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Enrichment Assessment for Geriatric African Old World Monkeys under Human Care

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ENRICHMENT ASSESMENT FOR GERIATRIC AFRICAN OLD WORLD MONKEYS UNDER HUMAN CARE

A Thesis

Presented to

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Central Washington University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

Primate Behavior and Ecology

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by

Amanda Elizabeth Osborne

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CENTRAL WASHINGTON UNIVERSITY

Graduate Studies

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ABSTRACT

ENRICHMENT ASSESSMENT FOR GERIATRIC AFRICAN OLD WORLD MONKEYS UNDER HUMAN CARE

by

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I proposed a study that determines whether enrichment regimes used for geriatric African Old World monkeys living under human care are effectively eliciting affiliative and active behaviors. I wanted to determine if alternating enrichment types used by the zoo staff were eliciting different social behaviors and locomotion in non-human primates based on different factors including ages, species, and sexes. My data collection took place at the Association of Zoos and Aquarium (AZA) accredited, Oregon Zoo in Portland, Oregon. I conducted my research from 11 June to 5 August 2017. I collected data from eight individuals of varying ages from three species: Allen's swamp monkey (*Allenopithecus nigroviridis*), De Brazza's monkey (*Cercopithecus neglectus*), and mandrill (*Mandrillus sphinx*), who are all members of the subfamily Cercopithecinae. I took observations were taken from 0930-1800h, seven days a week, which accounts for all hours that the primates were on display to the general public. I took 10 minute focal animal samples, and recorded behavior occurrences and durations from an ethogram. I used the ethogram to record locomotion and social interactions that occurred in the presence of provided enrichment. My study showed that my study subjects performed different behaviors during the zoo staff's use of different enrichment regimes. Some species were more active or inactive than others, age was significantly correlated with inactivity, and some enrichment types elicited those inactive behaviors more than other types. The three species of my study can be ranked by their inactiveness to activeness as follows: 1) *Cercopithecus neglectus*, 2) *Mandrillus sphinx,* and 3) *Allenopithecus nigroviridis*. Of the six enrichment types used during my study, *feeding forage/strategy*, *feeding strategy/toy*, *novel food/toy*, and *sensory/toy* enrichment types all equally correlated with more inactivity than did *olfactory/paper* enrichment. I discovered that the geriatric and non-geriatric De Brazza's are less active than all ages of swamp monkeys and mandrills. As there is little research on the evaluation of enrichment preferences for these three species of Old World monkeys, there is a need for further research from the scientific community to enable us to optimize welfare for primates under human care.

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CHAPTER I

INTRODUCTION

The scientific objective of my research is to determine whether daily enrichment regimes provided to aging, Old World monkeys under human care are effective in producing species and age appropriate locomotion and social behavior. Prior research on aging, captive non-human primates is mostly found in human biomedical research, but it rarely touches on the welfare of the animal (Huber, Gerow, & Nathanielsz, 2015; Sitzmann, Urbanski, & Ottinger, 2008; Black & Lane, 2002; Roth, Ingram, Black, & Lane, 2000; Austad, 1997; Price et al., 1991; Gould, Flint, & Graham, 1981).

I studied eight individuals from three species of Old World monkeys: Allen's swamp monkey (*Allenopithecus nigroviridis*), the De Brazza's monkey (*Cercopithecus neglectus*), and the mandrill (*Mandrillus sphinx*). In order for all eight individuals to receive the same amount of observation time within the eight hours allotted per day, I observed each monkey for four, 10 minute observations a day, for a total of 672 observations over the course of my study.

I created a behavioral ethogram utilizing published ethograms from a variety of previous studies (Fuller & Lukas, 2010; Jenny & Schmid, 2002; Oswald and Lockard, 1980; Oates, 1977). My ethogram focuses on three main aspects of behavior: locomotion, social, and other behaviors. The locomotion category includes behaviors such as hand/foot/mouth movements, upper torso movements, full body movements, and the absence of movement. I include locomotor behaviors to distinguish the effectiveness of enrichment types due to substantial evidence from enrichment experiments that measured various styles of locomotion (Baker, 1997; Forthman et al., 1992; Byrne & Suomi, 1991;

Line, Morgan, & Markowitz, 1991). The social content of my ethogram has been used in some experiments to determine efficacy of enrichment types (Byrne & Suomi, 1991; Line et al., 1991; Maki & Bloomsmith, 1989; Paquette & Prescott, 1988; Preilowski, Reger, & Engele, 1988). By studying old and young individuals who are in the same enclosure and who are being subjected to the same enrichment, I will be able to determine if there are differences in behavior as aging occurs. Appleby (1997) stated that while motivation can change with age, many animals actively seek out stimulation and enjoy it. It is possible that some of the enrichment types presented to geriatric primates will produce very little movement, while those same types produce participation by younger monkeys. Certain enrichment types may be effective in producing species and age appropriate behaviors from older primates and will expand our knowledge of their exhibit preferences. It is important to evaluate the differences between individuals' enrichment preferences because chimpanzees have been discovered to differ in affiliative and agonistic behaviors individually, but when the group was analyzed overall, differences were not found (Bloomstrand, Riddle, Alford and Maple (1986). Tarou and Bashaw (2007) found that some types of enrichment altered abnormal behavior to affiliative behavior better than others. Hosey (2005) and Novak and Suomi (1988) state that it is likely that behavior is not affected by any single variable, but by a number of independent variables acting together. By observing the behaviors of each individual in each group, I hoped to ascertain which specific enrichment elicited species-specific behavior. In addition to the lack of knowledge on aging primates, there is an ethical obligation to provide the best care for elderly animals under human care. Providing scientifically supported assessments of primates’ exposure to enrichment regimes will be useful for zoo staff in the future.

CHAPTER II

LITERATURE REVIEW

Cercopithecinae History

The Cercopithecinae subfamily has the largest number of species and subspecies in the primate order (Dugoujon, 1989). Distotell (1996) distinguishes Colobinae and Cercopithecinae within the family Cercopithecidae, based on their dietary adaptations, with colobines having specialized digestive tracts and cercopithecines having buccal pouches. Based upon research of genetic markers, and taking anatomical and behavioral evidence into account, the classification of *Allenopithecus nigroviridis* can be interpreted as either one genus, *Cercopithecus,* or as two separate genera *Cercopithecus* and *Allenopithecus* (Dugoujon, Anaud, Loirat, Hazout, & Constans, 1989). Guenons, which are any long-tailed, arboreal African monkeys (Merriam-Webster, n.d.) are restricted to the subfamily Cercopithecinae. Analysis of mtDNA supports the taxonomic categorization of *Allenopithecus nigroviridis* in Cercopithecinae (Pozzi et al., 2014). Based on three-dimensional coordinates of anatomical landmarks of the skull in species including *Allenopithecus nigroviridis* and *Cercopithecus neglectus,* phylogenetic traits were determined based on mean shape space and size space (Cardini & Elton, 2008). There are differences within guenons such as larger crania in *Allenopithecus nigroviridis* (Cardini & Elton, 2008).

The tribe Cercopithecini belongs to the subfamily Cercopithecinae along with the tribe Papionini, which includes the genera *Macaca, Cercocebus, Mandrillus, Lophocebus, Papio,* and *Theropithecus* (Butynski, 2002). Based on chromosomal and molecular data, *Mandrillus sphinx* is debated to belong to the tribe Papionin (Disotell, 1996). However, based on the mitochondrial DNA, it is argued that *Mandrillus* should be grouped with the *Macaca* genus rather than with *Theropithecus*, *Papio*, and *Lophocebus* (Pozzi, *et al*., 2014).

Allenopithecus nigroviridis

Allen's swamp monkeys are distributed in lowland forests of the central Congo basin, and swim between the islands and mainland (Maisels, Blake, Fay, Mobolambi, & Yako, 2006). They are listed under the least concern status according to International Union for Conservation of Nature's Red List (Oates & Groves, 2008). *Allenopithecus nigroviridis* inhabit swamp forests utilizing branches overhanging rivers as resting locations (McGraw, 1994; Maisels et al., 2006). Swamp monkeys are sympatric with many other primate species: De Brazza's monkeys (*Cercopithecus neglectus*), moustached monkeys, (*C. cephus*) (Maisels et al., 2006; McGraw, 1994), red-tailed guenons (*C. ascanius*) and Wolf's guenons (*C. wolfi*), (Jaffe & Isbell, 2011; Rowe, 1996). While swamp monkeys are sympatric with several similar species, it has not been proven that they have direct competition for resources (Tappen, 1960). These semi-terrestrial monkeys have been found to forage on the ground and no higher than 2 meters above the ground for food, are exceptional swimmers, and predominantly eat fruit (Rowe, 1996; McGraw, 1994; Gautier-Hion, 1988). *Allenopithecus nigroviridis* are preyed upon by crowned hawk eagles, large cats, snakes and possibly bonobos (McGraw, 1994).

There is currently little to no data on the reproductive parameters and social organization of the Allen's swamp monkeys, but generally monkeys in Cercopithecinae subfamily on average reach sexual maturity at about 64.4 months for males and about 47.6 months for females (Jaffe & Isbell, 2011). Cercopithecines have their first birth at 56.1-61.2 months on average (Jaffe & Isbell, 2011). *A. nigroviridis* are khaki colored, with long black hair extending from the cheeks, with a white chin and neck (Kingdon, 1988). Maisel and colleagues (2006) reported sexual dimorphism in *A. nigroviridis*, with males weighing 5950 g and females about 3700 g (Gautier-Hion, 1988). Captive adolescent swamp monkeys become independent of their mothers at three months of age (Fuller & Lukas, 2010) and the average gestation for cercopithecines is 163.2 to 180 days (Jaffe & Isbell, 2011). The average inter-birth interval for the cercopithecines is 25 to 52 months, and the mating seasons are distinctly between April and November (Jaffe & Isbell, 2011).

Allen's Swamp monkeys live in large multi-male, multi-female groups of 10-15 individuals (Maisels et al., 2006; Rowe, 1996; Loireau & Gautier-Hion, 1988), but further research is still needed on their dispersal and their mating systems (Jaffe & Isbell, 2011).

