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Master Thesis

Olfactory Enrichment for Captive Snow Leopards (*Uncia uncia*)

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Sammanfattning
Abstract:
In this study I assessed the effect of objects and odors as environmental enrichment for two captive snow leopards (*Uncia uncia*) at Kolmården Wildlife Park. Five odors (lavender, lemon balm, cumin, cinnamon and catnip) were used to impregnate four different types of enrichment objects (boomer balls®, tennis balls, ropes, logs). During test sessions, one odorized and one non-odorized enrichment object of the same type were introduced in the snow leopards' outdoor enclosure. The behavior, activity and location of the snow leopards were recorded and compared to their behavior during baseline sessions. During the test sessions I recorded the number and types of interactions with the enrichment objects. Both snow leopards interacted more often with odorized than with non-odorized enrichment objects. The number of interactions differed markedly between the types of enrichment objects and between the different odors. Both snow leopards interacted most often with boomer balls® and least often with logs. They interacted most often with cinnamon and least often with lemon balm (Brahma) and catnip (Binu). The results suggest that both the type of object and the odor play a role in capturing the interest of the snow leopards. The snow leopards behavioral diversity increased during the study and they could increase their performance of species-specific behavior. I did not see any indications of habituation during the testing period. The results indicate that enrichment objects impregnated with odors can be an effective environmental enrichment for captive snow leopards.

Nyckelord
Keyword:
environmental enrichment, felid, odor, olfaction, snow leopard (*Uncia uncia*)

Contents

1 Abstract

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Keywords: environmental enrichment, felid, odor, olfaction, snow leopard (*Uncia uncia*)

2 Introduction

2.1 Environmental enrichment

Environmental enrichment is a concept that describes how the environment of captive animals can be changed to better suit the inhabitants, taking their natural history and behavioral biology into consideration (Young, 2003). The five main goals that environmental enrichment is meant to achieve are: to increase behavioral diversity, to reduce the frequency of abnormal behavior, to increase the range or number of natural behavior patterns, to increase positive utilization of the environment and to increase the ability to cope with challenges in a more normal way. Meeting these goals ensures that the basic goal of animal welfare, which is to maintain the animals in good physical and psychological health, is met.

There are two different approaches to environmental enrichment, the naturalistic approach and the behavioral engineering approach (Young, 2003). These approaches do not oppose each other, but should rather be used together to make the habitat of captive animals as complete as possible. The naturalistic approach tries to create an environment that is similar to the animals´ natural habitat. This approach relies on the external stimuli to promote the animal to perform natural behavior patterns. It is a useful approach when dealing with environmental education and it is used for most species at Kolmården Wildlife Park. However, many behavior patterns are motivated by internal stimuli and then the behavioral engineering approach can be a good way to complement the habitat. In this approach artificial devices are used to elicit the animal to perform natural behavior patterns. Some devices elicit new behaviors which increases the behavioral diversity of the animal.

The greatest challenge for the zoos today is to provide environments that conserve both the animals´ behavior and genes. Environmental enrichment can play a crucial role in the conservation of natural behavior (Young, 2003).

2.2 The biology of snow leopards

The snow leopard is a large felid native to the mountain ranges of central Asia (Miller and Everett, 1986). Snow leopards live in the alpine and the subalpine ecological zones and are associated with broken, rocky terrain with shrubs and grasses as the dominating vegetation (McCarthy and Chapron, 2003). The estimated total population of snow leopards in the wild is between 4000 and 7500 individuals and they are classified as endangered on the *IUCN Red list of Threatened Species*. Some of the threats for the survival of snow leopards include reduction in natural prey, poaching for fur and poaching in retribution for killing domestic animals (McCarthy and Chapron, 2003).

Wild snow leopards are opportunists and have a very diverse diet with the main prey being mountain wild goats and sheep (*Capra ibex, Capra falconeri, Hemitragus jemlahicu, Ovis musimon*) (Hemmer, 1972). Snow leopards are solitary but home ranges of several individuals in the wild have been found to overlap substantially (McCarthy and Chapron, 2003). Snow leopards use scent markings to communicate with conspecifics and the frequency of markings is intensified during the mating season, which occurs between late January and mid-March (McCarthy and Chapron, 2003).

2.3 Olfaction in felids

Olfaction plays an important role in the every-day life of many mammals (Wilson and Stevenson, 2006). Mammals use olfaction to find food, identify mates, recognize kin, avoid predators, for territorial marking, homing and navigation (Wilson and Stevenson, 2006). Like most mammals, felids have two olfactory systems; the main olfactory system and the vomeronasal system (Conover, 2007). In mammals the main olfactory system samples the air for information about food, predators etc. whereas the vomeronasal system primarily samples for species-specific pheromones involved in endocrine responses and reproductive behaviors (Conover, 2007). Both olfactory systems are used to identify odors that the mammalian body produces. The major sources of these odors are the skin, the salivary glands, urine and vaginal secretions (Stoddart, 1980). Some of the skin glands are specialized to produce pheromones, which are used to communicate with conspecifics (Conover, 2007).

Felids mark their territories with scent and use their sense of smell to recognize sex and reproductive state in other individuals (Hairston, 1994). The main types of scent markings in felids are scratching trees, rubbing cheeks against objects and depositing urine by spray marking and urination (Feldman, 1994, citied by Funding, 1998). Poddar-Sarkar and Brahmachary (2004) concluded that scent marking presumably is the primary means of communication in wild leopards *(Panthera pardus),* tigers *(Panthera tigris)* and cheetas *(Acinonyx jubatus).*

Felids do not use olfaction to find food to the extent that canids do (Conover, 2007); when they hunt they primarily use their vision (Schuett and Frase, 2001).

2.4 Olfactory enrichment for captive felids

Captive carnivores are arguably the most difficult animals to develop environmental enrichment plans for (Shepherdson et al., 1998). These animals are often solitary hunters that roam large areas in their search for food and possible mates in the wild. It is impossible to meet those conditions in captivity, but the animal welfare can be increased by using environmental enrichment. Different types of olfactory enrichment have been shown to increase activity and to decrease stereotypic behavior in several species of captive felids (Baker et al., 1997; Schuett and Frase, 2001; Skibiel et al., 2007; Zar et al., 2005).

Enrichment objects and devices of various kinds have been shown to be an effective way to increase behavioral diversity and to promote performance of natural behavior in captive felids (Bosso, 2004; Hare et al., 1998; Jones, 2005; Mohnkern, 1999).

The odors that I tested with the snow leopards had been used in a similar study on seven adult lions (*Panthera* leo) performed by Mohnkern (1999). She recorded the behavior of the lions towards hanging sand-filled bags, hanging coconuts, watermelons, logs and sand on the ground. The objects were odorized with cumin, cardamom, cinnamon, lavender or citronella or were non-odorized. The lions interacted markedly more often with odorized than with non-odorized objects.
Based on this, I chose to provide enrichment objects impregnated with odors, using the behavioral engineering approach. The objects I used in this project were all artificial and the odors I used were not odors that snow leopards would come across in the wild. The means of presentation (on the ground or hanging above ground) and the texture of the enrichment objects differed to provide the snow leopards with tactile as well as visual and olfactory stimuli.
I chose to test catnip instead of cardamom, since catnip is known to stimulate an "innate releasing mechanism" (IRM), which elicits predictable playful behavior in domesticated cats (Hill et al., 1976). In large felids the responsiveness to catnip has been shown to be species specific (Hill et al., 1976), but no scientific studies have been performed on snow leopards.

2.5 Aim of the study
The aim of this study was to assess the effect of objects and odors as environmental enrichment for two captive snow leopards in Kolmården Wildlife Park.

3 Materials and methods

3.1 Snow leopards
The study was performed on two adult snow leopards in Kolmården Wildlife Park. The male, Brahma, was born in 2004 in Nordens Ark Animal Park in Sweden, and the female, Binu, was born in 2003 in Marwell Zoological Park in England, see figure 1. Both snow leopards arrived in 2006.

