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The Behavioral Effects of Feeding Enrichment on a Zoo-Housed Herd of African Elephants (Loxodonta africana)

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July, 2017

To the Dean of the Graduate School:

We are submitting a thesis written by Caroline Marie Driscoll entitled “The Behavioral Effects of Feeding Enrichment on a Zoo-Housed Herd of African Elephants (*Loxodonta africana)*.” We recommend acceptance in partial fulfillment of the requirements for the degree of Master of Science.

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THE BEHAVIORAL EFFECTS OF FEEDING ENRICHMENT ON A ZOO-HOUSLED HERD OF AFRICAN ELEPHANTS (*Loxodonta africana*)

A Thesis
Presented to the Faculty
of the
College of Arts and Sciences
in Partial Fulfillment
of the Requirements for the Degree
of
Master of Science
in the
Department of Biology
Winthrop University

July, 2017

By

Caroline Marie Driscoll
ABSTRACT

A comprehensive study on the behavioral effects of feeding enrichment was conducted on six African elephants housed at the North Carolina Zoological Park in Asheboro, NC. The herd is comprised of two adult males, three adult females, and one subadult female. The study was conducted over a 10-month period and consisted of focal sample observations across three conditions. Observations were recorded during the baseline condition (June to September) and continued through the introduction of feeding enrichment. Behavioral data were also collected when enrichment items were present but food presentation followed the historical husbandry routine, known as the experimental control (October to April). Data were collected on ten behaviors and analyzed to test for significant changes in the behaviors as a group, between the sexes, and for individual animals. The patterns that emerged from analysis for the herd as a whole did not necessarily apply to the analyses based on sex or for a given individual. In addition, individual elephants varied in the longevity of their behavioral changes to the feeding enrichment. These results provide evidence for the efficacy of feeding enrichment in general as well as for unique personalities and reactions to such enrichment. Furthermore, the findings of this study should encourage zoos to employ individual monitoring to enhance each elephant’s well-being.
This thesis is dedicated to the late Dr. Austin L. Hughes.

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Chapter 1

INTRODUCTION

I. Elephant natural history

African elephants (*Loxodonta africana*) are the largest terrestrial animals on earth; they typically weigh between 2,200 kg and 6,400 kg and stand 2.5 to 4 meters tall at the shoulder (African Elephant, 2012; Savanna Elephant, 2013). They are sexually dimorphic with the females occupying the lower halves of those ranges. After a 22-month gestation, elephant calves are born weighing approximately 90 kg and standing one meter tall at the shoulder (African Elephant, 2012; Savanna Elephant, 2013). The African elephant is currently present in 37 sub-Saharan African countries, inhabiting grassland and forested areas, and in arid deserts in low densities (Blanc, 2008).

Elephants live in family groups consisting of related adult females and their calves, and are led by the oldest and most dominant female, the matriarch (Archie et al., 2005; Vidya and Sukumar, 2005). These matriarchal groups create fission-fusion societies where multiple family groups coalesce around resources but then later disperse (Moss, 1988; Archie et al., 2006). When males reach sexual maturity, they leave their natal groups and live alone or temporarily join bachelor groups, typically interacting with females only during the reproductive season (Poole and Moss, 1981).

Elephants are intelligent creatures and research continues to find behaviors suggestive of sophisticated cognition comparable to that of apes and cetaceans (Shoshani et al., 2006; Jabr, 2014), such as, tool modification and use (Chevalier-Skolnikoff and
Liska, 1993; Hart and Hart, 1994; Hart et al., 2001), the ability to pass mirror self-recognition tests (Plotnik et al., 2006; Plotnik et al., 2010), a capacity for discriminant learning and categorization (Poole et al., 1998; Langbauer, 2000; Bates et al., 2007), and advanced memory retention (Markowitz et al., 1975). Recent studies have provided evidence for empathy in elephants, with reports of elephants delivering consolation to others in distress (Moss, 1988; Poole, 1996; Plotnik and de Waal, 2014) and grieving deceased conspecifics (Douglas-Hamilton et al., 2006). Evidence of empathy gives insight into the social lives of elephants, but it has also been linked to intelligence (Strayer, 1987). Empathy allows an individual to perceive the mental and emotional states of others; this can potentially improve one’s survival status by sensing another’s intention (Darwin, 1872; Strayer, 1987). Empathy can be considered a cognitive skill because of the analytic ability required to recognize and respond to non-communicated signals (Strayer, 1987).

Their complex social structures and engagement in fission-fusion societies have also been noted as evidence of higher cognitive abilities (Byrne and Whiten, 1988; Dunbar, 1992; Byrne and Bates, 2007) where elephants rely heavily on cooperation among herd members. Such behaviors have been seen both in wild (Dublin, 1983) and captive elephants (Plotnik et al., 2011). A matriarch will lead her group to out-of-sight resources and coordinate predator-specific defense responses and can call upon a life-time of experiences to locate resources during times of scarcity (McComb et al., 2001). Adult females are able to recognize 100+ other elephants (McComb et al., 2000) and are able to know the location of out-of-sight conspecifics (Bates et al., 2008).
In the wild, elephants spend about 16 hours a day foraging, where a large portion of foraging time is dedicated to locating food sources and manipulating items prior to consumption (McKay, 1973; Wyatt and Eltringham, 1974; Moss, 1982, 1988). Their diet consists of various parts of plants, including leaves, fruits, flowers, twigs, bark, and roots (Moss, 1982; Shepherdson, 1999). To obtain food resources, they travel long distances, typically walking 5-10km a day (Theuerkauf and Ellenberg, 2000; Whitehouse and Schoeman, 2003; Leighty et al., 2009).

Elephants are ecologically important to their habitats as they are constantly reconstructing areas (Haynes, 2012); they uproot trees and use their tusks to create watering holes during the dry season that will be used by multiple other species (Douglas-Hamilton and Douglas-Hamilton, 1975; Ramey et al., 2013). The time dedicated to foraging and socializing leaves little time for African elephants to be inactive and they typically only sleep for two hours a day thus qualifying them as the mammal with the shortest known sleep cycle (Gravett et al., 2017).

The International Union for Conservation of Nature and Natural Resources (IUCN) updated the African elephant’s conservation status from endangered to vulnerable in 2004. The greatest threat to African elephants is the poaching for their ivory which is used for decoration and in traditional Chinese medicine as it is believed to have healing properties (Blanc, 2008). Other threats include habitat destruction and fragmentation due to human population increase and the spread of civilization. Human-elephant conflict is another source of elephant population decline; as historic habitat is converted for agricultural routes and ancient migrations routes are disrupted, elephants
sometimes invade crop lands leading to retaliation on the elephants deemed responsible (Blanc, 2008; Human-Elephant Conflict, 2017).

II. Captive Elephants

Keeping elephants in captivity has been an issue of contention for many years (Stewart, 2003; Veasey, 2006; Jabr, 2014). Although, elephants can be difficult to manage due to their size, strength, advanced intelligence and sociality (Shepherdson, 1999; Veasey, 2006; Mason and Veasey, 2010), their presence in zoos contributes to educating the public about the species while promoting their conservation (Club and Mason, 2002).

Elephants in the wild encounter a variety of stimuli in terms of conspecifics, animals of other species, and different types of habitats that require further investigation and that individuals exploit their cognitive abilities (Baskaran et al., 1995). Elephants have evolved to perceive and overcome challenges, whether these arise from problem-solving when trying to obtain resources or interacting with other animals. Locating and acquiring resources, particularly during the dry season when resources are not abundant, constitute a large part of the day. Appropriate interaction with both familiar and unfamiliar conspecifics is also a common occurrence in wild elephant life (Poole and Granli, 2009). Captive settings can be limited in their environmental, spatial, and social intricacy as compared to the wild which may cause decreased mental and physical stimulation; that, in turn, can result in an increase in time spent inactive, or performing vacuum behaviors, or engaged in stereotypies (Varadharajan et al., 2015).
Reduced space and readily-available resources may lead to reduced movement and exercise for captive individuals. These situations can potentially result in weight gain and obesity, arthritis, inflammation and eventual loss of joint cartilage, and foot ailments (Fowler, 1993).

Vacuum behaviors are innate action patterns performed when the appropriate stimulus is not present, and which serve no clear biological purpose (Lorenz cited in Burkhardt, 2010). Engaging in vacuum behaviors suggests the physiological need to express species-typical behaviors, even when the appropriate outlet or context is not present. Vacuum behaviors are not necessarily stereotypical in nature but can later develop into stereotypy and can indicate suboptimal conditions (Mason and Veasey, 2010).

Stereotypies are repetitive behaviors that are relatively invariant in expression and apparently functionless (Odberg, 1978). Such abnormal behaviors have not been recorded in wild animals and reportedly arise in response to a large set of situations: the inability to engage in appetitive behaviors (Hughes and Duncan, 1988; Carlstead, 1996), the inability to escape confinement or to reach a desired destination (Carlstead, 1996), the inability to choose or exert control (Carlstead, 1998), rigid schedules and the anticipation of an impending event (Friend and Parker, 1999; Rees, 2004; Wilson et al., 2004; Elzanowski and Sergiel, 2006), as well as premature maternal separation (Latham and Mason, 2008). Age and seasonal variation have also been found to influence the occurrence of stereotypies, particularly in elephants, with an increase in performance by younger elephants (Friend and Parker, 1999; Gruber et al., 2000) as well as during winter months (Rees, 2004). The claim that the performance of stereotypic behavior indicates
compromised welfare is well-accepted in the scientific and animal welfare community (Broom, 1983; Dawkins, 1990; Broom and Johnson, 1993; Lawrence and Rushen, 1993; Mason and Latham, 2004; Mason, 2006).

However, some research has examined the connection between stereotypy and suffering or stress, and suggests that not all stereotyped behaviors are associated with poor welfare, with some stereotypic behaviors resulting in neutral consequences (reviewed in Mason and Latham, 2004). The “coping” hypothesis posits that the performance of stereotypies arises in reaction to stressful situations and serves to ameliorate anxiety levels (Mason, 1991; Rushen, 1993).

Multiple studies have found that captive elephants spend a considerable amount of time engaged in stereotypic behavior, which typically includes rocking/swaying and pacing, but also circling and feces manipulation (Friend and Parker, 1999; Clubb and Mason, 2002; Rees, 2009; Hasenjager and Bergl, 2015). Unfortunately, even if stereotypic behaviors are addressed and efforts are made to mediate their performance, once the behavior is a part of their repertoire it may be difficult to eradicate (Mason, 1991).

III. Enrichment

It is difficult to simulate all the complexities of the wild in captive environments; animals have evolved physical and mental abilities to meet the demands of their natural habitats but many of these abilities may become irrelevant in zoo settings (Markowitz, 1982; Newberry, 1995; Price, 1999; Fa et al., 2011). To help reduce the frequency of stereotypies and other abnormal behaviors, zoos rely on the implementation of
enrichment (Markowitz, 1982; Swaisgood and Shepherdson, 2005). Enrichment involves the introduction of novel and biologically relevant items that promote the performance of species-typical behaviors (Meehan and Mench, 2007; Greco et al., 2016) and is considered standard practice in captive husbandry routines (Mellen and MacPhee, 2001; Shepherdson, 2003). Deciding on the appropriate enrichment to increase the likelihood of its subsequent success must be predicated on extensive knowledge of the target species’ natural history (Shepherdson, 2003).

Enrichment items aim to improve welfare by adding complexity to captive settings and creating outlets for captive animals to engage in species-typical behaviors and exert control over their environment (Shepherdson, 2003). Enrichment provides cognitive and physical challenges that are associated with improving the mental and physical fitness of the animals (Chamove, 1989; Newberry, 1995; Mellen and Mench, 2001; Shepherdson, 2003). The implementation of enrichment also serves to improve the public’s perception of zoos which directly affects the success of those institutions (Rees, 2009).

To promote the longevity of enrichment’s positive effects, it is suggested enrichment be introduced on a random schedule to reduce predictability and avoid habituation (Goodyear and Schulte, 2015). However, this can be difficult due to staff time availability (Newberry, 1995) and can be particularly difficult for elephant keepers as the enrichment items capable of withstanding the strength and physical abilities of elephants are very large and heavy thus they are difficult to move in and out of enclosures.
There are many different types of enrichment including feeding, olfactory, auditory, cognitive, play, tactile, and grooming; depending on the species, a variety of enrichment items can be used (Animal Enrichment, 2017). Feeding enrichment is one of the main routes taken when modifying a captive environment, as food acquisition and manipulation are much different when performed in wild settings. Food accession behaviors have been shaped by evolution but these behaviors may not be necessary in captivity and thus captive animals may find another outlet to express them (Fraser, 1989). Typically, in captivity food presentation can be highly predictable and the items are easily accessed and consumed with little to no manipulation (Newberry, 1993). This situation can result in short periods of time dedicated to foraging, leaving excess time spent inactive and possibly lending itself to the development of stereotypies (Rushen, 1984; Terlouw et al., 1991). Because locating and manipulating food items requires wild elephants to dedicate a large proportion of their day to foraging, captive feeding regimes typically do not exploit the full suite of elephant skills dedicated to aid in foraging (Wiedenmayer, 1998; Morimura and Ueno, 1999; Stoinski et al., 2000). Implementing enrichment that increases the amount of time spent dedicated to foraging (without overfeeding the elephants) will help parallel wild activity budgets and allow elephants to engage in species-typical behaviors (Greco et al., 2016).

Previous research has looked at the relationship between feeding frequency and behavior in captive elephants (Stoinski et al., 2000; Rees, 2009; Greco et al., 2016). Rees (2009) found a significant negative correlation between the occurrence of foraging behaviors and the performance of stereotypic behaviors in eight Asian elephants housed at the Chester Zoo (UK). Stoinski et al. (2000) found that an 11% increase in browse
added to the diet of three female elephants at Zoo Atlanta resulted in a significant increase in time spent foraging and a significant decrease in time spent inactive due to the need to manipulate the browse before consumption. That investigation incorporated three study periods: baseline 1, before feeding enrichment was introduced, the experimental phase, and baseline 2, where the feeding regime returned to the diet without the additional foraging enrichment. Although, the additional browse was not present during the second baseline, feeding time remained elevated. Time spent inactive also continued to be affected during the second baseline with times increasing from the experimental period but still being significantly lower than during the first baseline. These results suggest that feeding enrichment can continue to affect elephant behavior even after it is removed thus potentially having prolonged benefits.

IV. Personality/Individuality

Studies on human personalities have found relationships with the immune system (Solomon and Moos, 1964) and response to stress. Solomon and Moos (1964) reported a positive correlation between the personality traits perfectionism, self-sacrifice, and denial of hostility and the occurrence of rheumatoid arthritis, an autoimmune disease, in humans. In a study conducted on 579 adult German people, Gottschling et al. (2016) found a negative correlation between the personality trait neuroticism and the ability to overcome stressful situations; the study also found a positive correlation between extraversion and the ability to cope with stress. Similar correlations could be found in animals and future research should concentrate on the relationship between personality
and physiological responses in animals as this could have important management implications for captive animals.

The presence of individual personalities in animals has been obvious to anyone with considerable interaction with animals and has recently received considerable attention in the scientific community with a rise in research focused on finding testable hypotheses (Gosling, 1998; Gosling, 2001; Stamps and Groothuis, 2010; Horback et al., 2013; Pennisi, 2016). Thus far, distinct animal personalities have been linked to breeding condition (Wielebknowski, 1999), group cohesion (Pruitt and Riechert, 2011), and vulnerability to parasites (Spiegel et al., 2016). Wielebknowski (1999) studied 44 captive-born adult cheetahs and found a negative correlation between the personality trait “tense-fearful” and breeding success. Pruitt and Riechert (2011) discovered that a species of small, brown spider (*Anelosimus studiosus*) live in groups where different personality types dictate the spiders’ labor role within the group. When colonies were artificially created, they found that the group restored balance by altering the reproductive rates of the different personalities. Research on sleepy lizards discovered that those considered more docile typically had more ticks than those deemed more aggressive (Speigel et al., 2016).

Understanding individual personalities and taking personal histories into account has important implications for animal care staff; such assessments can help caretakers improve welfare and discern individual needs such as social compatibility among captive groups, levels of desirable animal-caretaker interaction, and an animal’s other mental and physical needs (Carlstead et al., 1999; Highfill, 2008; Tetley and O’Hara, 2012). Personality assessments have been conducted on both wild African elephants (Lee and
Moss, 2012) and captive African elephants (Horback et al., 2013). Lee and Moss (2012) used a principal-components analysis to discern individual personality traits in eleven adult females and suggested that the cohesion of these varying traits led to the success of this family group. Horback et al. (2013) had the keepers at the San Diego Zoo rate each of the twelve African elephants across a list of 25 adjectives; their assessments were then compared to observational data collected by the researchers. Horback et al. found consistency across the two methods proposing that personality trait rating by caretakers may aid in creating individualized care plans to ensure the well-being of each animal and may be assessing reliable underlying features of the animals.

Knowledge of personal histories and the continued assessment of individual personalities in captive elephants is crucial in evaluating the well-being of the animals. Rees (2009) documented considerable individual variation in stereotypic behavior among the eight Asian elephants housed at the Chester Zoo (UK) and suggested that the elephants’ differences in experiences of husbandry preceding their housing at the Chester Zoo could have had either a positive or negative influence on their subsequent behavior.

Knowing what factors influence an individual’s responses to life in captivity can potentially elucidate care plans that improve well-being. As enrichment aims to promote engagement in species-typical behaviors, research on an individual’s responses to different enrichment items will help zoo keepers create individualized plans that increase each elephant’s welfare. Although previous research has found little difference in activity budgets between the sexes in wild elephants (Shannon et al., 2008), males and females differ in their social lives and are housed differently in captivity, thus, it may be
relevant to look at how sex may potentially influence captive behavior in terms of engagement in stereotypy and reaction to enrichment.

V. Study Purpose

This study examined how increased feeding enrichment altered the behavior and activity budgets of the five adult and one subadult African elephants (two males, four females) housed at the North Carolina Zoo in Asheboro, NC. The project measured herd member responses to presentation of food in enrichment items as compared to food presented in easily accessed hay boxes. Baseline data were collected before feeding enrichment was introduced and were compared to data collected when feeding enrichment was utilized, as well as when enrichment items were present but food was not associated with enrichment items.

The research looked at the behavioral changes in the elephants as a group, between the sexes, and individually. The study focused on feeding behavior because, as explained before, wild elephants spend around 70% of their day foraging. Thus, the project specifically assessed feeding enrichment’s influence on the occurrence of inactivity, vacuum behaviors, and stereotypy. I predicted foraging, locomotion, interaction with non-feeding enrichment items, and abiotic interaction would be greatest when feeding enrichment was utilized. I predicted standing with trunk movement, standing without trunk movement (inactivity), and stereotypic behaviors (rocking, pacing and circling) would decrease when feeding enrichment was utilized. I predicted self-maintenance, drinking and social behaviors would remain constant as they are neutral behaviors that are present in wild elephants and are not affected by long foraging times. Based on
Stoinski et al.’s (2000) finding that feeding enrichment continued to affect the elephants’ behavior once it was removed, I also predicted the presence of feeding enrichment would continue to influence the elephants’ behavior even when they were not presented with food.
Chapter 2

METHODS

I. Study Site

The six African elephants housed at the North Carolina Zoo in Asheboro, North Carolina, reside in an indoor barn facility when they are receiving husbandry care, are being trained, or when temperatures drop below about 5° C. The barn enclosure consists of multiple indoor stalls as well as four 15.24 X 15.24 meter outdoor paddocks, each with a sand substrate. When temperatures permit, the elephants typically occupy their outdoor paddocks between 7:30 am and 12 pm, where they are fed while waiting to receive keeper care before moving to their exhibit habitat.