Cercopithecus neglectus

Cercopithecus neglectus can be found in riverine forests of Zaire and Chad basins, northeast Gabon (Lernould, 1988), western Kenya, east of the Great Rift Valley, central Africa, Equatorial Guinea, southwestern Ethiopia, and Uganda (Walker & Sajita, 2011). IUCN Red List experts classify the De Brazza's monkey under the Least Concern status, but habitat loss and bushmeat trade may put them at risk of extinction in the future (Strushaker, Oates, Hart, & Butynski, 2008). The various habitats of De Brazza's monkeys include riparian, lowland, tropical forests; semi-deciduous woods; and bush savannah (Maisels *et al*., 2007; Decker, 1995). At less than 5 m, De Brazza's to sleep in the lower levels of trees, (Wahome *et al.*, 1993). De Brazza's tolerate vervets (*Chlorocebus pygerythrus*) and colobus (*Colobus guereza*), but they show aggression towards blue (*Cercopithecus mitis*) and red tail monkeys (*C. ascanius*) that live in the same territory (Mwenja, 2007; Wahome et al., 1993; Brennan, 1985). They are also sympatric with olive baboons (*Papio anubis*) (Decker, 1995).

De Brazza's monkeys eat large amounts of fruits and leaves, with feeding peaks during the morning and evening hours (Karere, 2000; Wahome, Rowell, & Tsingalia, 1993). They are considered omnivores, as they also eat insects and lizards (Wahome et al., 1993; Oswald & Lockard, 1980). Crown eagles prey on De Brazza's, and when this occurs the monkeys drop to undergrowth, freeze, charge with alarm barks, or tuck their bodies inward as an evasive maneuver (Wahome et al., 1993).

Oswald and Lockard (1980) describe De Brazza's monkeys as having "vividly ornamented faces" (p. 285) that are a combination of a ginger and black band across the eyes and a full white beard. The colors and markings of De Brazza's change over time. As infants, they are typically brown in color but still have the classic white beard, and as they become juveniles they develop red hindquarters with a white stripe on the thigh (Wahome et al., 1993). Wahome and colleagues (1993) found juvenile females grow into their grey, black, and white coats by the time they are half of their adult size, but males do not change to adult colors until they are the same size as adult females and are dispersing from the group. Full adult coats are found at 14 months, with black marking on the legs (Stevenson, 1973). De Brazza's are considered to be the most sexually dimorphic of the guenons (Wahome, et al., 1993). Wahome and colleagues (1993) described adult females as having an obvious perineal region with a white behind, and visible nipples, while adult males have a blue scrotum and/or red perineum.

Females give birth between 4-18 years of age, while males reach sexual maturity at 6-8 years of age and have a decline in reproductive capacity at about 18 years of age as well (Brennan, 1989). Female *Cercopithecus neglectus* successfully give birth to only one offspring at a time (Brennan, 1989), and there are peaks in births during the dry season, between December and March (Wahome et al., 1993). The average gestation period of a De Brazza monkey is about 170 days (Brennan, 1989; Rowell & Richards, 1979). De Brazza's monkeys have an inter-birth interval of 12-20 months (Brennan, 1989; Rowell & Richards, 1979).

De Brazza's monkeys live in groups of around 18 individuals or less (Mwenja, 2007). Brennan (1985) reported group sizes of 1-6 individuals in Kenya, while Wahome et al. (1993) reported larger group sizes of 11-16 individuals. It is possible that population sizes have grown over time as reports of deforestation was a major threat to the monkeys in earlier years (Brennan, 1985). De Brazza's in Uganda have an average population size of 5.8 individuals (Decker, 1995).

These primates live in polygynous groups with one male and multiple females (Mwenja, 2007; Wahome et al., 1993; Wahome, 1989), but they seem to have a flexible mating system that varies between monogamous and polygynous (Leutenegger & Lubach, 1987). Leutenegger & Lubach (1987) hypothesize that smaller group size may be an anti-predator strategy. De Brazza's do not have a dominance hierarchy, and there is little grooming. Adult members spend their days foraging or resting, while juveniles spend the majority of their time playing (Oswald & Lockard, 1980). Social behavior begins at seven weeks, with play at two months, and grooming at eight months (Stevenson, 1973).

Mandrillus sphinx

Mandrills are the largest Old World monkey species (Setchell, Lee, Wickings, & Dixson, 2002) and are found west of the Cameroon-Gabon forest and south of the Sanaga River (Grubb, 1973). Mandrills range across primary tropical rainforests of the west central African coast (Lahm, 1986) to moist, evergreen, or semi-deciduous forests (Jolly, 2007). IUCN Red List experts classify mandrills as Vulnerable due to habitat destruction and bushmeat trade (Oates & Butynski, 2008).

Jolly (2007) noted that papionins are omnivores, but mandrills specifically search the forest floor for fruit, seeds, fungi, small vertebrates, and invertebrates. Lahm (1986), however, argues that mandrills are mainly frugivorous, and argues that because of their diet, mandrills are likely seed dispersers. Due to patchy distribution and seasonal fluctuation of fruiting trees, as well as a shared habitat with 120 mammalian species and 200 bird species, the size of the mandrills' home range may fluctuate in order for them to find food (Lahm, 1986).

Male and female mandrills are indistinguishable until about four to six years of age (Setchell et al., 2005). Females' facial color indicates age: young females have black strips, and reproductive females have bright pink strips (Setchell, Wickings, & Knapp, 2006b). Aged adult females can again display a dark strip (Setchell et al., 2006b). Male and female mandrills are sexually dimorphic in coloration and body size (Setchell et al., 2002). Males weigh 3.4 times the amount of females and lengthwise are 1.3 times longer than females (Setchell, Lee, Wickings, & Dixson, 2001). Presumably, there are selective pressures for a larger and more colorful male (Setchell et al., 2001).

Males' canine teeth erupt and grow between ages 5-9 years old, and they maintain this tooth size until about 11 years old, after which time the tooth regresses (Leigh, Setchell, Charpentier, Knapp, & Wickings, 2008). Leigh and colleagues (2008) discovered that canine development and size correlated with lifespan and reproductive rates, with males being most reproductively fit and having higher offspring output during the time when canines were the largest, while rates lowered at around 16 years of age. Tooth size may be one way to determine whether a mandrill has reached the geriatric stage of life. Mandrills also have larger teeth than other species as the eruption of their teeth occurs over a longer period of time, which may reflect high levels of inter-male competition (Leigh, Setchell, & Buchanan, 2005). Male mandrills' lifespan in semi-wild environments averages 21 years (Setchell et al., 2006a).

Male mandrills have low reproductive output until age seven years, peak at 12 years and then begin to decline in success by about 19 years of age (Setchell et al., 2005). Setchell and colleagues (2005) found that males usually obtained alpha status between ages 9-14 years, that their reproductive success was greater than males who were not alphas, and this success was based on body size and sexual selection. Reproductive fitness depends on the male's ability to obtain and hold the alpha role. Males who lost their positions as alpha were likely to lose future reproductive opportunities, but they contributed to their offspring's fitness by protecting them from the new alpha, even though male mandrills are not known for their paternal care (Setchell, Wickings, & Knapp, 2006a).

Setchell and colleagues (2002) found that the median age for a female to first give birth was at 4.71 years, with all females successfully having at least three offspring by the age of 10 years. Most females are fertile until around 19 years. Females are more reproductively successful the older that they become, and if they are of higher rank, they are usually more successful at reproducing at a younger age than are low ranking females (Setchell et al., 2002; Setchell, Charpentier & Wickings, 2005).

The gestation period for wild female mandrills averages 175 days with birth peaks between January and March and an average interbirth interval of 405 days (Setchell et al., 2002). These intervals may vary in females based on offspring survival. Mandrill groups on average have about 620 individuals at a time, which are represented by about 96% females and offspring and only about 4% adult and sub-adult males (Abernethy, White & Wickings, 2002). Most groups are polygynous, with one male mating with multiple females. After departing from the females after the mating season, males live in solitude and have not been observed living in bachelor groups (Abernethy et al., 2002). It is typical for all species of the Cercopithecinae subfamily, including mandrills, to maintain a social structure of female philopatry and males' dispersal at sexual maturity (Abernethy et al., 2002; de Waal, 1989; Lindberg, 1969; Melnick, 1984). Troops of mandrills frequently join larger, temporary groups at sleeping and feeding sites, and acquire new members during births and immigrations (Jolly, 2007).

Non-human Primate Aging

Masoro (1992) defines aging as post-maturational changes that occur in an individual that create increasing vulnerability to daily challenges and decreasing ability to survive. Kitchener (2004) studied old bears (*Ursidae*) and stated that as the husbandry for animals in captivity has improved, so has their longevity. In the 1930s, zoo staff found it difficult to keep a gorilla (*Gorilla*) alive for more than seven years (Jones, 1962). Now many non-human primates in captivity are kept alive past their reproductive prime and outlive the average lifespan of their wild counterparts (Erwin, Hof, Ely, & Perl, 2002). Symptoms of old age that have been found in captive mammals include dental, skeletal and muscular deterioration; reproductive senescence; memory loss; and general cognitive and behavioral decline (Kitchener, 2004). While residing in a zoo setting primates are exposed to the continual presence of unfamiliar humans, restrictive space, and constant management (Hosey, 2005). As primates are subjected to this type of captive setting, it is our responsibility to evaluate their overall health. Morgan, Line and Markowitz (1998) stated that a basic incentive to improve living arrangements for captive animals is simply for humane care because of an animal's limited choice. When a primate is living such an extended time in an enclosure, it is essential to expand those limited choices. Erwin and colleagues (2002) found that while it is challenging and expensive to maintain geriatric animals in captivity, there is an ethical obligation on the part of caretakers to provide quality care for them. There are currently no studies on geriatric swamp monkeys, de Brazza's monkeys, or mandrills.

Welfare

Few studies conducted on captive and wild geriatric non-human primates focus on the welfare of the animals. Many researchers have chosen to study aging non-human primates as models for biomedical research relative to geriatric human healthcare (Huber, Gerow, & Nathanielsz, 2015; Sitzmann, Urbanski, & Ottinger, 2008; Black & Lane, 2002; Roth, Ingram, Black, & Lane, 2000; Austad, 1997; Price et al., 1991; Gould, Flint, & Graham, 1981). The Great Ape Aging Project was developed to enhance prospects for long-term support for chimpanzees (*Pan troglodytes*) and other great apes, but it is also valued for the data it provides relevant for human health (Erwin et al., 2002). A variety of non-human primate models have been used in biomedical research, including baboons (*Papio*), chimpanzees (*Pan troglodytes*), orangutans (*Pongo*), squirrel monkeys (*Saimiri*), and lemurs (*Lemur*) (Lane, 2000), but the rhesus macaques (*Macaca mulatta*) have been studied the most extensively. Lane (2000) mentions that 422 non-human primate references were made between 1995 and 2000 for biomedical research in human healthcare covering topics such as reproductive senescence, diabetes, caloric restrictions, neurobiology, visual system anatomy, and muscular degeneration. While most of this research is intended for human use, this data is helpful for providing a variety of age-markers and assistance for primatologists working in the field, zoos, and sanctuaries to study aging non-human primates.

