gharial to react in an aggressive manner.

The future of the gharial in the wild is as variable as that of captivity. Although restocking programs are now in place in India, mainly the National Chambal Sanctuary (Hussain 1998), habitat destruction continues to occur throughout the gharial's native range. Commercial fishing and lack of knowledge of these relatively timid crocodylians have also added to the reduction of populations along the Brahmaputra River (Choudhury 1997). The sanctuaries in India, however, appear to be the only hope for breeding captive gharials as of now. Due to their rarity and negative public response, this species has been neglected in behavioral studies. In order to increase the population of gharials in the wild and those kept for education purposes in captivity, one must better understand its natural habitat and behavior, and this can only be done by further research on the world's least known crocodylian.

APPENDIX I

Ethogram for *Gavialis gangeticus*

Type of Behavior	Behavior	Description of Behavior
<i>Solitary</i>	Passive/Rest	Lack of movement in water, but may be roused due to environment
	Swim	Movement throughout water column
	Walk	Movement on land or on substrate at bottom of water
	Bask	Situated body towards light and heat source, passive on land
<i>Food related</i>	Feeding	Consumes food it is given by keeper
<i>Social</i>	Social interaction	Touching and orienting towards another animal, or another animal orienting towards gharial
<i>Aggressive (all occurrence)</i>	Dominance display	Tail and snout erect and out of water, while torso remains in water
	Snap	Quick closing of the jaws directed towards another animal
	Grunt	Loud noise produced from the throat
	Headslap	Head comes down quickly onto surface of water

Location	Abbreviation	Description (for clarification see figure 1)
<i>Left water</i>	LW	Far left of water portion of exhibit to left stairs
<i>Middle water</i>	MW	Left stairs to right stairs
<i>Right water</i>	RW	Right stairs to far right of water portion of exhibit
<i>Left land</i>	LL	Far left of exhibit to log
<i>Middle land</i>	ML	Log to tree
<i>Right land</i>	RL	Tree to far right of exhibit

Proximity	Description
<i>Distant</i>	Animal greater than 1 meter from gharial
<i>Close</i>	Animal less than 1 meter from gharial, but not touching
<i>Touch</i>	Animal has direct physical contact with gharial
<i>Public</i>	Gharial is orienting towards public

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The Natural History of Osteoarthritis

ABSTRACT

Early signs of vertebral osteoarthritis begin to appear around the age of thirty. By age fifty, almost everyone exhibits some form of osteoarthritis in their spine, and with time the arthritis advances. The examination of a 3.2 million year-old ancestor verifies osteoarthritis' longstanding condition in bipeds. Osteoarthritis in the vertebral column is characterized by osteophyte formation, or "lipping," on any part of the vertebra (Nordin 1989). This comparative study aims to target the location, frequency, and severity of osteophyte formation in the thoracic and lumbar vertebrae of humans as well as the nonhuman primates. Each specimen was taken from The Hamann-Todd Osteological Collection at the Cleveland Museum of Natural History. The human sample comprises 89 specimens and the nonhuman sample 33. Each human and nonhuman specimen was closely examined in an effort to examine a potential relationship between the presence or absence of osteoarthritis in the flexible spinal column of the bipedal human and the largely immobile spinal column of the quadrupedal African apes.

INTRODUCTION

Osteoarthritis (OA), also known as degenerative joint disease, is a condition resulting from progressive erosion of joint cartilage. As a result of this progressive degeneration lesions begin to form (Aufderheide 1998). OA can be seen in numerous joints throughout the body, such as the knee, hip, shoulder, elbow and spine.

OA of the spine, also known as spondylosis, can be extremely debilitating. OA is manifested by lesions that are called "osteophytes,"

which are outgrowths of new bone (See Fig-1). In extreme cases this growth of new bone can lead to the fusion of two adjoining vertebrae (See Fig-1). In humans, range of motion and other movements such as rotation, flexion, and extension can be significantly decreased. If the fusion of two adjoining vertebrae occurs, adjacent vertebral bodies are at greater risk for OA. This stems from the adjacent vertebral bodies compensating for motion restricted in the fused vertebrae. If any movement at any level of the spine is restricted, the spine in turn will counteract by increasing motion at another level (Nordin 1989).

Few mammals possess the spinal flexibility of humans. For example, African apes such as gorillas (*Gorilla gorilla*), and chimpanzees (*Pan troglodyte*), have a stiff, inflexible spine as an adaptation to large bodied arboreality. Anatomically, the apes have decreased the number of lumbar vertebrae to three or four, as opposed to five, the condition most common in the human lumbar spine. The apes also have increased the height of the iliac blades. These two evolutionarily selected characteristics have stiffened the ape's spine to strictly support bridging and climbing. As a result, apes have severely comprised the mobility of their spines.

Although chimps and humans are phylogenetically very close, their vertebral columns differ dramatically. In contrast to the inflexible ape spine, humans possess an extremely flexible vertebral column. The extremely flexible nature of the human spine is a byproduct of our bipedal locomotion. The lumbar columns of early hominids such as *Homo erectus* and *Australopithecus* were comprised of six lumbar vertebrae, as opposed to the five vertebrae of modern *Homo sapiens*. The necessity of six lumbar vertebrae is derived from

early hominids' attempt to move the last thoracic vertebrae T13 into a lumbar element, thereby increasing spinal mobility and the ability to balance their torso over the hip joints (Latimer 1993). Habitual bipedality has promoted mechanical demands not seen in the quadruped. These mechanical demands have rendered alterations of vertebral curvatures. Among mammals only humans and our immediate ancestors' genus *Homo* and *Australopithecus* possess sinuous curves which cauterize the bipedal spine. These curvatures are comprised of an anteriorly directed kyphotic curve in the twelve thoracic vertebrae, and a posteriorly directed lordotic curve in the lumbar vertebrae. The reason for this peculiar anatomy is to balance and distribute loading over the hips during locomotion (Latimer 1993).

This comparative study examined whether the degeneration caused by OA is unique in humans due its evolutionarily selected mobile spine. We examined the flexible vertebral columns of humans as well as the rigid vertebral columns of apes. It is hypothesized that osteoarthritis is specific to humans due to our highly bendable spines. It is moreover further hypothesized that owing to their lack of functional mobility, the apes will not exhibit the extent of OA seen in the humans.

MATERIALS AND METHODS

Sample

Each specimen examined was from the Hamann-Todd Osteological Collection at the Cleveland Museum of Natural History. The human sample consisted of 90 specimens spanning over 6 decades. The breakdown by age category was specimens ranging from ten 20 year-olds, twenty 30 year-olds, twelve 40 year-olds, twenty 50 year-olds, fifteen 60 year-olds, and ten 80 year-olds.

