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APPROVAL OF HONORS PROGRAM SENIOR PROJECT

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Project Title

Frustration Responses in Domestic Cats (Felis catus): Behavioral Analysis in a Food Obstruction Experiment

This Senior Project is approved as acceptable

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Frustration Responses in Domestic Cats (*Felis catus*): Behavioral Analysis in a Food Obstruction Experiment

Roberta Vulcano

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Introduction

The ability to interpret how our domestic pets react to frustration can be the first step in addressing their welfare needs, especially in facilities where the management may interfere with access to certain resources or if they are presented with other forms of stress. While much of the recent research in this area has concerned domestic dogs, providing important insights into how they deal with frustration, especially when rewarding stimuli are out of reach (Bremhorst et al., 2019; Jakovcevic et al., 2013; McPeake et al., 2021), there has been an absence of experiments involving the other great companion animal: the domestic cat (*Felis catus*). This is a serious omission because cats are one of the most popular companion animals on the planet, and cats' emotional needs differ from those of dogs (Amat et al., 2015; Ellis, 2018).Particularly when it comes to food access, which can be one of the most powerful motivators for frustration, it is especially crucial to look more closely at how cats react to frustration because they often exhibit subtler and therefore more difficult-to-detect emotional cues.

As an emotional response, frustration tends to have a deep welfare impact on an animal: it represents an animal's motivation to obtain something that an obstacle prevents. When this occurs, behavioral and physiological changes can arise. These changes can be wide-ranging in cats. They might become more stressed and anxious, and respond with aggression, and if left to persist over time, they might adversely impact the cats' welfare (Amat et al., 2015; Hargrave, 2015). Once we grasp the specifics of how cats express frustration, we can take appropriate steps to address their emotional and psychological needs. This could be particularly helpful for those cats living in controlled environments, like shelters, veterinary clinics or even in multi-cat households, where access to resources such as

food, space or attention from owners and family members is restricted, and they risk experiencing negative emotional states (Gourkow & Phillips, 2016).

This behavioral research proposes to examine frustration responses in the domestic cat by observing each individual cat's behavioral reaction to an inaccessible food source. For this purpose, four cats from the Shaw Learning Center located at North Carolina Wesleyan University will be exhibited inaccessible but preferred food with perceived visual accessibility. Behavioral observations of proximity to food, body language and other frustration expressions will be assessed. Previous research has demonstrated that cats can become frustrated when their ability to access food has been delayed by requiring them to work at a food puzzle, although typically, access to food is eventually provided (Dantas et al., 2016). This experiment will utilize a more direct and controlled method of measuring frustration.

Compared with dogs, cats are usually thought to be more independent and less expressive, so it is much harder to discern whether they are feeling something like frustration. However, studies have shown that cats too can display emotions, including frustration, by subtle bodily postures and vocalizations (Ellis, 2018; Nicholson & O'Carroll, 2021). This research will employ observational methods to reliably quantify these reactions using a measurement ethogram adapted from studies of canine frustration behaviors to feline-specific behavioral markers (Jakovcevic et al., 2013). By scoring these behaviors in the context of food obstruction, this study seeks to expand our understanding of cat frustration, and ultimately contribute to the growing field of pioneering research that has already demonstrated the existence of advanced animal emotions and improved animal welfare (Vitale Shreve & Udell, 2015).

Conceptually, this work contributes to a poorly understood body of research in the field of animal learning and behavior: feline cognition. The understanding of motivation and learning, in general, has been limited by this gap in the literature on frustration. Feline frustration can have significant implications for cat welfare, in homes as well as shelters, sanctuaries, and veterinary clinics. Cats may become frustrated when their needs are unmet, particularly chronically, such as being frustrated by limited access to necessary or desired resources. In turn, that frustration can lead to behavioral issues including aggression, anxiety, and compulsive behaviors, which all have real welfare impacts on cats. A better understanding of the antecedents and consequences of frustration responses toward novel stimuli may help caretakers identify subtle signs of stress earlier, and that in turn could inform more proactive environmental enrichment and resource management strategies. For example, enrichment strategies, such as food puzzles or other cognitive challenges, have been shown to reduce stress and improve welfare in cats (Hargrave, 2015; Heath, 2018). Ultimately, by contributing to this line of research, I hope to fill a gap and inform future research in order to better understand cats' habits in a way that benefits our beloved companions.

General Overview of Feline Behavior

Domestic cats exhibit a range of behaviors rooted in their evolutionary legacy as hunters, but they've also learned to live alongside humans. In contrast to most domesticated animals, cats still possess a lot of behaviors that they inherited from wild ancestors, including foraging instincts that help form their relationships with humans and their environment (Stella & Croney, 2016). It's important to be able to understand their habits in order to ensure their well-being, particularly when they are in a multi-cat household and when they are not allowed to follow their natural instincts fully.

Territoriality and Environmental Preferences

Cats are naturally skilled predators that depend on the same territory for security, and use territorial behaviors such as scent marking and scratching to signal to others in the vicinity (Stella & Croney, 2016). Cat territoriality can mean creating a defined area in which cats feel secure, including a place to sleep, as well as a separate place to eat, wash and play. This organization is particularly relevant to multi-cat families, where competitive struggle over "resources" often creates stress and even conflict (Ellis, 2018).

If domestic cats are kept in a confined space, these natural instincts can be inhibited, and boredom and even behavioral issues develop if the cat's habitat is not well-enriched. Design details such as vertical areas (eg. shelves or cat trees) let cats explore and establish territory within the household, supporting their natural need for spatial diversity. Cats also like to occupy elevated places where they are safe to look around and feel protected, a practice that goes back to their predator-prey instincts (Stella & Croney, 2016).