Figure 1.The snow leopards Brahma (left) and Binu (right).

3.2 Animal facilities

The snow leopards were kept in an outdoor enclosure with an area of 3000 m^2, in which the tests were carried out between June and September 2008. The snow leopards also had temporary access to an indoor enclosure with an area of 80 m^2. The door to the indoor enclosure was closed during the opening hours of the park in June, July and August, but open during the nights. In September the door was open during the days as well as the nights. For a schematic drawing of the enclosures of the snow leopards, see figure 2.

Figure 2. A schematic drawing of the outdoor and indoor enclosures of the snow leopards.1: the shelf, 2: high mountain, 3: the ground, 4: the indoor enclosure, 5: by window, 6: the litter box, 7: the recording site and 8 marks the line from which the tennis balls were lowered into the enclosure.

3.3 Management

The snow leopards were fed three times a week; on Tuesdays, Thursdays and Saturdays. They were given whole body meat; horse, chicken or deer, with vitamins and minerals on it, on the ground or hanging from the log. The snow leopards were fed on different times of the day so that they would not predict the feeding time.

On feeding days the snow leopards were usually brought inside around 08:30 in the morning, so that the animal caretakers could go into the outdoor enclosure. To bring the animals in, the animal care takers called out their names and whistled for them, and most of the times the snow leopards came inside voluntarily and got some small pieces of meat as a reward. If they did not come inside there was nothing to do. When the care takers were in the outside enclosure they cleaned the windows, picked up old bones and made sure that there were no harmful objects in the enclosure.

3.4 Experimental material

3.4.1 Odors

The odors that I used were lavender *(Lavandula augustifolia)*, lemon balm (*Melissa officinalis*), cumin *(Cuminum cyminum)*, cinnamon *(Cinnamomum verum)* and catnip *(Nepeta cataria)*. The lavender, lemon balm and catnip were dried leaves; the cinnamon and cumin were grinded.

3.4.2 Enrichment objects

I used four different types of enrichment objects: one red and one blue plastic boomer ball® with a roughened surface, 25 cm in diameter and made of 6 mm thick polyethylene, 6 big tennis balls, 10 cm in diameter that were attached to strings, 6 rope toys which were 30 cm long with knots and made of cotton fibers, and 6 wooden logs, 60 cm long and 5 cm in diameter, see figure 3.

There was one enrichment object for every odor and one object as a control for all kinds of objects, except for the boomer balls®. The blue boomer ball® was used as a control and the red one was impregnated with the different odors. Both boomer balls® were washed thoroughly after every test session.

Figure 3. The enrichment objects used, from the left: boomer balls®, tennis balls, rope and log.

3.5 Experimental procedure

I grinded the odors that were dried leaves with a pestle, and mixed 5 ml of grinded odor with 10 ml of water. I used a toothbrush to impregnate the objects with the odors.

When the snow leopards were taken inside in the morning, I went into the outdoor enclosure and placed the objects for that testing day and retrieved the objects from the day before. On every testing day, I placed two objects of the same type in the enclosure of the snow leopards; one impregnated with one of the odors and one non-odorized. I placed the objects in different locations on every testing day, with the limitation that I could see them clearly from my observation site. I always placed the boomer balls® in the litter box to minimize the risk of them rolling into the water.

If the snow leopards were not taken inside I threw the objects into the enclosure from the roof above the enclosure. The tennis balls could be lowered into the enclosure without having to bring the snow leopards inside. They were presented hanging at a height of 50 cm above ground at the end of ropes.

I spread the tests so that the same odor or same enrichment object never were presented on consecutive days and I performed no testing on rainy days, since the rain could wash away the odors from the objects.

I tested the boomer balls® and the rope toys three times with all five odorants resulting in 12 hours of recording per combination. I tested the logs and tennis balls two times with all five odorants resulting in 8 hours of recording per combination. The total number of testing days was 50.

3.6 Recordings

I recorded the behavior of the snow leopards for two hours in the morning and for two hours in the evening. During the first months I recorded between 09:00 and 11:00 in the morning and between 19:00 and 21:00 in the evening. At the end of august I had to change the recording time in the evening since it became darker. At the end of September I recorded between 17:00 and 19:00 in the evening. I recorded the activity and location of the snow leopards with instantaneous sampling every five minutes. Table 1 summarizes the different types of activity and table 2 summarizes the locations inside the enclosure. All interactions with enrichment objects were videotaped. These interactions as well as other behaviors were timed and recorded using continuous sampling. Table 3 summarizes the recorded behaviors.

Table 1. The types of activity of the snow leopards.

Activity	Description
Moving	the animal is moving around includes both walking and running.
Standing	the animal is supporting itself on all four legs, without moving around.
Sitting	the animal is resting on its hind legs with its fore legs extended vertically.
Lying	the animal is reclining on its ventrum, its side or its back.
Out of sight	the animal cannot be seen from the recording site.

Table 2. The location of snow leopards in the enclosure.

Location	Description
Shelf	on the stone shelf on the mountain
High mountain	on the surface highest up on the mountain
Under mountain	under the roof on the mountain
Under log mountain	under the log on the right side of the mountain
Roof mountain	on the roof on the mountain
Low mountain	on the lower parts of the mountain
Log	on the log on the mountain
By log	beside the log on the mountain
Ground	on ground level in the enclosure
Inside	in the inside enclosure
In by door	the animal is inside near the door
Den	in the den located near the log on the mountain
By door	outside but near the door to the inside quarters
By service door	near the door the humans use to enter the outdoor enclosure

House	inside the house on the ground
Roof house	on the roof of the house
By window	very near the window
Rock by window	on the rock near the window
Litter box	the area covered with wooden chips
Rock in water	on the rock that is surrounded by water
Out of sight	the animal cannot be seen from the recording site

Table 3. The behaviors that were recorded.

Behavior	**Description**
Marking behaviors:	
Scrape urination	the animal makes a scraping movement with its hind paws, before urinating
Spray marking	the animal stands with the tail raised towards an object and ejects a spray of urine
Urination	the animal squats down and urinates.
Scrape	the animal uses its front paw to move loose material on the ground
Cheek rubbing	the animal rubs its cheeks against an object many times
Investigative behaviors:	
Sniffing	the animal uses its nose to investigate an object
Flehmen	the animal raises its upper lip and ejects its tongue in order to investigate the substance with its vomeronasal organ
Licking	the animal uses its tongue to investigate an object
Social behaviors:	
Autogrooming	the animal is licking its own fur
Allogrooming	the animal is licking the fur of the other animal
Head rubbing forehead	the animal rubs its cheeks or forehead against the other animal's cheeks or
Body rubbing	the animal slides along the body or head of the other animal, rubbing its body against parts of the other animal in the process
Aggression mild	all types of threats: striking with paws, showing of teeth without actual contact with the conspecific
Aggression serious	contact with either teeth or paws with the conspecific
Play behaviors:	

Play biting	biting the other individual during play
Play	chasing or running from another individual in a playful manner
Play attack	invites the other individual to play by attacking it
Play jump	jumping right up without target
Play wrestle	the animals play in a wrestling manor
Play hitting	hitting the other individual during play, without any sign of aggression
Behaviors towards enrichment objects:	
Approaching	approaching an enrichment object from the distance of at least one body length
Carrying	using its mouth and teeth to move an enrichment object
Manipulating	interacting with an enrichment object but impossible to see in detail
Hold	the animal uses one or both front paws to hold an enrichment object
Lift ground	the animal uses one or both front paws to lift an enrichment object above the
Ball walking	the animal uses both front paws to walk on one of the boomer balls®
Other behaviors:	
Biting	biting an object or another individual
Hitting	hitting an object or another individual
Dragging	using teeth or paws to drag an object on the ground
Rolling	lying and rolling from one body side to the other
Jump window	jumping towards the window and walking on the window pane
Scrape window	using front paws to scrape on the window
Pacing	walking stereotypically back and forth alongside the window
Long pace	walking from the window out on the rocks where the animal turns and walk back again
Eat	consuming food
Drink	drinking water
Vocal	all kind of sounds the snow leopards produce

3.7 Baseline study

I conducted a baseline study where I recorded the activity, location and behavior of the snow leopards during seven days, spread over the testing period. I recorded four hours per day, two in the morning and two in the evening. I used the same method and recorded the same behaviors as during the test sessions.