Fewer studies have been conducted on aging non-human primates for the sake of their welfare in captivity (Föllmi et al., 2007). Föllmi (2007) argued the need to evaluate geriatric animals in zoos. He studied geriatric individuals housed in five European zoos, including: wooly monkeys (*Lagothrix lagotricha*), green monkeys (*Cercopithecus aethiops*), spider monkeys (*Ateles geoffroyi*), and crab-eating macaques (*Macaca fascularis*). He developed a scoring system for general health and determined that animals who exceeded the maximum age of their wild counterparts were experiencing poor health. It is important to focus on geriatric Old World monkeys due to the limited number of studies that have been conducted on them, in comparison to research on large-bodied apes. McDonald-Pavelka (1994) noted that of almost 200 species of non-human primates, no species can be considered as representative of all others, so data are needed from a variety of species.

Enrichment

Poole (1998) states that different species have different needs for mental stimulation and require specific needs for their care. Bloomstrand and colleagues (1986) found that when studying technological enrichment used by chimpanzees, affiliative and agonistic behaviors differed individually, but when the group was analyzed over all, differences were not found, so we must look at each animal individually. Clay et al. (2011) states that the scientific community needs similar data types of from a broader array of species. Mason (2010) found that species can have different adaptive values using some enrichment versus others, therefore there are different responses to those stimuli (Clark & Mason, 1988). Crockett (1998) found that several studies provided supporting evidence for significant differences in enrichment devices based on the species, sex, age, and origin of the animal, so it is possible that there is a need for different enrichment types for different non-human primate species. In one study that took place over three years, researchers collected focal animal samples from orangutan hybrids (*Pongo pygmaeus x P. abelii*) and siamangs (*Hylobates syndactylus*), to determine whether their enclosures had an effect on other aspects of their behavior (White, Houser, Fuller, Taylor, & Elliot, 2003). They found that the environments affected the siamangs less than the orangutans.

Best practices in animal husbandry enable captive animals to engage in an array of natural behaviors (Dickie, 1998; Line, Morgan, & Markowitz, 1991), which in turn enables mental and physical stimulation (Laule & Desmond, 1998). Enrichment can encourage exercise, foraging, and positive social interactions (White et al., 2003). Kitchener (2004) urges the use of appropriate enrichment methods to simulate activity levels, not just for mental health, but specifically for long term care. While it is impossible to have an optimal enrichment agenda (Newberry & Estevez, 1997) zoo staff aim to maximize the welfare of their animals. Crockett (1998) recorded affiliative behaviors in response to enrichment objects and concluded that affiliative behaviors can occur at abnormally high or low rates but still reflect poor welfare. This indicates that it is essential for all animal caretakers to monitor all classifications of behavior and the context in which they occur to assess the welfare of animals.

Enrichment entails modifications of an environment to create an improvement in the biological functioning of a captive animal (Newberry, 1995). In order for zoo enclosures to be suitable for an animal, the enclosure should promote behavioral diversity, increase the primate’s ability to have control over its environment (Bloomstrand et al., 1989), stimulate cognitive states (Clay, Perdue, Gaalema, & Bloomsith, 2011), and prevent stereotypies (Jenny & Schmid, 2002). Stereotypies are behaviors that are physically and temporally linked to suboptimal features of the environment, have no obvious goal or function, and can develop from an animal’s frustration, unavoidable stress or fear, or lack of stimulation (Mason, 1991). Enrichment is generally divided into five types: social, physical, feeding, occupational, and sensory (Bloomsmith, Brent, & Schapiro, 1991).

The placement of other animals in an enclosure can also be enriching to the lives of captive primates. Monkeys have an innate need for social contact and grooming (Reinhardt, Houser, Eisele, Cowley, & Vertein, 1988). Novak (1988) stated to enhance a primate’s psychological welfare, enclosure space should promote these natural characteristics found in a primate’s social group. White et al. (2003) stated that in order for an exhibit to be successful, there must be variation within the exhibit, including encounters with other animals that elicit species-typical behaviors. Some species-typical behaviors include aggression and grooming. Previous studies have indicated that there is typically more aggression in same-sex individuals (Mitchell, Obradovich, Herring, Dowd, & Tromberg, 1991), while social grooming is a strong indicator of affiliation in Old World monkeys (McDonald-Pavelka, 1994). De Waal (1989) explained that while high levels of aggressive interactions occur between related females, there are also more opportunities for affiliative responses that repair disrupted familial ties.

Novak and Suomi (1988) found that long term housing with the same individuals led to boredom, as decline in social interactions occurred and passiveness increased, which may be due to stressful inter-individual incompatibilities. They continue to say that compatible social groups show high levels of interaction based on the kinship, age, and sex distribution. Reinhardt, Liss, and Stevens (1995) also found that social housing does not cause more distress than single housing, so it is important to know whether the social groups constructed by zoo staff are compatible. If the relationships are compatible, then individuals may act as buffers to one another when they are faced with stressors (Reinhardt et al., 1995). Stressors can include the visitors that the monkeys are exposed to on a daily basis, which have been shown to increase aggressive behaviors (Mitchell et al., 1991). Goo and Sassenrath (1980) also note that aggression isn't necessarily more stressful to primates than affiliative behaviors in social interactions, but de Waal states that even if aggression is low, there is no indication that primates are "unstressed" or "happy" since they may be constantly on guard to avoid friction. Hosey (2005) found that often when primates are crowded they deal with the issue by facing away from one another, and de Waal (1989) similarly found that primates avoid conflict to reduce tension. The affiliative behaviors that do occur between individuals lower the heart rates of the receiver (de Waal, 1989). A social category has been used in some experiments to determine the efficacy of enrichment types to reduce stress levels (Byrne & Suomi, 1991: Line et al., 1991: Macki & Bloomsmith, 1989; Paquette & Prescott, 1988: Preilowski, Reger & Engele, 1988).

Locomotion

Roth et al. (2000) found that locomotion declines with age in rhesus monkeys. Nichols and Zihlman (2002) noted that joints of the limbs and back, the main systems of locomotion, are frequently subjected to stress. They found that the larger the body size and the longer the lifespan of the apes, the greater the affect was on the aging pattern. Study of animals' physical or locomotor behaviors has been used to assess the effectiveness of enrichment types (Baker, 1997; Forthman, et al., 1992; Byrne & Suomi, 1991; Line, et al., 1991). Parks and Novak (1993) examined tool use in captive rhesus macaques by measuring locomotion and social contact. Line et al. (1991) studied the effects of natural objects, such as sticks, and unnatural objects, such as dog toys, on macaques and found that neither the toys nor sticks increased non-stereotypic locomotion or changes in any of their other general activities. Hosey (2005) showed that when active audiences at the zoo were present, a range of primate species increased their locomotive behaviors.

According to Yamanashi and Hayashi (2011), "One goal of captive management is to ensure that the activity budgets of captive animals are as similar as possible to those of their wild counterparts" (p. 1231). They found captive chimpanzees could achieve the same feeding time as wild chimpanzees with the right artificial apparatus for enrichment, which reduced levels of inactivity. There are many activities and behaviors that occur in the wild, which can be simulated by effective enrichment provided by care staff to elicit similar activities from zoo and sanctuary living primates. Goodall (1964) first found chimpanzees using natural objects such as sticks, stalks, stems, and twigs as tools to assist in consumption of foods in the wild. Nash (1982) found that captive chimpanzees would use different tools to extract food from an artificial termite mound simulating behaviors that are naturally found in the wild (Goodall, 1964). In previous studies it was discovered that mandrills in an enclosure that represented their ecosystem presented the same levels of foraging and feeding as unprovisioned mandrills in the wild (Chang, Forthman, & Maple, 1999; Altmann & Muruthi, 1988). Sometimes zoo primates are given food that is not part of their natural diet, which may have behavioral consequences (Hosey, 2005; Campbell, Glenn, Grossi, & Eisemann, 2001; Nijboer & Dierenfeld, 1996). In captivity, animals prefer to actively forage for food rather than eating food that is given to them (Neuringer, 1969). Poole (1998) found that incorporating complex foraging techniques were incorporated into caregiving routines increases mammal's mental stimulation.

Enrichment Objects

Maple and Finlay (1989) found that the most complex and advanced exhibits simulated naturalistic environments to allow animals to display all of their behavioral potential. Naturalistic enrichment has been implemented in captivity at Kyoto University with geriatric chimpanzees (Tonooka, Tomonaga, & Matsuzawa, 1997). Scientists there found that 15 kinds of tools were used after an artificial apparatus was installed into the enclosure, which simulated the emergence of social transmission and tool making that occurs in the wild. Herndon, Moss, Rosene, and Killiany (1997) found that one group of rhesus monkeys displayed specific rates of decline in task performance from young, mature and elderly aged groups after measuring several aspects of cognitive function. This may be predictive for the results of task performance in enrichment presented to geriatric primates in zoos.

Line and colleagues (1991) tested whether rhesus monkeys preferred objects made of natural materials over those made of rubber and nylon, but determined that there was no significant object preference or effect on their behaviors. They did find that captive-born monkeys showed higher toy use than did wild-born ones. White et al. (2003) tested three outdoor exhibits and one indoor exhibit, over three years, for four orangutans and two siamangs. The exhibits varied in size, shape, and configuration, and contained running streams, a glass wall for public viewing, and various manipulable objects. Orangutans 1 and 2 were the only orangutans with 10 observations over all three summers. Orangutan 1 had a significant decline in object manipulation over the summers, while Orangutan 2 had variations in object manipulations across the different exhibits and declined in behavioral response over each consecutive summer. All of these studies cited here are examples of occupational tasks that can be implemented captivity, but the studies show inconsistent results.

Sensory Enrichment

Auditory, olfactory, and visual sensory stimulation can enhance the physical and psychological welfare of captive animals (Wells, 2009), and it is critical that enrichment promotes the highest quality of well-being in geriatric individuals. Wild-born and captive-born cotton top tamarins (*Saguinus oedipus*) were tested for their behavioral responses to predator and non-predator fecal scents (Buchanan-Smith, Anderson, & Ryan, 2009). They were significantly anxious around predatory olfactory cues, but were less anxious around non-predator scents and had raised levels of curiosity to non-predatory cues, especially for the young individuals.