Social Structure and Human Interaction

Cats are traditionally considered solitary animals but have recently been shown to form social relationships, both among other cats and with humans. They are incredibly flexible in their social behavior and are shown to have individual temperaments and a predisposition to socialization. In contrast to pack-oriented animals, cats exhibit a "facultative social" structure, which simply means that they live collectively but do not innately need groups to survive (Vitale Shreve & Udell, 2015). Cats display this social affiliation through proximity, grooming and head-bumping, which are affiliative acts and expressions of familiarity (Ellis, 2018).

The cat's level of contact with humans depends on its temperament and socialization experience in its early stages of life. They make extensive use of subtle body language involving tail flicks, ear positioning and eye contact to communicate whether they are comfortable or uneasy around humans (Heath, 2018). Understanding these signals can strengthen the human-cat relationship, teaching owners to spot signs of contentment (a raised tail) or distress or aggression (flattened ears or puffy tail) (Ellis, 2018). Missing or misinterpreting these cues is bound to put the cat under unnecessary stress, thus reminding cat owners to become accustomed to feline body language and behavior signals (Heath, 2018).

Play and Hunting Behavior

Cats are predatory animals and their play patterns often resemble the stalk-pounce-kill pattern of a natural hunt (Stella & Croney 2016). When cats play with toys that act as prey in particular, they express the same instinct by chasing, pouncing and attacking them, a pattern that's deeply programmed in their evolutionary biology (Vitale Shreve & Udell, 2015). Cats who lack access to such natural predatory mechanisms might become frustrated and could develop unwanted behavioral issues, including aggression or destructive scratching (Stella & Croney, 2016).

In household settings, enrichment devices such as interactive toys and food puzzles can help cats channel these hunting behaviors in a safe and satisfying way (Dantas et al., 2016). Such devices also serve as cognitive tools, thus avoiding boredom and helping in maintaining physical wellbeing through movement. It is precisely this kind of enrichment that indoor cats need, Stella and Croney's article suggests since their natural behaviors are naturally more restricted than outdoor cats (2016).

Communication and Vocalization

Cats express themselves through a combination of vocalizations, body language and odor markings, although the vocalizations tend to be reserved for humans and not other cats, a kind of domestic adaptation (Bennett et al., 2017). Purring, for example, is primarily thought of as a sign of satisfaction, but can also be used as a form of self-soothing in the face of stress or pain (Bennett et al., 2017). Additionally, cats use many different meows and other vocalizations when communicating with humans, and modulate pitch and tone accordingly, providing evidence of social adaptation that could accommodate human needs (Bennett et al., 2017).

Cats communicate mostly with body language, most frequently by tail movement, ear placement and body posture. A cat that has a straight tail and forward-pointing ears is normally satisfied, whereas an arched back, puffed tail and flattened ears indicate terror or aggression, requiring owners to learn how to interpret these signs properly in order to ensure optimal human-cat interaction (Ellis, 2018). Understanding these signals is crucial to avoid miscommunications that might cause stress for the cat and allow owners to adjust their behavior to suit the cat's needs (Nicholson & O'Carroll, 2021).

Behavioral Flexibility and Cognitive Enrichment

Cats are highly behaviorally flexible and can change how they respond to stimuli from day to day. They're curious and drawn to exploration and challenges. Cognitive enrichment is necessary for their welfare, mental stimulation and initiation of natural behaviors in the captive context (Stella & Croney, 2016). Cognitive stimulators such as puzzle feeders can engage a cat's brain and simulate the process of foraging, which helps

indoor cats fulfill some of their natural cues and encourage a better mental state (Dantas et al., 2016).

The key to understanding how cats behave is to identify their specific territorial, social, communicative and intellectual needs. By offering them space, enrichment, and knowledge of social and territorial signals, these behavioral needs can be met and can exhibit their natural instincts in indoor environments (Stella & Croney, 2016).

Previous Behavioral Research

Behavioral Responses to Food Obstruction in Cats

Feline responses to food obstructiveness have not been studied as thoroughly as dog responses, though this is beginning to change. Dantas et al. (2016) studied how cats would react to food puzzles, and monitored their behavior, reporting that the puzzles encouraged problem-solving and cognitively stimulated the cats. But when cats could not complete the puzzle or get to the food within a reasonable amount of time, they would show frustration by pawing, vocalizing and circling around the puzzle. The frustration was caused by multiple unsuccessful attempts to retrieve the food, sometimes interrupted by displacement gestures such as grooming or scratching the ground surface.

Cats have been observed to paw at the barrier when the food is not available, or circle it, and even utilize excessive vocalization when the food is unreachable (Ellis, 2018). In shelter cats, according to Gourkow and Phillips (2016) research, cats who had been assessed as "frustrated" upon arrival tended to perform better when confronted with problems. The availability, or lack of, resources, plays a major role in cat emotional reactions and wellbeing.

The frustration-related behaviors seen in cats during food obstruction experiments often overlap with stress responses observed in other contexts, such as restricted movement or confinement (Hargrave, 2015; Heath, 2018). However, the emotional valence of these behaviors (whether they stem purely from frustration, anxiety, or a blend of both) is still a topic of debate in animal behavior research. According to Nicholson and O'Carroll (2021), creating ethograms, or behavioral catalogs, tailored to specific emotional contexts can improve the accuracy of assessing these complex behaviors.