![Figure 1: Hang Man structure (pictured with cylindrical barrel).](image1)

![Figure 2: Cage feeder](image2)

Each paddock shares a wall with part of the barn. The rest of the paddock is enclosed by three “walls” of round metal bollards that are 4 meters tall and arranged 30
centimeters apart. Each paddock wall has two large metal mesh windows. A 6-meter-tall metal hoist, called a Hang Man (Figure 1), is present in each paddock and allows enrichment items to be suspended above the elephants.

Each male elephant has his own paddock equipped with a cage feeder (Figure 2) from which hay is dispensed. The females are separated into pairs between the other two paddocks, each equipped with two cage feeders. All cage feeders are 0.35 meter off the ground, 0.92-meter-tall, 0.61-meter-wide and 0.61 meter deep. These elevated cage feeders are attached to the bollards and are placed on the outside of the paddocks. Semi-permanent hanging enrichment items (described below) flank the paddocks along with large tires, 1.5 meter in diameter and 45 centimeters wide, that are rarely moved from the enclosures due to their size and weight.

II. Study Subjects

All elephants are unrelated except for mother/daughter pair Tonga and Batir. Tonga is the oldest female, at 39 years old; weighs 4,069 kg and is the only female with both tusks, with her left tusk being shorter than her right. Tonga has been at the NC Zoo since 2007 when she arrived from Riddle’s Elephant Sanctuary in Arkansas.

Batir is the youngest elephant at 15 years of age and the only captive born elephant in the group. She came with Tonga to the NC Zoo from Riddle’s Sanctuary in 2007. She is the smallest member of the herd, weighing 2,793 kg, and only her right tusk is visible. Batir and Tonga are always housed together when in their paddock.

Nekhunda is 29 years old and weighs roughly 3,175 kg (her weight is approximate because she has not been weighed recently). She has been at the NC Zoo
since 2007 when she was transferred from The Valley Zoo in Canada. Nekhunda has no visible tusks and only one distal trunk finger due to a previous accident at another facility.

Rafiki is 36 years old and weighs 4,518 kg. She came to the NC Zoo in 2003 from the Toledo Zoo. Rafiki’s left tusk is not visible and her right tusk is short and straight. Rafiki and Nekhunda are always housed together when in their paddock.

C’sar is the oldest herd member at 43 years of age and weighs 5,693 kg. He has been at the NC Zoo since he was transferred from the International Animal Exchange in Michigan in 1978. C’sar is blind, his left ear lies flat against his head due to an old injury and he has thick, even tusks. C’sar is always housed alone when in his paddock.

Artie is 38 years old and weighs 6,130 kg. He arrived at the NC Zoo in 2007 with Tonga and Batir from Riddle’s Elephant Sanctuary in Arkansas. Artie has no visible tusks and has several notches along the edges of the ears. Artie is always solitary when housed in his paddock.

Table 1: Description of each elephant’s birth year, relation to one another, physical description, and sex.

<table>
<thead>
<tr>
<th>Artie</th>
<th>C’sar</th>
<th>Rafiki</th>
<th>Nekhunda</th>
<th>Tonga</th>
<th>Batir</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relation</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Mother of Batir</td>
</tr>
<tr>
<td>Physical Features</td>
<td>No visible tusks. Several notches along edges of ears.</td>
<td>Left ear injured, lays flat against head. Thick, even tusks.</td>
<td>Left tusk not visible, right tusk is short and straight.</td>
<td>Smaller ears. No visible tusks. Second smallest in herd.</td>
<td>Left tusk is shorter than the right tusk.</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>Male</td>
<td>Female</td>
<td>Female</td>
<td>Female</td>
</tr>
</tbody>
</table>
III. Experimental Design

The study focused on decreasing stereotypic behaviors (see Table 2) by introducing feeding enrichment to the elephants’ husbandry routine when they were believed to perform the greatest amount of stereotypy. These behaviors have not been observed in wild elephants and may be suggestive of suboptimal welfare (Hughes and Duncan, 1988; Wilson et al., 2004; Mason and Latham, 2004).

Foraging and manipulating browse were two units of behavior this study focused on. Wild individuals must work to not only find their food but also to acquire food items and then manipulate them before consumption; these processes account for a significant amount of the time elephants spend foraging, typically 14-16 hours a day (Moss, 1982, 1988). Since African elephants have been found to cover distances between 5km and 10km per day (Theuerkauf and Ellenberg, 2000; Whitehouse and Schoeman, 2003; Leighty et al., 2009), this study also concentrated on locomotion as another important unit of behavior.

I categorized elephant behavior using an ethogram adapted from one developed by the North Carolina Zoo (Table 2). In order not to influence elephant behaviors, I collected data by viewing surveillance footage of the elephants recorded in their outdoor paddocks. Video recordings were watched on PowerVideoPlus. Observations were recorded in 15 minute focal samples with the focal individual selected at random (Altman, 1974). Each elephant was assigned a number from 1 to 6, from oldest to youngest, and at the beginning of each sample period, a random number generator (random.org) was used to select a number that corresponded with one of the elephants. If that elephant was unavailable, either due to keeper interaction or was not in its paddock,
another number was generated. All behaviors were recorded and timed to the exact second they were performed. Recordings of behaviors were collected between 7:30am and 12pm while the staff carried out their daily husbandry routines prior to the elephants being transferred to their exhibit habitat. This time period was selected because the elephants were believed to spend more time in anticipatory behaviors during this time period and because it was when they are typically in the paddocks to which enrichment items could be more easily added (Personal communication, Corinne Kendall, North Carolina Zoo).

Table 2. Description of observed elephant behaviors.

<table>
<thead>
<tr>
<th>Ethogram of African Elephant Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Behavior</strong></td>
</tr>
<tr>
<td>Mud bathing</td>
</tr>
<tr>
<td>Dust bathing</td>
</tr>
<tr>
<td>Water bathing</td>
</tr>
<tr>
<td>Rubbing/Scratching</td>
</tr>
<tr>
<td>Stand- with trunk movement</td>
</tr>
<tr>
<td>Forage- Manipulation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Forage- Consumption</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Pacing</td>
</tr>
<tr>
<td>Rocking</td>
</tr>
<tr>
<td>Other Repetitive Behavior</td>
</tr>
<tr>
<td>Circling</td>
</tr>
<tr>
<td>Locomotion</td>
</tr>
<tr>
<td>Interacting- Exhibit Structure</td>
</tr>
<tr>
<td>Interacting- Caging</td>
</tr>
<tr>
<td>Interaction with Non-Feeding Enrichment Items</td>
</tr>
<tr>
<td>Affiliative- Contact</td>
</tr>
<tr>
<td>Drinking</td>
</tr>
</tbody>
</table>

Behavioral observations were divided into three phases (table 3). The first phase was the baseline conditions where data were collected between June 22, 2016 and
September 9, 2016 to serve as a control and measure the elephants’ behaviors when food was presented according to the zoo’s husbandry protocol. During the baseline condition, hay was offered to the elephants in elevated cage feeders.

The second phase was the enrichment condition where observations were recorded between October 2, 2016 and April 15, 2017. During this period, additional enrichment items (described below) were introduced and used to present food. Ideally, enrichment items should be introduced and then removed shortly after to retain their novelty; however, because elephants are incredibly large and strong, the enrichment material used had to be durable enough to withstand the elephants’ strength, thus resulting in heavy and cumbersome items that were difficult to install and remove.

On days when enrichment browsers were not used to present food to the elephants, the keepers introduced hay as they previously had (during baseline period). Data collected during the period of heightened enrichment but when food was not associated with enrichment were considered the “experimental control.” These observations were collected from October 5, 2016 to April 17, 2017.

The study consisted of 20 sample periods recorded for each elephant during each of the three conditions, resulting in a total of 90 hours of behavioral observations.

Table 3. Dates and descriptions of the three conditions.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Baseline</th>
<th>Enrichment</th>
<th>Experimental Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dates</td>
<td>June 22-September 9, 2016</td>
<td>October 2, 2016-April 15, 2017</td>
<td>October 5, 2016-April 17, 2017</td>
</tr>
<tr>
<td>Description</td>
<td>Food items offered in elevated cage feeders</td>
<td>Food items offered in feeding enrichment.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(feeding enrichment not present).</td>
<td>(feeding enrichment present).</td>
<td></td>
</tr>
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<td></td>
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</tbody>
</table>
The initial intention involved utilizing enrichment on a random basis; however, due to the amount of time required to set up feeding enrichment, this was only able to be done on days when four or more elephant keepers were present. Based on the daily husbandry routine and individual elephant needs, the keepers decided which elephants were enriched while complying with my request for each elephant to receive 20 days of feeding enrichment.

Enrichment items served as hay browsers that made feeding more difficult. Enrichment browsers were stuffed with hay and browse on days when the elephant staff had enough time to dedicate to enrichment. Browse consisted of tree limbs with attached leaves collected by the elephant keepers in the wooded areas surrounding the zoo. The type of browse collected depended on season and availability and most typically include *Morella cerifera* (wax myrtle), *Liquidambar styraciflua* (sweet gum), *Liriodendron tulipifera* (tulip poplar), *Quercus phellos* (willow oak), Bambusoideae (bamboo), *Elaeagnus angustifolia* (Russian olive), *Arundo donax* (giant cane), *Acer saccharum* (sugar maple), *Platanus occidentalis* (American sycamore), and *Carya glabra* (pignut hickory), as well as *Fagus grandifolia* (American beech), *Quercus prinus* (chestnut oak), *Ulmus alata* (winged elm), *Pinus virginiana* (Virginia pine), *Pinus taeda* (loblolly pine), and *Pinus palustris* (longleaf pine).

Before every focal sample period, the temperature, percent humidity, barometric pressure, pre-24-hour rainfall measurement, day-length and conditions were recorded. These figures were obtained online from Weather Underground (www.wunderground.com) which posts updates every 20 minutes. Weather Underground categorized conditions as clear, scattered clouds, mostly cloudy, overcast,
light rain, rain, heavy rain, thunderstorm, light snow, and snow. On days when temperatures were 5°C or below and the elephants were not transferred to their outdoor paddocks or to the exhibit and they remained in the barn where heaters are present. Under those conditions, enrichment was not manipulated by this study and no data were collected.

IV. Feeding Enrichment

Enrichment items were either purchased for this study from Desert Plastics, constructed by the researcher out of donated fire hose, constructed by the elephant keepers at the NC Zoo, or were previously purchased items that were not in use (see Appendix II for dimensions of feeding enrichment items).

Firequip Co (Burlington, NC) donated 320 meters of fire hose and another 91 meters were donated by the Concord (NC) Fire Department. Feeding enrichment items were constructed following instructions provided by Hose2Habitat (http://www.hose2habitat.org/enrichment-instructions), a non-profit that teaches zoo employees to create enrichment items from recycled fire hose.

To hang the feeding enrichment from the Hang Man structures, tree climbing line rope with 3,629 kg tensile strength was purchased at Dell’s Army Navy Surplus store in Asheboro, NC. The rope was fed through the Hang Man pole and tied to an iron ring secured with duct tape. Link chain was fed through the circle ring and the enrichment item and then connected using a clevis (Figure 3). The enrichment items were suspended from the Hang Man structures to introduce both physical and cognitive challenges associated with procuring food items; the elephants had to figure out how to reach the
enrichment items which typically required stepping a foot on a bollard or standing on hind legs and reaching with the trunk.

I constructed twelve browsers in a repetitive box-knot design that were hung from the top horizontal bollard in each of the paddocks (Figure 4). Hay and browse were stuffed in the openings to increase the amount of work necessary to obtain food items and to limit the amount of hay the elephants could grab at one time.

The elephant keepers at the zoo constructed two other browsers which consisted of two tires connected by fire hose sections woven together. These browsers were then tied to climbing rope which was fed through the Hang Man pole and suspended over the elephants’ outdoor paddocks (Figure 5). Hay was put inside the browser to make obtaining the food items more difficult.

Two polyethylene cylindrical feeder tubes were ordered from Wildlife Toy Box-Desert Plastics, LLC. Peanuts were put into the cylinders and they were suspending over
the paddocks via each Hang Man (Figure 6) and the elephants had to manipulate the feeder tubes until the peanuts were knocked out.

An enrichment browser, called the Holey Moley, was also purchased from Wildlife Toy Box- Desert Plastics, LLC. The Holey Moley is a rectangular feeder made of polyethylene with fifty-eight holes. A wide opening was made at the top by connecting previous holes using a saw. This was done to make inserting flakes of hay more efficient. The Holey Moley was suspended in the paddock via the Hang Man (Figure 7).

A rope net holding a bale of hay was suspended in the paddock using the Hang Man. A scent ball was filled with approximately 20 peanuts and placed on top of the hay
in the net (Figure 8). Once the hay was consumed from the net, the olfactory stimulus of
the peanuts would promote continued foraging efforts. The scent ball would need to be
manipulated by the elephants for the peanuts to fall through the openings.

![Figure 7: Holey-Moley browser](image)

![Figure 8: Rope net with scent ball and hay](image)

V. *Statistical Analysis*

To test the effect of increased feeding enrichment on the elephants’ behavior as a
group, the absolute number of seconds all the elephants engaged in a behavior during
each of the three conditions (baseline, enrichment, experimental control) were combined.
Because the data were not normally distributed and could not be normalized using
transformations, a non-parametric test had to be used for analysis. Since one elephant’s
behavior does not obviously influence another’s, an Independent-Samples Jonkheere-
Terpstra Test for Ordered Alternatives (from now on referred to as a J-T test) was used to
test whether there was a statistical difference in behavior across the three conditions (baseline, enrichment, and experimental control) when all elephants’ data was combined. Furthermore, the J-T test detected whether the behaviors followed the predicted trend across the three conditions. Data were analyzed as absolute number of seconds engaged in each behavior.

The following behaviors are considered species-typical and were predicted to increase from baseline to experimental control to enrichment: foraging, locomotion, interaction with non-feeding enrichment items, and abiotic interaction.

Three categories of behaviors were predicted to decrease from baseline to experimental control to enrichment. These behaviors are either not normally seen in the wild or are seen at low frequencies. The first category was inactivity, and due to lack of contradictory information, was considered a neutral behavior. During my observations, “standing without trunk movement” was considered inactivity. The next category was vacuum behaviors, which are not necessarily stereotypies, but can eventually become stereotypies. The vacuum behavior recorded during this study was “standing with trunk movement”; although this behavior has not previously been recognized as a vacuum behavior, I believe it fits the definition. The third category was recognized stereotypies and these consisted of rocking, pacing and circling. All the elephants engaged in rocking, except for Batir, who only circled and paced. These behaviors were analyzed as stereotypy.

The following behaviors were expected to show no significant difference across the three conditions: self-maintenance, drinking and social. Self-maintenance behaviors consisted of dust-bathing, mud-bathing, water-bathing, and scratching; occurrences of
these behaviors were combined and analyzed as self-maintenance. Social behaviors included interacting physically with another elephant by touching or being touched with the trunk, or by touching or rubbing their bodies together; occurrences of these behaviors were combined and analyzed as social behaviors.

When each individual elephant’s behavior was analyzed, many variables were not able to be normalized, thus a Related-Samples Friedman’s Two-Way Analysis of Variance by Ranks was used to test for potential significant differences in behavior across the three conditions. For all behaviors that revealed a significant difference according to Friedman’s tests, multiple Wilcoxon Paired Sign-Rank Tests were given to show differences between the conditions. When analysis produced significant differences, pairwise comparisons between the conditions were reported. Data were analyzed as absolute number of seconds spent engaged in each behavior.

Due to the Central Limit Theorem, an ANOVA can be fairly forgiving regarding normality; thus, a Repeated Measures ANOVA was also used to analyze individual elephant behavior (Selvin, 2004). In cases where sphericity could not be assumed, the Greenhouse Geisser test statistic was reported. If results from the Friedman’s test and the ANOVA agreed, both results were reported; however, if they did not agree, only results from the Friedman’s test were reported.
RESULTS

I present the results in three ways. The first is for the elephants as a group, followed by differences based in the animals’ sex and finally on individual bases. At each level, I show which behaviors were influenced by the enrichment regime and those that did not change. In each case, I refer to a pie chart showing a given behavior’s contribution to the overall activity budget in each condition. Finally, I present box and whisker plots showing pairwise comparisons across the three conditions for behaviors that revealed a significant change. I predicted foraging, locomotion, interaction with non-feeding enrichment items, and abiotic interaction would increase during enrichment. I anticipated the frequencies of stereotypical behavior, standing with trunk movement, and standing with no trunk movement to be significantly decreased during enrichment. I predicted that these changes in behaviors would continue to be influenced during the experimental control. Finally, I projected that the occurrence of self-maintenance behaviors, drinking and social-behaviors would remain constant across all three conditions.

I. Analysis of Overall Elephant Behavior (Figure 9)

When all the elephants’ data were combined and analyzed, I found that the new feeding regime had a significant effect on foraging, stereotypical behavior, standing with trunk movement, standing with no trunk movement, locomotion, and self-maintenance behaviors. There was no change in interaction with non-feeding enrichment, abiotic
interaction, drinking, and social behaviors. The effect feeding enrichment had on the behaviors is summarized in table 4.