Brooker (2016) studied the response of six captive lowland gorillas (*Gorilla gorilla gorilla*) to auditory cues based on musical genres of classical, rock and roll, and rainforest sounds, with differences in pitches and tempos. He found that on average, gorillas stayed in close proximity to the speakers, social behavior increased when music with low pitches was played, and increased affiliative movement occurred in relation to increased tempo, no matter what the music genre. This study supports the idea that by combining auditory and physical enrichment, animal welfare could be improved. Visual enrichment can be effective by supplementing color preferences of primates to their physical enrichment such as toys or blankets, as is supported by the preference of the color blue in western lowland gorillas and chimpanzees (Wells, McDonald, Ringland, 2008). Parks and Novak (1993) tested water troughs as enrichment for macaques (*Macaca mulatta*) at the University of Massachusetts Primate Laboratory and found that not only were the monkeys using various methods to obtain water, but the water itself was used to alter the condition of food before consumption. This form of enrichment is an example of an affordable cognitive supplement for zoos and sanctuaries. All of these examples are evidence that the types and variation of enrichment for captive primates should be carefully considered as part of overall animal management plans.

In my study of physical movement and socialization of mandrills, De Brazza's monkeys, and Allen's swamp monkeys at the Oregon Zoo, I planned to explore how enrichment impacts behavior, and if so, whether it was a positive or negative impact (Bayne, 2005). The Oregon Zoo staff provided enrichment for all of their animals and provided similar enrichment for all ages, species, and sexes. To provide a rich and stimulating environment there may be a need to supplement that enrichment due to differences in ages, species, and sexes.

Habituation to Enrichment

Certain enrichment schemes may promote more movement by accommodating the primates' innate desire to forage, while enrichment that is not creating a reaction, may not be considered useful. Zoo staff in my study provided an array of enrichment types that was rotated daily, and it is possible that enrichment that once worked no longer does, and it may need re-evaluation. Tarou and Bashaw (2007) found that some types of enrichment altered behaviors better than others, and some were only effective over a short time. An individual can become habituated to an enrichment scheme, which then becomes ineffective, but the enrichment can be re-introduced and once again become a novel stimulus if it is mixed into the regime (Tarou & Bashaw, 2007).

Habituation can be defined as instances of unlearned responses that occur when an organism, due to repetitive activation of enrichment, has lost the ability to respond to the effector (Harris, 1943). Evidence of habituation has been found in primates who were exposed to environmental stimulation. Chimpanzees who showed the most interest in the first two days of enrichment to a tree placed in their enclosure, reacted 704 times, but by the third day had lost interest and only reacted 162 times and continued to have low reaction occurrences (Maki & Bloomsmith, 1989). McSweeney and Roll (1998) deduced that individuals habituate to several characteristics of the reinforcer and alterations in the time, duration, and number of reinforcers changes their response pattern. Jenny and Schmid (2002) stated that long-term studies provide more information of behavioral changes in captive animals in response to their enrichment. Zoos house most animals their entire lives, which sometimes tests decades. By evaluating the enrichment provided extensively and repeatedly, we may find preferential changes in individuals over their lifetimes through scientific data collection in captivity.

It is possible that geriatric monkeys may not behave the same way that younger individuals do. Aging primates have been found to have changes in motivation in response to enrichment activities over time (Appleby, 1997). McFarland and Houston (1981) also state that aging individuals are not static, and Papaj (1994) found that aging individuals should be given the opportunity to live in an environment that allows flexibility for their behaviors. The Oregon Zoo staff, in addition to rotating the enrichment activities of their primates, also rotated the monkeys to different enclosures throughout the day. Rotating animals among enclosures has been predicted to increase animals’ exploration, including sensory investigation and locomotion (Tarou & Bashaw, 2007). In addition to an alternating enrichment schedule affecting the primates’ activity levels, outdoor exhibits produce higher levels of movement because of the similarity to a natural environment (Clay et al., 2011).

McDonald-Pavelka (1994) studied female non-human primate aging and intergenerational relations during daily activities in free-ranging Japanese macaques (*Macaca fuscata*). She found that mothers and daughters spend more time together than with other individuals. By studying old and young individuals who are in the same enclosure and who are receiving the same enrichment, differences can be determined in behavior based on age. Appleby (1997) stated that while motivation can change with age, many animals actively seek out stimulation and enjoy it. It is possible that some of the enrichment activities presented to the geriatric primates produced very little movement, while those same activities produced participation by younger monkeys. The social interactions between the age groups may have been the only elicitor of movement in old individuals. It is also possible that certain activities were effective in producing positive behaviors from older primates, thereby helping us understand their exhibit preferences. Clay et al. (2011) found that it was important to evaluate the differences between individuals' enrichment preferences, and Tarou and Bashaw (2007) found that some types of enrichment altered abnormal behavior to altruistic behavior better than did others. Hosey (2005) and Novak and Suomi (1988) state that it is likely that behavior is not affected by any single variable, but by a number of independent variables acting together. By observing the behaviors of each individual in each group, I compared monkeys' behaviors while each enrichment type was in their presence. My results may help zoo staff better understand how factors such as age, sex, and species influence their behavior in the presence of different enrichment types.

Hypotheses

From the literature I reviewed, I proposed a study focused on the behavior of monkeys in the presence of six enrichment regimes provided by the staff of the Oregon Zoo: *sensory/toy*, *feeding strategy/forage*, *novel food/toy*, *olfactory/paper*, *feeding strategy/toy*, and *big browse/paper* which included variations of social, physical, feeding, occupational, and sensory enrichment that are recommended types of enrichment to use on primates by a large body of scientific research. I hypothesized that: 1) the introduction of some enrichment types would be associated with differences in monkeys' locomotion and social behavior; 2) geriatric monkeys' behaviors would differ from young monkeys based on these different enrichment types; 3) species-specific behaviors would differ, based on the use of different enrichment types 4) sex-specific behaviors would differ, based on the use of different enrichment regimes.

CHAPTER III

METHODS

Study Site and Study Duration

My data collection took place at the Association of Zoos and Aquariums (AZA)-accredited Oregon Zoo in Portland, Oregon from 11 June to 5 August 2017. My study subjects are housed in the Africa Rainforest, Africa Savanna, and Tree Tops exhibits in indoor and outdoor enclosures. The enclosures at the Oregon Zoo include natural environmental designs that resemble the species' habitats in the wild (Maple & Finlay, 1989; Forthman Quick, 1984; McGrew, 1981; Hancocks, 1980).

Study Subjects

My data collection focused on three primate species: Allen's swamp monkey (*Allenopithecus nigroviridis*), De Brazza's monkey (*Cercopithecus neglectus*), and the mandrill (*Mandrillus sphinx*). These species include geriatric individuals at the zoo. In total, there were eight subjects: three Allen swamp monkeys consisting of one geriatric female (26 years), a young male (10 years), and a young female (14 years); two De Brazza's monkeys, including one old female (26 years) and one young male (4 years); and three mandrills, including one old adult male (19 years) and two old adult females (both 29 years) (Table 1). These individuals are determined to be geriatric by the Oregon Zoo staff based on the species' average lifespan under human care and how long the study individual has lived beyond that average. I was the only researcher who collected data on these study subjects. Two months before I collected data, I photographed and studied all individuals from the zoo, to test my ability to reliably identify my study subjects.

Table 1

Study Subjects and Life History

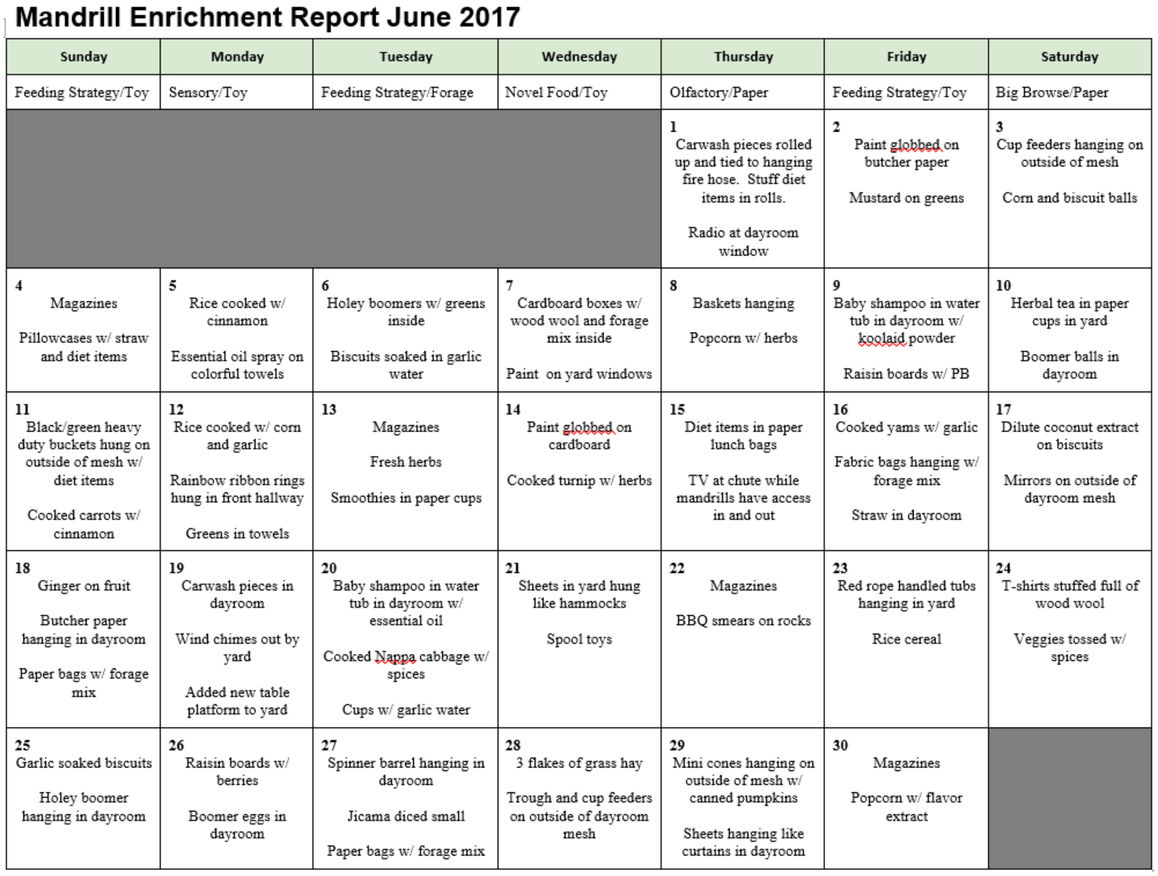
Name	Species	Sex	Age	Background	Considered Geriatric
Dannon	*Allenopithecus nigroviridus*	♀	26 yr	mother of Bleu	yes
Shaba	*Allenopithecus nigroviridus*	♂	10 yr	Unknown	no
Bleu	*Allenopithecus nigroviridus*	♀	14 yr	daughter of Dannon	no
Brooke	*Cercopithecus neglectus*	♀	26 yr	mother of Augustus	yes
Augustus	*Cercopithecus neglectus*	♂	4 yr	son of Brooke	no
Kinshasa	*Mandrillus sphinx*	♂	19 yr	Unknown	yes
Nikki	*Mandrillus sphinx*	♀	29 yr	half sister of Victoria (same father)	yes
Victoria	*Mandrillus sphinx*	♀	29 yr	half sister of Nikki (same father)	yes

The mandrills are housed in the African Savanna exhibit of the Oregon Zoo. There is one indoor exhibit with an upstairs holding space and an outdoor exhibit. Both are accessible to the mandrills. There are three public viewing areas that allowed my observations to be taken in an unobtrusive manner. The Allen’s swamp monkeys share the same outdoor enclosure with colobus monkeys (*Colobus guereza*) at the Africa

Rainforest exhibit. There are two viewing platforms and an additional up-close, viewing window for the public. The outdoor enclosure provides shelter for the monkeys. The De Brazza's monkey enclosure is in the Africa Savanna exhibit.