Comparative Analysis: Food Obstruction Studies in Dogs

The study of frustration reactions in domestic dogs (*Canis familiaris*) offers an excellent comparative guide to similar behavior in cats. Both species will demonstrate frustration when prevented from accessing food, but dogs have their own repertoire of reactions, usually reflective of their social preferences and dependence on human contact. In an experiment (Jakovcevic et al.,2013), dogs who couldn't get access to food vocalized, pawed and stared back at their human owners, indicating a social aspect to their reaction. Dogs often display "referential looking," in which they approach a human to ask for help or express distress.

McPeake and colleagues (2021) looked at dog frustration behaviors using the Canine Frustration Questionnaire and observed that dogs exhibit vocal and physical behavior, including barking and scratching, when denied access to food. Such behaviors, just as in cats, are a sign of frustration. Dogs (more than cats) are likely to rely on social signals, reaching out to human caregivers as part of their problem-solving repertoire. This social dependence suggests that dogs might have different experiences of frustration than cats, who tend to be less social and typically utilize more solitary coping mechanisms (Bremhorst et al., 2019). In

contrast, both cats and dogs can display aggression when repeatedly subjected to frustrating situations, or they can lead to serious behavioral issues in the long term.

Behavioral issues are one of the most common reasons for abandonment in pets, according to Hargrave (2015), with many cats either abandoned or put down due to inconvenient behaviors that owners cannot seem to bear. It's important to identify the emotional cause of these behaviors so that we can come up with strategies to intervene and preserve the cat's welfare. My proposed experiment in this thesis would help to close a literature gap and study frustration in domestic cats. Observing the behavioral responses of the cats in this context will provide valuable insights into their emotional states and coping mechanisms.

Materials and Methods

The experiment was conducted on four domestic cats of varying ages and sexes, all residing in the same cat lounge located in the Shaw Learning Center at North Carolina Wesleyan University. Each cat has been adopted from *Paws and All Feline Rescue*, located in Tarboro NC, at different times. Jack Jack, male, and Sara Sue, female, were adopted together in April 2023 and they are both at least 2.5 years old. Funky "Monk" Monkey (referred to as Monk) and Sassy, both approximately 1.5 years old females, were born around April 2023. They were adopted later in November 2023, at about seven months old, and are also bonded. Both were over a year old at the time of adoption, no longer considered kittens, and they have since formed a bonded pair even though they are not related.

Table 1: Introduction to Experimental Subjects			
Cat Name	Sex	Age	Bond
Jack Jack	Male	2.5 years old or more	Socially bonded pair
Sara Sue	Female	2.5 years old or more	
Monk	Female	1.5 years old	Socially bonded pair
Sassy	Female	1.5 years old	

Each cat was observed during an initial informal descriptive personality observation prior to the collection of data, where all cats were provided with the opportunity to taste different samples of cat food. All animals showed a strong preference towards wet salmon cat food, therefore it was chosen to be the food stimulus that was going to be used during trials.

Experimental Setup

Initially, tests were conducted in the small room adjacent to the cat lounge to exclude outside stimuli and distractors. During the early testing phase of the four cats tested, two showed substantial levels of stress including hiding in the corners of the room, trying to go back to the cat lounge, and general withdrawal from interacting with the food. Such response patterns and indicators could impact the validity of the frustration responses being measured; as a consequence, the experimental conditions were modified.

The trials were then moved to the cat lounge itself, so that the cats were already in a familiar and comfortable environment at all times, as a way of mitigating the stress and increasing the natural expression of their behaviors. Only one cat was tested at once. No other cats were allowed to view the trial in order to preclude social influences. Instead, the other three cats were kept in the small room (now a "waiting room"), along with a caretaker, who made sure they were comfortable and calm during their waiting time. This ensured that the experiment was run smoothly and ethically.

Experimental Procedure

Each trial provided the cat with a small plate of wet salmon cat food placed underneath a metal strainer. The strainer was taped to the floor, allowing the cat to see and smell the food but not reach it. The design was intended to create a frustrating situation in which the cat could see and smell the food but couldn't reach it.

Three concentric lines of tape placed on the ground around the strainer at distances of 1 inch, 5 inches, and 10 inches from the center of the food were used to measure both how interested and persistent cats were in getting to their food (Figure 1).

Each cat was tested separately on 7 different days, and every trial lasted 3 minutes and started when the cat was placed in the room. For the duration of the experiment, a stationary video camera filmed the cat continuously from above, so that each movement and behavior produced by the cat in the experimental arena remained clearly visible later on for analysis. These clips were labeled at a later time based on the observed behavioral responses of the cats.
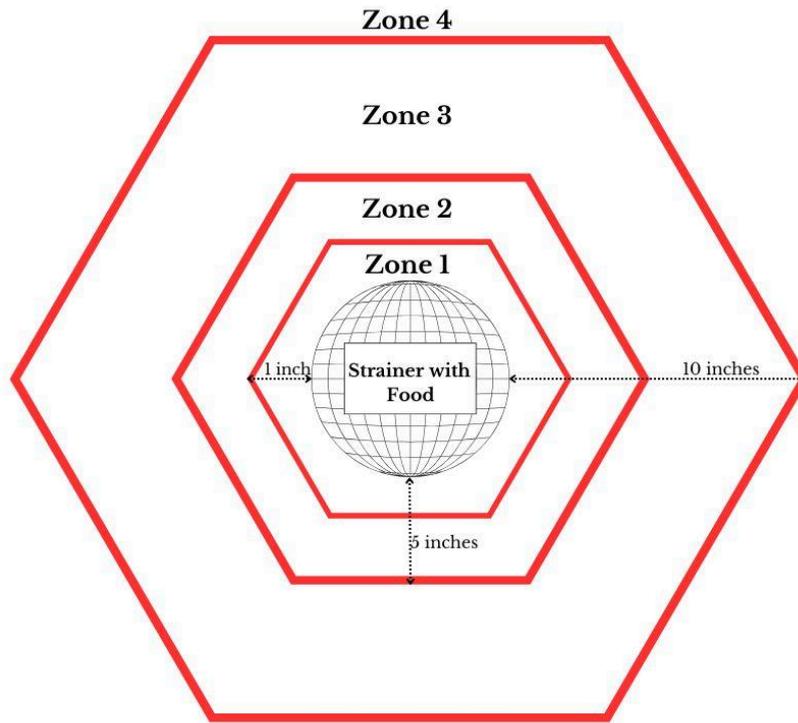
Figure 1. Experimental setting. The strainer with the food is placed in the middle, and concentric zones around it are 1 inch, 5 inches, and 10 inches away. The cat starts at the opposite end of the room, and its movements are monitored as it approaches the food.