Table 4: The increase (↑) and decrease (↓) in the frequency of behaviors with significant differences across the three conditions for the herd (-) indicates there was no significant difference in the frequency of the behavior.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Foraging</td>
<td>↑</td>
</tr>
<tr>
<td>Stereotypy</td>
<td>↓</td>
</tr>
<tr>
<td>Standing with Trunk Movement</td>
<td>↓</td>
</tr>
<tr>
<td>Standing with No Trunk Movement</td>
<td>↓</td>
</tr>
<tr>
<td>Locomotion</td>
<td>↑</td>
</tr>
<tr>
<td>Self-Maintenance</td>
<td>↓</td>
</tr>
<tr>
<td>Interaction with Non-Feeding Enrichment Items</td>
<td>-</td>
</tr>
<tr>
<td>Abiotic Interaction</td>
<td>-</td>
</tr>
<tr>
<td>Drinking</td>
<td>-</td>
</tr>
<tr>
<td>Social Behaviors</td>
<td>-</td>
</tr>
</tbody>
</table>
a. Foraging

During baseline observations, the elephants as a group spent a mean of 382.24 sec foraging (S.D. = 289.453), the median was 370.50 (range = 0-900), and on average for 42.47% of the daily activity budget. During experimental control, they spent a mean of 443.43 sec foraging (S.D. = 284.740), the median was 453.00 (range = 0-900) and on average accounted for 49.27% of the daily activity budget. During enrichment, they spent a mean of 688.43 sec foraging (S.D. = 189.889), the median was 759.00 (range = 0-900) and on average accounted for 76.92% of the daily activity budget. I found there was a significant difference in amount of time spent foraging, with foraging time increasing from baseline to enrichment (J-T test, T = 30,326.500, Z = 8.120, N = 360, P = 0.000). A pairwise comparison revealed a significant difference in time spent foraging between the baseline and the enrichment and between the experimental control and the enrichment, but no significant difference in foraging between the baseline and the experimental control (Baseline-Experimental Control: P = 0.148, Baseline-Enrichment: P = 0.000, Experimental Control-Enrichment: P = 0.000) (Figure 10).

b. Stereotypical Behavior

During baseline observations, the herd spent a mean of 188.68 sec engaged in stereotypy (S.D. = 276.470), the median was .00 (range = 0-900), and on average accounted for 20.96% of the daily activity budget. During experimental control, they spent a mean of 185.85 sec engaged in stereotypy (S.D. = 265.208), the median was 3.50 (range = 0-900) and on average accounted for 20.65% of the daily activity budget. During enrichment, they spent a mean of 28.13 sec engaged in stereotypy (S.D. = 97.701), the median was .00 (range = 0-817) and on average accounted for 3.13% of the
daily activity budget. A significant difference in stereotypy was found between the three conditions, with time spent engaged in stereotypy decreasing from baseline to enrichment (J-T test, T = 17,094.000, Z = -4.782, N = 360, P = 0.000). Pairwise comparisons indicated significant differences in stereotypy between baseline and enrichment, and between experimental control and enrichment, but no significant difference between baseline and experimental control (Baseline-Experimental Control: P = 1.000, Baseline-Enrichment: P = 0.000, Experimental Control-Enrichment: P = 0.000) (Figure 11).

c. Standing with Trunk Movement

The elephants as a group spent a mean of 122.58 sec standing with trunk movement during baseline observations (S.D. = 141.506), the median was 78.50 (range = 0-711), and on average accounted for 13.62% of the daily activity budget. They spent a mean of 120.59 sec standing with trunk movement during experimental control (S.D. = 143.083), the median was 79.50 (range = 0-678) and on average accounted for 13.47% of the daily activity budget. They spent a mean of 37.17 sec standing with trunk movement during enrichment (S.D. = 65.907), the median was 5.50 (range = 0-344) and on average accounted for 4.13% of the daily activity budget. There was a significant difference in the amount of time spent standing with trunk movement between the three conditions, with standing with trunk movement decreasing from baseline to enrichment (J-T test, T = 15,187.500, Z = -6.043, N = 360, P = 0.000). Pairwise comparisons showed significant differences in standing with trunk movement between the baseline and the enrichment, and between the experimental control and the enrichment, but no significant difference between the baseline and the experimental control (Baseline-Experimental Control: P =
1.000, Baseline-Enrichment: P = 0.000, Experimental Control-Enrichment: P = 0.000) (Figure 12).

d. Standing with No Trunk Movement

The elephants as a group spent a mean of 53.53 sec standing with no trunk movement during baseline observations (S.D. = 116.027), the median was .00 (range = 0-642), and accounted for 5.95% of the daily activity budget. They spent a mean of 17.91 sec standing with no trunk movement during experimental control (S.D. = 50.167), the median was .00 (range = 0-311) and accounted for 1.99% of the daily activity budget. They spent a mean of 4.07 sec standing with no trunk movement during enrichment (S.D. = 20.269), the median was 0.00 (range = 0-145) and accounted for 0.452% of the daily activity budget. I found a significant difference in standing with no trunk movement between the three conditions, with time spent standing with no trunk movement decreasing from baseline to enrichment (J-T test, T = 1,318.000, Z = -6.517, N = 360, P = 0.000). Pairwise comparisons indicated significant differences between baseline and experimental control, between baseline and enrichment, and between experimental control and enrichment (Baseline-Experimental Control: P = 0.002, Baseline-Enrichment: P = 0.000, Experimental Control-Enrichment: P = 0.000) (Figure 13).

e. Locomotion

The elephants as a group spent a mean of 82.27 sec in locomotion during baseline observations (S.D. = 73.836), the median was 69.50 (range = 0-525), and on average accounted for 9.14% of the daily activity budget. They spent a mean of 80.69 sec in locomotion during experimental control (S.D. = 49.358), the median was 74.00 (range = 0-197) and on average accounted for 8.97% of the daily activity budget. They spent a
mean of 91.06 sec in locomotion during enrichment (S.D. = 56.422), the median was 85.00 (range = 0-318) and on average accounted for 10.12% of the daily activity budget. A significant difference in locomotion was found between the three conditions, with time spent in locomotion increasing from baseline to enrichment (J-T test, T = 23,748.000, Z = 1.998, N = 360, P = 0.046). However, pairwise comparisons showed no significant difference in locomotion between any of the three conditions (Baseline-Experimental Control: P = .698, Baseline-Enrichment: P = .098, Experimental Control-Enrichment: P = .233) (Figure 14).

f. Self-Maintenance Behaviors

During baseline observations, the herd spent a mean of 10.42 sec engaged in self-maintenance behaviors (S.D. = 29.725), the median was 0.00 (range = 0-214), and on average accounted for 1.16% of the daily activity budget. During experimental control, they spent a mean of 4.86 sec engaged in self-maintenance behaviors (S.D. = 25.151), the median was 0.00 (range = 0-162) and on average accounted for 0.54% of the daily activity budget. During enrichment, they spent a mean of 0.97 sec engaged in self-maintenance behaviors (S.D. = 4.077), the median was 0.00 (range = 0-33) and on average accounted for 0.108% of the daily activity budget. There was a significant difference in self-maintenance between the three conditions, with time spent engaged in self-maintenance behaviors decreasing from baseline to enrichment (J-T test, T = 18,845.500, Z = -4.033, N = 360, P = 0.000). Pairwise comparisons revealed significant differences between baseline and experimental control, and between baseline and enrichment, with no significant difference between experimental control and enrichment (Baseline-
Experimental Control: P = 0.002, Baseline-Enrichment: P = 0.000, Experimental Control-Enrichment: P = 0.912) (Figure 15).

g. Interaction with Non-Feeding Enrichment Items

During baseline observations, the elephants as a group spent a mean of 8.08 sec interacting with non-feeding enrichment (S.D. = 24.642), the median was 0.00 (range = 0-131), and accounted for 0.898% of the daily activity budget. During experimental control, they spent a mean of 2.88 sec interacting with non-feeding enrichment (S.D. = 7.491), the median was 0.00 (range = 0-44) and accounted for 0.32% of the daily activity budget. During enrichment, they spent a mean of 10.72 sec interacting with non-feeding enrichment (S.D. = 66.362), the median was 0.00 (range = 0-635) and accounted for 1.19% of the daily activity budget. There was no significant difference in time spent interacting with non-feeding enrichment between the three conditions (J-T test, T = 21,098.500, Z = -0.724, N = 360, P = 0.469).

h. Abiotic Interaction

The herd spent a mean of 14.43 sec engaged in abiotic interaction during baseline observations (S.D. = 35.485), the median was 0.00 (range = 0-175), and accounted for 1.6% of the daily activity budget. They spent a mean of 32.63 sec engaged in abiotic interaction during experimental control (S.D. = 66.542), the median was 4.00 (range = 0-474) and accounted for 0.11% of the daily activity budget. They spent a mean of 8.48 sec engaged in abiotic interaction during enrichment (S.D. = 16.236), the median was 0.00 (range = 0-88) and accounted for 0.942% of the daily activity budget. I found no significant difference in time spent interacting with abiotic items between the three conditions (J-T test, T = 21,971.000, Z = -0.401, N = 360, P = 0.689).
i. **Drinking**

During baseline observations, the elephants as a group spent a mean of 11.03 sec drinking (S.D. = 36.771), the median was 0.00 (range = 0-263), and accounted for 1.23% of the daily activity budget. During experimental control, they spent a mean of 9.53 sec drinking (S.D. = 34.847), the median was 0.00 (range = 0-223) and accounted for 1.06% of the daily activity budget. During enrichment, they spent a mean of 20.46 sec drinking (S.D. = 61.858), the median was 0.00 (range = 0-413) and accounted for 2.27% of the daily activity budget. There was no significant difference in drinking across the three conditions (J-T test, T = 22,272.500, Z = .999, N = 360, P = 0.318).

j. **Social Behaviors**

The spent a mean of 4.14 sec engaging in social behaviors during baseline observations (S.D. = 21.490), the median was 0.00 (range = 0-216), and accounted for 0.46% of the daily activity budget. They spent a mean of 0.60 sec engaging in social behaviors during experimental control (S.D. = 2.690), the median was 0.00 (range = 0-15) and accounted for 0.066% of the daily activity budget. They spent a mean of 1.17 sec engaging in social behaviors during enrichment (S.D. = 4.832), the median was 0.00 (range = 0-34) and accounted for 0.13% of the daily activity budget. There was no significant difference in time engaged in social behaviors across the three conditions (J-T test, T = 21,529.500, Z = -.137, N = 360, P = 0.891).
Figure 9: An activity budget showing the average amount of time dedicated to each behavior displayed by the herd during baseline, experimental control, and enrichment observations.
Figure 10: The effect of feeding enrichment on the frequency of foraging behavior of the six elephants (Jonckheere-Terpstra Test, $T = 30,326.500$, $Z = 8.120$, $N = 360$, $P = .000$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).

Figure 11: The effect of feeding enrichment on the frequency of stereotypical behavior of the six elephants (Jonckheere-Terpstra Test, $T = 17,094.000$, $Z = -4.782$, $N = 360$, $P = .000$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).
Figure 12: The effect of feeding enrichment on the frequency of standing with trunk movement of the six elephants (Jonckheere-Terpstra Test, $T = 15,187.500, Z = -6.043, N = 360, P = .000$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).

Figure 13: The effect of feeding enrichment on the frequency of standing with no trunk movement of the six elephants (Jonckheere-Terpstra Test, $T = 1,318.000, Z = -6.517, N = 360, P = .000$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).
Figure 14: The effect of feeding enrichment on the frequency of locomotion of the six elephants (Jonckheere-Terpstra Test, $T = 23,748.000$, $Z = 1.998$, $N = 360$, $P = .046$). There were no significant differences between any of the three conditions. (Asterisks and circles represent extreme outliers in the data).

Figure 15: The effect of feeding enrichment on the frequency of self-maintenance behaviors of the six elephants (Jonckheere-Terpstra Test, $T = 18,845.500$, $Z = -4.033$, $N = 360$, $P = .000$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data.)
Based on the findings of Shannon et al. (2008), I did not expect the sexes to differ in their behavioral responses to feeding enrichment and predictions followed those for the herd; however, analyses across the three conditions revealed differences in the sexes’ reactions (Table 5).

Table 5: The increase (↑) and decrease (↓) in the frequency of behaviors with significant differences across the three conditions for each sex. (-) indicates there was no significant difference in the frequency of the behavior.

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<tr>
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<th>Males</th>
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<td>Social Behaviors</td>
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</tr>
</tbody>
</table>
a. Foraging

i. Males

During baseline observations, the males as a group spent a mean of 346.23 sec foraging (S.D. = 336.186), the median was 299.00 (range = 0-900), and accounted for 38.47% of the daily activity budget. During experimental control, the males as a group spent a mean of 304.03 sec foraging (S.D. = 309.217), the median was 245.00 (range = 0-900) and accounted for 33.78% of the daily activity budget. During enrichment, the males as a group spent a mean of 745.60 sec foraging (S.D. = 161.241), the median was 793.00 (range = 228-900) and accounted for 82.84% of the daily activity budget. A significant difference in their foraging behavior across the three conditions was found (J-T test, T = 3,388.500, Z = 4.775, N = 120, P = 0.000). The J-T test confirmed the prediction that foraging behavior increased from baseline to enrichment. Pairwise comparisons revealed significant differences between baseline and enrichment, and between experimental control and enrichment, but the baseline and experimental control were statistically similar (Baseline-Experimental Control: P = 0.836, Baseline-Enrichment: P = 0.000, Experimental Control-Enrichment: P = 0.000) (Figure 18).

ii. Females

The females as a group spent a mean of 400.25 sec foraging during baseline observations (S.D. = 263.486), the median was 390.00 (range = 0-900), and on average accounted for 44.47% of the daily activity budget. During experimental control, they spent a mean of 513.10 sec foraging (S.D. = 245.298), the median was 576.50 (range = 0-900) and on average accounted for 57.01% of the daily activity budget. During enrichment, they spent a mean of 659.84 sec foraging (S.D. = 197.477), the median was
726.50 (range = 0-900) and on average accounted for 73.31% of the daily activity budget. I found a significant difference in their foraging between the three conditions (J-T test, \( T = 13,406.500, Z = 6.500, N = 240, P = 0.000 \)). The J-T test confirmed the prediction that foraging would increase from baseline to enrichment. Pairwise comparisons revealed significant differences between baseline and experimental control, between baseline and enrichment, and between experimental control and enrichment (Baseline-Experimental Control: \( P = 0.008 \), Baseline-Enrichment: \( P = .000 \), Experimental Control-Enrichment: \( P = 0.000 \)) (Figure 19).

\( b. \, \textit{Stereotypical Behavior} \)

\( i. \, \textit{Males} \)

During baseline observations, the males as a group spent a mean of 290.58 sec engaging in stereotypy (S.D. = 331.535), the median was 155.50 (range = 0-900), and accounted for 32.29% of the daily activity budget. During experimental control, the males as a group spent a mean of 286.13 sec engaging in stereotypy (S.D. = 310.137), the median was 210.50 (range = 0-900) and accounted for 31.79% of the daily activity budget. During enrichment, the males as a group spent a mean of 26.08 sec engaging in stereotypy (S.D. = 71.379), the median was 0.00 (range = 0-375) and accounted for 2.89% of the daily activity budget. A significant difference in stereotypy was found between the three conditions (J-T test, \( T = 1,627.000, Z =-4.081, N = 120, P = 0.000 \)). The J-T test confirmed the prediction that stereotypy would decrease from baseline to enrichment. Pairwise comparisons revealed significant differences between baseline and enrichment, and between experimental control and enrichment, but baseline and experimental control were statistically similar (Baseline-Experimental Control: \( P = \)
1.000, Baseline-Enrichment: P = 0.000, Experimental Control-Enrichment: P = 0.000) (Figure 20).

ii. Females

The females as a group spent a mean of 137.73 sec engaging in stereotypy during baseline observations (S.D. = 230.194), the median was .00 (range = 0-871), and accounted for 15.3% of the daily activity budget. During experimental control, they spent a mean of 135.71 sec engaging in stereotypy (S.D. = 225.449), the median was .00 (range = 0-805) and accounted for 15.08% of the daily activity budget. During enrichment, they spent a mean of 29.16 sec engaging in stereotypy (S.D. = 108.904), the median was .00 (range = 0-817) and accounted for 3.24% of the daily activity budget. A significant difference in stereotypy was found between the three conditions (J-T test, T = 8,125.500, Z = -2.946, N = 240, P = 0.003). The J-T test supported the prediction that stereotypy would decrease from baseline to enrichment. Pairwise comparisons displayed significant differences between baseline and enrichment, and between experimental control and enrichment, with baseline and experimental control being statistically similar (Baseline-Experimental Control: P = 1.000, Baseline-Enrichment: P = 0.004, Experimental Control-Enrichment: P = 0.001) (Figure 21).

c. Standing with Trunk Movement

i. Males

The males as a group spent a mean of 108.33 sec standing with trunk movement during baseline observations (S.D. = 145.041), the median was 49.00 (range = 0-704), and accounted for 12.04% of the daily activity budget. They spent a mean of 145.08 sec standing with trunk movement during experimental control (S.D. = 157.189), the median
was 89.50 (range = 0-678) and accounted for 16.12% of the daily activity budget. They spent a mean of 20.03 sec standing with trunk movement during enrichment (S.D. = 28.073), the median was 2.00 (range = 0-118) and accounted for 2.22% of the daily activity budget. There was a significant difference in standing with trunk movement across the three conditions (J-T test, T = 1,737.000, Z = -3.243, N = 120, P = 0.000). The J-T test confirmed the prediction that standing with trunk movement would decrease from baseline to enrichment. Pairwise comparisons revealed significant differences between baseline and enrichment, and between experimental control and enrichment, but that baseline and experimental control were statistically similar (Baseline-Experimental Control: P = 0.207, Baseline-Enrichment: P = 0.002, Experimental Control-Enrichment: P = 0.000) (Figure 22).

ii. Females

During baseline observations, the females as a group spent a mean of 129.71 sec standing with trunk movement (S.D. = 140.083), the median was 91.50 (range = 0-711), and on average accounted for 14.41% of the daily activity budget. During experimental control, they spent a mean of 108.35 sec standing with trunk movement (S.D. = 134.853), the median was 79.50 (range = 0-674) and on average accounted for 12.04% of the daily activity budget. During enrichment, they spent a mean of 45.74 sec foraging (S.D. = 77.012), the median was 7.00 (range = 0-900) and on average accounted for 5.08% of the daily activity budget. A significant difference in standing with trunk movement was found between the three conditions (J-T test, T = 6,714.000, Z = -4.988, N = 240, P = 0.000). The J-T test confirmed the prediction that standing with trunk movement would decrease from baseline to enrichment. Pairwise comparisons revealed significant
differences between baseline and enrichment, and between experimental control and enrichment, with baseline and experimental control being statistically similar (Baseline-Experimental Control: $P = 0.625$, Baseline-Enrichment: $P = 0.000$, Experimental Control-Enrichment: $P = 0.000$) (Figure 23).

d. Standing with No Trunk Movement

i. Males

During baseline observations, the males as a group spent a mean of 56.20 sec standing with no trunk movement (S.D. = 132.212), the median was 0.00 (range = 0-642), and accounted for 6.24% of the daily activity budget. During experimental control, they spent a mean of 25.05 sec standing with no trunk movement (S.D. = 44.982), the median was 0.00 (range = 0-190) and accounted for 2.78% of the daily activity budget. During enrichment, they spent a mean of 4.70 sec standing with no trunk movement (S.D. = 23.577), the median was 0.00 (range = 0-145) and accounted for 0.522% of the daily activity budget. I found a significant difference in standing with no trunk movement between the three conditions (J-T test, $T = 1.946.000$, $Z = -2.812$, $N = 120$, $P = 0.005$). The J-T test confirmed the prediction that time engaged in standing with no trunk movement would decrease from baseline to enrichment. Pairwise comparisons indicated significant differences between baseline and enrichment, and between experimental control and enrichment, with baseline and experimental control being statistically similar (Baseline-Experimental Control: $P = 1.000$, Baseline-Enrichment: $P = 0.006$, Experimental Control-Enrichment: $P = 0.001$) (Figure 24).

ii. Females
The females spent a mean of 52.19 sec standing with no trunk movement during baseline observations (S.D. = 107.907), the median was 0.00 (range = 0-625), and accounted for 5.8% of the daily activity budget. During experimental control, they spent a mean of 14.34 sec standing with no trunk movement (S.D. = 52.473), the median was 0.00 (range = 0-311) and accounted for 1.59% of the daily activity budget. During enrichment, they spent a mean of 3.75 sec standing with no trunk movement (S.D. = 18.550), the median was 0.00 (range = 0-138) and accounted for 0.42% of the daily activity budget. A significant difference in standing with no trunk movement was found between the three conditions (J-T test, $T = 6.971.500$, $Z = -6.057$, $N = 240$, $P = 0.000$). The J-T test supported the prediction that standing with no trunk movement would decrease from baseline to enrichment. Pairwise comparisons found significant differences between baseline and experimental control, between baseline and enrichment and between experimental control and enrichment (Baseline-Experimental Control: $P = 0.000$, Baseline-Enrichment: $P = 0.000$, Experimental Control-Enrichment: $P = 0.044$). (Figure 25).

e. Locomotion

i. Males

The males as a group spent a mean of 61.78 sec in locomotion during baseline observations (S.D. = 96.804), the median was 33.50 (range = 0-525), and accounted for 6.86% of the daily activity budget. They spent a mean of 71.08 sec in locomotion during experimental control (S.D. = 50.040), the median was 62.50 (range = 0-193) and accounted for 7.89% of the daily activity budget. They spent a mean of 81.10 sec in locomotion during enrichment (S.D. = 74.657), the median was 71.50 (range = 0-318)
and accounted for 9.01% of the daily activity budget. There was a significant difference in locomotion between the three conditions (J-T test, $T = 2,892.000, Z = 2.373, N = 120, P = 0.018$). The J-T test confirmed the prediction that locomotion would increase from baseline to enrichment. Pairwise comparisons showed significant differences between baseline and experimental control, between baseline and enrichment, and between experimental control and enrichment (Baseline-Experimental Control: $P = 0.032$, Baseline-Enrichment: $P = 0.032$, Experimental Control-Enrichment: $P = 0.000$) (Figure 26).