3.8 Statistical analysis

3.8.1 Activity and location

All statistical analysis was done separately for the two snow leopards.
To assess possible effects of the environmental enrichment on the snow leopards activity level, I calculated the percentage of time per hour that the animals performed the different types of activity. I compared the activity during the baseline sessions, consisting of seven days, to the activity during seven randomly chosen testing days.
To assess whether the snow leopards significantly changed their activity during the test sessions compared to the baseline sessions, I compared the same type of activity between the baseline sessions and the test sessions using a Wilcoxon signed rank test. I did the same with the locations and analyzed the seven locations that were most frequently visited.
To assess if the snow leopards were performing any type of activity more than another, I used a Wilcoxon signed rank test, to compare the different types of activity performed for test sessions and baseline session respectively.

3.8.2 Enrichment objects and odors

The videotaped interactions with the enrichment objects were analyzed using The Observer ® XT 9.0, © Noldus Information Technology. I included all behaviors performed towards the enrichment objects in the category named "interacting" and calculated the number of interactions per hour for every test session. I then calculated the mean frequency (times per hour) of interacting with every combination of enrichment object and odor. This data was then used in further analysis.
In order to assess whether there was a difference in the interest towards different types of enrichment objects, I calculated the mean frequency (times per hour) and the standard error of interacting with all objects of the same type. I used a Mann-Whitney U-test to assess possible significant differences in interacting with the different types of objects.
In order to assess whether there was a difference in interest towards odorized or non-odorized objects in general, I conducted a Wilcoxon signed rank test on the data of interacting with all odorized objects and all non-odorized objects.
In order to assess whether there was a difference in the interest towards odorized and non-odorized enrichment objects of the same type, I calculated the mean frequency (times per hour) and the standard error of interacting with odorized and non-odorized objects of the same type. I conducted a Wilcoxon signed rank test for every combination of odorized and non-odorized objects of the same type.
In order to assess whether there was a difference in the interest towards the different odors, I calculated the mean frequency (times per hour) and the standard error of interacting with enrichment objects impregnated with the same odor, irrespective of the type of object. I used a Wilcoxon signed rank test to assess possible significant differences in the number of times the snow leopards interacted with the different odors.

4 Results

4.1 Comparison of activity during baseline and test sessions

In figure 4, Brahma's activity during baseline sessions and test sessions is displayed.
Brahma spent most of his time lying. Brahma spent significantly more time lying than any of the other behaviors during baseline sessions (lying versus moving $p=0.007$, standing $p=0.002$, sitting $p=0.003$, out of sight $p=0.044$) and test sessions (lying versus moving $p=0.0019$, standing $p=0.001$, sitting $p=0.002$, out of sight $p=0.002$). There were no significant differences in Brahma's activity between baseline sessions and test sessions.

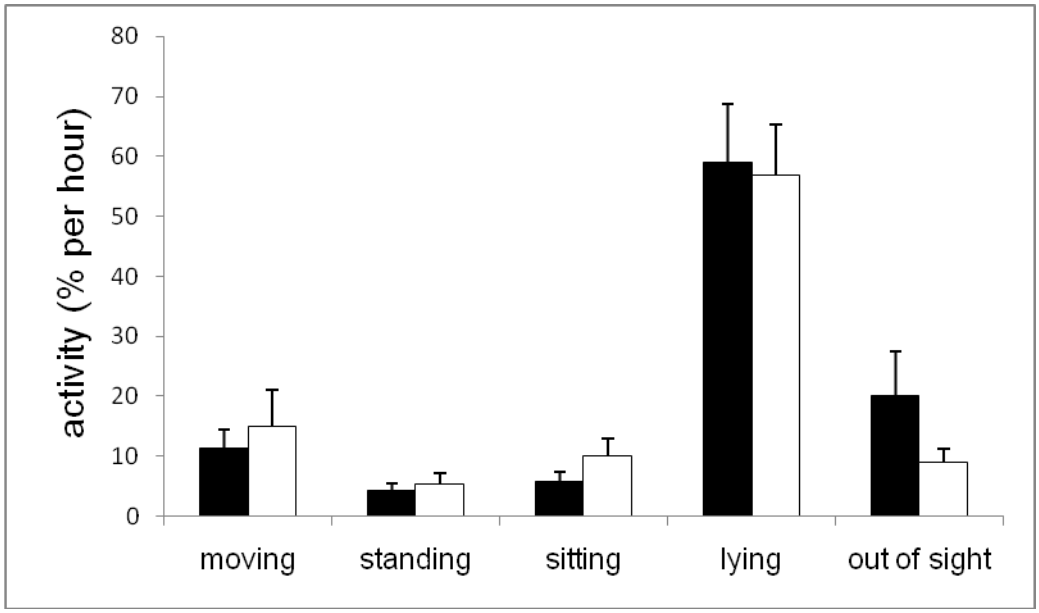

Figure 4. The activity of Brahma during test session (black bars) and baseline sessions (white bars). Values are presented as mean ± SEM. *p< 0.05, ** p< 0.01, *** p< 0.001

In figure 5, Binu's activity during baseline sessions and test sessions is displayed.
Binu spent most of her time lying. Binu spent significantly more time lying than any of the other behaviors during baseline sessions (lying versus moving p=0.001, standing p=0.001, sitting p=0.001, out of sight p=0.018) and test sessions (lying versus moving p=0.0001, standing p=0.001, sitting p=0.001, out of sight p=0.001). Binu was sitting significantly more during baseline sessions compared to test sessions (p=0.044). There was a trend that Binu was out ot of sight more during test sessions than during baseline sessions (p=0.054).

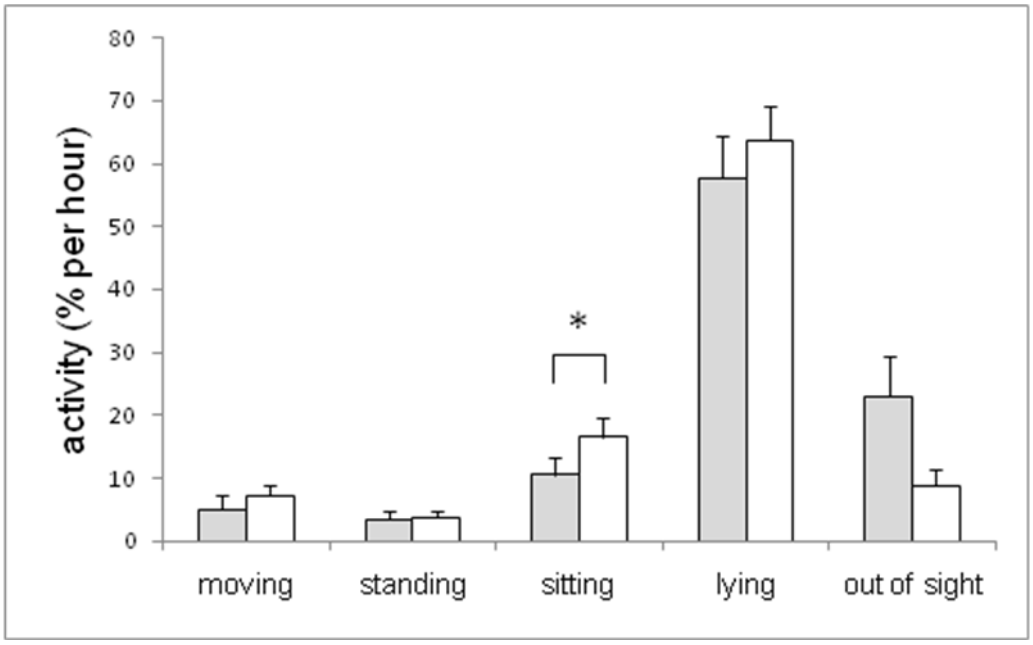

Figure 5. The activity of Binu during test sessions (grey bars) and baseline sessions (white bars). Values are presented as mean ± SEM. *p< 0.05, ** p< 0.01, *** p< 0.001

4.2 Comparison of location during baseline and test sessions

In figure 6, Brahma's location during baseline sessions and test sessions is displayed.
Brahma spent most of his time on the shelf during both baseline and test sessions. There were no significant differences Brahma's location between baseline sessions and test sessions.