Table 2. Ethogram: Frustration Responses in Cats			
Behavior Category	Behavior Name	Description	Category (State/Event)
1. Proximity to Food	Standing farther than 10 inches	Cat position towards the food, not crossing any lines (10-inch, 5-inch, 1-inch).	State
	Standing Within 5-10 Inches	Cat stands or remains within the 10-inch boundary but does not cross closer to the strainer.	
	Standing Within 1-5 Inches	Cat stands or remains within the 5-inch boundary but does not cross the 1-inch line.	
	Standing Within 1 Inch	Cat stands or remains directly next to the strainer, within 1 inch of the trapped food.	
2. Interaction with Strainer	Sniffing Strainer	Cat sniffs the area around the metal strainer while in close proximity.	Event
	Pawing at Strainer	Cat reaches out with paws to push or manipulate the strainer to access the food.	
	Biting Strainer	Cat uses its mouth to try to bite or pull at the metal strainer.	
	Licking Strainer	Cat uses its mouth to try to lick the food on the other side of the metal strainer.	
3. Movement Around Room	Exploring Room	Cat moves around the room and doesn't pay attention to the food.	State
	Circling Strainer	Cat walks in circles around the strainer, paying attention to the food and staying within boundary lines.	
4. Vocalization	Meowing	Cat emits vocalizations (meows) during or after attempting to reach food.	Event
	Growling or Hissing	Cat emits growls or hisses during or after failed attempts to access the food.	
5. Displacement Behaviors	Grooming	Cat engages in self-grooming behaviors (licking or scratching) as a possible stress-relief response.	Event
	Scratching at Ground/Surface	Cat scratches at the floor, walls, or nearby surfaces near the food, possibly as a frustration outlet.	
	Chewing Non-Food Items	Cat chews items that are not food, possibly to redirect its attention from the frustrating task.	
	Rolling	Cat rolls on itself as a self-soothing strategy as a stress relief response.	

Behavioral Observations

An ethogram (see Table 1) based on previous studies regarding frustration responses in dogs was modified to meet the criteria needed to measure the same response in domestic cats (Jakovcevic et al., 2013):

1. **Proximity to the Food**: This category quantified how many times a particular cat approached the strainer within 4 defined zones of interest (1 inch = zone 1, 1-5 inches = zone 2, 5-10 inches = zone 3, and farther than 10 inches = zone 4). These

measurements can show how persistent cats were in getting the food. If they stayed at the closer zones for more time, then they will likely be more invested in getting the food. This measurement is considered to be a state, and therefore measured in seconds.

2. **Interaction with the Strainer**: As a behavioral coding technique to capture the extent of food obstruction, any gesture directed immediately at the food barrier (the strainer) was recorded, for instance, pawing, licking or biting the strainer as they were frustrated by their inability to access food (Ellis, 2018). The frequency of such interaction served as a measure of frustration response. This behavior is considered to be an event and therefore measured as such by counting occurrences in each specific behavior.

3. **Movement Around the Room**: Attention was given to general activity in the room, as well as circling around the strainer, and to exploration of the room. Very high movement could be reflective of restlessness or anxiety, while little or no movement could be indicative of avoidance of the situation or loss of interest (Ellis, 2018). This behavior is also classified as a state and therefore measured in seconds.

4. **Vocalizations**: During the trials, cats produced several vocalizations, including meowing and growling/hissing. Vocalizations can reflect affective states, such as frustration or distress (Ellis, 2018). Various factors such as the type and frequency of different vocalizations were investigated as markers of frustration. This type of behavior is classified as an event and therefore measured in each occurrence.

5. **Displacement Behaviors**: Behaviors unrelated to the task at hand (reaching food) and commonly observed in the presence of frustration. These included behaviors such as grooming and scratching at the floor surface and were considered to be indicators of stress. Displacement behaviors are suggested to reflect when the animal has identified

an unachievable goal and thus has to use other coping mechanisms (Bennett et al., 2017).

By giving a name to each behavior and categorizing them into these five sections, the ethogram would allow for the observations of the cats' reactions to be recorded in a structured, detailed and measured way. The use of video recording also ensured that the cats' behavior would be transcribed with absolute accuracy and that all behavior produced in response to the food obstruction could be studied in detail, post-experiment.

Data Collection and Analysis

Quantitative data were collected for each of the five behavioral categories for every trial. The video records were carefully screened to precisely code each individual cat for all the behaviors that were part of the ethogram. The number of occurrences and the duration of the behaviors in each of the behavior categories were quantified for every cat, providing data that allowed comparing individual cats during the same trial and among the different trials.