Gender and race were noted as well. Forty-one females were examined (23 black, 18 white) and forty-six males (21 black, and 25 white). One *Australopithecus* (Lucy) was examined. From the African ape collection twelve gorillas (*Gorilla*) (6 male, 6 female) and twelve chimpanzees (*Pan*) (6 male, 6 female) were examined. In addition four orangutans (*Pongo*) (2 males, 2 females), two baboons (*Papio*) and four gibbons (*Hylobates*) were studied.



Figure-1 this is a superior view of a L4 element showing prolific osteophyte formation on the vertebral body.

Method

Each specimen's thoracic and lumbar vertebrae were examined for the presence of OA. OA is characterized by the presence of osteophytes. Using a diagram which illustrated a lateral, superior and inferior view of the thoracic and lumbar vertebrae, arthritic development was noted on the facet joints, or the superior and inferior vertebral bodies. Any appearance of "lipping," or osteophyte formation (see Fig-1), was noted on the corresponding diagram. Location, shape, size, and severity were recorded. The presence of Schmorl's nodes (a herniation through the intervertebral disc through the end-plate) (Schmorl 1930), infection, and previously scanned CT bone mineral densities were

recorded as well.

After each vertebra was closely examined and all manifestations of OA recorded, the degree of arthritis was then scored on a severity scale from 0-4. Zero indicated no osteophyte formation; one indicated very slight osteophyte formation; two indicated clear osteophyte formation; three indicated prominent osteophytes; and finally, four designates very extensive osteophyte formation, frequently resulting in the fusion of two or more vertebrae.

RESULTS

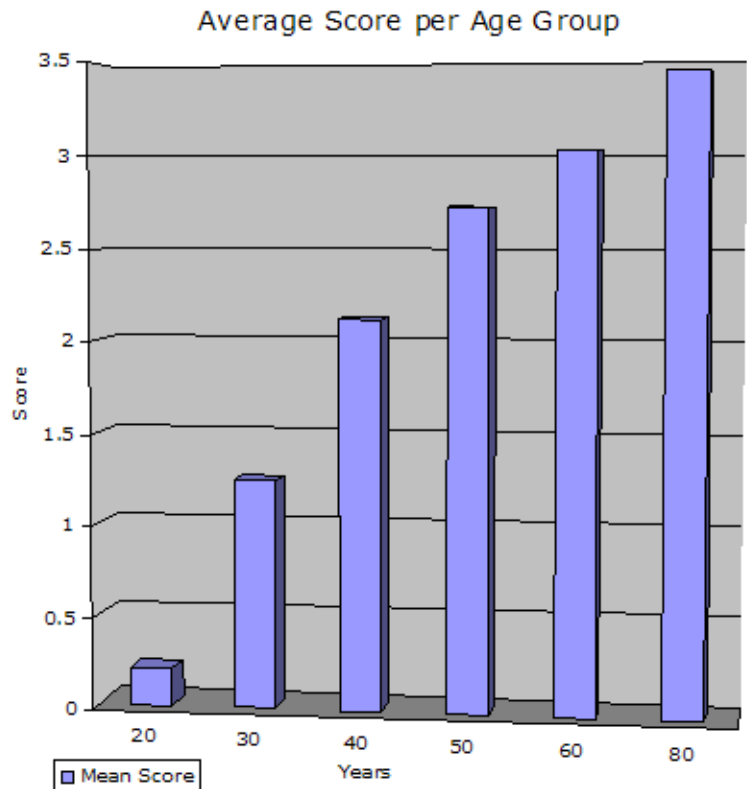


Figure-2 illustrates the relationship between age and severity of osteoarthritis in humans. It is apparent that the severity of OA increases with age.

Age vs. Severity of OA in Humans

The specimens examined were broken into age categories 20, 30, 40, 50, 60, and 80. The severity and preva-

lence of OA gradually increased with each decade. The human specimens began exhibiting minimal signs of OA during the third decade of life, and it progressed gradually up through age 80 (Fig. 2). Of the ten 20 year-olds examined only two (20%) of the ten exhibited any arthritis, both of which scored a 1. This yielded a mean score of 0.2. An increase in ten years results in a definite increase in the amount of arthritis.

Of the twenty 30 year-olds that were examined, sixteen (80%) of the twenty exhibited at least some form of arthritis. When compared to the previous group (20-year olds) a 60% jump in frequency of OA was noted. Of the twenty 30 year-olds, eight scored a 0, eight (40%) scored a 1, seven (35%) scored a 2, and the remaining specimen (5%) scored a 3. This yielded a mean score of 1.25. Of the 40 year-olds, eleven (91.6%) of the twelve specimens exhibited some form of OA.

Only one specimen (8.3%) exhibited no arthritis, three (25%) scored a 1, three (25%) scored a 2, five (42%) scored a 3, and one (8.3%) scored a 3.5. This totaled a mean score of 2.13. Again, the arthritis continues to increase in severity from progressive age group to age group.

By the 6th decade of life, all twenty (100%) of the specimens exhibited some form of arthritis. The severity score also rose with a majority of thirteen (65%) out of twenty scoring a 3 or higher. The 50 year-olds had an average severity score of 2.73. Each 60 year-old specimen had arthritis and the mean score climbed to 3.03. Finally, the last age group, the 80 year-olds, as expected, exhibited the most extensive forms of OA. Six (60%) of the 80

year-old specimens displayed the most severe forms of OA, scoring the highest rating, 4. These rates yielded a final mean score of 3.45. These results indicate that OA is age-related, showing a definite increase in frequency and severity with time. (See Fig-2)

OA in Humans

Figure-3 displays the distribution of OA among the thoracic and lumbar vertebral elements. The prevalence of arthritis peaked at T7 which is anatomically located at the depth of the thoracic kyphosis. At T7 arthritis appeared a total of fifty-three (63%) out of eighty-nine times. After T7 the arthritis gradually decreases. However, there is a slight increase in prevalence at L4 and L5.