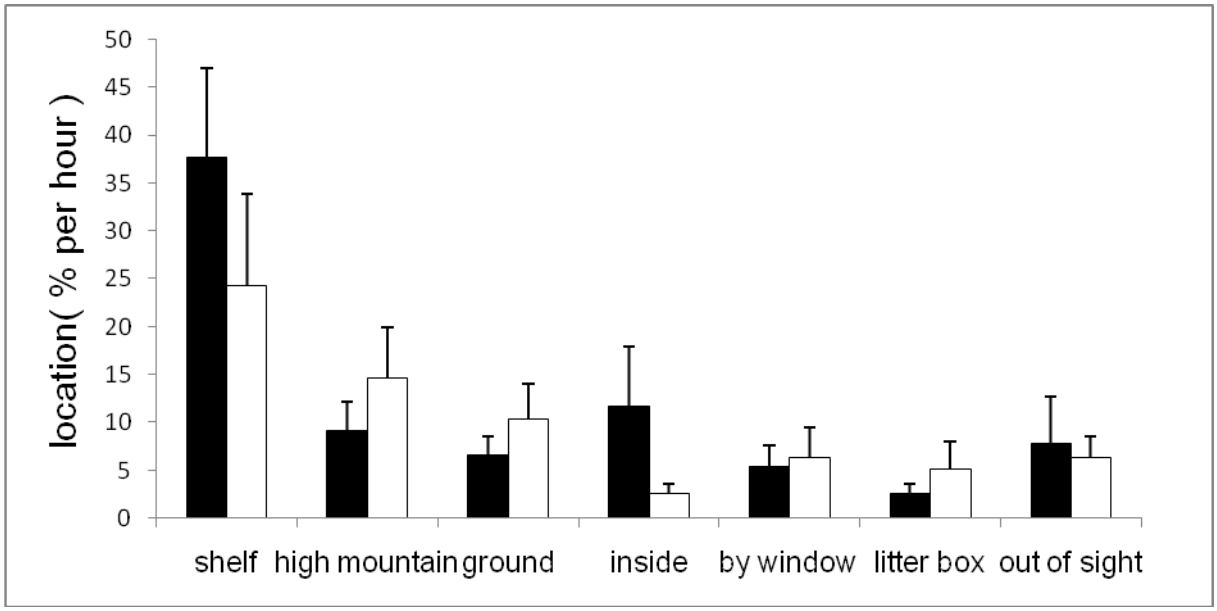

Figure 6. The location of Brahma during test sessions (black bars) and baseline sessions (white bars). Values are presented as mean ± SEM. *p< 0.05, ** p< 0.01, *** p< 0.001

In figure 7, Binu's location during baseline sessions and test sessions is displayed.
Binu spent most of her time on the shelf and on the high mountain. Binu spent significantly more time on the ground during baseline sessions than during test sessions (p= 0.016).

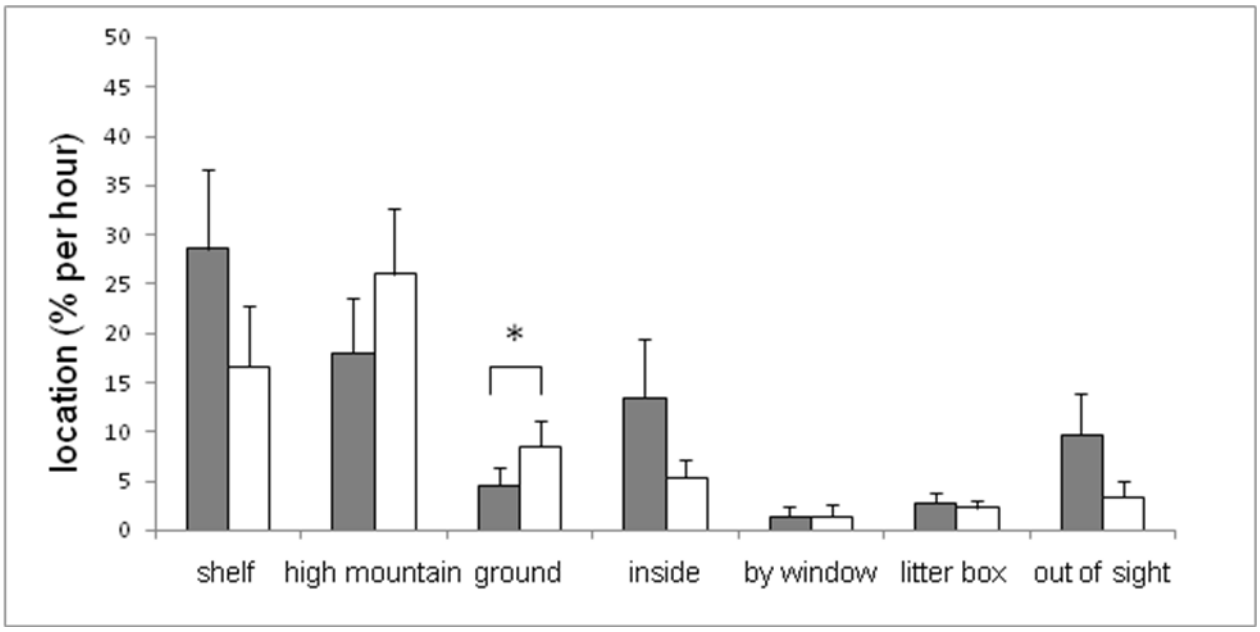

Figure 7. The location of Binu during test sessions (grey bars) and baseline sessions (white bars). Values are presented as mean ± SEM. *p< 0.05, ** p< 0.01, *** p< 0.001

4.3 Comparison of interactions with different types of enrichment objects

In figure 8, Brahma's interactions with the different types of enrichment objects, irrespective of if they were odorized or non-odorized, are displayed.

There were marked differences in the frequency Brahma interacted with the different types of enrichment objects. Brahma interacted most often with boomer balls® and least often with logs. Brahma interacted significantly more often with boomer balls® than with logs (p=0.0001), tennis balls (p=0.0007) and ropes (p= 0.0041). Brahma interacted significantly more often with ropes than with logs (p=0.0105). Comparisons between the other types of enrichment objects failed to find any significant differences.