<center>**Results**</center>

Proximity to Food

The average time spent by the cats close to the food varied across the four zones around the food. In the first zone, within 1 inch from the food and the absolute closest, their presence on average was highest: 82 seconds on Day 1, 91 seconds on Day 2, 83 seconds on Day 3, and 95 seconds on Day 4 (except for a little dip to 64 seconds on Day 3), which indicates a high motivation from the cats to stay physically near the food. The second zone, between 1 and 5 inches away from the food, showed more variation: on Day 1, the average time spent there was 20 seconds; it decreased to 17 seconds on Day 2, and again further to 12 seconds on Day 4 and then skyrocketed to 22 seconds on Day 5 (see Figure 2). Inconsistency in Zone 2 likely reflects the cats' variation in frustration or indecision levels between trial days. Zone 3, 5-10 inches from food, saw relatively low engagement, the average times ranging from 9 to 22 seconds. The regularity of these lengths suggests the cats rarely stayed in zone 3 for long periods. Zone 4, the farthest from food, showed a general downward trend over the days studied, with the time in the zone starting at 52 seconds on Day 1 and decreasing to 11 seconds on Day 6 with periodic spikes, reaching 64 seconds on Day 3 and 73 seconds on Day 7. This trajectory suggests that over time, the cats became less inclined to stay far from the food reward, likely due to a growing focus on gaining access to food closer to its location. Overall, the results point to cats prioritizing being near the food with the zones in the middle showing fluctuations likely reflecting intense periods of frustration.
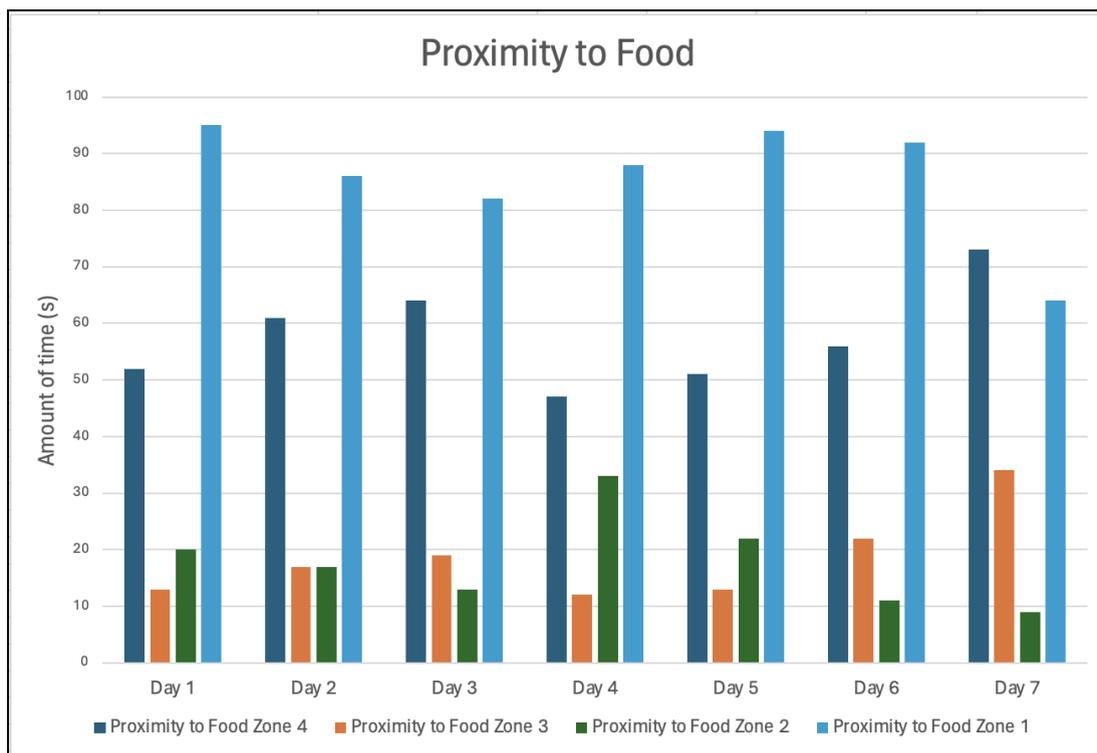
<center>18</center>

Figure 2. Time allocation across proximity zones in feline subjects during the study. The graph shows the average time (in seconds) cats spent in each of four designated zones relative to the food over a seven-day trial period (n = 4 cats over 7 days). Zone 1 = within 1 inch from food, Zone 2 = within 1-5 inches from food, Zone 3 = within 5-10 inches from food, and Zone 4 = farther than 10 inches from food.

Movement Around the Room

In general, cats spent different amounts of time exploring the room, compared with circling the strainer, over the course of the seven-day trial. Unsurprisingly, circling the strainer was the dominant behavior: it peaked on Day 4 at 133 seconds, and then dipped slightly toward the end of the trial, reaching 86 seconds at the end of the seventh day (see Figure 3). This pattern suggests that, as the trials continued over time, cats continued to increasingly focus on the food underneath the strainer, so circling around the food was a consistent behavior that they returned to multiple times as they tried to figure out a way around the strainer. In contrast, time spent exploring the room started at 65 seconds on Day 1,