Data Collection and Sampling Schedule

The planned enrichment schedule for the three species of primates was created by the staff of the Oregon Zoo. The zoo staff created calendars (Figure 1) for each species, which show enrichment types.



Mandrill Enrichment Report June 2017

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Feeding Strategy/Toy	Sensory/Toy	Feeding Strategy/Forage	Novel Food/Toy	Olfactory/Paper	Feeding Strategy/Toy	Big Browse/Paper
				1 Carwash pieces rolled up and tied to hanging fire hose. Stuff diet items in rolls. Radio at dayroom window	2 Paint globbed on butcher paper Mustard on greens	3 Cup feeders hanging on outside of mesh Corn and biscuit balls
4 Magazines Pillowcases w/ straw and diet items	5 Rice cooked w/ cinnamon Essential oil spray on colorful towels	6 Holey boomers w/ greens inside Biscuits soaked in garlic water	7 Cardboard boxes w/ wood wool and forage mix inside Paint on yard windows	8 Baskets hanging Popcorn w/ herbs	9 Baby shampoo in water tub in dayroom w/ koolaid powder Raisin boards w/ PB	10 Herbal tea in paper cups in yard Boomer balls in dayroom
11 Black/green heavy duty buckets hung on outside of mesh w/ diet items Cooked carrots w/ cinnamon	12 Rice cooked w/ corn and garlic Rainbow ribbon rings hung in front hallway Greens in towels	13 Magazines Fresh herbs Smoothies in paper cups	14 Paint globbed on cardboard Cooked turnip w/ herbs	15 Diet items in paper lunch bags TV at chute while mandrills have access in and out	16 Cooked yams w/ garlic Fabric bags hanging w/ forage mix Straw in dayroom	17 Dilute coconut extract on biscuits Mirrors on outside of dayroom mesh
18 Ginger on fruit Butcher paper hanging in dayroom Paper bags w/ forage mix	19 Carwash pieces in dayroom Wind chimes out by yard Added new table platform to yard	20 Baby shampoo in water tub in dayroom w/ essential oil Cooked Nappa cabbage w/ spices Cups w/ garlic water	21 Sheets in yard hung like hammocks Spool toys	22 Magazines BBQ smears on rocks	23 Red rope handled tubs hanging in yard Rice cereal	24 T-shirts stuffed full of wood wool Veggies tossed w/ spices
25 Garlic soaked biscuits Holey boomer hanging in dayroom	26 Raisin boards w/ berries Boomer eggs in dayroom	27 Spinner barrel hanging in dayroom Jicama diced small Paper bags w/ forage mix	28 3 flakes of grass hay Trough and cup feeders on outside of dayroom mesh	29 Mini cones hanging on outside of mesh w/ canned pumpkins Sheets hanging like curtains in dayroom	30 Magazines Popcorn w/ flavor extract	

Figure 1. Mandrill Enrichment Report June 2017

Not all designed enrichment was implemented every day, every week, or even every month, but were alternated to reduce habituation. I did not alter the planned enrichment schedule. The zoo categorizes enrichment combinations into six regimes. The enrichment types are *feeding strategy/toy*, *sensory/toy*, *feeding strategy/forage*, *novel food/toy*, *olfactory/paper*, and *big browse/paper*, which was used seven days a week by repeating *feeding strategy/toy* twice a week. I collected observations from 0930-1800h, 7 days a week, which accounted for all hours that the primates were on display, but excluding 6 July and 7 July. I viewed each species every day. In order for all eight individuals to receive the same amount of observation time within the 8 hours of daily allotted data collection, I attempted to observe each monkey for four, 10 minute focal samples a day over the course of the study. This resulted in a collection of 1,688 focals which accounted for 281 hours and 20 minutes of observations. Due to inclement weather, the zoo closed early on some focal days resulting in shortened focals. Because of this, some individuals were focaled more (207-219 samples) or longer (34 hours and 30 minutes to 36 hours and 30 minutes) than others.

I took a 30-minute lunch break between the hours of 1200h and 1500h each week, to avoid omission of behaviors that may have occurred at certain times of the day. I arranged my samples into a schedule that was randomized for each species. My rests and lunch breaks were distributed so that the monkeys' behaviors were not recorded according to a particular time of day (Altmann, 1974). I randomized the sampling schedule using the *Researcher Randomizer* (Version 4.0) (Urbaniak & Plous, 2015).

Focal Samples

I created one behavioral ethogram based on several published ethograms and due to the lack of content, also created my own descriptions of behaviors based on my knowledge from other primate literature (Fuller & Lukas, 2010; Jenny & Schmid, 2002; Oswald and Lockard, 1980; Oates, 1977). Table 2 displays all 18 behaviors that describe agonistic, affiliative, active, non-active, and other behaviors I observed in my study.

Active behaviors include behaviors Autogroom, Climb, Drink, Enrichment Interaction, Food Carry, Food Process, Forage Sit, Forage Quadrupedal, Jump, and Walk/Run, while the inactive behaviors included Rest and Stop/Stare. Past experiments measured modes of locomotion to assess efficacy of enrichment (Baker, 1997; Forthman et al., 1992; Byrne & Suomi, 1991; Line, Morgan, & Markowitz, 1991), and I used these findings in my study to record active and inactive behaviors. Affiliative behaviors Groom and Being Groomed represent the affiliative behaviors I observed, while the agonistic behaviors include Aggressive Display and Avoid. Affiliative and agonistic behaviors were used in some experiments to assess efficacy of enrichment types (Byrne & Suomi, 1991; Line, et al., 1991; Maki & Bloomsmith, 1989; Paquette & Prescott, 1988; Preilowski, Reger, & Engele, 1988), so I collected data on these behaviors.

Table 2

Agonistic, Affiliative, Active and Inactive Behaviors in Enclosure

Behavior	Definition	Code	Citations
Autogroom (S)	Self-directed cleaning of the skin or fur by an oral or manipulatory process using the mouth, teeth or digits	AU	Fuller & Lukas, 2010; Oswald & Lockard, 1980
Aggressive Display (E)	Individual exhibits aggressive contact, gestures or displacement towards another individual such as biting, grabbing, hitting, pulling, pushing, slapping, staring, teeth-baring, etc.	AT	Fuller & Lukas, 2010; Oates, 1977; Oswald & Lockard, 1980
Avoid (E)	Individual moves away from position, due to the approach of another individual, leaving favored feeding, grooming or resting site occupied by the approacher	AV	Oates, 1977

Table 2 (continued)

Behavior	Definition	Code	Citations
Being Groomed (S)	Individual is receiving a cleaning bout of their skin or fur from another individual by an oral or manipulatory process using the mouth, teeth or digits	BG	
Climb (E)	Individual is ascending or descending a vertical surface in a quadrupedal locomotion mode	CL	Fuller & Lukas, 2010
Drink (S)	Individual ingests water	D	
Enrichment Interaction (S or E)	Individual manipulates or participates with an enhancement of the exhibit (i.e. rope, food, toy, music)	EI	
Food Carry (E)	Individual transports food item in hands prior to consumption	FC	Oswald & Lockard, 1980
Food Process (S)	Individual cleans and prepares food items for ingestion with mouth or digits	FM	Oswald & Lockard, 1980
Foraging Sit (S)	Individual stays in an idle position while searching through the substratum for food items with subsequent consumption	FS	Oswald & Lockard, 1980
Foraging (Quadrupedal) (S)	While two or more feet are in movement, an individual searches through the substratum for food items with subsequent consumption	FQ	Oswald & Lockard, 1980
Groom (S)	Cleaning of the skin or fur of another individual by an oral or manipulatory process using the mouth, teeth or digits	G	Fuller & Lukas, 2010; Oswald & Lockard, 1980
Jump (E)	Any degree of spring clear of the ground or other support by a sudden muscular effort of the limbs	J	Oswald & Lockard, 1980
Out of View	Individual and/or its behavior are clearly not visible	OS	Fuller & Lukas, 2010

Table 2 (continued)

Behavior	Definition	Code	Citations
Other	Individual is engaged in an active behavior that is not defined	O	Fuller & Lukas, 2010
Rest (S)	Individual is in a motionless state while sitting, hanging, or lying down	R	Fuller & Lukas, 2010; Oswald & Lockard, 1980
Stop/Stare (S)	Prolonged immobile stance	SS	
Walk/Run (S)	Non-vertical quadrupedal locomotion where two or more feet are in movement	W	Oswald & Lockard, 1980

Note, S=state, E=event

Unless bad weather caused an alteration in my schedule, I collected focal animal samples (Altmann, 1974) of each monkey for 10 minutes, during which I recorded the behaviors the animal was exhibiting, the behaviors' durations and/or occurrences, and the interactions between the focal monkey and other individuals. I took 5-minute breaks in between each focal to decrease observer fatigue. In order to determine which behaviors were occurring during each enrichment type, I used monthly enrichment calendars from the Oregon Zoo for the months of June, July, and August. I recorded the duration of state behaviors and counted the number of times an event occurred during the focal, letting the events overlap with the duration of states. The ethogram behaviors were mutually exclusive, so I recorded each monkey as engaging in only one state behavior at a time.