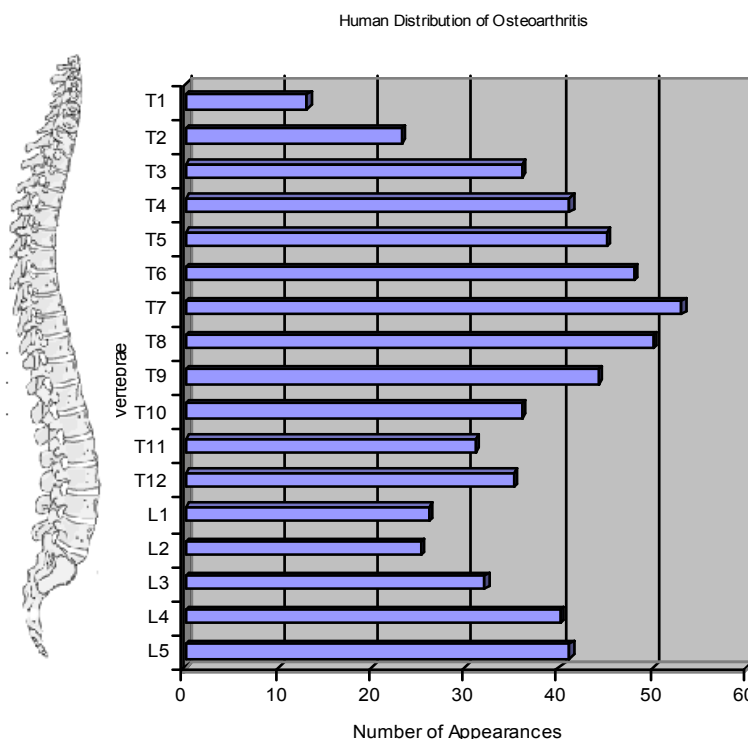


Figure-3 illustrates the distribution of OA among the thoracic and lumbar elements. It is apparent that at T7 the frequency of OA is more prevalent.

Figure-4 shows the distribution of relative moment arms among the various thoracic and lumbar vertebrae while under compression. The reason for the distribution seen in Fig-4 can be explained by looking at the human thoracolumbar column in lateral view. The vertebra subject to the greatest loads was T7. All other elements T1-L5 were measured with a moment arm relative to T7. Under compressive loading the mid thoracic spine

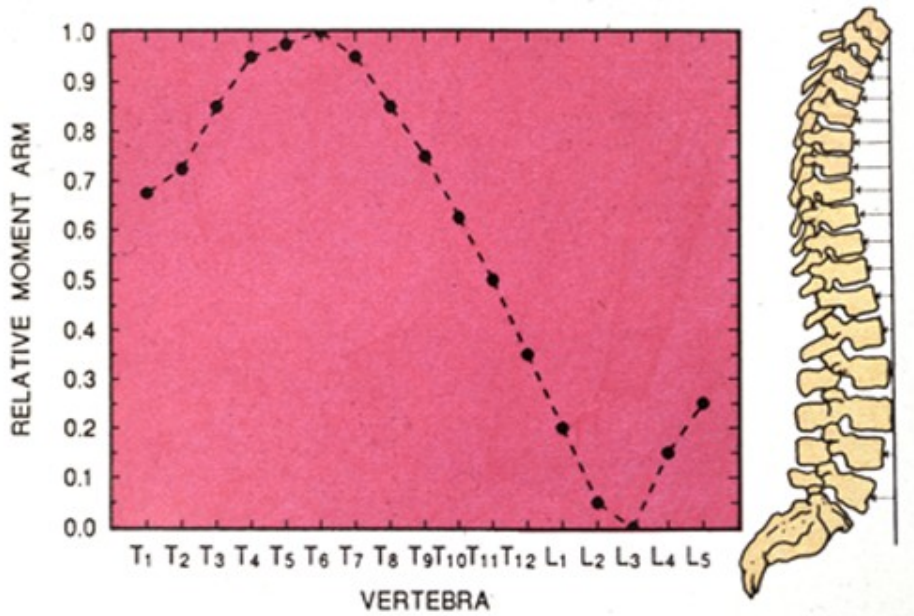


Figure-4 (above) shows the moment arm's measurements of each vertebra under compression in relation to the T7th element. The moment arm is perpendicular to the bodyweight vector.

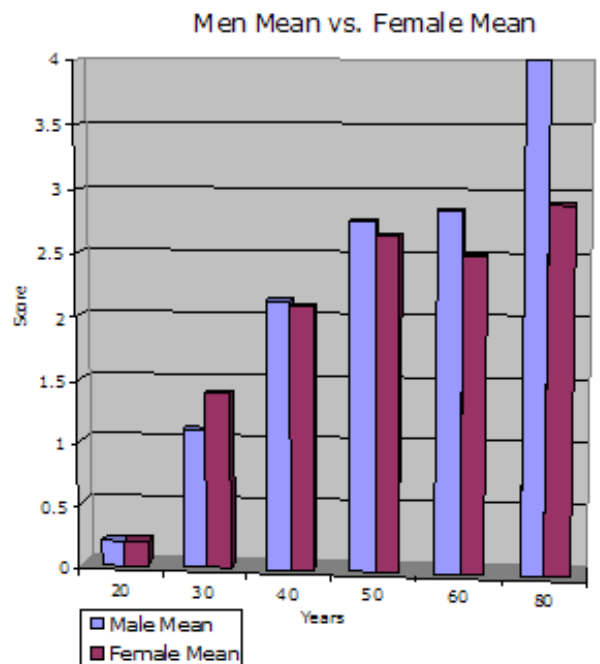
bears the greatest bending stress. Interestingly, Figure-4's graph of the thoracic and lumbar elements essentially mimics that of the OA distribution graph seen in Figure-3. They both peak at T7 and then drop off. However, there is a slight increase at L4 and L5 due to the lumbar lordosis.

Gender and OA in Humans

The specimens were examined to see if gender played a role in OA. Results indicated that men had more exten-

sive OA than females (See Fig-5). The total male population consisted of forty-six specimens, and the total female population consisted of forty-one specimens. Gender differences were examined by taking the mean severity scores per decade of the male population versus female population. At age 20 both males and females had the same severity average, 0.2. At age 30 the females scored 1.4 and males 1.1. This gave the female population the lead with a differential of 0.3. At ages 40, 50, and 60, the male population exhibits higher severity scores, and by the 9th decade of life the average severity score for the males is 4.0, females 2.9. At 80 years-old this yielded a significant differential of 1.1 (See-Fig-5).

Figure-5 (below) shows the male average severity score versus the female average severity score per decade. The male population exhibits more OA than the female population in every group except 30.



OA in Australopithecus “Lucy” (A.L.288-1)

A cast of the 3.2 million year-old *Australopithecus* “Lucy” was examined for signs of OA in the same manner noted above. Lucy exhibited osteophyte formation at the T10 element projecting superiorly from the vertebral body. An additional thoracic vertebra was present with slight osteophyte formation: the exact location of this thoracic vertebra in the column is unknown (Johanson 1982). Figure-6 shows the cast of Lucy with lipping.



Figure-6: This is a superior view of the specimen “Lucy”. The red arrow is pointing to superior lipping present medially on the specimen’s superior vertebral body

OA in Gorillas and Chimpanzees

The chimp and gorilla sample consisted of 24 specimens which were examined for OA in the same fashion as the human sample. After studying twelve gorillas (*Gorilla*) and twelve chimpanzees (*Pan*) it was obvious that the African apes do not demonstrate human-like patterns of OA. Indeed, the ape pattern differs dramatically from that in the human sample. From the twelve Gorillas examined three (25%) of the twelve showed no sign of

arthritis, scoring a 0 out of 4. However, three (25%) of the twelve did show OA scoring a 2. Half the gorillas, six (50%) out of twelve, showed minimal arthritis, scoring a 1. Not one gorilla exhibited enough OA to score a 3 or 4. Thus, the total mean severity score among the gorillas was 0.54 out of 4.0. Of the chimps, one (8%) out of twelve displayed minimal arthritis scoring a 1; the other eleven specimens showed no sign of OA. This yielded the chimpanzees a mean severity score of 0.08 out of 4.0. These findings identify the Lowland Gorilla as the ape most susceptible to arthritis, yet the severity remains extremely low, not even reaching 1.0.