peaking on Day 6 at 71 seconds, but also notably dropping on Days 4 and 5, at 45 and 63 seconds, respectively. Exploration likely decreased as the cats gradually became more focused on the food. As the interval increased, the data show that the cats' choices shifted, spending more time circling the food and less on the more general exploration of the room.
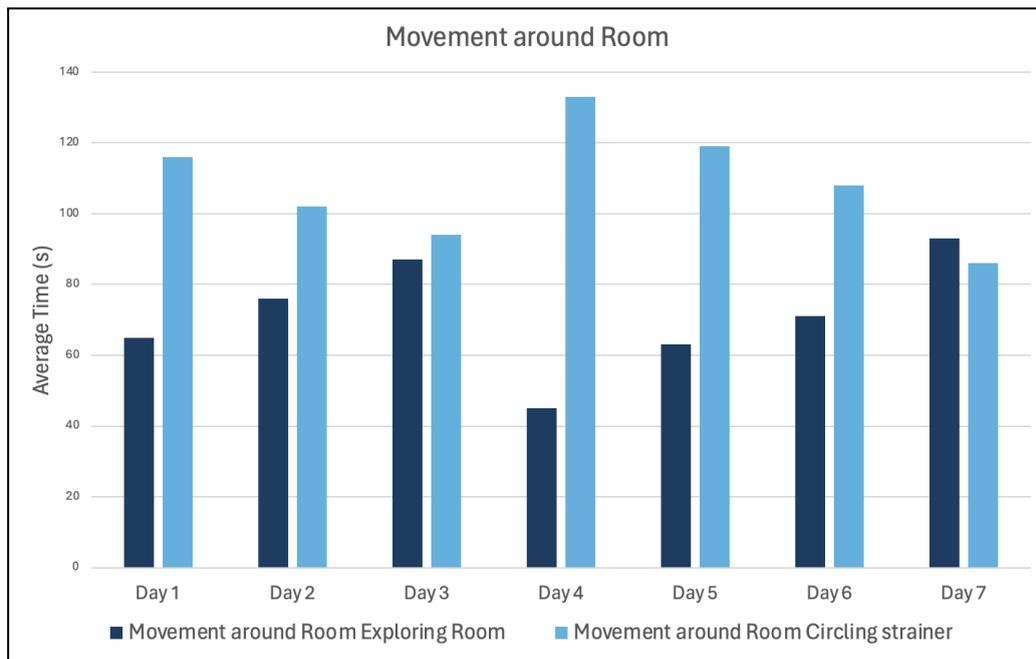

Figure 3. Exploration and circling behaviors in feline subjects during the study. The graph depicts the average time (in seconds) that cats spent exploring the room versus circling the strainer over a seven-day trial period (n = 4 cats over 7 days).

Interaction with Strainer

Across the seven-day trial, a pattern of variable behavior and differing types of interaction is clearly apparent. There are clear differences in the frequency of pawing, sniffing, licking, and biting, with pawing at the strainer being the most common behavior across all trial days (peaking at 32 times on Day 4 and then significantly decreasing in subsequent days, ending at 12 times on Day 7, see Figure 4 for reference), indicating that they were initially eager to physically gain access to the food. Pawing was followed closely

by sniffing, with the cats maintaining their engagement across the trial (peaking at 22 times on Day 4 and substantially dropping only towards the end on Day 7). The consistent engagement with sniffing and pawing on Day 4 in particular suggests that the cats were more interested on this day in understanding the nature of the food barrier.

Licking and biting were less present but still observed, and again higher in frequency on Days 4 and 5. Licking spiked to 9 instances on Day 4, this could suggest frustration-driven behavior as the cats explored alternate paths to access the food. By contrast, biting was rare, with spikes on Days 1 and 4, when the cats gravitated towards direct engagement with the food barrier. This low frequency of biting may indicate that, at least for some cats, the strainer was not viewed as a productive behavior or that individual differences in interacting behaviors predominated in the setting.

The trend shows that over the course of the trials, there was an initial high degree of physical interaction (mostly pawing) which peaked in the middle of the trials (fourth day) and slowly began to recede by Day 7. Interestingly, this receding interaction could be an indication of what is termed a learning effect, namely that, after a certain number of trials, the cats became aware of the futility of their attempts to remove the strainer and shifted to other behaviors, or else lost the initial drive altogether and in the process displayed a reduced effort over time.
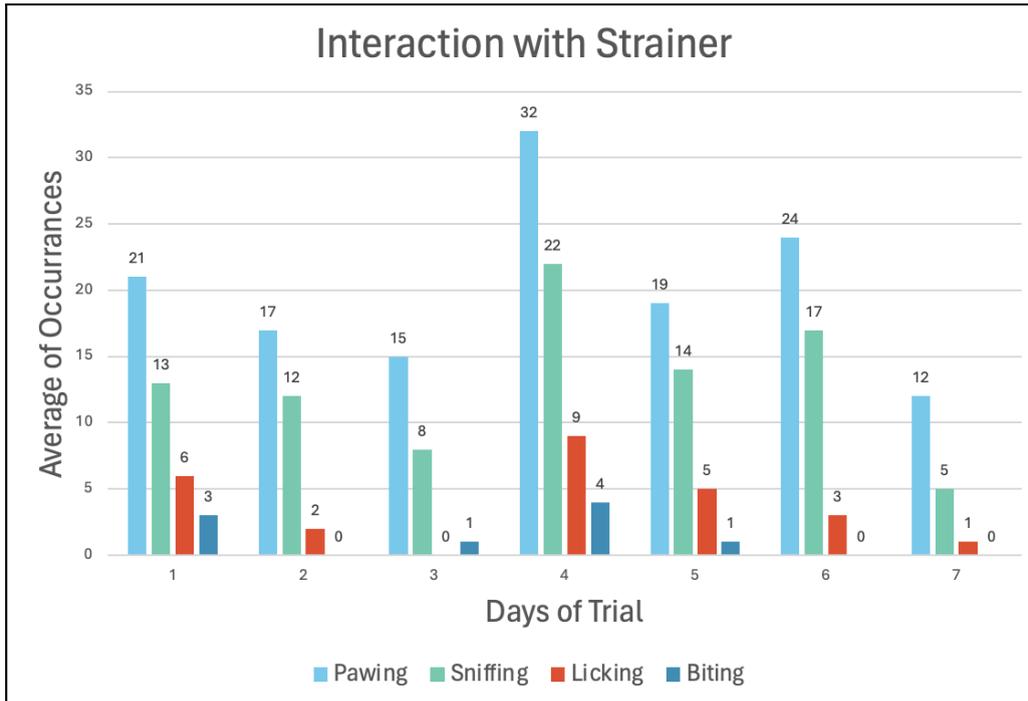
Figure 4. Occurrence of interaction behaviors directed at the strainer in feline subjects during the study. Pawing, sniffing, licking, and biting behaviors were observed over a seven-day trial period to assess the cats' frustration responses. The graph shows the average occurrences per day (n = 4 cats over 7 days).