**ii. Females**

The females spent a mean of 92.51 sec in locomotion during baseline observations (S.D. = 57.158), the median was 91.00 (range = 0-245), and accounted for 10.27% of the daily activity budget. During experimental control, the females spent a mean of 85.50 sec in locomotion (S.D. = 48.615), the median was 76.00 (range = 0-197) and accounted for 9.5% of the daily activity budget. During enrichment, the females spent a mean of 96.04 sec in locomotion (S.D. = 44.366), the median was 91.50 (range = 11-217) and accounted for 10.67% of the daily activity budget. No significant difference was found between the three conditions for locomotion (J-T test, $T = 10,046.000, Z = 0.762, N = 240, P = 0.446$).

**f. Self-Maintenance Behaviors**

**i. Males**

The males as a group spent a mean of 5.75 sec engaging in self-maintenance behaviors during baseline observations (S.D. = 20.237), the median was 0.00 (range = 0-112), and accounted for 0.619% of the daily activity budget. During experimental
control, they spent a mean of 1.15 sec engaging in self-maintenance behaviors (S.D. = 5.805), the median was 0.00 (range = 0-30) and accounted for 0.127% of the daily activity budget. During enrichment, they spent a mean of .73 sec engaging in self-maintenance behaviors (S.D. = 2.331), the median was 0.00 (range = 0-3) and accounted for 0.08% of the daily activity budget. No significant difference was found between the three conditions for self-maintenance behaviors (J-T test, T = 2,343.000, Z = -.528, N = 120, P = 0.598).

\[ ii. \quad \textit{Females} \]

During baseline observations, the females as a group spent a mean of 12.75 sec engaging in self-maintenance behaviors (S.D. = 33.350), the median was 0.00 (range = 0-214), and accounted for 1.42% of the daily activity budget. During experimental control, they spent a mean of 6.71 sec engaging in self-maintenance behaviors (S.D. = 30.496), the median was 0.00 (range = 0-162) and accounted for 0.75% of the daily activity budget. During enrichment, they spent a mean of 1.09 sec engaging in self-maintenance behaviors (S.D. = 4.723), the median was 0.00 (range = 0-33) and accounted for 0.19% of the daily activity budget. A significant difference in self-maintenance was found between the three conditions (J-T test, T = 7,884.000, Z = -4.305, N = 240, P = 0.000). The J-T test found that self-maintenance behaviors decreased from baseline to enrichment. Pairwise comparisons revealed significant differences between baseline and experimental control, and between baseline and enrichment, with experimental control and enrichment being statistically similar (Baseline-Experimental Control: P = 0.002, Baseline-Enrichment: P = 0.000, Experimental Control-Enrichment: P = 0.608). (Figure 27).
g. Interaction with Non-Feeding Enrichment Items

i. Males

The males as a group spent a mean of 5.63 sec interacting with non-feeding enrichment during baseline observations (S.D. = 18.127), the median was 0.00 (range = 0-72), and accounted for 0.626% of the daily activity budget. During experimental control, they spent a mean of 1.15 sec interacting with non-feeding enrichment (S.D. = 3.393), the median was 0.00 (range = 0-16) and accounted for 0.128% of the daily activity budget. During enrichment, they spent a mean of 1.33 sec interacting with non-feeding enrichment (S.D. = 4.434), the median was 0.00 (range = 0-22) and accounted for 0.148% of the daily activity budget. There was no significant difference for interaction with non-feeding enrichment items between the three conditions (J-T test, T = 2,386.000, Z = -.125, N = 120, P = 0.900).

ii. Females

During baseline observations, the females as a group spent a mean of 9.31 sec interacting with non-feeding enrichment (S.D. = 27.347), the median was 0.00 (range = 0-131), and accounted for 1.03% of the daily activity budget. During experimental control, they spent a mean of 3.74 sec interacting with non-feeding enrichment (S.D. = 8.751), the median was 0.00 (range = 0-44) and accounted for 0.39% of the daily activity budget. During enrichment, they spent a mean of 15.41 sec interacting with non-feeding enrichment (S.D. = 80.975), the median was 0.00 (range = 0-635) and accounted for 1.71% of the daily activity budget. I found no significant difference interaction with non-feeding enrichment items between the three condition (J-T test, T = 9,303.000, Z = -.739, N = 240, P = 0.460).
h. Abiotic Interaction

i. Males

During baseline observations, the males as a group spent a mean of 18.40 sec engaging in abiotic interaction (S.D. = 34.475), the median was 0.00 (range = 0-137), and accounted for 2.04% of the daily activity budget. During experimental control, they spent a mean of 63.15 sec engaging in abiotic interaction (S.D. = 98.350), the median was 15.50 (range = 0-474) and accounted for 7.02% of the daily activity budget. During enrichment, they spent a mean of 3.63 sec engaging in abiotic interaction (S.D. = 8.028), the median was 0.00 (range = 0-33) and accounted for 0.43% of the daily activity budget. I found no significant difference in abiotic interaction between the three conditions (J-T test, T = 2,075.500, Z = -1.747, N = 120, P = 0.081).

ii. Females

During baseline observations, the females as a group spent a mean of 12.44 sec engaging in abiotic interaction (S.D. = 36.027), the median was 0.00 (range = 0-175), and accounted for 1.38% of the daily activity budget. During experimental control, the females spent a mean of 17.36 sec engaging in abiotic interaction (S.D. = 34.452), the median was 0.00 (range = 0-264) and accounted for 1.93% of the daily activity budget. During enrichment, the females spent a mean of 10.91 sec engaging in abiotic interaction (S.D. = 18.637), the median was 0.00 (range = 0-88) and accounted for 1.21% of the daily activity budget. I found a significant difference in abiotic interaction between the three conditions (J-T test, T = 10,575.000, Z = -1.747, N = 240, P = 0.048). The J-T test supported the prediction that abiotic interaction would decrease from baseline to enrichment. Pairwise comparisons revealed significant differences between baseline and
experimental control, and between baseline and enrichment, but no significant difference
between experimental control and enrichment (Baseline-Experimental Control: \( P = 0.002 \), Baseline-Enrichment: \( P = 0.029 \), Experimental Control-Enrichment: \( P = 0.351 \)).
(Figure 28).

\( i. \) Drinking

\( i. \) Males

The males spent a mean of 3.33 sec drinking during baseline observations (S.D. = 21.029), the median was .00 (range = 0-133), and accounted for 0.369% of the daily activity budget. During experimental control, they spent a mean of 1.43 sec drinking (S.D. = 6.316), the median was .00 (range = 0-31) and accounted for 0.158% of the daily activity budget. During enrichment, they spent a mean of 2.15 sec drinking (S.D. = 11.542), the median was .00 (range = 0-72) and accounted for 0.239% of the daily activity budget. There was no significant difference for drinking across the three conditions (J-T test, \( T = 2.438.000 \), \( Z = .529 \), \( N = 120 \), \( P = 0.597 \)).

\( ii. \) Females

The females as a group spent a mean of 14.89 sec drinking during baseline observations (S.D. = 42.110), the median was 0.00 (range = 0-263), and accounted for 1.65% of the daily activity budget. During experimental control, the females spent a mean of 13.58 sec drinking (S.D. = 41.948), the median was 0.00 (range = 0-223) and accounted for 1.51% of the daily activity budget. During enrichment, the females spent a mean of 29.61 sec drinking (S.D. = 73.780), the median was 0.00 (range = 0-413) and on average accounted for 3.29% of the daily activity budget. There was no significant
difference in drinking between the three conditions (J-T test, $T = 10,005.500$, $Z = 0.976$, $N = 240$, $P = 0.329$).

j. Social Behaviors

i. Males

During baseline observations, the males as a group spent a mean of 5.40 sec engaging in social behaviors (S.D. = 34.153), the median was 0.00 (range = 0-216), and accounted for 0.6% of the daily activity budget. No social behaviors were recorded during experimental control nor during enrichment. I found no significant difference in social behaviors between the three conditions (J-T test, $T = 2,360.000$, $Z = -1.225$, $N = 120$, $P = 0.221$).

ii. Females

During baseline observations, the females as a group spent a mean of 3.51 sec engaging in social behaviors (S.D. = 10.892), the median was 0.00 (range = 0-54), and on average accounted for 0.397% of the daily activity budget. During experimental control, the females spent a mean of 0.90 sec engaging in social behaviors (S.D. = 3.259), the median was 0.00 (range = 0-15) and on average accounted for 0.1% of the daily activity budget. During enrichment, the females spent a mean of 1.75 sec engaging in social behaviors (S.D. = 5.843), the median was 0.00 (range = 0-34) and accounted for 0.19% of the daily activity budget. I found no significant difference in social behaviors between the three conditions (J-T test, $T = 9,618.500$, $Z = 0.056$, $N = 240$, $P = 0.955$).
Figure 16: An activity budget showing the average amount of time dedicated to each behavior displayed by the males during baseline, experimental control, and enrichment observations.

Figure 17: An activity budget showing the average amount of time dedicated to each behavior displayed by the females during baseline, experimental control, and enrichment observations.
Figure 18: The effect of feeding enrichment on the frequency of foraging behavior of the male elephants (Jonckheere-Terpstra Test, $T = 3,388.500$, $Z = 4.775$, $N = 120$, $P = .000$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).

Figure 19: The effect of feeding enrichment on the frequency of foraging behavior of the female elephants (Jonckheere-Terpstra Test, $T = 13,406.500$, $Z = 6.500$, $N = 240$, $P = .000$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).
Figure 20: The effect of feeding enrichment on the frequency of stereotypical behavior of the male elephants (Jonckheere-Terpstra Test, $T = 1,627.000, Z = -4.081, N = 120, P = .000$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).

Figure 21: The effect of feeding enrichment on the frequency of stereotypical behavior of the female elephants (Jonckheere-Terpstra Test, $T = 8,125.500, Z = -2.946, N = 240, P = .003$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).
Figure 22: The effect of feeding enrichment on the frequency of standing with trunk movement of the male elephants (Jonckheere-Terpstra Test, $T = 1,737.000$, $Z = -3.243$, $N = 120$, $P = .000$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).

Figure 23: The effect of feeding enrichment on the frequency of standing with trunk movement of the female elephants (Jonckheere-Terpstra Test, $T = 13,406.500$, $Z = 6.500$, $N = 240$, $P = .000$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).
Figure 24: The effect of feeding enrichment on the frequency of standing with no trunk movement of the male elephants (Jonckheere-Terpstra Test, $T = 1,946.000$, $Z = -2.812$, $N = 120$, $P = .005$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).

Figure 25: Box and whisker plot of the effect of feeding enrichment on the frequency of standing with no trunk movement of the female elephants (Jonckheere-Terpstra Test, $T = 6,971.500$, $Z = -6.057$, $N = 240$, $P = .000$)
Figure 26: The effect of feeding enrichment on the frequency of locomotion of the male elephants (Jonckheere-Terpstra Test, $T = 2,892.000$, $Z = 2.373$, $N = 120$, $P = .018$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).
Figure 27: The effect of feeding enrichment on the frequency of self-maintenance behaviors of the female elephants (Jonckheere-Terpstra Test, $T = 7,884.000$, $Z = -4.305$, $N = 240$, $P = .000$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).

Figure 28: The effect of feeding enrichment on the frequency of abiotic interaction of the female elephants (Jonckheere-Terpstra Test, $T = 10,575.000$, $Z = 1.977$, $N = 240$, $P = .048$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).
III. Analysis of Individuals

I had no prediction on the potential variation in behavioral responses between the individuals. Analyses of the individual’s behaviors across the three conditions showed variations in the elephants’ responses to the feeding enrichment (Table 6).

Table 6: The increase (↑) and decrease (↓) in the frequency of behaviors with significant differences across the three conditions for each elephant. (-) indicates there was no significant difference in the frequency of the behavior.

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a. *C’sar (Figure 29)*

i. Foraging

During baseline observations, *C’sar* spent a mean of 374.60 sec foraging (S.D. = 335.154), the median was 332.00 (range = 0-900). During experimental control, he spent a mean of 347.80 sec foraging (S.D. = 301.459), the median was 359.50 (range = 0-900). During enrichment, he spent a mean of 714.30 sec foraging (S.D. = 182.393), the median was 772.50 (range = 0-900). *C’sar* displayed a significant difference in his foraging between the three conditions (Friedman’s, F = 10.101, df = 2, N = 20, P = 0.006; ANOVA, F = 9.981, df = 2, 38, P = .000). Wilcoxon’s pairwise comparison found a significant difference between experimental control and enrichment, but not with baseline and experimental control or baseline and enrichment (Baseline-Experimental Control: P = 1.000, Baseline-Enrichment: P = 0.098, Experimental Control-Enrichment: P = 0.006) (Figure 30).

ii. Stereotypical Behavior

During baseline observations, *C’sar* spent a mean of 199.30 sec engaging in stereotypy (S.D. = 313.765), the median was .00 (range = 0-900). During experimental control, he spent a mean of 226.35 sec engaging in stereotypy (S.D. = 287.691), the median was 56.50 (range = 0-830). During enrichment, he spent a mean of 27.55 sec engaging in stereotypy (S.D. = 57.553), the median was .00 (range = 0-177). A significant difference in stereotypy was found between the three conditions (Friedman’s, F = 6.255, df = 2, N = 20, P = 0.044; ANOVA, F = 4.376, df = 2, 38, P = 0.019). However, Wilcoxon’s pairwise comparisons revealed no significant difference between baseline and experimental control, between baseline and enrichment, or between
experimental control and enrichment (Baseline-Experimental Control: $P = 1.000$, Baseline-Enrichment: $P = 0.707$, Experimental Control-Enrichment: $P = 0.173$) (Figure 31).

iii. Standing with Trunk Movement

C’sar spent a mean of 148.30 sec standing with trunk movement during baseline observations (S.D. = 167.274), the median was 129.50 (range = 0-704). During experimental control, he spent a mean of 140.25 sec standing with trunk movement (S.D. = 163.937), the median was 89.50 (range = 0-678). During enrichment, he spent a mean of 15.45 sec standing with trunk movement (S.D. = 18.597), the median was 772.50 (range = 0-58). A significant difference in standing with trunk movement was found between the three conditions (Friedman’s, $F = 12.658$, df = 2, N = 20, $P = 0.002$; Greenhouse-Geisser, $F = 5.576$, df = 1.491, 28.326, $P = 0.015$). Wilcoxon’s pairwise comparisons revealed significant differences between baseline and enrichment, and between experimental control and enrichment, but not with baseline and experimental control (Baseline-Experimental Control: $P = 1.000$, Baseline-Enrichment: $P = 0.022$, Experimental Control-Enrichment: $P = 0.004$) (Figure 32).

iv. Standing with No Trunk Movement

C’sar spent a mean of 77.95 sec standing with no trunk movement during baseline observations (S.D. = 166.595), the median was .00 (range = 0-642). During experimental control, he spent a mean of 44.80 sec standing with no trunk movement (S.D. = 56.767), the median was 24.50 (range = 0-190). During enrichment, he spent a mean of 9.40 sec standing with no trunk movement (S.D. = 33.083), the median was .00 (range = 0-145). I found no significant difference standing with no trunk movement between the three
conditions (Friedman’s, F = 4.654, df = 2, N = 20, P = 0.098; Greenhouse-Geisser, F = 2.262, df = 1.266, 24.045, P = 0.141).

v. Locomotion

C’sar spent a mean of 81.45 sec in locomotion during baseline observations (S.D. = 128.795), the median was 43.50 (range = 0-525). During experimental control, he spent a mean of 378.70 sec in locomotion (S.D. = 54.533), the median was 75.00 (range = 0-193). During enrichment, he spent a mean of 108.000 sec in locomotion (S.D. = 93.199), the median was 95.50 (range = 0-318). No significant difference was found between the three conditions for locomotion (Friedman’s, F = 1.333, df = 2, N = 20, P = 0.513; Greenhouse-Geisser, F = .498, df = 1.384, 26.293, P = 0.546).

vi. Self-Maintenance Behaviors

During baseline observations, C’sar spent a mean of 4.85 sec engaging in self-maintenance behaviors (S.D. = 14.214), the median was 0.00 (range = 0-60). During experimental control, C’sar was not recorded engaging in self-maintenance behaviors. During enrichment, he spent a mean of 1.45 sec in engaging in self-maintenance behaviors (S.D. = 3.170), the median was 95.50 (range = 0-10). There was no significant difference in self-maintenance behaviors between the three conditions (Friedman’s, F = 3.895, df = 2, N = 20, P = 0.143; Greenhouse-Geisser, F = 1.789, df = 1.075, 20.427, P = 0.196).

vii. Interaction with Non-Feeding Enrichment Items

Throughout baseline and experimental control observations, C’sar was not recorded interacting with non-feeding enrichment. During enrichment, he spent a mean of 2.65 sec interacting with non-feeding enrichment (S.D. = 6.055), the median was 0.00 (range = 0-
22). Interaction with non-feeding enrichment items was significantly different between the three conditions (Friedman’s, $F = 8.000$, df = 2, $N = 20$, $P = 0.018$). However, Wilcoxon’s pairwise comparisons revealed no statistical differences between baseline and experimental control, between baseline and enrichment, or between experimental control and enrichment (Baseline-Experimental Control: $P = 1.000$, Baseline-Enrichment: $P = 1.000$, Experimental Control-Enrichment: $P = 1.000$) (Figure 33).

viii. Abiotic Interaction

During baseline observations, C’sar spent a mean of 29.80 sec engaging in abiotic interaction (S.D. = 44.926), the median was 0.00 (range = 0-137). During experimental control, he spent a mean of 61.70 sec engaging in abiotic interaction (S.D. = 111.555), the median was 15.50 (range = 0-474). During enrichment, he spent a mean of 4.95 sec engaging in abiotic interaction (S.D. = 8.494), the median was 0.00 (range = 0-26). No significant difference for abiotic interaction was found between the three conditions (Friedman’s, $F = 4.900$, df = 2, $N = 20$, $P = 0.086$; Greenhouse-Geisser, $F = 3.352$, df = 1.216, 23.096, $P = 0.073$).

ix. Drinking

C’sar was not recorded drinking during baseline or experimental control observations. During enrichment, he spent a mean of 0.70 sec drinking. I found no significant difference drinking between the three conditions (Friedman’s, $F = 2.000$, df = 2, $N = 20$, $P = 0.368$; Greenhouse-Geisser, $F = 1.000$, df = 1.0, 19.0, $P = 0.330$).

x. Social Behaviors

C’sar spent a mean of 10.80 sec engaging in social behaviors (S.D. = 48.299), the median was 0.00 (range = 0-216). He was not recorded engaging in social behaviors
during experimental control or enrichment. There was no significant difference in social behaviors between the three conditions (Friedman’s, $F = 2.000$, df = 2, N = 20, P = 0.368; Greenhouse-Geisser, $F = 1.000$, df = 1.0, 19.0, P = 0.330).
Figure 29: An activity budget showing the average amount of time dedicated to each behavior displayed by C’sar during baseline, experimental control, and enrichment observations.
Figure 30: The effect of feeding enrichment on the frequency of C’sar’s foraging behavior between the three conditions (Friedman’s, F = 10.101, df = 2, N = 20, P = .006). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).