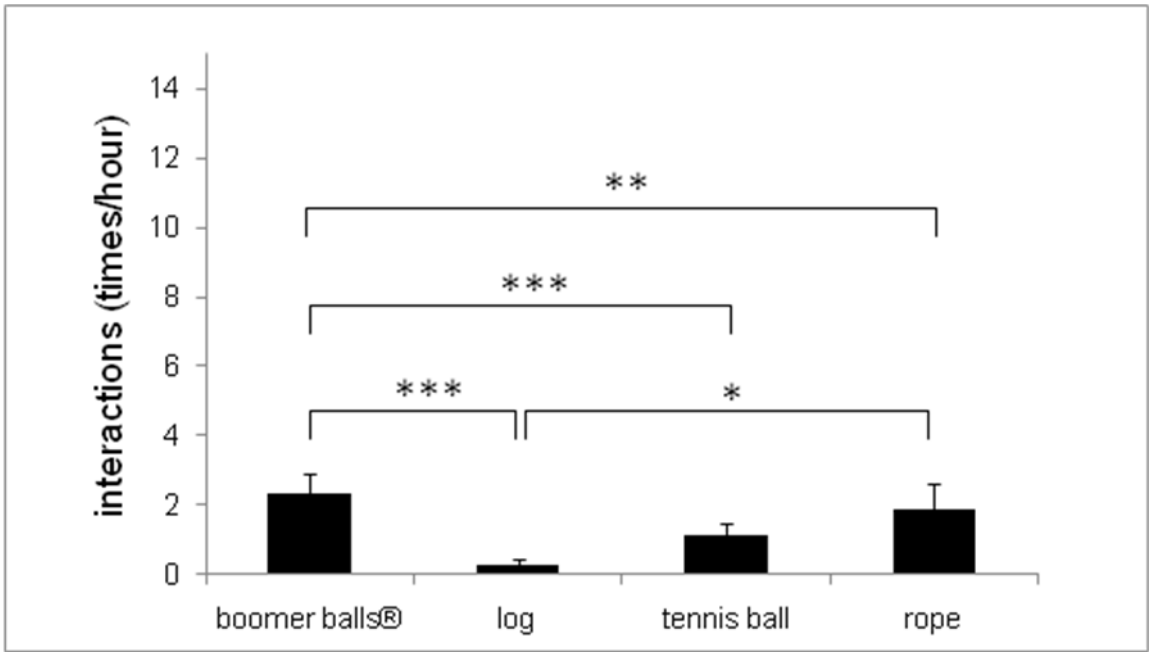

Figure 8. Interactions made by Brahma with enrichment objects of different type, irrespective of if they were odorized or non-odorized. Values are presented as mean ± SEM. *p< 0.05, ** p< 0.01, *** p< 0.001

In figure 9 Binu's interactions with the different types of enrichment objects, irrespective of if they were odorized or non-odorized, are displayed.

There were marked differences in the frequency Binu interacted with the different types of enrichment objects. Binu interacted most often with boomer balls® and least often with logs. Binu interacted significantly more often with boomer balls® than with logs (p=0.0001), tennis balls (p=0.0001) and ropes (p= 0.0001). Comparisons between the other types of enrichment objects failed to find any significant differences.

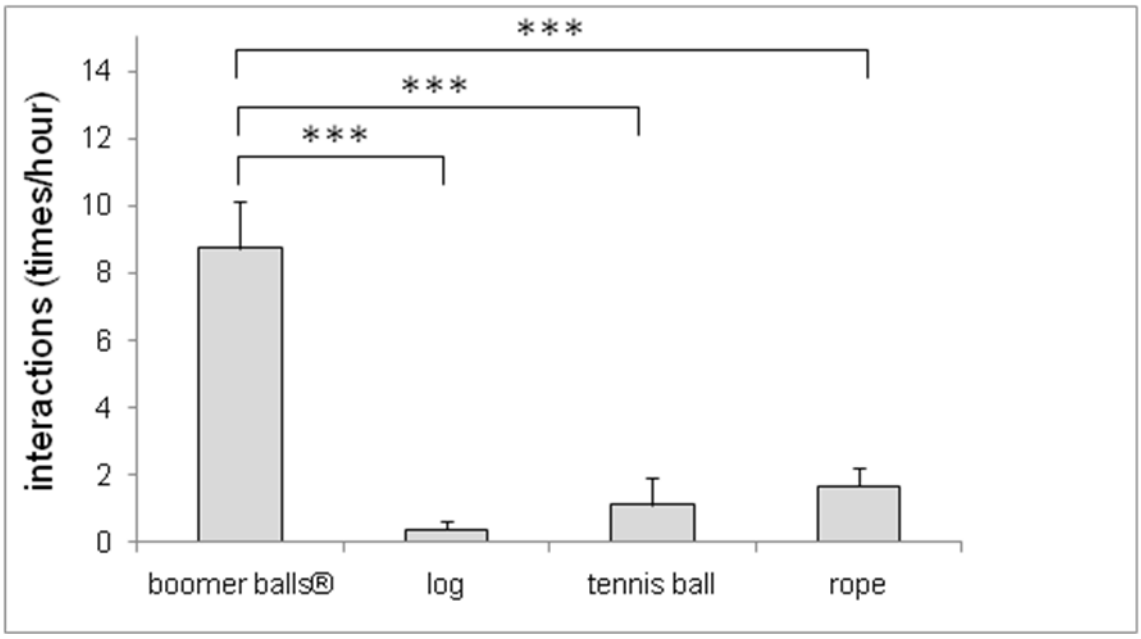

Figure 9. Interactions made by Binu with enrichment objects of different type, irrespective of if they were odorized or non-odorized. Values are presented as mean ± SEM. *p< 0.05, ** p< 0.01, *** p< 0.001

4.4 Comparison of interactions with odorized and non-odorized enrichment objects

In figure 10, interactions made by both individuals towards odorized and non-odorized enrichment objects, are compared.

Both individuals interacted significantly more often with odorized objects than with non-odorized objects, (p=0.0001 for Brahma and p=0.0012 for Binu).

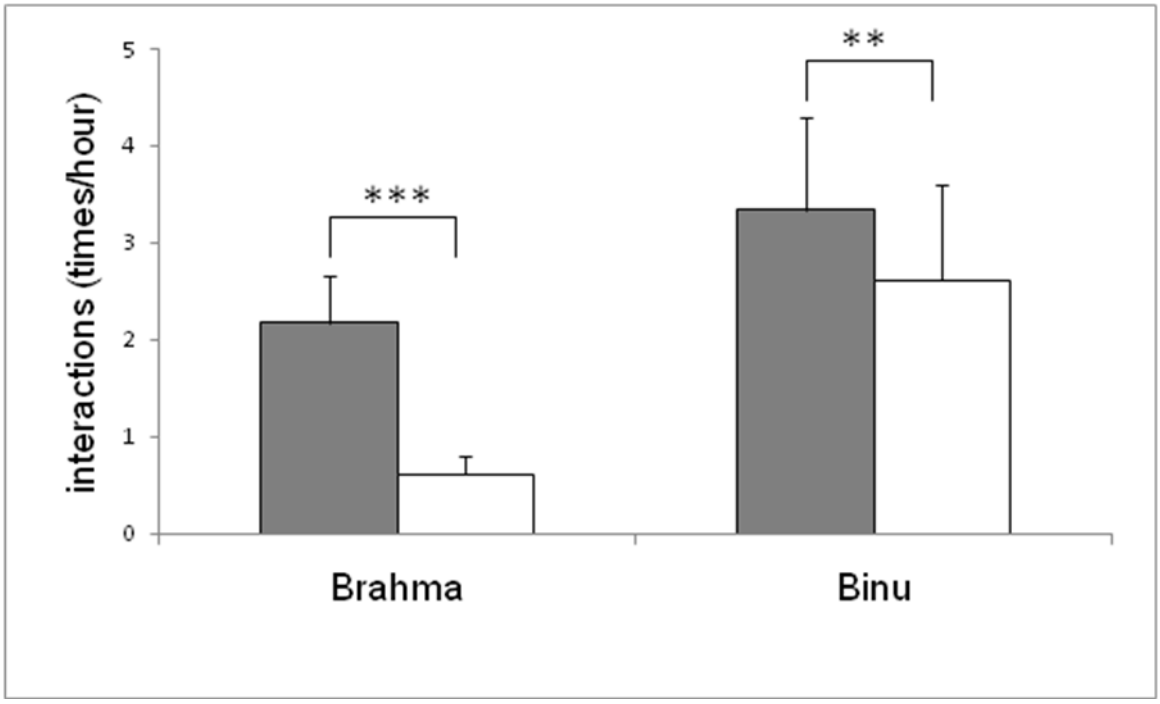

Figure 10. Interactions with all odorized enrichment objects (grey bars) and with all non-odorized enrichment objects (white bars). Values are presented as mean ± SEM. *p< 0.05, ** p< 0.01, *** p< 0.001

4.5 Comparison of interactions with odorized and non-odorized enrichment objects of the same type

In figure 11, Brahma's interactions with odorized and non-odorized enrichment objects of the same type, are compared.