Vocalization

Vocalizations (meowing) were infrequent overall, with events on Days 3 and 4 with an average of 1 meow per day (see Figure 5). The appearance of vocalizations (meowing) on those two consecutive days may be indications of peak frustration, or more effortful attempts at communication, or may signal when cats' emotional state shifted during the task. The fact that hissing and/or growling wasn't utilized at all on any day could show that the frustration levels didn't reach intensity for such vocalization, as these are commonly associated with more intense frustration or agony. It seems likely that more passive frustrated behavior was vented during the sessions on those other days, as shown by the other behavioral data collected. Further, the reduced amount of growling or hissing might have to do with cat temperament, and perhaps the display of frustrated vocal behavior varies between cats. The vocal peak on Days 3 and 4 might reflect a peak in frustration before these cats learned that

reaching the food was futile, thus reducing motivation to vocally rehearse frustration in subsequent trials.
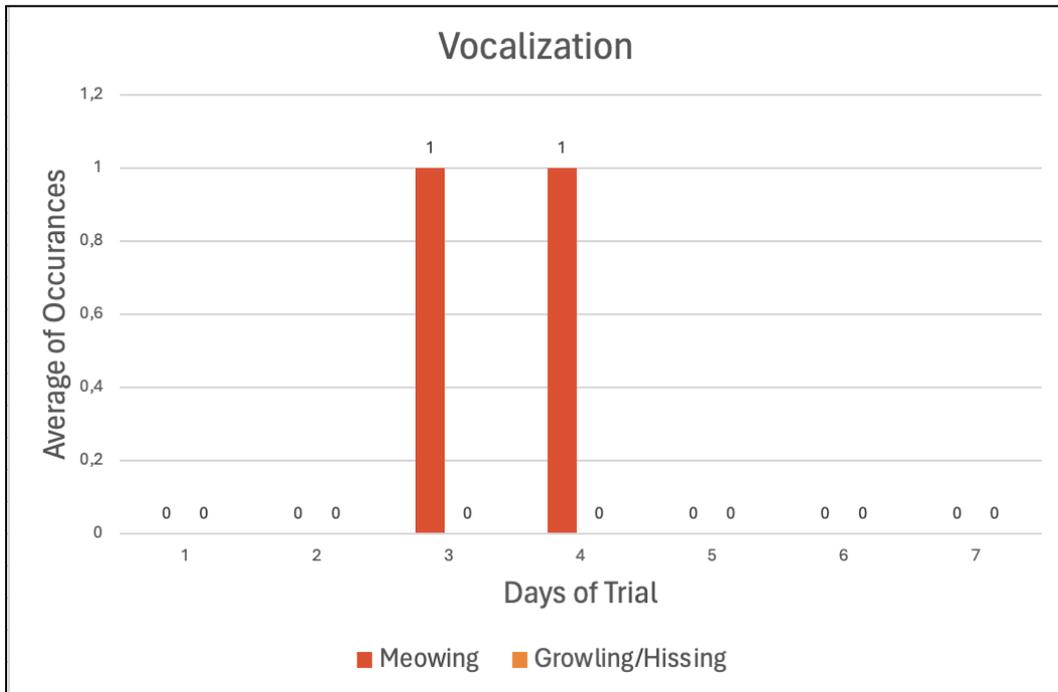

Figure 5. Occurrence of vocalizations in feline subjects during the study. Vocal behaviors, specifically meowing and growling/hissing, were recorded over a seven-day trial period to assess potential signs of frustration. The graph displays the average occurrences per day (n = 4 cats over 7 days).

Displacement Behaviors

The displacement behaviors occurred within a wide range of frequencies, with rolling and scratching at the ground surface the most frequently performed. Grooming was performed relatively regularly, averaging 1 occurrence per day throughout but with small peaks on Days 2 and 4. Scratching at the ground surface is also more typical on Days 2 and 4, at around 2 occurrences per day on average, before dropping in the later trials (see Figure 6). Chewing non-food items was observed on the most numerous occasions, particularly on Days 2, 5 and 6, but peaking on Day 5 with more than four occurrences on average. The increase in this behavior might be indicative of more frustration-related behavior. Rolling was the most