After differentiating the chimp and gorilla sample for gender, results indicated that among the gorillas, both males and females had equal mean severity scores of 1.0. However there was a difference between male and female chimps. The male chimps averaged a severity score of 0.2 while the female chimps exhibited no arthritic development averaging a 0. The apes were stratified for age by dental wear, but no correlation between age and arthritic development was found. The additional nonhuman primates, orangutans, gibbons, and baboons were each examined, but the sample sizes were small and no OA was noted.

Discal Infection in Chimpanzees and Gorillas

While very little arthritis was seen in the nonhuman primate collection, it became apparent that many of these apes suffered from a problem other than OA. A large portion of the chimp and gorilla sample exhibited intradiscal infections, seven out of twelve (58%) gorillas, and five out of twelve (42%) chimpanzees. See (Fig-7) for illustration of an intradiscal infection in one of the examined gorillas.



Figure-7 shows the inferior view of an intradiscal infection on the L1 element of a female gorilla.

OA in Apes vs. Humans

It is difficult to gauge the distribution of OA from the ape sample, because little was present. There were distinct differences between the arthritic distributions in humans and apes. The frequency in which arthritis appeared in the gorillas and chimpanzees was predominantly concentrated from T1-T9. At T2, T4, and T5 the arthritis reaches its peak, appearing only four times. From T10-T13 there is no arthritis present. At L1, L2 it appears only 1-2 times. The highest frequency of arthritic development in the ape is located in the portion of the spine that is adjacent to the highly flexible cervical spine, as opposed to the human where the high frequency of arthritic development is located at the mid-thorax. Figure-8 compares the distribution and frequency of OA in chimpanzee and gorilla sample to that of the human sample.

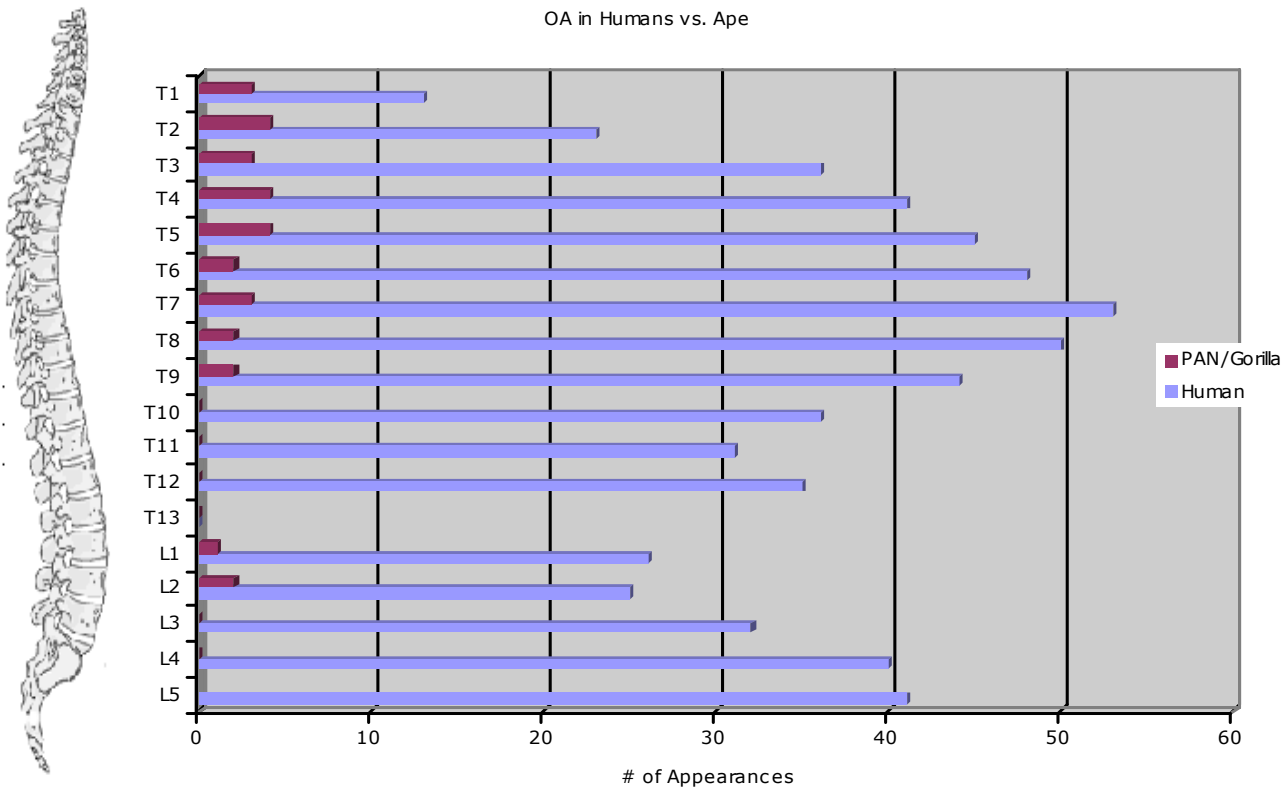


Figure-8 compares the distribution of OA between humans and chimpanzees/gorillas. NOTE: Humans do not have a T13, and apes do not have an L5.

DISCUSSION

This study sought to compare the nature of the flexible human spine to that of the inflexible ape spinal column in relation to OA. The humans exhibited dramatically greater numbers and a more advanced arthritis than the apes. Not a single ape demonstrated enough arthritic damage to warrant a 3 or 4 severity rating. This data indicates that it is the biomechanical loading of the uniquely curved human spine that results in OA. Given that OA is seen in Lucy's mid-thoracic column, the evidence indicates that OA has been a problem among the bipeds over the ages.

Plotting arthritis in relation to age signifies that OA is age-related. Spondylosis begins to appear in its minimal form around age 20 and continues to increase in frequency and severity with time. The increase in the incidence is attributed to the increased wear on the vertebrae over time. Averaging scores among gender and

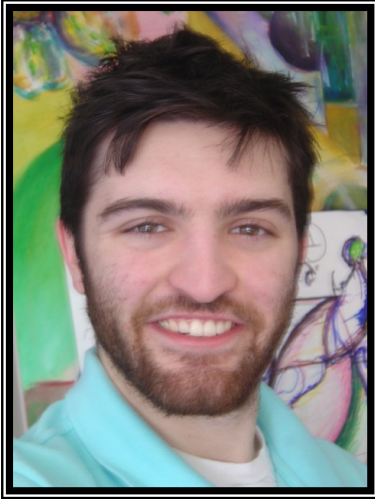
race attributes OA to be more common and severe in males likely due to activity.