There were marked differences in the frequency that Brahma interacted with odorized and non-odorized enrichment objects of the same type. Brahma interacted most often with odorized boomer balls® and odorized ropes and least often with non-odorized logs. Brahma interacted more often with the odorized than the non-odorized enrichment object for all types of enrichment objects.

Brahma interacted significantly more often with odorized boomer balls® than with non-odorized boomer balls® (p=0.0006), significantly more often with odorized tennis balls than with non-odorized tennis balls (p=0.0026) and significantly more often with odorized ropes than with non-odorized ropes (p=0.0006). There was no significant difference in the amount of interactions with odorized and non-odorized logs.

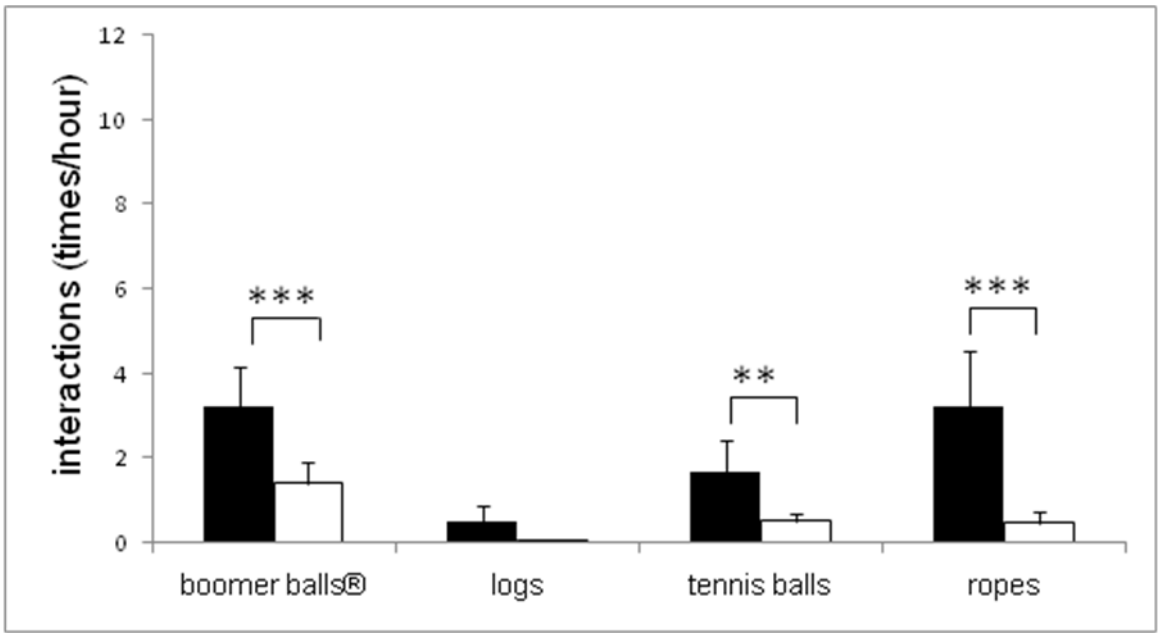

Figure 11. Interactions made by Brahma with odorized enrichment objects (black bars) and with non-odorized enrichment objects (white bars). Values are presented as mean ± SEM. *p< 0.05, ** p< 0.01, *** p< 0.001

In figure 12, Binu's interactions with odorized and non-odorized enrichment objects of the same type, are compared.

There were some differences in the frequency that Binu interacted with odorized and non-odorized enrichment objects of the same type. Binu interacted most often with odorized and non-odorized boomer balls® and least often with odorized and non-odorized logs.

When I compared the same type of enrichment objects to each other, Binu interacted more often with odorized tennis balls than with non-odorized tennis balls and more often with odorized ropes than with non-odorized ropes. Binu interacted significantly more often with odorized ropes than with non-odorized ropes (p=0.0033). There was no significant difference

in the interactions with odorized and non-odorized boomer balls®, odorized and non-odorized logs, and odorized and non-odorized tennis balls.

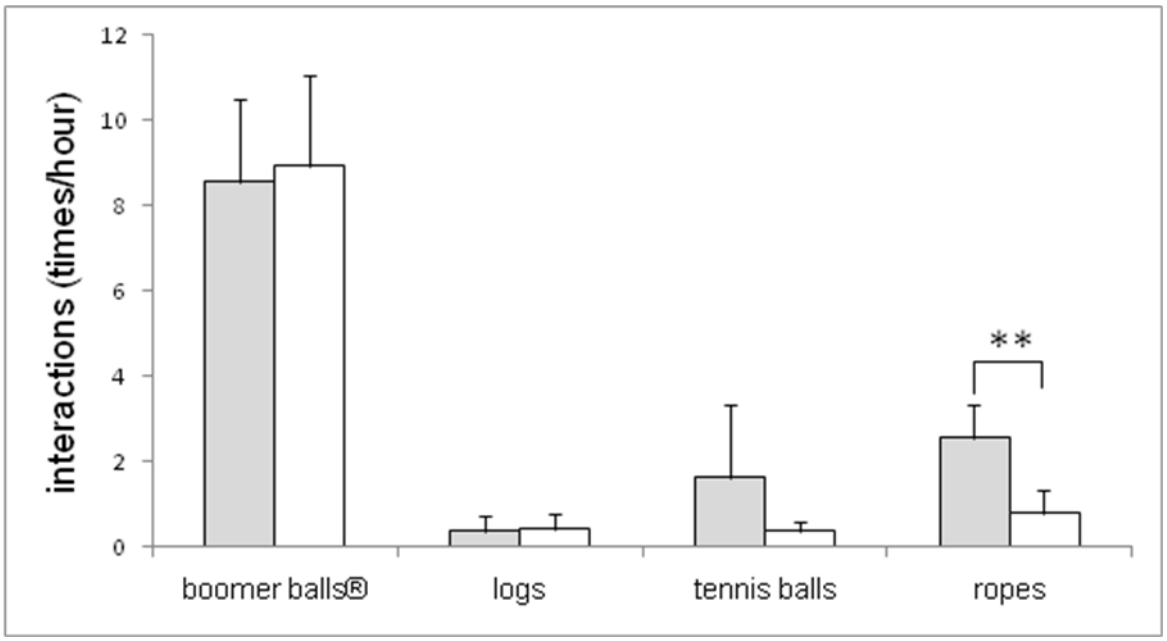

Figure 12. Interactions made by Binu towards odorized enrichment objects (grey bars) and with non-odorized enrichment objects (white bars). Values are presented as mean ± SEM. *p< 0.05, ** p< 0.01, *** p< 0.001

4.6 Comparison of interactions with different odors

In figure 13, Brahma's interactions with all enrichment objects, irrespective of type, impregnated with the same odor, are displayed.

There were marked differences in the frequency Brahma interacted with objects impregnated with the different odors. Brahma interacted most often with objects impregnated with cinnamon and lavender and least often with objects impregnated with lemon balm. Brahma interacted significantly more often with enrichment objects impregnated with cinnamon than with lemon balm (p=0.0044) and cumin (p=0.0125). Further, Brahma interacted significantly more often with enrichment objects impregnated with lavender than with lemon balm (p=0.0163) and cumin (p=0.0076).