Equipment

I used a timer to record behavior durations. I used binoculars to enhance my visual acuity when needed. I recorded all data by hand entry into notebooks.

Analysis

My independent variables are monkey ages, sexes and species and enrichment types. I categorized my dependent variables as affiliative, agonistic, active, and non-active behaviors performed by the study subjects. My four dependent variables are compilations of sixteen behaviors I observed during data collection, excluding “out of view” and “other” behaviors. I collected behaviors as durations and then converted durations into rates to correct for the different amounts of focals between different individuals before performing any analytical tests. I analyzed the behaviors of the monkeys’ relationships to their enrichment types, age, sex, and species by using the multivariate analysis of variance (MANOVA) test in R software (R core team, 2016).

The multivariate analysis of variance compares means of multiple groups simultaneously in an analysis, with multiple dependent variables. This test makes three assumptions (Whitlock & Schluter, 2015), and my data follows the assumptions: 1) every group represents a random sample for the populations of primate species, 2) the data are normally distributed in each population, and 3) the variances are equal in all populations (Whitlock & Schluter, 2015). I confirmed that the datasets were not normal using the Anderson-Darling Test of Normality, before performing MANOVAs. The Anderson-Darling test determines whether each dataset exhibits a standard normal distribution by giving more weight to the tails of the distribution (R core team, 2016). In order to make the standard deviations more similar to the other groups and to improve the fit of the normal distribution to the data, I used a square root transformation on behaviors Agonism and Affiliation, a cube transformation for Active behavior, and a log transformation for Inactive behavior. A log transformation converts each data point to its logarithm

(Whitlock & Schluter, 2015). A cubed transformation raises the response variables to the power of 3. The square root transformations work well with count data such as mine and improve standard deviations that are left skewed (Whitlock & Schluter, 2015).

I then ran a new set of Anderson Darling tests for normality to determine if the transformations created linearity and confirmed that the p-values for Agonism, Active, and Inactive behaviors were > 0.05. The p value for Affiliation behavior was < 0.05. Before running the MANOVAs, I also ran Bartlett tests which determine whether the variances in each group are the same, but do not alter the variances (R Core Team, 2016). The Bartlett tests verified that the p values for Agonism, Affiliation, and Inactive behaviors were > 0.05, meaning the variances were homogenous. The p value of Active behavior was < 0.05, which means the variances were unequal.

I then performed MANOVAs and if the results were significant, with a p value < 0.05, then I would perform a post-hoc Tukey honestly significant difference (HSD) test, which allowed me to test all pairs of means to determine which groups contributed most to the size of the statistic (Whitlock & Schluter, 2016). After performing the post-hoc tests, I then determined the means and standard deviations of the significant findings using R (R Core Team, 2016). From my literature review, I considered increases in locomotive behaviors and affiliative social behaviors as positive reactions to the enrichment regimes. I compared all geriatric individuals to the non-geriatric individuals across each of the six enrichment types. The feeding strategy/toy enrichment type was used twice a week, unlike all other enrichment types, so the rates of behavior that occurred during feeding strategy/toy enrichment were divided in half to avoid skewing my results. By making these comparisons, I ascertained how enrichment regimes produced behaviors in specific primate species and age groups.

CHAPTER IV

RESULTS

I collected 1,688 focals (281 hours and 20 minutes). Although I attempted to collect four, 10 minute focal samples a day from each individual, some individuals received more focals than others because of bad weather. I observed Augustus 211 focal samples (35 hours and 10 minutes), Bleu 211 focal samples (35 hours and 10 minutes), Brooke 211 focal samples (35 hours and 10 minutes), Dannon 208 focal samples (34 hours and 40 minutes), Kinshasa 211 focal samples (35 hours and 10 minutes), Nikki 207 focal samples (34 hours and 30 minutes), Shaba 210 focal samples (35 hours), and Victoria 219 focal samples (36 hours and 30 minutes). Table 3 below includes each individual's focal times in hours, minutes, and seconds for each behavior and the associated enrichment type. I have also included the sums of each behavior for each individual overall and the grand total sums of counts and durations of the behaviors performed. I chose to not include the time that accounts for behaviors "other" or "out of view" in Table 3, as I did not analyze them. I abbreviated the enrichment types (E. types) as follows: 1) B.Br./Paper (*big browse/paper*), 2) Fd.Str./Forage (*food strategy/forage*), 3) Fd.Str./Toy (*food strategy/toy*), 4) Olf./Paper (*olfactory/paper*), 5) Sensory/Toy (*sensory/toy*), 6) Nov.Fd./Toy (*novel food/toy*).

Table 3

Focal Counts and Duration Sums for Correlated Enrichment Types and Behaviors

	E. Type	Total Focal Count	Total Focal Minutes	Agonism Durations	Affiliation Durations	Active Durations	Inactive Durations
Augustus	**SUM**	**211**	**2110**	**0:01:46**	**0:10:32**	**12:07:01**	**21:44:06**
	B.Br./Paper	26	260	0:00:00	0:00:00	1:23:23	2:44:01
	Fd.Str./Forage	34	340	0:00:02	0:00:00	1:57:55	3:11:14
	Fd.Str./Toy	59	590	0:01:16	0:03:43	3:29:26	8:03:00

Table 3
(continued)

	E.Type	Total Focal Count	Total Focal Minutes	Agonism	Affiliation	Active	Inactive
	Olf./Paper	28	280	0:00:07	0:01:09	1:37:06	2:09:29
	Sensory/Toy	32	320	0:00:19	0:02:19	1:43:24	2:38:24
	Nov.Fd./Toy	32	320	0:00:02	0:03:21	1:55:47	2:57:58
Bleu	**SUM**	**211**	**2110**	**0:14:37**	**0:59:10**	**17:14:05**	**9:43:07**
	B.Br./Paper	31	310	0:02:42	0:10:27	2:19:29	1:04:59
	Fd.Str./Forage	30	300	0:02:02	0:08:16	2:13:15	1:39:47
	Fd.Str./Toy	61	610	0:03:48	0:13:04	5:01:28	2:51:58
	Olf./Paper	24	240	0:02:18	0:06:42	2:17:01	0:55:28
	Sensory/Toy	33	330	0:00:32	0:13:52	2:44:16	1:51:36
	Nov.Fd./Toy	32	320	0:03:15	0:06:49	2:38:36	1:19:19
Brooke	**SUM**	**211**	**2110**	**0:00:26**	**0:15:33**	**6:14:17**	**1:03:38**
	B.Br./Paper	26	260	0:00:00	0:00:00	0:48:37	3:19:20
	Fd.Str./Forage	35	350	0:00:08	0:00:00	1:15:29	3:16:09
	Fd.Str./Toy	61	610	0:00:01	0:08:03	2:00:01	7:19:28
	Olf./Paper	28	280	0:00:00	0:04:46	1:05:54	2:45:47
	Sensory/Toy	29	290	0:00:00	0:02:44	0:41:58	3:46:50
	Nov.Fd./Toy	32	320	0:00:17	0:00:00	0:22:18	4:36:04
Dannon	**SUM**	**208**	**2080**	**0:17:48**	**0:54:16**	**14:27:47**	**9:55:43**
	B.Br./Paper	30	300	0:00:29	0:09:46	1:31:35	1:18:46
	Fd.Str./Forage	29	290	0:01:15	0:00:48	2:22:16	1:10:56
	Fd.Str./Toy	60	600	0:11:11	0:27:13	4:23:53	2:36:47
	Olf./Paper	24	240	0:01:30	0:04:40	2:01:57	1:10:29
	Sensory/Toy	33	330	0:02:33	0:03:30	1:58:33	2:11:16
	Nov.Fd./Toy	32	320	0:00:50	0:08:19	2:09:33	1:27:29
Kinshasa	**SUM**	**211**	**2110**	**0:09:04**	**1:10:33**	**12:39:51**	**13:10:15**
	B.Br./Paper	25	250	0:03:26	0:08:24	1:04:13	2:01:10
	Fd.Str./Forage	33	330	0:01:17	0:17:18	1:37:19	2:43:56
	Fd.Str./Toy	60	600	0:01:47	0:31:34	3:52:05	3:36:44
	Olf./Paper	28	280	0:00:05	0:03:50	1:20:14	1:15:22
	Sensory/Toy	33	330	0:00:06	0:07:45	2:14:20	1:57:17
	Nov.Fd./Toy	32	320	0:02:23	0:01:42	2:31:40	1:35:46
Nikki	**SUM**	**207**	**2070**	**0:06:32**	**0:30:39**	**17:34:24**	**12:21:32**
	B.Br./Paper	25	250	0:01:18	0:00:00	2:00:14	1:25:16
	Fd.Str./Forage	31	310	0:00:03	0:05:36	2:47:49	1:51:18
	Fd.Str./Toy	60	600	0:02:06	0:03:54	4:38:34	3:59:19
	Olf./Paper	28	280	0:00:54	0:11:52	2:22:51	1:32:59
	Sensory/Toy	31	310	0:01:45	0:09:17	2:30:48	1:59:02

Table 3 (continued)

	E.Type	Total Focal Count	Total Focal Minutes	Agonism	Affiliation	Active	Inactive
	Nov.Fd./Toy	32	320	0:00:26	0:00:00	3:14:08	1:33:38
Shaba	**SUM**	**210**	**2100**	**0:07:17**	**0:10:47**	**15:11:17**	**12:44:05**
	B.Br./Paper	28	280	0:00:40	0:00:10	2:01:21	2:05:15
	Fd.Str./Forage	29	290	0:00:02	0:01:12	2:07:30	1:32:49
	Fd.Str./Toy	66	660	0:04:38	0:08:05	4:38:44	4:10:35
	Olf./Paper	23	230	0:00:00	0:00:50	2:12:07	1:00:15
	Sensory/Toy	31	310	0:01:40	0:00:01	1:51:15	1:47:17
	Nov.Fd./Toy	33	330	0:00:17	0:00:29	2:20:20	2:07:54
Victoria	**SUM**	**219**	**2190**	**0:29:47**	**0:35:18**	**18:04:40**	**13:54:06**
	B.Br./Paper	24	240	0:05:34	0:08:38	2:06:17	1:11:03
	Fd.Str./Forage	34	340	0:04:45	0:00:00	2:56:01	2:06:44
	Fd.Str./Toy	66	660	0:06:35	0:17:20	5:25:27	4:21:00
	Olf./Paper	28	280	0:02:49	0:05:18	2:36:46	1:37:06
	Sensory/Toy	35	350	0:04:45	0:04:02	3:05:12	2:08:10
	Nov.Fd./Toy	32	320	0:05:19	0:00:00	1:54:57	2:30:03
Grand Total		**1688**	**16880**	**01:27:17**	**04:46:48**	**17:33:22**	**22:36:32**

Agonism

After running the Anderson Darling Test of Normality for the agonism behavior by age (*p* = 0.115), and the Bartlett Test of Homogeneity of Variances of agonism by age (*p* = 0.341), I ran a MANOVA because I met the test assumptions. I ran the MANOVA for agonism against the age, enrichment types, species, and sex variables. There were no significant values for any of these variables in relation to agonism.