Figure 31: The effect of feeding enrichment on the frequency of C’sar’s stereotypical behavior between the three conditions (Friedman’s, F = 6.255, df = 2, N = 20, P = .044). There were no significant differences between any of the conditions. (Asterisks and circles represent extreme outliers in the data).
Figure 32: The effect of feeding enrichment on the frequency of C’sar’s standing with trunk movement between the three conditions (Friedman’s, $F = 12.658$, $d f = 2$, $N = 20$, $P = .002$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).

Figure 33: The effect of feeding enrichment on the frequency of C’sar’s interaction with non-feeding enrichment between the three conditions (Friedman’s, $F = 8.000$, $d f = 2$, $N = 20$, $P = .018$). There were no significant differences between any of the conditions. (Asterisks and circles represent extreme outliers in the data).
b. Artie (Figure 34)

i. Foraging

Artie spent a mean of 317.85 sec foraging during baseline observations (S.D. = 343.463), the median was 272.00 (range = 0-900). He spent a mean of 260.25 sec foraging during experimental control (S.D. = 318.356), the median was 133.50 (range = 0-859). He spent a mean of 776.90 sec foraging during enrichment (S.D. = 134.298), the median was 816.50 (range = 421-886). Artie displayed a significant difference in his foraging between the three conditions (Friedman’s F = 18.795, df = 2, N = 20, P = 0.000; ANOVA, F = 22.150, df = 2, 38, P = 0.000). Wilcoxon’s pairwise comparison revealed significant differences between baseline and enrichment, and between experiment control and enrichment, but not between baseline and experimental control (Baseline-Experimental Control: P = 1.000, Baseline-Enrichment: P = 0.000, Experimental Control-Enrichment: P =0 .002) (Figure 35).

ii. Stereotypical Behavior

Artie spent a mean of 381.85 sec engaging in stereotypy during baseline observations (S.D. = 331.101), the median was 335.50 (range = 0-900). He spent a mean of 345.90 sec engaging in stereotypy during experimental control (S.D. = 327.329), the median was 234.00 (range = 0-900). He spent a mean of 24.60 sec engaging in stereotypy during enrichment (S.D. = 84.504), the median was .00 (range = 0-375). There was a significant difference in stereotypy between the three conditions (Friedman’s, F = 15.855, df = 2, N = 20, P = 0.000; Greenhouse-Geisser, F = 9.812, df = 1.501, 28.512, P = 0.001). Wilcoxon’s pairwise comparison showed significant differences between baseline and enrichment, and experimental control and enrichment, but not between baseline and
experimental control (Baseline-Experimental Control: P = 1.000, Baseline-Enrichment: P = .005, Experimental Control-Enrichment: P = .004) (Figure 36).

**iii. Standing with Trunk Movement**

During baseline observations, Artie spent a mean of 68.35 sec standing with trunk movement (S.D. = 108.794), the median was 20.50 (range = 0-357). During experimental control, he spent a mean of 149.90 sec standing with trunk movement (S.D. = 154.251), the median was 105.00 (range = 0-476). During enrichment, he spent a mean of 24.60 sec standing with trunk movement (S.D. = 35.039), the median was .00 (range = 0-118). I found a significant difference in standing with trunk movement between the three conditions (Friedman’s, F = 13.059, df = 2, N = 20, P = 0.001; ANOVA, F = 7.696, df = 2, 38, P = 0.002). Wilcoxon’s pairwise comparison showed a significant difference between experimental control and enrichment, but not between baseline and experimental control, or between baseline and enrichment (Baseline-Experimental Control: P = 0.464, Baseline-Enrichment: P = 0.173, Experimental Control-Enrichment: P = 0.003) (Figure 37).

**iv. Standing with No Trunk Movement**

During baseline observations, Artie spent a mean of 34.45 sec standing with no trunk movement (S.D. = 83.718), the median was 0.00 (range = 0-353). During experimental control, he spent a mean of 5.30 sec standing with no trunk movement (S.D. = 10.468), the median was .00 (range = 0-37). During enrichment, Art was not recorded standing with no trunk movement. No significant difference in standing with no trunk movement was found between the three conditions (Friedman’s, F = 5.000, df = 2, N = 20, P = 0.082; Greenhouse-Geisser, F = 2.824, df = 1.021, 19.398, P = 0.108).
v. **Locomotion**

During baseline observations, Artie spent a mean of 42.10 sec in locomotion (S.D. = 42.807), the median was 26.50 (range = 0-152). During experimental control, he spent a mean of 63.45 sec in locomotion (S.D. = 45.207), the median was 51.50 (range = 0-178). During enrichment, he spent a mean of 54.20 (S.D. = 35.092), the median was 47.50 (range = 14-135). There was no significant difference in locomotion between the three conditions (Friedman’s, F = 3.700, df = 2, N = 20, P = 0.157; ANOVA, F = 1.434, df = 2, 38, P = 0.251).

vi. **Self-Maintenance Behaviors**

Artie spent a mean of 6.65 sec engaging in self-maintenance behaviors during baseline observations (S.D. = 25.236), the median was 0.00 (range = 0-112). He spent a mean of 2.30 sec engaging in self-maintenance behaviors (S.D. = 6.974), the median was 0.00 (range = 0-30). He was not recorded engaging in self-maintenance behaviors during enrichment. I found no significant difference in self-maintenance behaviors between the three conditions (Friedman’s, F = 2.800, df = 2, N = 20, P = 0.247; Greenhouse-Geisser, F = .975, df = 1.103, 20.962, P = 0.344).

vii. **Interaction with Non-Feeding Enrichment Items**

Artie spent a mean of 11.25 sec interacting with non-feeding enrichment during baseline observations (S.D. = 24.655), the median was 0.00 (range = 0-72). He spent a mean of 2.30 sec interacting with non-feeding enrichment during experimental control (S.D. = 4.556), the median was 0.00 (range = 0-16). He was not recorded interacting with non-feeding enrichment during enrichment observations. There was no significant difference in interaction with non-feeding enrichment items between the three conditions.
(Friedman’s, $F = 5.304$, df = 2, N = 20, P = 0.070; Greenhouse-Geisser, $F = 3.533$, df = 1.052, 19.987, P = 0.073).

viii. Abiotic Interaction

Artie spent a mean of 7.00 sec engaging in abiotic interaction during baseline observations (S.D. = 12.153), the median was 0.00 (range = 0-42). He spent a mean of 64.60 sec engaging in abiotic interaction during experimental control (S.D. = 86.055), the median was 20.50 (range = 0-296). He spent a mean of 2.30 sec engaging in abiotic interaction during enrichment (S.D. = 7.512), the median was 0.00 (range = 0-33). A significant difference in abiotic interaction was shown between the three conditions (Friedman’s, $F = 9.480$, df = 2, N = 20, P = 0.009; Greenhouse-Geisser, $F = 9.504$, df = 1.039, 19.796, P = 0.006). However, Wilcoxon’s pairwise comparison revealed no significant difference between baseline and experimental control, between baseline and enrichment, or between experimental control and enrichment (Baseline-Experimental Control: P = 0.291, Baseline-Enrichment: P = 1.000, Experimental Control-Enrichment: P = 0.053) (Figure 38).

ix. Drinking

During baseline observations, Artie spent a mean of 6.65 sec drinking (S.D. = 29.740), the median was 0.00 (range = 0-133). During experimental control, he spent a mean of 2.85 sec drinking (S.D. = 8.810), the median was 0.00 (range = 0-31). During enrichment, he spent a mean of 3.60 sec drinking (S.D. = 16.100), the median was 0.00 (range = 0-72). I found no significant difference in drinking between the three conditions (Friedman’s, $F = .500$, df = 2, N = 20, P = 0.779; Greenhouse-Geisser, $F = 0.190$, df = 1.479, 28.100, P = 0.761).
x. *Social Behaviors*

No social behaviors were recorded across the three conditions.
Figure 34: An activity budget showing the average amount of time dedicated to each behavior displayed by Artie during baseline observations.
Figure 35: The effect of feeding enrichment on the frequency of Artie’s foraging behavior between the three conditions (Friedman’s, $F = 18.795$, $d f = 2$, $N = 20$, $P = .000$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).

Figure 36: The effect of feeding enrichment on the frequency of Artie’s stereotypical between the three conditions (Friedman’s, $F = 15.855$, $d f = 2$, $N = 20$, $P = .000$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).
Figure 37: The effect of feeding enrichment on the frequency of Artie’s standing with trunk movement between the three conditions (Friedman’s, $F = 13.059$, $d f = 2$, $N = 20$, $P = .001$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).

Figure 38: The effect of feeding enrichment on the frequency of Artie’s abiotic interaction between the three conditions (Friedman’s, $F = 9.480$, $d f = 2$, $N = 20$, $P = .009$). There were no significant differences between any of the conditions. (Asterisks and circles represent extreme outliers in the data).
c. Tonga (Figure 39)

i. Foraging

Tonga spent a mean of 467.75 sec foraging during baseline observations (S.D. = 316.085), the median was 470.50 (range = 0-889). She spent a mean of 490.40 sec foraging during experimental control (S.D. = 251.442), the median was 530 (range = 0-809). She spent a mean of 747.65 sec foraging during enrichment (S.D. 119.511), the median was 793.50 (range = 412-889). Tonga showed a statistical difference in her foraging between the three conditions (Friedman’s, F = 14.700, df = 2, N = 20, P = 0.001; Greenhouse-Geisser, F = 7.622, df = 1.351, 25.622, P = 0.006). Wilcoxon’s pairwise comparisons revealed significant differences between baseline and enrichment, and between experimental control and enrichment, but not between baseline and experimental control (Baseline-Experimental Control: P = 1.000, Baseline-Enrichment: P = 0.003, Experimental Control-Enrichment: P = 0.003) (Figure 40).

ii. Stereotypical Behavior

Tonga spent a mean of 85.70 sec engaging in stereotypical behavior during baseline observations (S.D. = 181.4138), the median was 0.00 (range = 0-570). She spent a mean of 4.75 sec engaging in stereotypical behavior during experimental control (S.D. = 7.866), the median was 0.00 (range = 0-21). She spent a mean of 1.00 sec foraging during enrichment (S.D. = 4.472), the median was 0.00 (range = 0-20). There was no significant difference in stereotypy between the three conditions (Friedman’s, F = 5.421, df = 2, N =20, P =0.067; Greenhouse-Geisser, F = 4.157, df = 1.004, 19.079, P =0.055).

iii. Standing with Trunk Movement
During baseline observations, Tonga spent a mean of 138.85 sec standing with trunk movement (S.D. = 164.388), the median was 76 (range = 0-507). During experimental control, she spent a mean of 222.30 sec standing with trunk movement (S.D. = 204.871), the median was 137.00 (range = 19-674). During enrichment, she spent a mean of 48.65 sec standing with trunk movement (S.D. = 86.645), the median was .00 (range = 0-208). A significant difference in standing with trunk movement was found between the three conditions (Friedman’s, F = 16.718, df = 2, N = 20, P = 0.000; ANOVA, F = 6.593, df = 2,38, P = 0.003). Wilcoxon’s pairwise comparisons showed significant differences between baseline and enrichment, and between experimental control and enrichment, but not between baseline and experimental control (Baseline-Experimental Control: P = 0.618, Baseline-Enrichment: P = 0.022, Experimental Control-Enrichment: P = 0.000) (Figure 41).

iv. **Standing with No Trunk Movement**

Tonga spent a mean of 21.95 sec standing with no trunk movement during baseline observations (S.D. = 34.846), the median was 0.00 (range = 0-99). She spent a mean of 16.10 sec standing with no trunk movement during experimental control (S.D. = 35.809), the median was 0.00 (range = 0-100). She spent a mean of 0.50 sec standing with no trunk movement during enrichment (S.D. = 2.236), the median was 0.00 (range = 1-10). I found no significant difference in standing with no trunk movement between the three conditions (Friedman’s, F = 5.842, df = 2, N = 20, P = 0.054; Greenhouse-Geisser, F = 2.781, df = 1.522, 28.923, P = 0.091).

v. **Locomotion**
During baseline observations, Tonga spent a mean of 93.65 sec in locomotion (S.D. = 74.646), the median was 83.00 (range = 9-231). During experimental control, she spent a mean of 104.00 sec in locomotion (S.D. = 55.288), the median was 77.00 (range = 28-197). During enrichment, she spent a mean of 81.05 sec in locomotion (S.D. = 42.748), the median was 72.00 (range = 11-185). No significant difference was found for locomotion between the three conditions (Friedman’s, F = 1.595, df = 2, N = 20, P = 0.450; ANOVA, F = .737, df = 2, 38, P = 0.485).

vi. Self-Maintenance Behaviors

Tonga spent a mean of 35.85 sec engaging in self-maintenance behaviors during baseline observations (S.D. = 55.210), the median was 6.50 (range = 0-214). She spent a mean of 25.50 sec engaging in self-maintenance behaviors during experimental control (S.D. = 57.905), the median was 0.00 (range = 0-162). She spent a mean of 1.40 sec engaging in self-maintenance behaviors during enrichment (S.D. = 5.205), the median was 0.00 (range = 0-23). There was a significant difference in self-maintenance between the three conditions (Friedman’s, F = 7.560, df = 2, N = 20, P = 0.023). However, Wilcoxon’s pairwise comparisons showed no significant differences between baseline and experimental control, between baseline and enrichment, or between experimental control and enrichment (Baseline-Experimental Control: P = 1.000, Baseline-Enrichment: P = 0.098, Experimental Control-Enrichment: P = 0.464) (Figure 42).

vii. Interaction with Non-Feeding Enrichment Items

During baseline observations, Tonga spent a mean of 2.05 sec interacting with non-feeding enrichment items (S.D. = 9.168), the median was 0.00 (range = 0-41). During experimental control, she spent a mean of 7.15 sec interacting with non-feeding
enrichment (S.D. = 8.171), the median was 5.00 (range = 0-26). She was recorded
interacting with non-feeding enrichment items during enrichment. I found a significant
difference in interaction with non-feeding enrichment items between the three conditions
(Friedman’s, F = 23.676, df = 2, N = 20, P = 0.000; Greenhouse-Geisser, F = 5.306, df =
1.557, 29.586, P = 0.016). Wilcoxon’s pairwise comparisons revealed significant
differences between baseline and experimental control, and between experimental control
and enrichment, but not between baseline and enrichment (Baseline-Experimental
Control: P = 0.010, Baseline-Enrichment: P = 0.100, Experimental Control-Enrichment:
P = 0.004) (Figure 43).

viii. Abiotic Interaction

Tonga spent a mean of 6.35 sec in abiotic interaction during baseline observations
(S.D. = 15.177), the median was 0.00 (range = 0-53). She spent a mean of 27.65 sec in
abiotic interaction during experimental control (S.D. = 58.610), the median was 12.00
(range = 0-264). She spent a mean of 9.20 sec in abiotic interaction during enrichment
(S.D. = 15.548), the median was 0.00 (range = 0-50). There was no significant difference
in abiotic interaction between the three conditions (Friedman’s, F = 4.745, df = 2, N = 20,
P = 0.093; Greenhouse-Geisser, F = 2.141, df = 1.189, 22.600, P = 0.155).

ix. Drinking

During baseline observations, Tonga spent a mean of 1.95 sec drinking (S.D. =
8.721), the median was 0.00 (range = 0-39). She was not recorded drinking during
experimental control. During enrichment, she spent a mean of 2.40 sec drinking (S.D. =
10.733), the median was 0.00 (range = 0-48). I found no significant difference in
drinking between the three conditions (Friedman’s, $F = 1.000$, df = 2, $N = 20$, $P = 0.607$; Greenhouse-Geisser, $F = .498$, df = 1.516, 28.811, $P = 0.562$).

x. Social Behaviors

Tonga spent a mean of 0.45 sec engaging in social behaviors (S.D. = 2.012), the median was 0.00 (range = 0-9). She spent a mean of 2.15 sec engaging in social behaviors during experimental control (S.D. = 4.534), the median was 0.00 (range = 0-13). She spent a mean of 1.70 sec engaging in social behaviors during enrichment (S.D. = 7.603), the median was 0.00 (range = 0-34). No significant difference was found for social behaviors between the three conditions (Friedman’s, $F = 3.000$, df = 2, $N = 20$, $P = 0.223$; Greenhouse-Geisser, $F = .539$, df = 1.1484, 28.195, $P = 0.542$).
Figure 39: An activity budget showing the average amount of time dedicated to each behavior displayed by Tonga during baseline, experimental control, and enrichment observations.
Figure 40: The effect of feeding enrichment on the frequency of Tonga’s foraging behavior between the three conditions (Friedman’s, $F = 14.700$, $d f= 2$, $N = 20$, $P = .001$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).

Figure 41: The effect of feeding enrichment on the frequency of Tonga’s standing with trunk movement between the three conditions (Friedman’s, $F = 16.718$, $d f= 2$, $N = 20$, $P = .000$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).
Figure 42: The effect of feeding enrichment on the frequency of Tonga’s self-maintenance behavior between the three conditions (Friedman’s, F = 7.560, df = 2, N = 20, P = .023). There were no significant differences between any of the conditions. (Asterisks and circles represent extreme outliers in the data).