This study rendered numerous results proving the role and type of movement in relation to spondylosis. However, the nonhuman primate sample revealed numerous manifestations of infections, thus indicating that the lack of mobility in the vertebral column may predispose one to infection. The intradiscal infection may arise from the lack of adequate perfusion to the intervertebral disc.

This comparative study supports the fact that our evolutionarily selected highly movable spine has disposed the human to spinal OA as a byproduct of locomotion. Although OA will likely develop in all humans with time, our highly mobile spine has decreased a predisposition to the intradiscal infections seen in the African apes.

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-Nick Davis-

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Art, Hallucination, and Embodiment

This essay will discuss visual perception as well as examine the relationship between art and hallucination. The paper is divided into three sections. The first section will explore phenomenological aspects of the Ayahuasca hallucinations described in Benny Shanon's book *Antipodes of the Mind*. In the second section, it will analyze certain aspects of abstract art. This art style will be used because it enables the viewer to form their own image from the constituent elements of the piece. With these two sections, the experience of hallucinations will be likened to viewing the world as an abstract art piece, and viewing abstract art will be likened to inducing a hallucinatory state. The third section explains a model that motivates this analogy by applying the theory of embodiment to a ven diagrammatic structure.

Part One: Hallucinations

Ayahuasca is a psychedelic drug that induces visions as well as hallucinations in all other perceptual modalities¹. The drug is created by combining parts from two plants: the vines of *Banisteriopsis caapi* and the leaves of *Psychotria viridis*². The vine is cut, pounded, and then brewed along with the leaves, all in a ceremonial context, in order to create the Ayahuasca drink³. Shanon immersed himself in the culture of a South American tribe to gain knowledge about this practice. This drink is deeply rooted in this culture, being used for "for curing, for divination, as a diagnostic tool and a magical pipeline to the supernatural realm."⁴

Ayahuasca alters one's consciousness in many interesting ways. It confuses one's sense of self-agency, meaning one can no

longer distinguish between one's own thoughts and those of other people. An individual is not sure whether (s)he actually owns his/her thoughts, or whether an external agent is forcing these thoughts. According to Shanon, it almost seems as if an external agent is implanting foreign thoughts into the mind of the person experiencing the hallucination.⁵

The identity of the participant is also affected. A person will identify with anything that (s)he looks at⁶. In essence, the person 'becomes' the inspected object. There is no separation between the object present in the world and the person; the person understands their complete state of being in terms of the object that is perceived. For example, if a person were to inspect a hammer and hold it in his hand, that person would become the hammer and exist as the hammer; there would be no distinction between self and hammer.

Not only does a person identify with an object, but the meaning of objects in the world changes. Mundane objects are understood to be part of a cosmic organization in which all parts play an intrinsic role⁷. In this way, "many phenomena pertaining to the Ayahuasca experience may be regarded as the products of affording the world an intense metaphoricity."⁸ The drinker takes the constituents of reality to mean something else; they may appear to be one thing, but they actually represent a deeper structure. Shanon references this to the platonic theory of essences when speaking about the underlying structure of objects in the world. It is as if one is actually viewing the essences of things through the window provided by the object in the world.⁹

While intoxicated, a person interprets the con-

stituents of objective reality to be mere suggestions of what is truly there. The objects are taken as a metaphor for a deeper structure that is created by meanings attributed to a cosmic order. Mundane things in reality are recognized as a normal instance of a given object, but they somehow mean something different. Reality becomes less objective and more laden with the meaning derived from beliefs and intuitions. This in turn drives the hallucination; it drives the actual perceptual process of the drinker. For example, Shanon cites one instance of a man having a vision of Christ. Upon further questioning, the man admits that "what actually can be said about the vision is only the figure of a loving young man, clad in white and radiating light was seen."¹⁰ The viewer did not necessarily see a being with a label 'Christ,' but rather saw a man fitting the description of Christ given by his religious history, and interpreted this man to be Christ. Shanon goes on to argue that any cognition is closely tied to the meaning one imparts on a scene, stating that "from a cognitive-psychological point of view, if the figure seen was identified as being Jesus, then phenomenologically this is indeed who was seen."¹¹ His stance is that the meaning imparted on a scene will affect the actual perceptual experience. The reasoning behind this stance will be used later in the discussion of abstract art. The perceptual process of viewing abstract art is influenced by the meaning attributed to the scene at hand, and as such serves as a thread of similarity between art and hallucination.

Consciousness often loses its unity after drinking the brew. A person can become dissociated from their body and observe their previous identity from an outside perspective.¹² This can create recursive dissocia-

tion from identities, leading to an infinite regress of exiting the current identity and observing the previous identity from an outside perspective.¹³ The dissociation can also be on a perceptual level, leading to a split in the visual field. A drinker will sometimes see half of their visual field as a hallucination while the other half remains objective reality.¹⁴

While under the effects of the drug, it is difficult to differentiate psychological states. One is unsure whether one is “perceiving or remembering, whether one is perceiving or imagining, [or] whether one is thinking or perceiving the thoughts of others.”¹⁵ The mode of thought becomes cloudy; the normal boundaries between observation and imagination are diluted and these distinctions seem to become irrelevant. One exists in terms of the surrounding environment; imaginings becomes reality and thoughts may not be one’s own. This would seem to impact one’s theory of mind, “the ability to represent the mental states of others.”¹⁶ If one is unsure if thoughts are self-generated or those of another individual, then one may start to question the extent to which other people have minds that are creating thoughts distinct from one’s own. This leads into the next aspect, that of individuation.

Drinkers report a feeling of connectedness to all aspects of reality.¹⁷ It is as if they are integrated into a kind of supreme consciousness. The distinction between self and other is diminished by the realization that they and everyone else are part of a larger whole. This agrees with the theory of mind hypothesis by making the intentions and thoughts of others irrelevant because each person is considered to be connected to a sort of super consciousness, and it is this consciousness that governs ex-

istence. One is also said to gain knowledge of a supreme sort: knowledge of the ‘true’ nature of reality. Also, the normal constituents of reality are seen as ‘more real than real.’ Sensory perceptions are intensified, resulting in a different interpretation of the objects that exist in the world.