Affiliation

After running the Anderson Darling test for affiliation behavior without significance (*p* = 0.031) and a Bartlett test with significance (*p* = 0.543), I chose to run the MANOVA on the affiliation behavior. The square root transformation gave me the best *p*-value to normalize the data set for the monkeys' affiliative behavior. I ran the

MANOVA for affiliation was run against age, enrichment types, species, and sex. The pairwise comparison of age and sex variables were significant [F (1, 6) = 11.157, *p* = 0.016] so I continued analysis with a Tukey HSD test. After using the Tukey, there were no significant p-values for age and sex variables.

Active

After performing the Anderson Darling test for active behavior confirming statistical significance (*p* = 0.129), but a Bartlett test without significance (*p* = 0.013), I chose to run an MANOVA. The cubed transformation gave me the highest p-values for the Anderson Darling test and Bartlett test of all transformations for normalization. I ran a MANOVA of duration in active behavior against individuals' age, enrichment types, species, and sex. Species differed significantly in active durations [F (2, 6) = 6.008, *p* = 0.037). I performed a Tukey test which showed that the mandrills (0.06 ± 0.02), (mean ± standard deviation) were more active than were De Brazza's monkeys (0.04 ± 0.01) (*p* = 0.044).

Inactive

I ran the Anderson-Darling test for inactive behavior to confirm normality (*p* = 0.5785) and the Bartlett test for inactive behavior and age and confirmed homogeneity (*p* = 0.680). I then ran a MANOVA on average inactive duration with individuals' age, enrichment type, species and sex. Enrichment type [F (5, 6) = 10.499, *p* = 0.006], species [F (2, 6) = 110.162, *p* = 1.86e] and age by species [F (1, 6) = 8.726, *p* = 0.025] were all significant.

The Tukey test revealed that *feeding strategy/forage* (0.06 ± 0.02) significantly correlated to non-active behavior more than the *olfactory/paper* (0.04 ± 0.02) (*p* = 0.017).

Feeding strategy/toy (0.07 ± 0.03) significantly correlated with non-active behavior more than *olfactory/paper* enrichment (0.04 ± 0.02) ($p = 0.011$). *Novel food/toy* (0.06 ± 0.03) was also more significantly correlated to non-active behavior than *olfactory/paper* (0.04 ± 0.02) ($p = 0.017$). The *sensory/toy* enrichment (0.07 ± 0.02) was significantly correlated with non-active behavior more than the *olfactory/paper* (0.04 ± 0.02) ($p = 0.007$) as well.

The Tukey tests on species revealed that De Brazza’s monkeys (0.09 ± 0.02) were significantly less active than Allen’s swamp monkeys (0.04 ± 0.01) ($p < 0.001$), as were the mandrills (0.05 ± 0.01) who also performed the non-active behaviors significantly more than the swamp monkeys (0.04 ± 0.01) ($p = 0.029$). The De Brazza’s monkeys (0.09 ± 0.02) were also significantly less active than the mandrills (0.05 ± 0.01) ($p < 0.001$).

I found six significant test results in my Tukey-HSD test of age and species. Geriatric De Brazza’s monkey (0.10 ± 0.02) were significantly less active than geriatric Allen’s swamp monkeys (0.04 ± 0.01) ($p < 0.001$), and the non-geriatric De Brazza’s monkey (0.08 ± 0.02) was significantly less active than the geriatric Allen’s swamp monkeys (0.04 ± 0.01) ($p < 0.001$). The geriatric De Brazza’s monkey (0.10 ± 0.02) was significantly less active than the non-geriatric swamp monkeys (0.04±0.01) ($p < 0.001$), and the non-geriatric De Brazza’s monkey (0.08 ± 0.02) was significantly less active than the non-geriatric Allen’s swamp monkey (0.04 ± 0.01) ($p < 0.001$). Finally, the geriatric De Brazza’s monkey (0.10 ± 0.02) was inactive significantly more than the geriatric mandrills (0.05 ± 0.01) ($p < 0.001$) and the non-geriatric De Brazza’s monkey (0.08 ± 0.02) was also inactive significantly more than the geriatric mandrills (0.05 ± 0.01) ($p = 0.003$).

CHAPTER V

DISCUSSION

I conducted this research to determine the effectiveness of enrichment regimes in geriatric, Old World monkeys. Non-human primates are so successfully maintained in zoos that they live well past their reproductive prime and outlive the average lifespan of their wild counterparts (Erwin et al., 2002). Previous studies have indicated that there is a need for more scientific research to evaluate the welfare of these geriatric animals in captivity (Főllmi, 2007). I chose to assess members of the Cercopithecinae subfamily, due to the general lack of research on three of the species classified therein. McDonald-Pavelka (1994) asserts that, with almost 200 species of non-human primates, no one species should considered be representative of all others, so data collection from a variety of species is necessary. Novak and Suomi (1988) state that a desirable behavioral profile for a captive animal might be one in which the animal displays high frequencies and durations of affiliative, exploratory, and/or playful behaviors, is active within its environment, and shows low levels of aggression and stereotyped activities. My results established that monkeys in my study performed different behaviors during the zoo staff's use of different enrichment regimes. I found that some species were more active or inactive than others, age was significantly correlated with inactivity, and some enrichment types elicited those inactive behaviors more than others. My study is the first to explore social and locomotive patterns in these three species of Old World monkeys in relation to their age and the daily enrichment given by zoo management.

Social Behaviors

Monkeys have an innate need for social contact and grooming, which are intimate social behavior patterns (Reinhardt, Houser, Eisele, Cowley, & Vertein, 1988). It is important to understand these social interactions by assessing the affiliative and agonistic behaviors that occur in human managed, artificial settings. Compatible social housing does not cause more distress to primates than single housing (Reinhardt, Liss, & Stevens, 1995), which makes this research relevant to knowing whether the social compositions at the Oregon Zoo were compatible. Reinhardt and colleagues (1995) explain that compatible relationships ultimately act as buffers to stress. The non-human primates at the Oregon Zoo spent many hours during the day in front of visitors, which may be stressful to monkeys and may evoke increased aggressive behaviors (Mitchell et al., 1991). Grooming is an affiliative behavior in primates that has even been shown to slow the heart rate of the receiver (de Waal, 1989). At the Oregon Zoo, I collected data on both affiliative and aggressive behaviors to determine whether there were any significant patterns correlated to enrichment types and monkeys' ages, species, and sexes.

Affiliative Behavior

My data did not show any significant differences in affiliative behaviors during the caregivers' use of six different enrichment protocols. Beyond the enrichment type comparisons, there were also no significant differences in affiliative behaviors between species, ages, or sexes. The rates of affiliative behaviors can be seen in Table 4. I argue that because there is a lack of significantly high levels of affiliation elicited by the enrichment types in any of the species, ages or sexes, there may be some social incompatibilities between some individuals housed together, because it seems improbable that there would be no significant affiliative behaviors occurring. This absence of significantly high affiliative behaviors may have to do with high levels of inactivity in my dataset, fitting an undesirable profile in some species.

Novak and Suomi (1988) found that long term housing with the same individuals led to boredom, as decline in social interactions occurred in their study, and passiveness increased due to stressful inter-individual incompatibilities, which may support possible social disinterest among all three species of primates in my study. The geriatric, female mandrills, both 29 years old, have been housed together most of their long lives. The mother-daughter swamp monkeys have also been together for about 14 years. While both species are female philopatric, the small group size and lack of fluctuation in group structures may be causing a general disinterest in each other and lack of significant affiliative interactions with each other. Male mandrills tend to live in solitude when they are not mating (Abernethy et al. 2002), which may explain why I observed low levels of affiliation among the mandrills, since all three individuals in my dataset are past their reproductive prime.

Rhesus monkeys, other members of the Cercopithecinae subfamily, are also female philopatric, while the males disperse when they reach sexual maturity (Abernethy et al., 2002; de Waal, 1989; Lindberg, 1969; Melnick, 1984). This type of behavior was could not be expressed for the De Brazza’s group placed in a zoo setting which may account for the lack of significant differences in affiliative behavior during the use of different enrichment types. In my study De Brazza’s group, low levels of copulation occurred between mother and son, which resulted in Brooke’s (mother) impassivity to Augustus (son) by distancing herself from him and then briefly grooming him. As there are apparent incompatibilities between Brooke and Augustus, it may be beneficial to move Augustus to a bachelor group (Hosey, 2005), if there are no available breeding females at other zoos.

Agonistic Behavior

My data did not show any significant differences in agonistic behaviors during the caregivers' use of six different enrichment protocols. There were also no significant differences in agonistic behaviors based on species, ages, or sexes. The rates of agonistic behaviors can be seen in Table 4. I again argue that because there is a lack of significant differences in agonism during the use of different enrichment regimes, in addition to insignificant differences in affiliative behaviors, elicited by the enrichment types in any of the species, ages or sexes, there may be some disinterests. This absence of significant differences in agonistic behaviors may again have to do with the high overall levels of inactivity.

Previous studies have indicated there is usually more aggression in same sex individuals (Mitchell et al., 1991) and found that females fought more within their own matrilines, in addition to high levels of friendly interactions because as related females, such as within sister and mother/daughter relationships, there is more opportunity for repair of familial ties (de Waal, 1989). Anecdotally, I would say that I have observed more aggression in the matrilineal relationships in the mandrill and swamp monkey enclosures. Future analysis of individual relationships in these enclosures may be able to answer whether a true correlation exists between higher amounts of aggression in related female monkeys at the Oregon Zoo than their male counterparts.

Primates typically avoid conflict to reduce social tensions (de Waal, 1989). De Waal (1989) found that even if aggression levels are low, animals are not necessarily "unstressed" or "happy" since they are constantly on guard to avoid friction. I collected anecdotal evidence that shows that the geriatric swamp monkey avoided conflict, by disappearing with food during feeding enrichment. I could not quantify this because her behavior was recorded as "Out of View" so this will need further investigation. This behavior is species-typical, as cercopithecines conceal food in their cheek pouches. I anecdotally observed similar behavior in the mandrills as well.