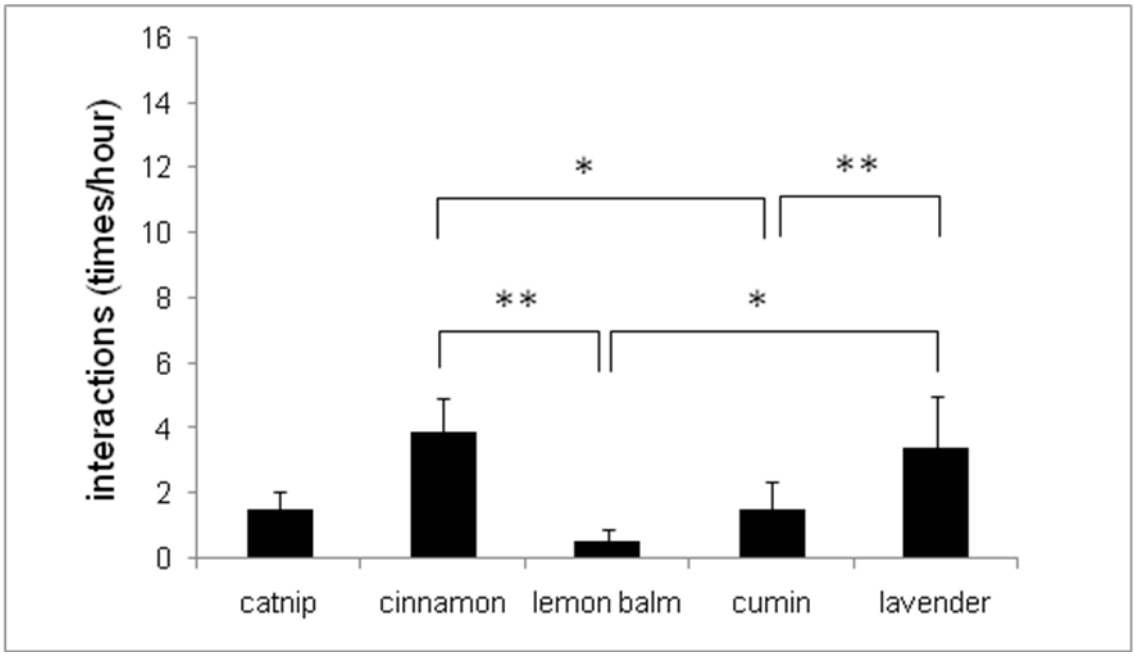

Figure 13. Interactions made by Brahma with all enrichment objects, irrespective of type, impregnated with the same odor. Values are presented as mean ± SEM. *p< 0.05, ** p< 0.01, *** p< 0.001

In figure 14, Binu's interactions with all enrichment objects, irrespective of type, impregnated with the same odor, are displayed.
There were marked differences in the frequency Binu interacted with objects impregnated with the different odors. Binu interacted most often with objects impregnated with cinnamon and least often with objects impregnated with catnip. Binu interacted significantly more often with enrichment objects impregnated with cinnamon than with catnip (p=0.005), lemon balm (p=0.005), cumin (p=0.005) and lavender (p=0.0217). Further, Binu interacted more often with enrichment objects impregnated with lavender than with lemon balm (p=0.0394) and there was a trend that Binu interacted more often with enrichment objects impregnated with lavender than with catnip (p=0.0679).

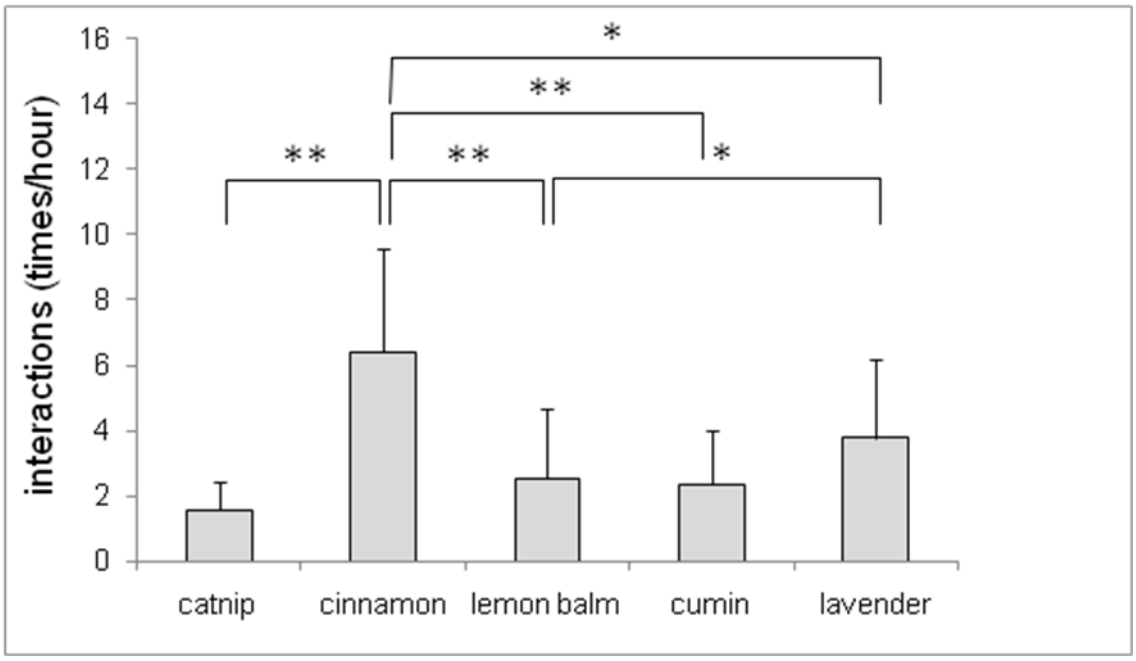

Figure 14. Interactions made by Binu with all enrichment objects, irrespective of type, impregnated with the same odor. Values are presented as mean ± SEM. *p< 0.05, ** p< 0.01, *** p< 0.00

5 Discussion

5.1 Main findings

The two snow leopards interacted more often with odorized than with non-odorized enrichment objects. They both interacted most often with objects impregnated with cinnamon and they both interacted most often with boomer balls®. These findings indicate that certain enrichment objects and odors are more effective as environmental enrichment than others for the two snow leopards.

5.2 The goals of environmental enrichment

There are five main goals that environmental enrichment is meant to achieve according to Young (2003). They are to increase behavioral diversity, to reduce the frequency of abnormal behavior, to increase the range or number of natural behavior patterns, to increase positive utilization of the environment and to increase the ability to cope with challenges in a more normal way.

In this study I did not investigate the possibility of the environmental enrichment to achieve all these goals but at least two of them have been met.

The behavioral diversity of the snow leopards was increased, since the snow leopards executed new behaviors while interacting with the objects during the test sessions. One example of such a new behavior was ball walking.

The goal to increase the number of natural behavior patterns was met, since the enrichment objects allowed the snow leopards to perform natural behaviors such as playing, play wrestling, chin rubbing, licking, sniffing etc.

By meeting two of the goals of environmental enrichment, the welfare of the snow leopards was possibly increased during the testing period. I did not see any signs of habituation to the objects or the odors during the testing period, which suggests that an interval of approximately one week for presentation of the same object or odor was suitable to keep the

snow leopards interested in the environmental enrichment throughout the testing period of four months.

5.3 Activity and location

Snow leopards are active during dusk, night and dawn in the wild as well as in captivity (Hemmer, 1972). These two snow leopards were inactive during most of the day. Inactivity during the daylight hours has been found in other species of felids as well. Shepherdson et al. (1998) studied 68 captive individuals from 16 small felid taxa and found that they were inactive 57 % of their time. Captive Geoffroy's cat spent 75 % of day time inactive (Johnson and Franklin, 1991, cited by Shepherdson et al., 1998) and captive ocelots spent 57 % of day time inactive (Ludlow and Sundqiust,1987; Crawshaw and Quigley,1989, citied by Shepherdson et al. 1998). Shepherdson et al. (1998) suggested, based on this data, that the duration of daytime inactivity in small felids and their wild counterparts is largely fixed and that it may be unnatural to try to increase daytime activity in captive felids.

During my study, Brahma was lying 59 % of time per hour during baseline sessions and 57 % during enrichment sessions, Binu was lying 58 % and 64 % of time per hour, respectively.