Continuing along this same thread of individuality is the phenomenological report of varying senses of a coherent self. Participants often report losing their sense of self, or having only a slight remnant of their self.¹⁸ This varies with the experience of the drinker; novice drinkers often completely lose their sense of self, while more experienced drinkers are able to maintain a more coherent sense of self throughout the experience.¹⁹

This concludes the summary of the phenomenological effects of the drug Ayahuasca. The third section of this paper will deal with creating a model of perception that is able to account for how an individual is able to experience these things in terms of everyday cognition. However, it is first necessary to talk about abstract art viewing and relate this experience to hallucination.

Part Two: Abstract Art

Viewing abstract art is an interactive and engaging activity. The process has both a bottom up (autonomous cognitive processes influence higher order thinking)²⁰ and top down (higher order thinking drives the autonomous processes)²¹ aspect. The bottom up approach to perception has been analyzed by Rudolf Arnheim, David Marr, and Gestalt Psychology. The theories presented by these paradigms will be summarized and applied to the viewing of abstract art. These models

will be further elaborated on by including a top down element that drives perception based upon meaning attributed to a scene.

Arnheim proposes a theory of art perception that is largely based upon what he has termed ‘psychological forces.’ These are forces that arise from the physical qualities of elements on a page. He thinks that certain placement, size, shape, and relationships between elements directly affects the perceptual process, inducing tensions and weights stemming from a given arrangement.²² For example, if a circle is placed slightly off center, it will then create a greater unease in the observer than if the circle was placed much off center.²³ This, he claims, is not a higher order process of evaluating the scene and making a response based upon thought, but rather a gut reaction; there are certain qualities on a page which are inherently pleasing or displeasing to the human perceptual processes.²⁴

Marr has created a strict bottom up approach to perception that is based upon a computerized object recognition paradigm. This is a modular process which relies largely on a computer being able to recognize sharp value changes and noting these areas as most important.²⁵ This process is employed for a whole image to produce what he calls a ‘raw primal sketch.’²⁶ This sketch consists of the crucial areas in an image that has significant value changes. This raw sketch then goes onto the next module further refining the sketch by techniques to produce a more information laden ‘full primal sketch.’²⁷ This entire process produces a schematic replication of the original image. The next step, which addresses object recognition, applies gestalt rules in order to group objects based upon the principles of Gestalt

psychology.

Gestalt psychology proposes a theory of grouping objects based upon general principles extracted from rigorous experimentation on the nature of human perception. These principles are: the law of proximity (close features will be grouped), the law of similarity (objects of similar form will be grouped), the law of good continuity (objects that demonstrate a certain smoothness will be grouped as one), the law of closure (gaps will be filled in if a figure appears as a coherent object), and the law of Pragnanz (the most notable and stable geometric form will be chosen).²⁸

Multiple layers of perception occur when one views abstract art. At the base, one has the psychological forces described by Arnheim. Certain elements of the piece, such as balance and flow are simply felt. No higher order interpretation is needed for this to happen. This analysis of different layers of perception will be aided by a concrete example. Figure 1 shows a work composed by the author of this essay.

Arnheim thinks that darker colors have less ‘visual weight’ than lighter colors, and also that the bottom of the page is weighted heavier than the top.²⁹ Hence, this image would be balanced according to those terms because the bottom is darker than the top. The same is true for the two circles in the image. The bottom circle would normally have more weight, but its darkness creates a sense of balance with the lighter circle. These forces all act at a very low level of perception, he claims, without the aid of higher order thinking.

The green form in the center of the painting exhibits the law of similarity and continuity. The form is one coherent and continuous color, which leads the



Figure 1

viewer to perceive this as one object. The blue background, although it is interrupted by the dark circle at the bottom, is perceived as one coherent frame because the color is similar throughout. Motivating these gestalt principles would be Marr's approach of detecting various light intensities. Each object in the piece has a different light intensity which would be noted by his program and sketched out in the raw and full primal sketch. The gestalt principles would then be applied to arrive at coherent objects within the image.

In addition to the above analysis, the attribution of meaning to the art piece will influence one's perception of it. One could look at this piece, either alone or

with another person, and say that the green figure in the middle looks like a body with the light blue region being the head. This would follow the law of *Pragnanz* because a body is a very stable shape that one is accustomed to seeing. However, this is gestalt grouping based upon higher order thinking. Gestalt psychologists hold that all of their laws appear only in bottom up perception, without any thought. However, Gestalt principles may be active on both levels of perception after one attributes meaning to a scene. Moreover, once this higher level Gestalt grouping takes place, it seems that another level of psychological forces arise, leading to a narrative interplay between the elements on the page. The human figure seen can be said to hold more visual weight, thus redistributing the psychological forces, therefore altering the physical perception of the art piece. It is in this way that viewing abstract art can be likened to a hallucination.

The meaning ascribed in this process influences what one perceives to be on the page. The perception is now altered and it would be hard to view this piece again without seeing the green form as a human body. This is the parallel with the Christ figure. Although what is seen is only a person clad in white, or a green form, the perception is based upon the interpretation. The perceptual experience of the observer is altered according to the meaning assigned to the object in the world. The viewer of the art piece is seeing something in reality that is not necessarily there. This would fall under the definition of a hallucination.

There may be a modular process of bottom up perception as Marr puts forward, and psychological forces and Gestalt principles may be at work in this

process, but there is also another level of perception that has to do with the meaning assigned to an object. Elements on the page are regrouped to arrive at this new meaning, and that grouping has its own set of psychological forces that motivate deeper meaning to a piece. This newfound meaning may even motivate another sequence of grouping based upon further reflection of the meaning of the piece, and this cycle will continue until the participant ceases to contemplate the piece at hand. At every stage of this regrouping, the perception of the piece is varied. The physical perception, meaning what is actually seen and comprehended, varies with respect to the degree of meaning associated with the piece. The viewer induces different levels of hallucination based upon the meaning assigned to the piece.

Following this argument would be that claim that experiencing a drug induced hallucination is like interpreting the world as an abstract art piece. As Shanon states, referents in the world are seen as metaphorical, they are not perceived as what is actually there; they are only a suggestion, a guide, a conduit for perception which is based on the meaning assigned to the metaphorical object. Altering certain aspects of the previous theories allows for this to happen. Elements in the world are grouped in a bottom up manner, but this is not where the process ends; it continues based upon the meaning assigned to the scene at hand. This meaning then evokes a second order grouping which alters the perception of the individual, thus creating a subjective perception of things in the world that do not exist objectively for everyone, a phenomena also known as a hallucination.

Part Three: A Model of Perception

Embodiment, as defined in the field of Cognitive Science, is the theory that human cognition is largely influenced by how the body interacts with the world. Thought is constrained based upon how the body is able to manipulate physical reality. Followers of the embodiment paradigm hold that cognition is always embodied. Our interaction with the world completely shapes our cognitive patterns, thus no thought may exist outside of the embodied realm. That is not to say that all thoughts have to do with how the body can interact with the world, but the mind has developed in a body, therefore all thoughts have arisen from a mind that can only function in relation to the body and how it can interact with the world. An example of embodied cognition would be looking at a hammer and thinking about the hammer in terms of its function; I can swing the hammer, hold the hammer, and pound with the hammer, all these aspects have to do with how my body can manipulate the hammer.³⁰

Ultimately, during a hallucination as well as abstract art viewing, the world is increasingly perceived in terms of meanings arising from an embodied mind. The ven diagram model in Figure 2 models this process.