Active Behavior

Hosey (2005) found that for some species, captive and wild animals' activity budgets differed, while for other animals, budgets were the same. If the staff at the Oregon Zoo only observed the behaviors of their mandrill population and assumed they represented all other cercopithecine populations, they might overlook species-specific behavior patterns that occur during the use of the six different enrichment types. Other studies found that species have different needs for mental stimulation and care (Poole, 1998), due to different adaptive values of the enrichment regimes provided by zoo staff (Mason, 2010), and who will need continuous data collection from the scientific community on every species (Clay et al., 2001). My study indicates either that mandrills are generally more active than De Brazza's monkeys, or that the six enrichment regimes used on both species are eliciting active behavior better for mandrills (see Table 4). Using different methods, future researchers may seek to understand what makes the enrichment less effective for *Cercopithecus neglectus*. My findings support my hypothesis that there would be differences between species and demonstrate the need to investigate enrichment effectiveness of multiple genera of Old World African monkeys under human care in zoo and sanctuary settings.

Inactive Behavior

My results show that *feeding forage/strategy*, *feeding strategy/toy*, *novel food/toy*, and *sensory/toy* enrichment types all equally correlated with more inactivity than *olfactory/paper* enrichment in the Old World monkeys (see Table 4). Primate foraging studies determined that while *feeding forage*/*strategy* can promote species-appropriate time budgets and locomotion (Byrne & Suomi, 1991; Forthman et al., 1992), there may be the same amount of inactive time (Baker, 1997). This may explain why in my data correlated more strongly with *feeding forage/strategy*. Baker (1997) argues that foraging enrichment strategies are advantageous because it is impossible for one individual to monopolize that type of enrichment and habituation to it does not occur.

Line (1991) found that the use of toys elicited low levels of use and high amounts of inactivity in rhesus macaques of all ages. My study confirms those findings, as toys were used in both the *food strategy/toy* and *novel food/toy* enrichment types, which both correlated with significantly high levels of inactivity.

Dickie (1998) found that food enrichment like *novel food/toy* in my study, should promote more activity, because it mimics seasonally available food in the wild. My results show that there were significantly high levels of inactive behavior during the use of *novel food/toy*. Evidence shows that many animals will eventually tire of an enrichment object or toy (Dickie, 1998; Paquette & Prescott, 1988). For this enrichment type it is possible that the use of toy enrichment is impacting the behavior more than the novel food, but further research would be required to confirm my hypothesis.

Dickie (1998) also stated that allowing an animal to process food creates physical and mental challenges for animals that could be beneficial. *Food strategy/toy* was implemented in my study for all species, every week, but this enrichment also correlated with significantly high levels of inactivity. Again, it is possible that the toy enrichment is promoting the inactive behaviors of the monkeys like the *novel food/toy* but this will also need further investigation to determine if the monkeys are habituated to this aspect of this particular type of enrichment.

Auditory, olfactory, and visual enrichment are all types of sensory stimulation, which have been found to be physically and psychologically beneficial to captive animals (Wells, 2009). In my study, zoo staff distributed sensory toys weekly for all subjects, but it was associated with high levels of inactivity. It is possible that the current types of sensory toys are ineffective enrichment for all three species. I did anecdotally observe Brooke, a geriatric De Brazza's monkey, frequently use a provided mirror (*sensory/toy*). It may be very important to look at individuals separately in future research, to determine if there are individual preferences for certain enrichment types.

Feeding strategy/forage, *feeding strategy/toy*, *novel food/toy*, and *sensory/toy* enrichments were associated with high levels of inactivity and were more significant than the *olfactory/paper* enrichment. Buchanan-Smith and colleagues (2009) found that cotton-top tamarins were more active and curious during the use of non-predatory olfactory enrichment. The monkeys in my study were also more active when *olfactory/paper* enrichment was presented to them.

My data show that De Brazza's monkeys and mandrills were significantly less active than were Allen's swamp monkeys. I found that the De Brazza's were also less active than the mandrills. The monkeys can be ranked by their inactiveness to activeness as follows: 1) *Cercopithecus neglectus*, 2) *Mandrillus sphinx*, 3) *Allenopithecus nigroviridis*.

Different species have different needs for stimulation and require specific care for their needs (Poole, 1998). Primatologists and animal caregivers need continued research to determine why poorly-known species differ in their different levels of inactivity (Clay et al. 2011). Since different species may value enrichment differently based on their ecological adaptations (Mason, 2010), it is possible that giving all three species identical types of enrichment is ineffective. Since the De Brazza's monkeys were the least active, mandrills were intermediate in their activity levels, and Allen's swamp monkeys were the most active, my research may also show that this collection of weekly enrichment regimes are more effective in decreasing inactivity in swamp monkeys, and were less successful in decreasing inactivity in the De Brazza's monkeys.

I found that geriatric and non-geriatric De Brazza's monkeys were less active than the geriatric and non-geriatric swamp monkeys. Both the geriatric and non-geriatric De Brazza's were also more inactive than the geriatric mandrills. Kitchener (2004) stresses that the use of appropriate enrichment will stimulate higher activity levels for long term care, but as locomotive behaviors decline as monkeys get old (Roth et al., 2000), it may become more difficult to find effective enrichment. Nichols and Zihlman (2002) found that the larger and older the primate becomes, the more negatively their locomotive patterns were affected over time. My findings do not support previous research on aging, because these findings are only reinforcing the trend found between species differences and not differences in age. Clark and Mason (1988) found that different species showed a pattern of differences in response to stimuli. These results of age by species do support the trend that there are differences in inactivity between species because not only was the geriatric, De Brazza's monkey (Brooke) more inactive than were the geriatric and non-geriatric swamp monkeys and mandrills, but the non-geriatric De Brazza's monkey (Augustus) was as inactive as well. Each species varies in size and average lifespan, so it is possible that there are physical differences that cause different levels of inactivity, but could be due to ineffective enrichment as my research shows a pattern of inactivity with the entire *Cercopithecus* population at the Oregon Zoo.

Research Limitations

One research limitation of my study is the inclusion of a mixed-species exhibit, which may potentially promote behavior that would not normally occur with the absence of an additional species within the same enclosure (Hosey, 2005). Many zoos implement mixed-species exhibits (Hosey, 2005) because they simulate naturalistic environments for animals (Dickie, 1998). The Allen's swamp monkeys were housed with black and white colobus monkeys (*Colobus guereza*), a common sympatric species of *Allenopithecus nigroviridis* (Maisels et al., 2006; McGraw, 1994). It is possible that my research results are skewed because of the behavioral dynamics between the swamp and colobus monkeys, due to competition for food and enrichment.

Hosey (2005) showed that animals were affected by whoever had previously been former inhabitants of an enclosure, especially if current occupants were exposed to scents of their predators or their prey. The De Brazza's monkeys were previously in an enclosure within the Primate Forest, but they were moved into the Tree Exhibit before my data collection began. It is possible that they were exposed to scents of animals previously residing in the enclosure, which may have altered their behavior.

The weather is another potential research limitation in my study. June had a 3 day stretch of 32°C or higher, July's temperatures were between 27-37°C, and the warmest stretch of days was from July 29th, 2017 to August 11th, 2017 with the highest temperature reaching 41°C (NWS Forecast Office, 2017). The office also stated that it was the third longest dry season of 57 days, in history. These extreme temperatures may have greatly affected the behavior of the monkeys, but likely affected all of them in the same way.

Other limitations to my methods and results may have been due to the enrichment schedule created and implemented by the staff of the Oregon Zoo. Many times the specific enrichment items used during the six different enrichment types, did not necessarily fit the enrichment type description. The enrichment used may be misrepresenting the categories and ultimately be portraying ineffective enrichment types that would not normally be ineffective if designed correctly. The enrichment items used also varied between each species' enclosures. While each species may have been receiving the same type of enrichment, they may not have been receiving the same enrichment item at the same time, which could be altering the behaviors of each species, and therefore skewing the data to show significant differences. Another limitation to my research, based on the enrichment schedules is that each enrichment type is made up of two different enrichment types such as *sensory/toy*. It was impossible to determine whether sensory enrichment or toy enrichment was eliciting desired or undesired behaviors more effectively. The enrichment schedule could potentially be skewing results in any of these ways.

Studying the long-term effects of enrichment, including times when enrichment is not present, would have helped me to evaluate the state of welfare in these lifelong zoo residents (Bashaw, Bloomsmith, Marr, & Maple, 2003). Other notable research limitations may include the monkeys' habituation to enrichment types, small sample size, lack of non-geriatric individuals in the mandrill group, and visitor impediments to my visual acuity.

CHAPTER VI

CONCLUSIONS

Generalized enrichment regimes may not be effective at promoting appropriate levels of social and locomotive behaviors in the three species and ages of cercopithecines in my study. I concluded that some enrichment types significantly associated with inactive behaviors across all species I observed. Some species were more active and inactive than others: Allen’s swamp monkeys were most active and the De Brazza’s were the least active, which suggests that these different enrichment regimes cannot be generalized for an entire subfamily of primates. My literature review on captive primate populations showed that different primate species have different needs, use different modes of locomotion, come from different habitats, and have different species-typical responses to conspecifics and to various enrichment. I chose to study African, Old World monkey because this is a group of primates that are underrepresented in the scientific literature.

De Brazza’s monkeys, regardless of age, were more inactive than any other species of any age group tested, which may reflect inappropriate daily enrichment and social incompatibilities between a mother and son pair of De Brazza’s monkeys housed together. Previous literature indicated that geriatric individuals would be generally inactive, which was indicated through the generally high levels of inactivity elicited by all species of cercopithecines in my study. It may be useful to link specific enrichment items, rather than types, to behaviors that were being observed, which was not possible in my study. The lack of studies of geriatric non-human primates in zoo and sanctuaries underscores the need for further research for specialized enrichment to elicit healthy behavioral profiles for these long term residents.

It is likely that the lack of significant difference in social behaviors I observed in my study is influenced by the high levels of inactivity in my study subjects, which may reflect possible incompatible relationships within each enclosure. Further investigations should focus attention on individual behaviors performed by subjects during the caregivers' use of different enrichment regimes. Research should be conducted to continue exploration of how individuals, species, and ages of Old World monkeys influence behavior under different enrichment protocols, as there are currently very few studies focused on enrichment effectiveness in zoo and sanctuary settings.

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