Figure 43: The effect of feeding enrichment on the frequency of Tonga’s interaction with non-feeding enrichment between the three conditions (Friedman’s, F = 23.676, df = 2, N = 20, P = .000). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).
d. Rafiki (Figure 44)

i. Foraging

Rafiki spent a mean of 320.25 sec foraging during baseline observations (S.D. = 227.622), the median was 290.50 (range = 0-727). She spent a mean of 535.60 sec foraging during experimental control (S.D. = 159.654), the median was 454.00 (range = 376-843). She spent a mean of 676.90 sec foraging during enrichment (S.D. = 155.957), the median was 708.50 (range = 319-867). Rafiki displayed a significant difference in her foraging between the three conditions (Friedman’s, F = 11.100, df = 2, N = 20 P = 0.004; ANOVA, F = 18.178, df = 2, 38, P = 0.000). Wilcoxon’s pairwise comparisons showed a significant difference between baseline and enrichment, but not between baseline and experimental control, or between experimental control and enrichment (Baseline-Experimental Control: P = 0.464, Baseline-Enrichment: P = 0.003, Experimental Control-Enrichment: P = 0.173) (Figure 45).

ii. Stereotypical Behavior

During baseline observations, Rafiki spent a mean of 225.80 sec engaging in stereotypical behavior (S.D. = 285.065), the median was 53.00 (range = 0-871). During experimental control, she spent a mean of 174.35 sec engaging in stereotypical behavior (S.D. = 161.939), the median was 145.00 (range = 0-399). During enrichment, she spent a mean of 12.45 sec engaging in stereotypical behavior (S.D. = 30.576), the median was 0.00 (range = 0-128). I found a significant difference in stereotypy between the three conditions (Friedman’s, F = 8.955, df = 2, N = 20, P = 0.011; Greenhouse-Geisser, F = 6.380, df = 1.356, 25.770, P = 0.012). However, Wilcoxon’s pairwise comparisons revealed no significant differences between baseline and experimental control, between
baseline and enrichment, or between experimental control and enrichment (Baseline-Experimental Control: P = 1.000, Baseline-Enrichment: P = 0.053, Experimental Control-Enrichment: P = 0.053) (Figure 46).

iii. Standing with Trunk Movement

Rafiki spent a mean of 123.05 sec standing with trunk movement during baseline observations (S.D. = 117.234), the median was 106.00 (range = 0-397). She spent a mean of 74.50 sec standing with trunk movement during experimental control (S.D. = 68.315), the median was 33.00 (range = 0-219). She spent a mean of 64.94 sec standing with trunk movement during enrichment (S.D. = 101.500), the median was 11.50 (range = 0-344). There was no significant difference in standing with trunk movement between the three conditions (Friedman’s, F = 3.039, df = 2, N = 20, P = 0.219; ANOVA, F = 1.705, df = 2, 38, P = 0.195).

iv. Standing with No Trunk Movement

During baseline observations, Rafiki spent a mean of 58.85 sec standing with no trunk movement (S.D. = 122.294), the median was 0.00 (range = 0-477). During experimental control, Rafiki spent a mean of 2.80 sec standing with no trunk movement (S.D. = 5.074), the median was 0.00 (range = 0-14). During enrichment, she spent a mean of 2.10 sec standing with no trunk movement (S.D. = 9.391), the median was 0.00 (range = 0-42). There was a significant difference in standing with no trunk movement between the three conditions (Friedman’s, F = 6.526, df = 2, N = 20, P = 0.038). However, Wilcoxon’s pairwise comparisons showed there was no statistical difference between baseline and experimental control, between baseline and enrichment, or between experimental control and enrichment (Baseline-Experimental Control: P = 1.000,
Baseline-Enrichment: P = 0.246, Experimental Control-Enrichment: P = 0.805) (Figure 47).

v. **Locomotion**

Rafiki spent a mean of 81.30 sec in locomotion during baseline observations (S.D. = 47.188), the median was 73.00 (range = 0-160). She spent a mean of 81.65 sec in locomotion during experimental control (S.D. = 45.573), the median was 75.00 (range = 25-162). She spent a mean of 93.15 sec in locomotion during enrichment (S.D. = 39.195), the median was 101.00 (range = 21-155). No difference in locomotion was found between the three conditions (Friedman’s, F = 0.700, df = 2, N = 20, P = 0.705; ANOVA, F = 0.487, df = 2, 38, P = 0.618).

vi. **Self-Maintenance Behaviors**

During baseline observations, Rafiki spent a mean of 2.00 sec performing self-maintenance behaviors (S.D. = 6.122), the median was 0.00 (range = 0-26). She was not recorded engaging in self-maintenance behaviors during experimental control or enrichment. There was a significant difference in self-maintenance between the three conditions (Friedman’s, F = 6.000, df = 2, N = 20, P = 0.050). However, Wilcoxon’s pairwise comparison showed there was no statistical difference between baseline and experimental control, between baseline and enrichment, or between experimental control and enrichment (Baseline-Experimental Control: P = 1.000, Baseline-Enrichment: P = 1.000, Experimental Control-Enrichment: P = 1.000) (Figure 48).

vii. **Interaction with Non-Feeding Enrichment Items**

Rafiki spent a mean of 18.85 sec interacting with non-feeding enrichment items during baseline observations (S.D. = 44.426), the median was 0.00 (range = 0-131).
During experimental control, she was not recorded interacting with non-feeding enrichment items. During enrichment, she spent a mean of 1.15 sec interacting with non-feeding enrichment items (S.D. = 3.964), the median was 0.00 (range = 0-17). No significant difference in interaction with non-feeding enrichment items was found between the three conditions (Friedman’s, F= 4.000, df= 2, N= 20, P= 0.135; Greenhouse-Geisser, F= 3.329, df= 1.011, 19.217, P= 0.083).

viii. *Abiotic Interaction*

During baseline observations, Rafiki spent a mean of 28.40 sec in abiotic interaction (S.D. = 55.545), the median was 0.00 (range = 0-175). During experimental control, she spent a mean of 23.30 sec in abiotic interaction (S.D. = 24.544), the median was 14.50 (range = 0-70). During enrichment, she spent a mean of 20.15 sec in abiotic interaction (S.D. = 26.814), the median was 5.50 (range = 0-88). I did not find a significant difference in abiotic interaction between the three conditions (Friedman’s, F = 1.000, df = 2, N = 20, P = 0.607; Greenhouse-Geisser, F = .237, df = 1.537, 29.194, P =0 .732).

ix. *Drinking*

Rafiki spent a mean of 8.05 sec drinking during baseline observations (S.D. = 21.284), the median was 0.00 (range = 0-87). She spent a mean of 6.35 drinking during experimental control (S.D. = 14.106), the median was 0.00 (range = 0-44). She spent a mean of 14.40 sec drinking during enrichment (S.D. = 25.541), the median was 0.00 (range = 0-78). There was no significant difference in drinking between the three conditions. (Friedman’s, F = .222, df = 2, N = 20, P =0 .895; ANOVA, F = .739, df = 2, 38, P = 0.484).

x. *Social Behaviors*
During baseline observations, Rafiki spent a mean of 2.40 sec engaging in social behaviors (S.D. = 5.576), the median was 0.00 (range = 0-20). During experimental control, she spent a mean of 1.45 sec engaging in social behaviors (S.D. = 4.466), the median was 0.00 (range = 0-15). During enrichment, she spent a mean if 1.30 sec engaging in social behaviors (S.D. = 3.213), the median was 0.00 (range 0-13). I did not find a significant difference in social behaviors between the three conditions (Friedman’s, F = .500, df = 2, N = 20, P = 0.779; ANOVA, F = .318, df = 2, 38, P = 0.730).
Figure 44: An activity budget showing the average percent of time dedicated to each behavior displayed by Rafiki during baseline, experimental control, and enrichment observations.
Figure 45: The effect of feeding enrichment on the frequency of Rafiki’s foraging behavior between the three conditions (Friedman’s, $F = 11.100$, $d f = 2$, $N = 20$, $P = .004$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).

Figure 46: The effect of feeding enrichment on the frequency of Rafiki’s stereotypical behavior between the three conditions (Friedman’s, $F = 8.955$, $d f = 2$, $N = 20$, $P = .011$). There were no significant differences between any of the conditions. (Asterisks and circles represent extreme outliers in the data).
Figure 47: The effect of feeding enrichment on the frequency of Rafiki’s standing with no trunk movement between the three conditions (Friedman’s, $F = 6.526$, $d f = 2$, $N = 20$, $P = .038$). There were no significant differences between any of the conditions. (Asterisks and circles represent extreme outliers in the data).

Figure 48: The effect of feeding enrichment on the frequency of Rafiki’s self-maintenance behaviors between the three conditions (Friedman’s, $F = 6.000$, $d f = 2$, $N = 20$, $P = .050$). There were no significant differences between any of the conditions. (Asterisks and circles represent extreme outliers in the data).
e. **Nekhunda (Figure 49)**

i. **Foraging**

Nekhunda spent a mean of 358.55 sec foraging during baseline observations (S.D. = 224.474), the median was 390.50 (range = 0-694). She spent a mean of 583.25 sec foraging during experimental control (S.D. = 253.279), the median was 613.50 (range = 11-886). She spent a mean of 577.70 sec foraging during enrichment (S.D. = 22.083), the median was 616.50 (range = 0-831). Nekhunda displayed a significant difference in her foraging between the three conditions (Friedman’s, F = 12.700, df = 2, N = 20, P = 0.002; ANOVA, F = 4.328, df = 2, 38, P = 0.020). Wilcoxon’s pairwise comparisons showed significant differences between baseline and experimental control, and between baseline and enrichment, but not between experimental control and enrichment (Baseline-Experimental Control: P = 0.005, Baseline-Enrichment: P = 0.008, Experimental Control-Enrichment: P = 1.000) (Figure 50).

ii. **Stereotypical Behavior**

Baseline observations revealed that Tonga spent a mean of 36.70 sec engaging in stereotypical behavior (S.D. = 140.209), the median was 0.00 (range = 0-623). During experimental control, she spent 49.70 sec engaging in stereotypical behavior (S.D. = 117.009), the median was 0.00 (range = 0-377). During enrichment, she spent a mean of 21.25 sec engaging in stereotypical behavior (S.D. = 66.716), the median was 0.00 (range = 0-278). There was no significant difference in stereotypy between the three conditions (Friedman’s, F = .667, df = 2, N = 20, P = 0.717; ANOVA, F = .292, df = 2, 38, P = 0.748),

iii. **Standing with Trunk Movement**
During baseline observations, Nekhunda spent a mean of 160.55 sec standing with trunk movement (S.D. = 153.575), the median was 118.50 (range = 0-711). During experimental control, she spent a mean of 70.40 sec standing with trunk movement (S.D. = 81.243), the median was 61.00 (range = 0-261). During enrichment, she spent a mean of 19.85 sec standing with trunk movement (S.D. = 26.778), the median was 6.50 (range = 0-78). There was a significant difference in standing with trunk movement between the three conditions (Friedman’s, F = 14.519, df = 2, N = 20, P = 0.001; Greenhouse-Geisser, F = 9.336, df = 1.429, 27.156, P = 0.002). Wilcoxon’s pairwise comparisons found a significant difference between baseline and enrichment, but not between baseline and experimental control or between experimental control and enrichment (Baseline-Experimental Control: P = 0.081, Baseline-Enrichment: P = 0.001, Experimental Control-Enrichment: P = 0.399) (Figure 51).

iv. Standing with No Trunk Movement

Nekhunda spent a mean of 97.70 sec standing with no trunk movement during baseline observations (S.D. = 161.914), the median was 22.50 (range = 0-625). She spent a mean of 38.45 sec standing with no trunk movement during experimental control (S.D. = 95.754), the median was 0.00 (range = 0-311). She spent a mean of 12.40 sec standing with no trunk movement during enrichment (S.D. = 35.072), the median was 0.00 (range = 0-138). There was a significant difference in standing with no trunk movement between the three conditions (Friedman’s, F = 7.388, df = 2, N = 20, P = 0.025). However, Wilcoxon’s pairwise comparisons found no significant differences between baseline and experimental control, between baseline and enrichment, or between experimental control and enrichment (Baseline-Experimental Control: P = 0.399,
Baseline-Enrichment: $P = 0.119$, Experimental Control-Enrichment: $P = 1.000$) (Figure 52).

\textit{v. Locomotion}

During baseline observations, Nekhunda spent a mean of 112.90 sec in locomotion (S.D. = 58.449), the median was 111.50 (range = 0-245). During experimental control, she spent a mean of 87.90 sec in locomotion (S.D. = 44.243), the median was 85.00 (range = 13-162). During enrichment, she spent a mean of 101.75 sec in locomotion (S.D. = 36.052), the median was 100.50 (range = 45-169). No difference in locomotion was found between the three conditions (Friedman’s, $F = 1.103$, df = 2, N = 20, $P = 0.576$; ANOVA, $F = 1.551$, df = 2, 38, $P = 0.225$).

\textit{vi. Self-Maintenance Behaviors}

Nekhunda spent a mean of 9.30 sec engaging in self-maintenance behaviors during baseline observations (S.D. = 25.976), the median was 0.00 (range = 0-113). She spent a mean of 1.35 sec engaging in self-maintenance behaviors during experimental control (S.D. = 4.158), the median was 0.00 (range = 0-14). She spent a mean of 0.40 sec engaging in self-maintenance behaviors during enrichment (S.D. = 1.273), the median was 0.00 (range = 0-5). I found a significant difference in self-maintenance between the three conditions (Friedman’s, $F = 6.333$, df = 2, N = 20, $P = 0.042$). However, Wilcoxon’s pairwise comparisons showed no significant differences between baseline and experimental control, between baseline and enrichment, or between experimental control and enrichment (Baseline-Experimental Control: $P = 0.805$, Baseline-Enrichment: $P = 0.618$, Experimental Control-Enrichment: $P = 1.000$) (Figure 53).

\textit{vii. Interaction with Non-Feeding Enrichment Items}
During baseline observations, Nekhunda spent a mean of 13.00 sec interacting with non-feeding enrichment items (S.D. = 25.746), the median was 0.00 (range = 0-104). During experimental control, she spent a mean of 6.10 sec interacting with non-feeding enrichment items (S.D. = 13.776), the median was 0.00 (range = 0-44). During enrichment, she spent a mean of 50.50 sec interacting with non-feeding enrichment items (S.D. = 157.047), the median was 0.00 (range = 0-635). I found no difference in interaction with non-feeding enrichment items across the three conditions (Friedman’s, F = 2.114, df = 2, N = 20, P = 0.347; Greenhouse-Geisser, F = 1.306, df = 1.047, 19.894, P = 0.269).

viii. Abiotic Interaction

Nekhunda spent a mean of 5.15 sec in abiotic interaction during baseline observations (S.D. = 23.032), the median was 0.00 (range = 0-103). She spent a mean of 11.10 sec in abiotic interaction during experimental control (S.D. = 17.741), the median was 0.00 (range = 0-49). She spent a mean of 6.00 sec in abiotic interaction during enrichment (S.D. = 10.214), the median was 0.00 (range = 0-37). I found a significant difference in abiotic interaction between the three conditions (Friedman’s, F = 6.450, df = 2, N = 20, P = 0.040). However, Wilcoxon’s pairwise comparison revealed no statistical differences between baseline and experimental control, between baseline and enrichment, or between experimental control and enrichment (Baseline-Experimental Control: P = 0.291, Baseline-Enrichment: P = 0.464, Experimental Control-Enrichment: P = 1.000) (Figure 54).

ix. Drinking
During baseline observations, Nekhunda spent a mean of 44.70 sec drinking (S.D. = 73.709), the median was 0.00 (range = 0-263). During experimental control, she spent a mean of 47.95 sec drinking (S.D. = 73.692), the median was 0.00 (range = 0-223). During enrichment, she spent a mean of 10.85 sec drinking (S.D. = 120.889), the median was 65.50 (range = 0-413). There was no significant difference in drinking between the three conditions (Friedman’s, $F = 2.758$, df = 2, N = 20, $P = 0.252$; ANOVA, $F = 1.869$, df = 2, 38, $P = 0.168$).

x. Social Behaviors

Nekhunda spent a mean of 10.65 sec engaging in social behaviors during baseline observations (S.D. = 19.443), the median was 0.00 (range = 0-54). She was not recorded engaging in social behaviors during experimental control. She spent a mean of 2.40 sec engaging in social behaviors during enrichment (S.D. = 7.769), the median was 0.00 (range 0-34). I found a significant difference in social behaviors between the three conditions (Friedman’s, $F = 7.300$, df = 2, N = 20, $P = 0.026$; Greenhouse-Geisser, $F = 5.135$, df = 1.244, 23.634, $P = 0.026$). However, Wilcoxon’s pairwise comparisons showed no significant differences between baseline and experimental control, between baseline and enrichment or between experimental control and enrichment (Baseline-Experimental Control: $P = 0.537$, Baseline-Enrichment: $P = 1.000$, Experimental Control-Enrichment: $P = 1.000$) (Figure 55).
Figure 49: An activity budget showing the average percent of time dedicated to each behavior displayed by Nekhunda during baseline, experimental control, and enrichment observations.
Figure 50: The effect of feeding enrichment on the frequency of Nekhunda’s foraging behavior between the three conditions (Friedman’s, $F = 12.700$, $d.f = 2$, $N = 20$, $P = .020$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).

Figure 51: The effect of feeding enrichment on the frequency of Nekhunda’s standing with trunk movement between the three conditions (Friedman’s, $F = 14.519$, $d.f = 2$, $N = 20$, $P = .002$). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).
Figure 52: The effect of feeding enrichment on the frequency of Nekhunda’s standing with no trunk movement between the three conditions (Friedman’s, $F = 7.388$, $df = 2$, $N = 20$, $P = .025$). There were no significant differences between any of the conditions. (Asterisks and circles represent extreme outliers in the data).

Figure 53: The effect of feeding enrichment on the frequency of Nekhunda’s self-maintenance behavior between the three conditions (Friedman’s, $F = 6.333$, $df = 2$, $N = 20$, $P = .042$). There were no significant differences between any of the conditions. (Asterisks and circles represent extreme outliers in the data).
Figure 54: The effect of feeding enrichment on the frequency of Nekhunda’s abiotic interactions between the three conditions (Friedman’s, $F = 6.450$, $d f = 2$, $N = 20$, $P = .040$). There were no significant differences between any of the conditions. (Asterisks and circles represent extreme outliers in the data).

Figure 55: The effect of feeding enrichment on the frequency of Nekhunda’s social behaviors between the three conditions (Friedman’s, $F = 7.300$, $d f = 2$, $N = 20$, $P = .026$). There were no significant differences between any of the conditions. (Asterisks and circles represent extreme outliers in the data).
f. Batir (Figure 56)

i. Foraging

Batir spent a mean of 454.45 sec foraging during baseline observations (S.D. = 264.755), the median was 418.00 (range = 0-900). She spent a mean of 443.15 sec foraging during experimental control (S.D. = 293.116), the median was 425.50 (range = 49-900). She spent a mean of 637.10 sec foraging during enrichment (S.D. = 242.972), the median was 709.00 (range = 0-880). Batir displayed a significant difference in her foraging between the three conditions (Friedman’s, $F = 6.700$, df = 2, N = 20, $P = 0.035$). Wilcoxon’s pairwise comparisons showed a significant difference between baseline and enrichment, but not between baseline and experimental control or between experimental control and enrichment (Baseline-Experimental Control: $P = 1.000$, Baseline-Enrichment: $P = 0.034$, Experimental Control-Enrichment: $P = 0.246$) (Figure 57).

ii. Stereotypical Behavior

During baseline observations, Batir spent a mean of 202.70 sec engaging in stereotypical behavior (S.D. = 245.524), the median was 156.50 (range = 0-794). During experimental control, she spent a mean of 314.05 sec performing stereotypical behaviors (S.D. = 332.336), the median was 281.50 (range = 0-805). During enrichment, she spent a mean of 81.95 sec performing stereotypical behaviors (S.D. = 199.48), the median was 0.00 (range = 0-817). There was no difference in stereotypy between the three conditions (Friedman’s, $F = 2.225$, df = 2, N = 20, $P = 0.329$; ANOVA, $F = 3.031$, df = 2, 38, $P = 0.069$).

iii. Standing with Trunk Movement
Batir spent a mean of 96.40 sec standing with trunk movement during baseline observations (S.D. = 122.209), the median was 40.00 (range = 0-346). She spent a mean of 66.20 sec standing with trunk movement during experimental control (S.D. = 64.136), the median was 52.00 (range = 0-184). She spent a mean of 49.50 sec standing with trunk movement during enrichment (S.D. = 70.820), the median was 11.00 (range = 0-256). There was no significant difference in standing with trunk movement between the three conditions (Friedman’s, F = 1.400, df = 2, N = 20, P = 0.497; Greenhouse-Geisser, F = 1.683, df = 1.325, 25.168, P = 0.209).

iv. Standing with No Trunk Movement

During baseline observations, Batir spent a mean of 30.25 sec standing with no trunk movement (S.D. = 48.286), the median was 0.00 (range = 0-176). She was not recorded standing with no trunk movement during experimental control or enrichment. Batir displayed a significant difference in standing with no trunk movement between the three conditions (Friedman’s, F = 18.000, df = 2, N = 20, P = 0.000; Greenhouse-Geisser, F = 7.849, df = 1.000, 19.000, P = 0.011). However, Wilcoxon’s pairwise comparisons showed no significant differences between baseline and experimental control, between baseline and enrichment, or between experimental control and enrichment (Baseline-Experimental Control: P = 0.098, Baseline-Enrichment: P = 0.098, Experimental Control-Enrichment: P = 1.000) (Figure 58).

v. Locomotion

Batir spent a mean of 82.20 sec in locomotion during baseline observations (S.D. = 41.092), the median was 89.50 (range = 0-147). She spent a mean of 68.45 sec in locomotion during experimental control (S.D. = 45.252), the median was 281.50 (range =
0-146). She spent a mean of 108.20 sec in locomotion during enrichment (S.D. = 55.519), the median was 111.00 (range = 2-217). I found no significant difference in locomotion between the three conditions (Friedman’s, F = 5.038, df = 2, N = 20, P = 0.081).