Objective Reality consists of elements that exist in physical reality that are an agreed upon norm. Mental reality consists of all the workings of the mind. The degree of overlap (embodiment) determines the extent to which the environment will be perceived in terms of the meanings concocted by the mind.

In this model, the amount of overlap can be modulated in two ways. First, it can occur naturally by assigning meaning to the external world. The more

meanings assigned, the greater the overlap that occurs. Thus, perception will increasingly become driven by the meanings assigned to an object, as in the case of interpreting abstract art. The more meanings are assigned to an art piece results in a perception that is more based upon higher order thinking than lower level processing. As a result of this the actual perception changes; what a person visually sees is a function of the meaning assigned to the scene at hand. This is exemplified by attributing a human body to the green form in Figure 1.

The second way this overlap can be modulated is artificially, as in the case of the drug induced hallucination. The two spheres are forced together and as a result the environment is prone to be perceived to a greater extent in terms of the meanings invoked upon it by the mind. Normally, attributed meaning would gradually bring the spheres together; the modulation is a function of meaning attribution. However, if the spheres are forced together one must, according to this model, perceive the world in terms of meanings assigned to objects to a greater extent. One could then ask: Why would drugs force the spheres together? The drugs may force one to perceive the world in a more embodied way, thus forcing the spheres together by an increase in the overlapping space. In summary, natural modulation is a function of assigning meaning, whereas artificial modu-

lation is a function of increased embodiment that then gives rise to perceiving the world in terms of the meanings assigned to it.

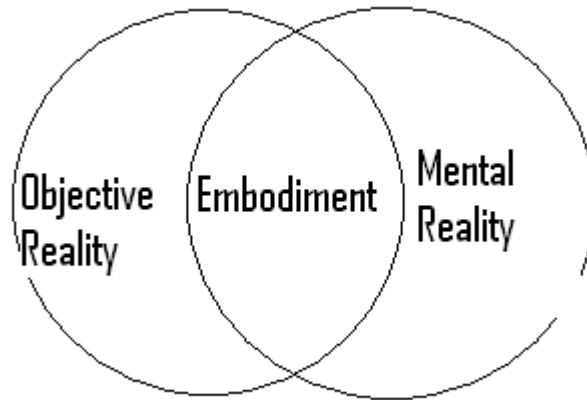


Figure 2

nals to direct attention, or write information down so it does not have to be remembered. Another aspect is object affordance, which is illustrated in the aforementioned hammer example. Humans think of tools in terms of how they can be used and manipulated. Thirdly, Cognition is situated, meaning that cognition is happening as a result of the current situation humans find themselves in. For example, if one is in a car, one's cognition will have to do with where one is going, how to get there, traffic laws, etc. And finally, cognition is time-pressured, meaning that it is happening in real time. For example, drawing on the car scenario again, if a turn is coming up, one cannot pause time and think about whether this is the turn one needs to make; it will happen in real time. This analysis assumes an extreme overlap of mental and objective reality leading to a large embodiment space as illustrated in Figure 3 on the following page.

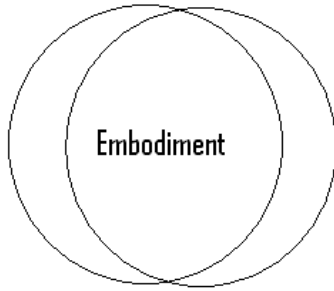


Figure 3: The spheres have been artificially combined using the drug, thus leading to a greater level of embodiment.

The issue of identity with the Ayahuasca drinkers can be reconciled with this model. A thought experiment that takes the normal features of embodiment and hypothesizes what these aspects would look like in an extreme case may lead to an understanding of what is going on during the hallucination. Identifying oneself as the object of inspection may be an extension of object affordance and off loading cognition onto the environment. This situation is an exaggerated sense of object affordance because the object is not only understood in ways that the body can manipulate it, but it is taken a few steps further and considered an actual extension of the body. This situation also exemplifies an amplified version of off-loading cognition onto the environment because the drinker's mental processes are completely transferred to the object. Normally, this component of embodied cognition would be used to aid in memory and cognitive load by using the environment as a reminder of sorts.

This model also gives insight into the lack of differentiation between the psychological states of drinkers. In this situation, one is not able to tell if one is thinking or imagining, thinking or perceiving, or think-

ing or viewing the thoughts of other people. When these circles are artificially combined, the mental reality is transposed upon the objective reality, leading to a progressive representation of mental reality as objective reality. The perceived world may be constituted of thought processes, imaginings, or actual objectively defined events. This distinction is blurred as one progressively comprehends the world in a more embodied way. Normally, the two spheres are at a regulated distance from each other and the mind is able to tell that the meaning it is attributing to the world comes from itself and the resulting perception is influenced by thought processes, but when the circles overlap in an extreme sense, this distinction is no longer possible; objective reality is intermixed with mental reality. Again, this could be a result of fully offloading cognition onto the environment.

The loss of the sense of self may be explained with this model as well. For the sake of discussion, let us term the normal overlap between the two spheres as an arbitrary value of thirty percent embodied cognition. In the hallucination, maybe 80% of cognition is embodied (reserving 100% embodied for a different purpose to be expounded upon later). The sense of self associated with each of these states - 30% and 80% embodied - would be radically different. While perceiving the world from a consciousness that is 80% embodied the mental workings constitute practically all of reality; cognition is 80% off loaded onto the environment. That is, the self is constituted of 20% mental workings and 80% existing as the environment. This is not a normal state of being, and one may not be able to maintain a sense of self during this radical transformation. It is as if one has become a

different entity that is able to perceive the world in a much different manner. This would explain why novice drinkers, and not experienced drinkers, often report a sense of complete loss of self. The experienced drinker may be more familiar with the eighty percent embodied state and realize that, 'Yes-this is me in this reality still, but with much altered surroundings; I have experienced this before and recognize this state.' Whereas the novice would have nothing to compare this experience to, leading him to believe that he no longer exists as the same individual.

Drinkers often report a sense of connection to a kind of super consciousness. They feel as if all things are connected in some intricate way and every part of reality has an important purpose. This would follow from understanding objective reality in terms of mental reality. All things would be considered connected through the mind of the perceiver because all the referents in the world would be a product of the mental reality. This is because the mental reality sphere is almost completely overlapped with the objective reality sphere. Thus, all of objective reality is seen as constitutive of the workings of the mind. There would be an inherent connection of things if one is generating all the images in a scene. The super consciousness would then be defined as a progressive embodiment of the universe. As the spheres are pushed together, the totality of objective reality is being merged with the mental reality, creating one reality that is constituted of the workings of an individual mind. This can be likened to the reports of nirvana reached in a deep state of meditation. Meditation would then be a natural means of merging the two spheres of reality.