These data were collected under different conditions and on different species and cannot be directly compared but they suggest that felids in general are mostly inactive during daytime. Even though I adjusted my recording sessions to the hours when the snow leopards seemed to be more active, with the limitation of the keepers' schedule, the snow leopards spent more than half of my recording time lying down.

One explanation for the inactivity of the snow leopards could be the long days of the Swedish summer. During June and July it wasn't getting dark when I finished my recordings at 21.00. The long days could affect the behavior of the snow leopards since they are active during dusk, dawn and night (Hemmer, 1972). The high temperatures during the summer could also affect the activity of the snow leopards. Snow leopards in the wild move up into the mountains during summer and thereby avoid the higher temperatures in the valleys.

It would be interesting to perform a study of the behavior of snow leopards at night as this would give us additional data about their activity patterns.

In this study I did not find any difference in the activity of the snow leopards between baseline and test sessions. The lack of difference could be due to the small number of baseline days (seven). This was due to the fact that I did not record during rainy days and when the summer turned out to be very wet, I gave the test sessions the higher priority.

The fact that the snow leopards did not increase their activity level during the test sessions suggests that we should focus on the quality of the behaviors that they are performing during their active time period and not only their activity level. When they are active they should be given environmental enrichment that encourages them to perform a diverse range of behaviors.

There were no remarkable differences in the location of the snow leopards during baseline and test sessions. Both snow leopards spent most of their time on the high mountain and on the shelf, from where they had a view of the enclosure and the visitors passing by. I expected the snow leopards to spend more time on the ground and in the litter box during test sessions, since the enrichment objects were presented there, but they did not. When the snow leopards were active they used all of their enclosure which explains why I recorded so many locations. Since there was no difference in activity and location I did not proceed to analyze the specific behaviors that I recorded continuously during baseline and test sessions.

5.4 Olfactory enrichment

Both snow leopards interacted significantly more often with odorized than with non-odorized objects, when all objects and all odors were summarized. This suggests that odorized objects were more interesting to the snow leopards irrespective of object and odor type.

The two snow leopards both interacted most often with enrichment objects impregnated with cinnamon. According to personal communication with Palmer (2009), lions prefer pungent odors like rhino urine, whereas snow leopards and tigers have a strong preference for cinnamon, nutmeg, allspice and perfumes. This is partly supported by the results in the present study.

Felid´s interest in spices and their effect on the behavior of big and small felid species has been investigated in several other studies. In a study on captive lions performed by Schuett and Frase (2001), cinnamon was the odor that elicited the second highest number of active behaviors, after zebra dung. During that study the lions reduced inactivity and increased social interactions, without increasing aggression, as an effect of the olfactory enrichment.

In another study on lions, Baker et al. (1997) used fecal material from 5 different prey species and two adversary species as environmental enrichment. The lions investigated the samples and the pride maintained elevated levels of social activity during the 24 hour presentation and the investigatory behavior continued for the next 48 hours.

Skibiel et al. (2007) found that there was an increase in activity and a decrease in stereotypic pacing during presentation of environmental enrichment with cinnamon, chili-powder and cumin in six cat species (cheetah (*Axininyx jubatus*), ocelot (*Leopardus pardalis*), tiger (*Panthera tigris*), jaguar (*Panthera onca*), lion (*Panthera leo*) and cougar (*Puma concolor*)). Similar findings were made in a study with environmental enrichment for Siberian Lynx (*Lynx lynx*) by Zar et al. (2005). The enrichment had a prolonged effect on the three lynxes' behavior which resulted in decreased stereotypic pacing post-enrichment, compared to pre-enrichment. The lynxes' favorite enrichment item was scented cardboard boxes.

The fact that cats like to interact and rub against certain odors can be useful for practical implications in the work of conservation biologists. Weaver et al. (2005) used hair snares scented with a mixture of catnip and a scent lure called Weavers' Cat Call to attract and promote rubbing behavior in wild ocelots. He collected the hair that got stuck on the snare and used DNA-analysis to determine the population size and genetic status of the ocelots.

Another scent that has promoted rubbing behavior in ocelots and cheetahs is the cologne Obsession by Calvin Klein (Marker and Dickman, 2003). The Obsession perfume is described to have a spicy and oriental scent which may explain the cats' reactions.

Lavender has not been used in many studies with felids but the two snow leopards in this study interacted second most often with it and the lions in the study by Mohnkern (1999) interacted a lot with lavender as well. Lavender is regarded to have a calming effect on humans but the psychological effect on animals is not well investigated (Peter, 2004).

Catnip is known to stimulate an "innate releasing mechanism" (IRM), which elicits predictable playful behavior in domesticated cats (Hill et al., 1976). Binu interacted least often with catnip and Brahma second least, after lemon balm, so in these snow leopards catnip did not stimulate an IRM. From these two snow leopards I cannot draw any conclusions about the responsiveness to catnip of snow leopards in general, but they are probably not highly responsive to it.

Binu interacted approximately as often with lemon balm as with cumin, whereas Brahma interacted less often with lemon balm than with cumin. Neither of these two odors seemed to be of special interest to the snow leopards so further use of them as olfactory enrichment is not encouraged.

5.5 Environmental enrichment with objects

Binu interacted significantly more often with the boomer balls® than with any of the other types of objects. She was introduced to rope balls when she was living in England (pers. comm. Fox, 2009), which could explain her special interest in boomer balls®. Brahma had never played with balls before and was frightened of them the first time he accessed them. He played with them but not as much as Binu did.

Both snow leopards interacted second most often with the ropes and significantly more with the odorized alternative. The rope was a good object type since it allowed the snow leopards to perform almost all the behaviors I recorded.
The logs were the type of object that the snow leopards interacted least often with and they only interacted slightly more often with the tennis balls. This could perhaps be explained by the carnivore way of playing with objects, which often resembles the hunting behavior of the particular species (Young, 2003). The boomer balls® were light and they moved and bounced in an unpredictable way, perhaps resembling prey. The lack of interest in the logs could be due to the fact that they were harder to manipulate and did not move in unpredictable and prey-like ways.
There are several studies that have tested different enrichment objects and their effect on activity and stereotypies in captive felids. Enrichment objects and devices can be a great tool when trying to increase the opportunity for felids to express natural behavior patterns when kept in small enclosures (Alexeev, 2005). Watermelons have been shown to be a great toy for Siberian tigers (Bosso, 2004) and lions (Mohnkern, 1999). In a study at The Grizzly Discovery Center, live rats were placed in the habitat of brown bears (*Ursus arctos*) and wolves (*Canis lupus*), giving the captive animals an opportunity to perform natural hunting behavior (Hammond, 1998).
Providing captive predators with live prey is illegal in many countries and therefore many studies aim to invent artificial prey for carnivores that elicits similar behavior patterns that live prey do. Hare et al. (1998) created an artificial prey from a jute bag attached to a garage door spring, hanging from a tree. The jute bag bounced back when the tigers tried to catch it. Jones (2005) constructed a keeper controlled device called the "Lionrover" which worked as an artificial prey for lions. The lions were given a bag on top of the device containing olfactory enrichment (catnip and zebra dung, respectively) and as a result the lions increased the number of natural hunting behaviors performed as well as the number of social rubbing between pride members.

5.6 Conclusions and outlook

From the results of the present study I conclude that both the type of object and the type of odor play a role in capturing the interest of the snow leopards. Two of the goals of environmental enrichment were met, suggesting that the animal's welfare increased during the testing period.
According to Skibiel et al. (2007), it is important to introduce novel objects in the environment of captive animals, in order to change behavioral patterns. By combining old objects with novel odors and vice versa, perhaps the effect of the environmental enrichment can be prolonged. Since objects are easy to purchase and numerous different odors can be used and tested for their effectiveness, this can be a good environmental enrichment scheme for the snow leopards.
As an addition to creating an environment that resembles the species' natural habitat and to provide the animals with an irregular feeding schedule, environmental enrichment with objects and odors can be an effective way to increase the welfare of the two snow leopards in Kolmården Wildlife Park.

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