**vi. Self-Maintenance Behaviors**

During baseline observations, Batir spent a mean of 3.85 sec engaging in self-maintenance behaviors (S.D. = 9.218), the median was 0.00 (range = 0-41). She was not recorded performing self-maintenance behaviors during experimental control. During enrichment, she spent a mean of 2.55 sec engaging in self-maintenance behaviors (S.D. = 7.742), the median was 0.00 (range = 0-33). I found a significant difference in self-maintenance behaviors between the three conditions (Friedman’s, F = 7.400, df = 2, N = 20, P = 0.025). However, Wilcoxon’s pairwise comparisons showed no significant differences between baseline and experimental control, between baseline and enrichment, or between experimental control and enrichment (Baseline-Experimental Control: P = 0.291, Baseline-Enrichment: P = 1.000, Experimental Control-Enrichment: P = 1.000) (Figure 59).

**vii. Interaction with Non-Feeding Enrichment Items**

Batir spent a mean of 3.35 sec interacting with non-feeding enrichment items during baseline observations (S.D. = 13.635), the median was 0.00 (range = 0-61). She spent a mean of 1.70 sec interacting with non-feeding enrichment items during experimental control (S.D. = 4.964), the median was 0.00 (range = 0-21). She spent a mean of 10.00 sec interacting with non-feeding enrichment items during enrichment (S.D. = 28.159), the median was 0.00 (range = 0-122). No significant difference was
found in interaction with non-feeding enrichment items between the three conditions (Friedman’s, $F = 2.077$, df = 2, N = 20, $P = 0.354$; Greenhouse-Geisser, $F = 1.159$, df = 1.253, 23.812, $P = 0.307$).

viii. **Abiotic Interaction**

During baseline observations, Batir spent a mean of 9.85 sec in abiotic interaction (S.D. = 34.361), the median was 0.00 (range = 0-154). During experimental control, she spent a mean of 7.40 sec in abiotic interaction (S.D. = 16.987), the median was 0.00 (range = 0-67). During enrichment, she spent a mean of 8.30 sec in abiotic interaction (S.D. = 15.924), the median was 0.00 (range = 0-47). A significant difference was not found for abiotic interaction (Friedman’s, $F = 1.632$, df = 2, N = 20, $P = 0.442$; ANOVA, $F = .050$, df = 2, 38, $P = 0.951$).

ix. **Drinking**

Batir spent a mean of 4.85 sec drinking during baseline observations (S.D. = 11.997), the median was 0.00 (range = 0-43). She was not recorded drinking during experimental control. She spent a mean of 0.80 sec drinking during enrichment (S.D. = 3.578), the median was 0.00 (range = 0-16). I did not find a significant difference in drinking between the three conditions (Friedman’s, $F = 5.200$, df = 2, N = 20, $P = 0.074$; Greenhouse-Geisser, $F = 2.523$, df = 1.118, 21.250, $P = 0.124$).

x. **Social Behaviors**

During baseline observations, Batir spent a mean of 0.55 sec engaging in social behaviors (S.D. = 2.460), the median was 0.00 (range = 0-11). She was not recorded engaging in social behaviors during experimental control. During enrichment, she spent a mean of 1.60 sec performing social behaviors (S.D. = 3.575), the median was 0.00
There was a significant difference in social behaviors between the three conditions (Friedman’s, F = 7.538, df = 2, N = 20, P = 0.023). However, Wilcoxon’s pairwise comparisons showed no significant differences between baseline and experimental control, between baseline and enrichment, or between experimental control and enrichment (Baseline-Experimental Control: P = 1.000, Baseline-Enrichment: P = 1.000, Experimental Control-Enrichment: P = 0.912) (Figure 60).
Figure 56: An activity budget showing the average percent of time dedicated to each behavior displayed by Batir during baseline, experimental control, and enrichment observations.
Figure 57: The effect of feeding enrichment on the frequency of Batir’s foraging behavior between the three conditions (Friedman’s, \( F = 6.700, \) \( df = 2, N = 20, P = .035 \)). Conditions with the same letter are not significantly different from each other. (Asterisks and circles represent extreme outliers in the data).

Figure 58: The effect of feeding enrichment on the frequency of Batir’s standing with no trunk movement between the three conditions (Friedman’s, \( F = 18.000, \) \( df = 2, N = 20, P = .000 \)). There were no significant differences between any of the conditions. (Asterisks and circles represent extreme outliers in the data).
Figure 59: The effect of feeding enrichment on the frequency of Batir’s self-maintenance behaviors between the three conditions (Friedman’s, $F = 7.400$, $d.f = 2$, $N = 20$, $P = .025$). There were no significant differences between any of the conditions. (Asterisks and circles represent extreme outliers in the data).

Figure 60: The effect of feeding enrichment on the frequency of Batir’s social behaviors between the three conditions (Friedman’s, $F = 7.538$, $d.f = 2$, $N = 20$, $P = .023$). There were no significant differences between any of the conditions. (Asterisks and circles represent extreme outliers in the data).
Chapter 4

DISCUSSION

It is obvious from the results that some behaviors were affected by increased feeding enrichment while others were not. Because foraging involves a large portion of an individual’s daily activity budget (McKay, 1973; Wyatt and Eltringham, 1974; Moss, 1982, 1988), increasing the effort required to eat reduces the time available for other activities; in captivity that would include stereotypies and other non-typical behaviors. Furthermore, self-maintenance behaviors, drinking and social behaviors, in general, would remain constant as these are performed by wild elephants despite spending the majority of their day foraging, thus, increased foraging times would not affect the occurrence of these behaviors. Individual personalities and unique personal histories will also influence reactions to changes in the husbandry routine; thus, my analyses looked at responses of the herd as a group, the sexes, and of the individuals to the enrichment regime.

I. Overall Elephant Behavior

a. Foraging

The aim of this study was to examine how six captive African elephants responded to the use of feeding enrichment and how it could potentially influence their activity budgets. As predicted, the elephants, as a group, showed a significant increase in foraging when feeding enrichment was utilized to present food. Foraging was significantly higher during the feeding enrichment than during either the baseline or the experimental control suggesting that when enrichment items are presented with food,
they offer a sufficient challenge for the elephants that it resulted in a dramatic increase in
time spent foraging. Although there was no significant difference in foraging time
between the baseline and the experimental control, more time was spent engaged in
foraging behaviors during the experimental control. This suggests that the feeding
enrichment had a prolonged effect on the elephants’ foraging behavior, possibly because
the elephants spent time exploring the feeding enrichment items for food before realizing
they were empty. Stoinski et al. (2000) also found that foraging times remained elevated
after feeding enrichment was no longer present.

b. Stereotypical Behavior

Stereotypical behaviors, especially rocking, were performed by all elephants,
except Batir, who instead was only individual to show circling and pacing. Stereotypy
was significantly reduced when feeding enrichment was used to present food to the
elephants confirming that the increase in foraging time promoted by feeding enrichment
can subsequently reduce the performance of stereotypies. This supports the conclusions
of both Stoinski et al. (2000) and Rees (2009) that documented a negative correlation
between time spent foraging and the performance of stereotypies. Furthermore,
observations were collected in the morning when the keepers reported stereotypies to be
most commonly expressed, thus this decrease is of particular importance.

All zoos accredited by the Association of Zoos and Aquariums follow
management guidelines that require the use of enrichment for elephants (AZA, 2012) to
minimize the prevalence of stereotypies (Swaisgood and Shepherdson, 2005; Mason et
al., 2007). Furthermore, the observation of stereotypies by zoo-goers has been reported
to reflect poorly on zoos and potentially influences the public to not support zoo efforts (Rees, 2009).

c. Standing with Trunk Movement

Standing with trunk movement consisted of twisting the distal portion of the trunk, swinging the trunk from side to side or back and forth, rolling the trunk either up or down, and touching the top of the head or other body part briefly. These movements were performed in no particular order and in different variations. Because this behavior was significantly lower during the enrichment condition than during the baseline or experimental control and because of its seemingly aimless nature, I suggest that standing with trunk movement is a vacuum behavior. A vacuum activity is an innate behavior performed without the necessary signal stimulus. Such abnormal behaviors are typically seen in captive animals; Lorenz explains that animals have a biological need to express natural behaviors even if the behavior serves no true function (Burkhardt, 2010). Although vacuum behaviors are not necessarily stereotypical in nature, their continued performance can give rise to the development of stereotypies (Mason and Veasey, 2010). Thus, the significant decline in standing with trunk movement during the enrichment condition is a positive consequence.

d. Standing with No Trunk Movement (Inactivity)

A significant decrease in standing with no trunk movement from the baseline, to the experimental control, and again to the enrichment condition suggests the increase in foraging resulted in less time spent inactive and provides additional support of Stoinski et al. ’s (2000) findings which revealed a significant decrease in inactivity when feeding enrichment was introduced. Additionally, Rees (2009) found that the elephants who
spent the most amount of time foraging, displayed the lowest frequencies of inactivity. This strongly suggests improved welfare, as wild elephants spend little time inactive (Wyatt and Eltringham, 1974; Gravett et al., 2017).

\( e. \) **Locomotion**

The significant increase in locomotion during the enrichment condition is a positive consequence of the feeding enrichment. Getting captive animals to exhibit activity budgets as close to those of their wild counterparts is recommended to increase their well-being (Fa et al., 2011); in the wild, African elephants cover 5km per day on average, but up to 80 km per day depending on the season and resource availability (Theuerkauf and Ellenberg, 2000; Whitehouse and Schoeman, 2003; Leighty et al., 2009). By adding variety to the feeding regimen, the elephants appear to have been encouraged to explore multiple potential places where food had been presented.

\( f. \) **Self-Maintenance Behaviors**

 Unexpectedly, self-maintenance behaviors decreased significantly from the baseline, to the experimental control, and again to the enrichment condition. This could be due to the increased amount of time spent foraging during the experimental control and enrichment conditions. While self-maintenance behaviors are common among elephants, some research has suggested that at times self-maintenance behaviors in captive animals may be vacuum or displacement behaviors expressed when anxious or are looking to engage in natural behaviors (Rees, 2002; Blood et al., 2007). Thus, their reduction in frequency may be a positive outcome.

On the other hand, the significant decrease in self-maintenance behaviors may not have been entirely in response to the feeding enrichment but also in reaction to the
change in weather. Baseline observations were collected between June and September when the temperature ranged from 11°C to 35°C, while experimental control and enrichment observations were collected between October and April when the temperature ranged from -13°C to 30°C. Rees (2002) found a positive correlation between the maximum daily temperature and the frequency of dust bathing of eight captive Asian elephants; furthermore, he found that when temperature dropped below 13°C, the elephants seldom dust-bathed.

g. Interaction with Non-Feeding Enrichment Items

I had to reject my hypothesis that interaction with non-feeding enrichment items would increase when feeding enrichment was present as there was no significant difference in enrichment interaction between the three conditions. This suggests that the introduction of feeding enrichment has no effect on the elephants’ desire to engage with non-feeding enrichment items or that engaging with the feeding enrichment items satisfied their desire to perform exploratory behaviors.

h. Abiotic Interaction

Contrary to expectation, there was no significant difference in abiotic interaction (touching enclosure structure, mesh window) between the three conditions. I expected this behavior to increase when feeding enrichment was utilized as touching abiotic structures appears to be an exploratory behavior and would help the elephants find changes in their environment; however, the presence or absence of food in the feeding enrichment may have been obvious and thus required little exploration. This provides additional support to the findings of Stoinski et al. (2000), who found no significant difference in “object exam” when feeding enrichment was introduced.
i. Drinking

As expected, there was no difference in drinking between the three conditions. The presence of feeding enrichment did not increase the amount of time the elephants spent drinking at their fountains. Drinking is a physiological necessity for elephants and shouldn’t be disrupted by increased foraging times. However, this contradicts the findings of Stoinski et al. (2000), who found a significant decrease in drinking when additional browse was added to the husbandry routine, probably due to the water content of the browse.

j. Social Behaviors

As expected, there was no difference in social behaviors between the three conditions. The presence of feeding enrichment did not promote or discourage the frequency at which the elephants engaged in social interactions. The elephants have social relationships with each other and it is a positive that the use of feeding enrichment did not disrupt the frequency of affiliative behaviors.

II. Comparisons Between the Sexes

Although, previous research has found that male and female elephants do not differ in their behavioral patterns or activity budgets in the wild (Shannon et al., 2008) the findings of this study suggest males and females may differ in their responses to feeding enrichment. As explained more in depth below, in some cases males and females displayed significant changes in behaviors where the other sex did not. Furthermore, in general, females showed a prolonged effect of the feeding enrichment on their behaviors, with significant changes in behavior sustained through the experimental control, while
certain males’ behaviors only significantly changed when feeding enrichment was utilized. This could potentially be an effect of sociality and social conditions where the females housed together are influencing each other’s behavior. Although males in the wild are typically solitary, they do interact with conspecifics (Poole and Moss, 1981); however, the males in this study were housed alone when in their paddocks. It is possible that these results have also been influenced by the small sample size of the study (males= 2, females= 4) hence the need for further research into behavioral differences between the sexes of captive elephants.

a. Foraging

When the data were analyzed between the sexes, both males and females as groups showed significant increases in their foraging behavior when feeding enrichment was utilized. However, for only the females, foraging remained elevated during the experimental control suggesting the feeding enrichment had a sustained effect on their behavior. Stoinski et al. (2000) also found that the introduction of feeding enrichment increased the amount of time the elephants foraged and remained elevated when the feeding enrichment was gone; however, the elephants from Stoinski et al.’s study were all females.

b. Stereotypical Behavior

There was a significant decrease in stereotypic behavior when feeding enrichment was utilized for both the males and females. This implies that the increased foraging time had a similar influence on the frequencies with which males and females performed stereotypies. These results are consistent with the findings of Stoinski et al. (2000) and
Rees (2009) where increased engagement in foraging behaviors resulted in a decrease in the frequency of stereotypical behaviors.

c. *Standing with Trunk Movement*

Both males and females showed significant decreases in standing with trunk movement during the enrichment condition as compared to both the baseline and the experimental control. This shows that males and females responded to increased foraging times in the same manner in terms of standing with trunk movement.

d. *Standing with No Trunk Movement (Inactivity)*

Because both males and females had significant decreases in standing without trunk movement between the three conditions, it can be assumed that increased foraging times reduces the occurrence of inactivity. However, for the males, standing without trunk movement was only significantly reduced during the enrichment condition, while for the females, the frequency in which they were inactive continued to decrease from the baseline, to the experimental control, to enrichment, suggesting the feeding enrichment had a prolonged effect on their behavior.

e. *Locomotion*

The males had a significant difference in locomotion between the three conditions with frequency increasing from baseline, to experimental control, to enrichment. However, the females displayed no significant difference in their locomotion between the three conditions. This difference in locomotion between the sexes could have been influenced by the difference in which the sexes are housed, with females being two to a paddock and males occupying a paddock alone. Females may be communicating the
presence of absence of additional food items, while the males walked around and searched the rest of their paddocks for more foraging material.

\textit{f. Self-Maintenance Behaviors}

The males showed no significant difference in their self-maintenance activities between the three conditions. However, the females significantly decreased their self-maintenance behaviors between the three conditions with the frequency decreasing from baseline, to experimental control, to enrichment. There may have been no difference in the males’ self-maintenance behavior as they were rarely observed performing such behaviors; overall, the females engaged in self-maintenance behaviors more frequently than the males. This significant reduction experienced by the females contradicts the findings of Stoinski et al (2000), which document no significant changes in self-maintenance behaviors of the three females in relation to additional feeding enrichment. However, due to the small sample sizes of both studies, further research should be conducted to test whether captive female elephants perform self-maintenance behaviors more frequently than do males.

\textit{g. Interaction with Non-Feeding Enrichment Items}

Neither the males nor females had significant differences in interaction with non-feeding enrichment items between the three conditions. Therefore, the increased foraging time did not influence the frequencies with which males or females engaged with non-feeding enrichment items and potentially reveals similarities in the sexes’ responses to feeding enrichment in regard to this behavior.
h. Abiotic Interaction

The touching of enclosure structures such as bars and mesh window could be the elephants exploring their environment and familiarizing themselves with any potential changes. While there was no significant difference in abiotic interaction across the three conditions for the males, the females showed a significant decrease in abiotic interaction during both the enrichment and experimental control. This decrease could be because the feeding enrichment provided a satisfying outlet to express exploratory behaviors; conversely, exploratory behaviors did not significantly change with the addition of feeding enrichment for the female elephants from the study conducted by Stoinski et al (2000). However, the observations of the elephants in Stoinski et al.’s research were collected when the elephants were in their outdoor exhibit and feeding enrichment was in the form of additional browse as opposed to the feeding enrichment items used in this study.

i. Drinking

Neither the males nor females had a significant difference in drinking between the three conditions. As stated before, drinking water is a biological need and increased foraging time should not influence the frequencies with which males or females drank water.

j. Social Behaviors

Again, the elephants have social relationships with each other and, as expected, increased foraging times did not influence the rate of affiliative behaviors for either males or females. This contradicts Stoinski et al.’s (2000) discovery of a significant decrease in physical contact between the elephants when feeding enrichment was introduced. Again,
the elephants in their study were observed when located in their outdoor habitat, which would be much larger than the paddocks of this study’s elephants and potentially influenced the occurrence of social behaviors.

III. Individual Behavior

Research detailing unique personalities in animals has garnered increased attention in the scientific community with accounts of individual traits influencing habitat selection, group living and the dissemination of knowledge (Pennisi, 2016). Individual variations in the behavior of captive elephants have been documented (Rees, 2009) and can have important management implications. Overall, increased use of novel feeding enrichment led to changes in elephant behavior that suggest improved welfare and thus this type of enrichment merits further use. However, differences in behavior and changes to behavior with feeding enrichment vary by individual and thus warrant individual assessment.

a. Foraging

In response to the introduction of feeding enrichment, foraging time significantly increased during the enrichment condition for all six elephants, a finding consistent with the conclusions made by Stoinski et al. (2000). Foraging was the only behavior that all six elephants had a significant difference between the three conditions, suggesting that the feeding enrichment was challenging enough to increase the frequency in which the elephants engaged in foraging behavior. Nevertheless, there was individual variation in the foraging behavior. For C’zar, Artie, Tonga, and Batir foraging increased significantly from baseline to enrichment, but then decreased during experimental control to frequencies similar to baseline.
However, while Rafiki’s and Nekhunda’s foraging times significantly increased from baseline to enrichment, their foraging frequencies remained elevated during the experimental control suggesting the feeding enrichment had prolonged effects on their foraging behavior. Rafiki and Nekhunda are housed together and potentially they influenced the other’s prolonged response.

b. Stereotypical Behavior

C’sar, Artie and Rafiki all demonstrated significant decreases in their stereotypic behavior between the three conditions suggesting the feeding enrichment and subsequent increased foraging resulted in reduced stereotypy as previously seen in other studies (Stoinski et al., 2000; Rees, 2004). Furthermore, C’sar, Artie, and Rafiki increased their foraging behavior by 37% or more from baseline to enrichment.