Monks and other people who meditate often recount feelings of a connectedness to all beings and a sense of cosmic consciousness of which they are a part.^{31,32} This would stem from a progressive embodiment of the environment. The constituent parts of the universe are defined to be a part of the self through this process. The external world is redefined, thus merging the two spheres, leading to progressively perceiving the universe in terms of one's own body; in this scenario one would be identifying self as the universe. This case is not so unlike the identification of the self with the hammer, but the object of identification is much larger and more abstract, yielding a larger percent of embodiment. This nirvanic experience is what I reserved the 100% embodiment condition for. Therefore, enlightenment would be defined as completely existing as the universe; there is no separation between objective reality and mental reality. One exists in a state of complete embodiment with the universe.

Another aspect that bridges the artificial versus natural merge of the spheres is the domain of interpreting referents in the world to mean something different. Ayahuasca drinkers report the feeling that things in the world are actually metaphors for a deeper structure. They can then employ a meaning of their choosing onto the object, thus impacting their perception of the object. This meaning assignment is a direct example of understanding objective reality in terms of mental reality. The object in the world is interpreted to mean something different and is therefore perceived as a different object. The same was said about viewing abstract art earlier in the discussion. Each of the constituent parts were grouped and regrouped based upon higher order opera-

tions therefore leading to a different perceptual experience of the art piece. This is the common grounds between art and hallucination.

It would seem that psychological forces and Gestalt grouping could happen on a low level as suggested in Marr's model, but there is also a higher order counterpart that drives perception in an equally important way. This higher order counterpart is what increases the level of overlap between the two spheres. Assigning meaning to objects in the world makes one increasingly understand objective reality in terms of one's mental reality, thus increasing the amount that cognition is embodied. In viewing art, the percent of embodiment may vary minimally from 30% to 35%³³, depending on the amount of meanings assigned to a piece. Thus, the perception of the piece alters according to this because the amount that cognition is embodied dictates the extent to which one's mental processes are represented in the perception of the piece. If the embodiment rate is high, like in a hallucination, one will assign meaning to elements in an artwork, and it will transform completely based upon these assignments. If the rate is normal, then perception of the piece will change but not so drastically as to create a movie scene or something to that effect.

The three theories put forth by the Marr, Arnheim, and Gestalt Psychologists serve to create a situation of normal overlap between objective reality and mental reality. Interpretation uses a second order gestalt grouping that is influenced by a new set of psychological forces on a higher order that stem from assigning meaning to a piece. Each meaning assigned to the piece lets one perceive the objective world increasingly in terms of mental reality. Thus, the embodiment overlap

increases and one is able to increasingly identify the self with the object in the world. In extreme cases, such as in the Ayahuasca hallucination, the person will not be able to differentiate self from the abstract art piece and this is an example of extreme off loading of cognition onto the environment to such an extent that there is no separation between self and environment. This can lead to a loss of self as evidenced in the Ayahuasca reports, but as a person becomes familiar with this state of embodiment one is able to recognize a sliver of self and maintain a coherent identity throughout the hallucination.

To summarize, altering the overlap between the objective reality sphere and the mental reality sphere constitutes altering one's state of consciousness. In these different states of consciousness one perceives things in the world differently than one would in a normal state of consciousness. These differences in perception can be rectified by looking at the features of embodiment and performing a thought experiment on how they would manifest themselves in an extreme case. These two spheres may be modulated artificially, by drugs, or naturally by meditation, viewing abstract art, creativity, reading, and any other activity that requires one to attribute meaning to an object in the world.

NOTES

- 1 - Shanon, B. (2002). *The Antipodes of the Mind*, NY: Oxford University Press. pg. 12
- 2 - Ibid. pg. 15
- 3 - Ibid.
- 4 - Riba, Jordi et. al., "Effects of ayahuasca on sensory and sensorimotor gating in humans as measured by P50 suppression and prepulse inhibition of the startle reflex, respectively," *Psychopharmacology* 165: 18-28 (2002), <http://www.springerlink.com/content/k18tmq4u0r78ymjj/fulltext.pdf>
- 5 - Shanon, *Antipodes*. pg. 199
- 6 - Ibid. pg. 200
- 7 - Ibid. pg. 242
- 8 - Ibid. pg. 243
- 9 - Ibid.
- 10 - Ibid. pg. 253
- 11 - Ibid.
- 12 - Ibid. pg. 207
- 13 - Ibid.
- 14 - Ibid.
- 15 - Ibid. pg. 200
- 16 - Ward, Jamie. (2006). *The Student's Guide to Cognitive Neuroscience*. NY: Psychology Press. Pg. 325
- 17 - Shanon, *Antipodes*. pg. 201
- 18 - Ibid.
- 19 - Ibid.
- 20 - Itti, Laurent, "Models of Bottom-Up and Top-Down Visual Processes" California Institute of Technology Doctoral Thesis (2000), http://etd.caltech.edu/etd/available/etd-12022005-103530/unrestricted/Itti_1_2000.pdf
- 21 - Ibid.
- 22 - Arnheim, R. (1974). *Art and Visual Perception: A Psychology of the Creative Eye*: University of California Press.
- 23 - Ibid.
- 24 - Ibid.
- 25 - Bruce, V. & Roth, I (1995). *Perception and Representation: Current Issues*. Philadelphia, PA: Open University Press. Part 2
- 26 - Ibid.
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- 28 - Ibid.
- 29 - Arnheim, R. (1974). *Art and Visual Perception: A Psychology of the Creative Eye*: University of California Press.
- 30 - *Embodied Material*: Clark, A. (1997). *Being There: Putting Brain, Body, and World Together Again*. Cambridge, MA: The MIT Press.
- 31 - "When a person (no matter who) learns to focus and concentrate on SPIRIT, their Mind will gather from their Cosmic Consciousness, the deepest secrets of the Universe, as to how it is composed, by what means, and to what end." <http://www.pymander.com/AETHEREAL/COSMIC~1.htm>
- 32 - "Advanced yogis experience Cosmic Consciousness, Cosmic Vision. This is a rare experience. It is like a glimpse in the beginning. .. You will feel that the world is nothing but pure Consciousness...During deep meditation, the aspirant forgets the external world and then the body. You will not hear any sound. The consciousness of egoism will gradually vanish." http://www.divinelifesociety.org/graphics/sadhana/meditation/experience_in_meditation.html
- 33 - The 30% normal range was created as an arbitrary reference point to explore the possible outcomes of modulating the embodiment percentage.

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