In contrast, Tonga, Nekhunda and Batir showed no significant decrease in stereotypy when feeding enrichment was utilized. Tonga and Nekhunda may have shown no significant decrease in stereotypy because they rarely engaged in stereotypic behavior to begin with; however, both had significant decreases in standing with trunk movement and self-maintenance behaviors, and Nekhunda also displayed a significant decrease in standing with no trunk movement. All of those can potentially be considered vacuum behaviors that could ultimately give rise to an increased frequency in stereotypy.

The lack of a significant decrease in Batir’s stereotypic behavior could also be a result of her age; previous research has found a negative correlation between age and stereotypic behavior (Friend and Parker, 1999; Gruber et al., 2000). Another potential factor could be Batir’s personal history as she is the only herd member born in captivity. Her lack of experience with a wild setting could influence the frequency in which she
performs stereotypical behaviors. I have found no previous research to support this claim; however, the potential influence of personal history on the ability to adapt to captive life should be investigated. Batir experienced the lowest increase in foraging behavior during enrichment with a 20.3% increase from baseline; this degree of change in foraging behavior may not have been enough to influence a decrease in stereotypical behavior. Furthermore, I rarely observed Batir actively manipulating the enrichment items. Instead, she typically waited for Tonga to manipulate the enrichment articles and would feed on the hay that was subsequently released and fell to the ground; thus, the frequency with which she foraged increased due to the prolonged dispersion of food items. This suggests that Batir may have had limited opportunity to directly access feeding enrichment when Tonga was present, this may change with age as she becomes more independent. Potentially, multiple feeding enrichment items could be used at one time to reduce the possibility of one elephant dominating an item.

\(c. \text{ Standing with Trunk Movement}\

Although I could not find standing with trunk movement categorized as a vacuum behavior anywhere in the literature, I argue that standing with trunk movement fits the definition of a vacuum behavior. Therefore, I expected a significant reduction in the behavior when foraging behavior significantly increased; however, I was only able to accept this hypothesis for four of the elephants.

C’zar, Artie, Tonga and Nekhunda showed significant differences in their standing with trunk movement behavior between the three conditions. For C’zar and Tonga, the frequency in which they performed the behavior was significantly lower during the enrichment condition as compared to both the baseline and experimental
control. This makes sense for both animals because their foraging behavior was greatest during the enrichment condition. Artie’s pairwise comparisons showed a significant decrease in standing with trunk movement during enrichment but then significantly increased from enrichment to experimental control suggesting Artie had grown accustomed to the increased stimulation of the feeding enrichment and its absence actually promoted his performance of this vacuum behavior. As for Nekhunda, her standing with trunk movement behavior was significantly reduced from baseline to enrichment with its frequency being intermediate during experimental control. Nekhunda’s foraging behavior followed an inversed pattern between the three conditions, suggesting the feeding enrichment and increased foraging time had a prolonged effect on her engagement in standing with trunk movement.

Because neither Rafiki nor Batir displayed significant differences in their standing with trunk movement across the three conditions it can be assumed that the presence of the feeding enrichment and significant increases in foraging behavior did not reduce the frequency in which they engaged in this particular vacuum behavior. This is important as vacuum behaviors can eventually develop into stereotypies and Rafiki and Batir already displayed the high frequencies of stereotypy.

d. Standing with No Trunk Movement (Inactivity)

When data on standing with no trunk movement were combined and analyzed, significant decreases were demonstrated during enrichment by the herd, by the males and by the females; however, only three elephants displayed a significant decrease in this behavior. Again, this inconsistency in results between the groups’ and individual’s
findings could be potentially misleading and further suggests the need for individual assessments to gauge reactions to changes in husbandry routines.

Rafiki, Nekhunda, and Batir displayed significant differences in standing with no trunk movement between the three conditions with their frequencies decreasing from baseline, to experimental control, to enrichment. Besides these three females being the youngest in the herd, I cannot postulate as to why only they demonstrated significant decreases in their occurrence of inactivity.

Neither C’sar, Artie nor Tonga showed significant differences in their standing with no trunk movement between the three conditions. Thus, the feeding enrichment and increased foraging time did not significantly decrease their levels of inactivity.

e. Locomotion

None of the six elephants had a significant difference in their locomotion between the three conditions. However, when the elephants’ locomotive data were combined, the analysis found a significant difference; so, as a group locomotion increased when feeding enrichment was utilized but no one individual had this significant increase. This may be an issue of sample size as the sample is greatly reduced when measuring individual behavior as compared to group behavior.

f. Self-Maintenance Behaviors

Tonga, Rafiki, Nekhunda, and Batir all displayed significant differences in their self-maintenance behaviors between the three conditions, while C’sar and Artie did not. C’sar and Artie were rarely observed participating in self-maintenance behaviors and thus it is not surprising that changes in this behavior were not found for either of the males. This is important because the group analysis found a significant decrease in self-
maintenance behaviors which, without individual analyses, could be interpreted as a result reflective of all individuals in the group; hence, this discrepancy between group results and individual analyses provides evidence for the need for personalized monitoring.

g. Interaction with Non-Feeding Enrichment Items

Only the analyses on C’zar’s and Tonga’s interaction with non-feeding enrichment items revealed significant differences between the three conditions. However, C’zar’s enrichment interaction was greatest during the enrichment condition, suggesting the increase in foraging time promoted exploratory and play behaviors by him. In contrast, Tonga experienced the lowest frequency of enrichment interaction during the enrichment condition, suggesting the increase in foraging time actually discouraged her desire or need to engage with non-feeding enrichment, possibly because the interaction with feeding enrichment provided suitable mental and physical stimulation.

When the occurrence of interaction with non-feeding enrichment items was analyzed for the group, no significant change was detected. These opposing behavioral responses to feeding enrichment detected by individual analyses, along with the lack of change in enrichment interaction for Artie, Rafiki, Nekhunda, and Batir, provides evidence for unique differences in elephant personality and the need for individualized assessments.

h. Abiotic Interaction

Artie and Nekhunda showed significant differences in their abiotic interactions between the three conditions. While each individual’s pairwise comparisons revealed the
frequencies of abiotic interaction were statistically similar between each of the conditions, both Artie and Nekhunda had increasing frequencies from enrichment, to baseline, to experimental control. This suggests that when feeding enrichment was no longer utilized during the experimental control, their exploratory behaviors increased, as they were possibly inspecting their surroundings for other potential changes. Besides both elephants having no visible tusks, I cannot postulate as to why only Artie and Nekhunda displayed this change in behavior.

i. **Drinking**

As expected, none of the elephants revealed a significant difference in drinking between the three conditions. Consuming water is a biological need; thus, this behavior can serve as a control to which increased foraging times did not influence.

j. **Social Behaviors**

C’sar, Artie, Tonga and Rafiki had no significant differences in their social behaviors between the three conditions. However, Nekhunda and Batir did show significant differences in their social behavior between the three conditions. Although pairwise comparisons revealed the frequencies of Nekhunda’s social behaviors were statistically similar between each of the conditions, her engagement in social behaviors decreased from baseline, to enrichment, to experimental control. Batir’s pairwise comparisons also revealed that her social behaviors were statistically similar between each pair of conditions, however, her social behaviors increased from baseline to enrichment and then decreased to their lowest frequency during the experimental control. This result could be because she relied on Tonga to gain access to food when feeding enrichment was utilized but because she was accustomed to the increased stimulation and
foraging time, on experimental control days Batir’s attention was shifted to finding other outlets to exploit.

IV. Conclusions

This study looked at all behaviors performed by the elephants to determine which behaviors would be altered by a new enrichment regime. Although wild elephants spend the majority of time foraging, they engage in other behaviors such as self-maintenance behaviors, exploratory behaviors, drinking, and social behaviors (Moss, 1982; Shannon et al., 2008). These behaviors are important components of elephant life and although they may not be as relevant in captivity as they are in the wild, it is important that the implementation of feeding enrichment didn’t eradicate from the elephants’ repertoire entirely. While this study focused on reducing the occurrence of abnormal behaviors, it was necessary to analyze all behaviors to ensure increased foraging times weren’t reducing the performance of other species-typical behaviors to very low frequencies.

Previous studies have demonstrated the effective use of feeding enrichment as a means to provide both mental and physical challenges for captive animals (Chamove, 1989; Shepherdson et al., 1999; Shepherdson 1999, 2003; Stoinski et al., 2000). As expected, the introduction of feeding enrichment significantly increased the amount of time the elephants spent foraging, which altered the occurrence of other behaviors. Most prominently, a significant reduction in the performance of stereotypical behavior was displayed by the herd, by both sexes, and by three individuals (the other three experienced reductions but they were not found to be significant) during the enrichment condition. The performance of stereotypies is common among captive elephants
(Stoinski et al., 2000; Rees, 2004, 2009; Wilson et al., 2004; Greco et al., in press) and is suggestive of compromised welfare (Broom, 1983; Dawkins, 1990; Broom and Johnson, 1993; Lawrence and Rushen, 1993; Mason and Latham, 2004; Mason, 2006); hence, the aim of this study was to decrease the occurrence of these behaviors.

While, this researched focused on the reduction of stereotypical behavior, it also explored the occurrence of other abnormal behaviors as well as species-typical behaviors performed at higher than normal frequencies. Standing with trunk movement has not previously been described as a vacuum behavior but I argue that based on its seemingly aimless nature and its significant decrease during enrichment overall, it may be classified as one. Further examination into this behavior and other potential vacuum behaviors should be conducted as I could find no literature on vacuum behaviors in elephants.

Because standing with no trunk movement, which I categorized as inactivity, had an overall reduction in occurrence during enrichment, I suggest that introducing challenges associated with food procurement could be used to decrease the amount of time captive elephants spend inactive. Although, wild elephants do spend time inactive, its occurrence is at low levels (Gravett et al., 2017). Wild elephants encounter an abundance of social and sensory stimuli and are presented with several challenges that are absent in captivity. Reduction in the complexity the animals encounter can result in an increase in time spent inactive (Varadharajan et al., 2015). Moreover, increased inactivity in captive elephants has been linked to weight gain and obesity, arthritis, inflammation and eventual loss of joint cartilage, and foot ailments (Fowler, 1993).
V. Presence of Personality and its Management Implications

Elephants are intelligent, social and long-lived creatures and thus likely to display distinct personalities. Both their genetic makeup and unique personal histories will contribute to form each individual's disposition and temperament (Lee and Moss, 2012; Horback et al., 2013). The results from the study reveal the inconsistencies between the analyses of the elephants’ behaviors when data were combined and analyzed as a whole group or as one of the sexes as compared to when data were analyzed for each individual separately. This study revealed the individual variation in behavioral responses to the presence of feeding enrichment and how increased foraging times influenced each individual’s activity budget. These findings contribute to the growing literature on animal personality (Dingemanse and Réale, 2005) and should encourage the practice of individual assessments in future elephant management practices.

Although wild elephants spend the majority of their day foraging, other species-typical behaviors should be encouraged in captive settings. A large problem with implementing enrichment, particularly for elephants, is the large amount of time it takes and the high cost of enrichment items (Newberry, 1995). While establishing a schedule will be time consuming at first, rotating the paddocks in which the elephants reside could introduce sensory enrichment and could reduce the time dedicated to changing out enrichment items.

Even though the current study found no indication of inadequate levels of locomotion or self-maintenance behaviors, other zoos have introduced enrichment focused on promoting these behaviors as they are species-typical. One example is the creation of an elephant trail for the elephants to go for a walk; the National Zoo in Washington D.C.
introduced a quarter mile trail for the elephants to get more exercise in 2010 (National Zoo, 2010). While all AZA accredited elephant habitats have large swimming pools, possibly adding a shower to one or more of the paddocks where the elephants can regulate the water flow could promote both play behaviors and bathing while allowing the elephants to exert control over their environment.

Because enrichment items can be expensive, garnering the support of the community and local businesses can help ease the burden. Non-profits, like Hose2Habitat, teach courses on how to use out-of-commission fire house to create browsers (like the ones used for this study). Old fire hose can be collected from local fire stations. Another resource are car wash companies that could potentially donate used brushes that the elephants can rub against.

The time frame in which the study was conducted potentially introduced some biases and limitations; the time of year was different for baseline observations as compared to experimental control and enrichment which means differences in the weather, amount of time elephants spent in their paddocks, and hormones, all of which can influence the elephants’ behavior. Furthermore, I should have recorded how long the focal animal was in the paddock before the observation period began and recorded the total amount of time the individual was in the paddock to test whether either factor had an influence on behavior. This also could elucidate if some elephants spent more time in a paddock, and off exhibit, than others, which could potentially influence their behaviors.

Future work should concentrate on using personality trait rating (Horback et al., 2013) in collaboration with personalized activity budget monitoring to assess the well-being of each elephant and create customized care plans. Knowing an individual’s
personality, personal history and activity budget can help caretakers create and implement enrichment items that will best serve each elephant.
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Appendix I. Ethogram of African elephant behavior  
(* denotes behaviors not recorded during this study)

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Description</th>
<th>Category for Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mud bathing</td>
<td>Using trunk to scoop mud and sling onto body.</td>
<td>Self- Maintenance</td>
</tr>
<tr>
<td>Dust bathing</td>
<td>Using trunk to scoop dust and sling over body.</td>
<td>Self- Maintenance</td>
</tr>
<tr>
<td>Water bathing</td>
<td>Using trunk to expel water onto body.</td>
<td>Self- Maintenance</td>
</tr>
<tr>
<td>Rubbing/Scratching</td>
<td>Using objects in enclosure to rub up against in a back and forth manner.</td>
<td>Self- Maintenance</td>
</tr>
<tr>
<td>*Resting- Lying Down</td>
<td>No visible or audible interactions with conspecifics, environment or keepers.</td>
<td>Resting</td>
</tr>
<tr>
<td></td>
<td>No visible body movements.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Can be asleep or awake Lying down.</td>
<td></td>
</tr>
<tr>
<td>*Resting- Partial</td>
<td>No visible or audible interactions with conspecifics, environment or keepers.</td>
<td>Resting</td>
</tr>
<tr>
<td></td>
<td>No visible body movements.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Can be asleep or awake Partially lying down, head may be upright but body is touching the ground.</td>
<td></td>
</tr>
<tr>
<td>*Resting- Stand</td>
<td>No visible or audible interactions with conspecifics, environment or keepers.</td>
<td>Resting</td>
</tr>
<tr>
<td></td>
<td>No visible body movements.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Individual is standing.</td>
<td></td>
</tr>
<tr>
<td>Activity</td>
<td>Description</td>
<td>Category</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>Stand- with trunk movement</td>
<td>Standing in place and moving trunk without acting. Includes twisting of the trunk, touching top of head, moving trunk side to side or up and down.</td>
<td>Stand with Trunk Movement</td>
</tr>
<tr>
<td>Forage- Manipulation</td>
<td>Actions involved in altering food item before consumption; includes breaking apart, discarding specific parts, pulling apart.</td>
<td>Forage (Note diet type: Prepared diet, exhibit vegetation, browse, sand)</td>
</tr>
<tr>
<td>Forage- Consumption</td>
<td>The act of grabbing a food item and putting into the mouth and chewing.</td>
<td>Forage (Note diet type: Prepared diet, exhibit vegetation, browse, sand)</td>
</tr>
<tr>
<td>Pacing</td>
<td>Pacing back and forth between point A and B or in a circle.</td>
<td>Stereotypic Behavior</td>
</tr>
<tr>
<td>Rocking</td>
<td>Swaying back and forth with no locomotion.</td>
<td>Stereotypic Behavior</td>
</tr>
<tr>
<td>Other Repetitive Behavior</td>
<td>Other repetitive behavior whose cause and function are unknown.</td>
<td>Stereotypic Behavior</td>
</tr>
<tr>
<td>Circling</td>
<td>Turning in circle repetitively.</td>
<td>Stereotypic Behavior</td>
</tr>
<tr>
<td>Locomotion</td>
<td>Walking or running non-repetitively.</td>
<td>Locomotion</td>
</tr>
<tr>
<td>*Vocalization</td>
<td>Makes audible sound.</td>
<td>Vocalize</td>
</tr>
<tr>
<td>*Keeper Interaction</td>
<td>Interacting with a keeper.</td>
<td>Keeper Interaction</td>
</tr>
<tr>
<td>Interacting- Exhibit Structure</td>
<td>Interacting with permanent exhibit structures.</td>
<td>Abiotic Interaction</td>
</tr>
<tr>
<td>Interacting- Caging</td>
<td>Interacting with cage bars/fencing.</td>
<td>Abiotic Interaction</td>
</tr>
<tr>
<td>Interaction with Non-Feeding Enrichment Items</td>
<td>Manipulating any enrichment item (not associated with procurement of food)</td>
<td>Interaction with Non-Feeding Enrichment Items</td>
</tr>
<tr>
<td>*Agonism- Non- Contact</td>
<td>Threats (ears extended, charging, head shake, pursuit). No physical</td>
<td>Social (Note: Agonism/Affiliative, Contact/Non- Contact. If non-contact, note distance)</td>
</tr>
<tr>
<td>Behavior</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><em>Agonism- Contact</em></td>
<td>Aggressive behavior involving physical contact between individuals; including biting, head-butting, poking, striking with trunk, pushing.</td>
<td></td>
</tr>
<tr>
<td>Affiliative- Contact</td>
<td>Behaviors that involve any non-aggressive physical contact; including trunk placed within another elephant's mouth, trunks intertwining, touching another elephant without obvious use of force.</td>
<td></td>
</tr>
<tr>
<td><em>Displace</em></td>
<td>Focal elephant approaches another elephant, which then leaves its position; focal elephant assumes now vacant position.</td>
<td></td>
</tr>
<tr>
<td><em>Displaced</em></td>
<td>Focal elephant moves from its position as another elephant approaches it; the approaching elephant than assumes now vacant position.</td>
<td></td>
</tr>
<tr>
<td>Drinking</td>
<td>Drinking from exhibit pond or paddock drinker.</td>
<td></td>
</tr>
<tr>
<td>Other Solitary Behavior</td>
<td>Other solitary behaviors; including urinating, defecating.</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Elephant is engaging in any behavior that does not meet the above behaviors.</td>
<td></td>
</tr>
</tbody>
</table>
Appendix II. Dimensions of Feeding Enrichment Items

Listed in order of appearance in methods

1. Tree-climbing rope: 72 meters

2. Link Chain: four centimeters

3. Box-knot browsers:
   - Five: 106.68 centimeters long and 78.74 centimeters around with openings that were 2.24 centimeters tall and 8.89 centimeters wide
   - Five: 86.36 centimeters long and 73.66 centimeters around with 3.81 centimeters tall and 8.89 centimeters wide openings.
   - One: 85.09 centimeters long and 43.18 centimeters around with 2.54 centimeters tall and 10.16 centimeters wide openings.
   - One: 30.48 centimeters long and 30.48 centimeters around with openings that were 1.27 centimeters tall and 10.16 centimeters wide.

4. Tire and fire hose browser: two tires connected by 91.44 centimeters of fire hose

5. Cylindrical feeder tubes: Each was 86.36 centimeters long and 30.48 centimeters in diameter. One tube had ten 3.81-centimeter diameter holes and the other had ten 1.91-centimeter diameter holes. The 1.91-centimeter holes were too small to fit any elephant treats so two 5.08-centimeter diameter holes were made using a keyhole saw.

6. Holey Moley: The Holey Moley is a rectangular feeder made of polyethylene that is 116.84 centimeters by 91.44 centimeters by 15.24 centimeter with fifty-eight 7.62 centimeter holes. A 42.72-centimeter long and 7.62-centimeter-wide opening was made at the top by connecting previous holes using a saw.

7. Scent ball: 121.92-centimeter polyethylene scent ball with 1.91-centimeter holes