variable behavior, notably peaking on Day 5 and also reaching its highest occurrence average (almost four occurrences) in the distribution of all the observations. The diversity of displacement behaviors (particularly the spikes seen in rolling and chewing non-food items on Day 5) suggests that they could be coping mechanisms for the cats when they experience higher levels of frustration. Decreases in occurrences of these behaviors in later days can indicate a lack of interest or disengagement with the experimental setting or perhaps the tasks as the cats become accustomed to them.
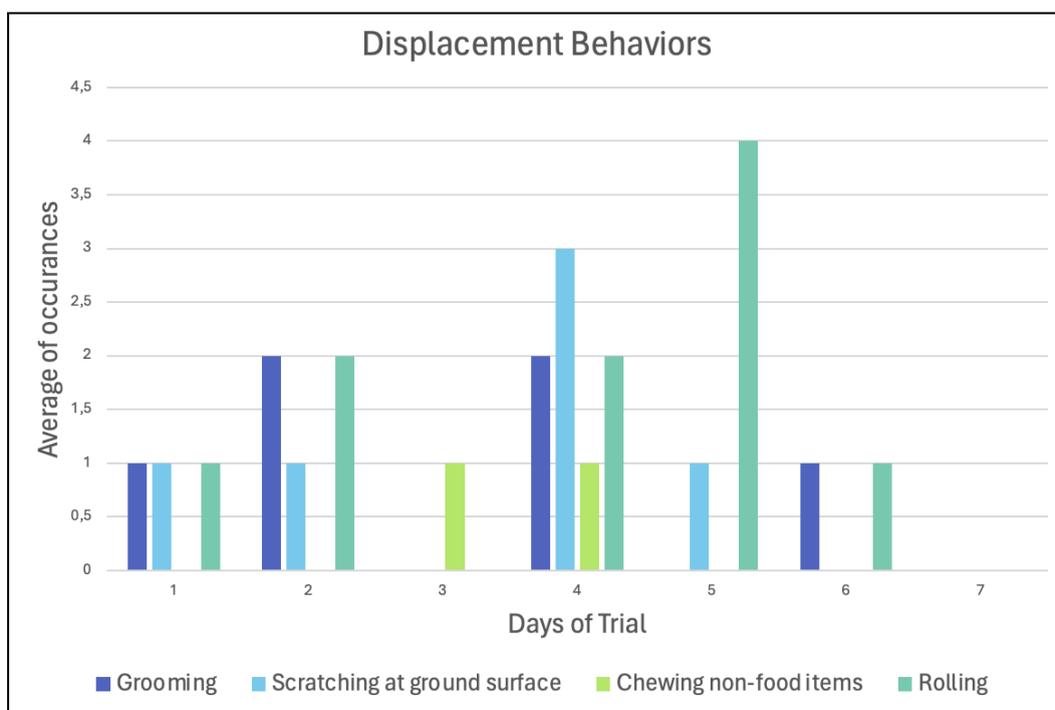
Figure 6. Occurrence of displacement behaviors in feline subjects during the study. Displacement behaviors, including grooming, scratching at the ground surface, chewing non-food items, and rolling, were tracked over a seven-day trial period to assess signs of frustration. The graph displays the average occurrences per day (n = 4 cats over 7 days).

Data Analysis

This experiment utilized a Chi-square independence test to understand whether the four cats behaved significantly differently or if they expressed similar behaviors among each other. The null hypothesis (H_o) was that there is no significant difference in the frequency of behaviors exhibited by the four cats across the defined behavior categories, indicating that behaviors are equally distributed among the cats. The alternative hypothesis (H_a) was that there is a significant difference in the frequency of behaviors exhibited by the four cats, suggesting variation in behavioral expression among them.

By analyzing each behavior category, the Chi-square test was applied to determine whether the observed frequencies of behaviors deviated significantly from the expected frequencies. Each behavioral variable was compared across all four subjects using the Chi-square test available on the Graph Pad website. The median frequencies for each behavior category were plotted against the expected values to identify the behavioral range and variability of each of the four cats.

Table 3. Chi-Square Test Results				
Behavior Category	Behavior/Position	Chi-Square (X^2)	p-value (3 df)	Significance
1. Proximity to Food	Zone 1	73.159	<0.0001	Significant
	Zone 2	5.625	0.1514	Not Significant
	Zone 3	21.537	<0.0001	Significant
	Zone 4	93.018	<0.0001	Significant
2. Interaction with Strainer	Sniffing Strainer	15.293	0.0016	Significant
	Pawing at Strainer	47.371	<0.0001	Significant
	Biting Strainer	2.000	0.5724	Not Significant
	Licking Strainer	19.308	0.0002	Significant
3. Movement Around Room	Exploring Room	58.361	<0.0001	Significant
	Circling Strainer	36.354	<0.0001	Significant
5. Displacement Behaviors	Grooming	3.667	0.2998	Not Significant
	Scratching at Ground/Surface	3.000	0.3916	Not Significant
	Rolling	8.600	0.0351	Significant
	Chewing Non-Food Items	/	/	Zero Inflated Data
4. Vocalization	Meowing	/	/	Zero Inflated Data
	Growling or Hissing	/	/	Zero Inflated Data

Proximity to food

For Zone 1, the Chi-square statistic was X^2=73.159 (3 degrees of freedom) and a two-tailed p-value less than 0.0001, which suggested a statistically significant relationship between measured behavior and this zone indicating a difference among each cat's behavior (see Figure 7). However, for Zone 2, the Chi-squared ratio was X^2=5.625 with 3 degrees of freedom, and the two-tailed p-value was 0.1514, which is statistically insignificant, indicating that observed behaviors in this zone did not depart significantly from expectation and therefore we cannot reject the null hypothesis (see Figure 8). Zone 3 exhibited a Chi-square value of X^2=21.537 with 3 degrees of freedom and a p-value below 0.0001, meaning that behavioral outcomes differ highly within this zone (see Figure 9). Finally, Zone 4 had a Chi-square value of X^2=93.018, 3 degrees of freedom and a p-value less than 0.0001, again indicating statistical significance for observed behavior within the zone (see Figure 10).

These findings suggest that certain zones, namely Zones 1, 3 and 4, show distinctly different behavior patterns among the different subjects, whereas Zone 2 shows no significant deviation from expectations. This could reflect the fact that each cat's personality plays a role in their behavioral responses regarding proximity to food and their inability to access it.
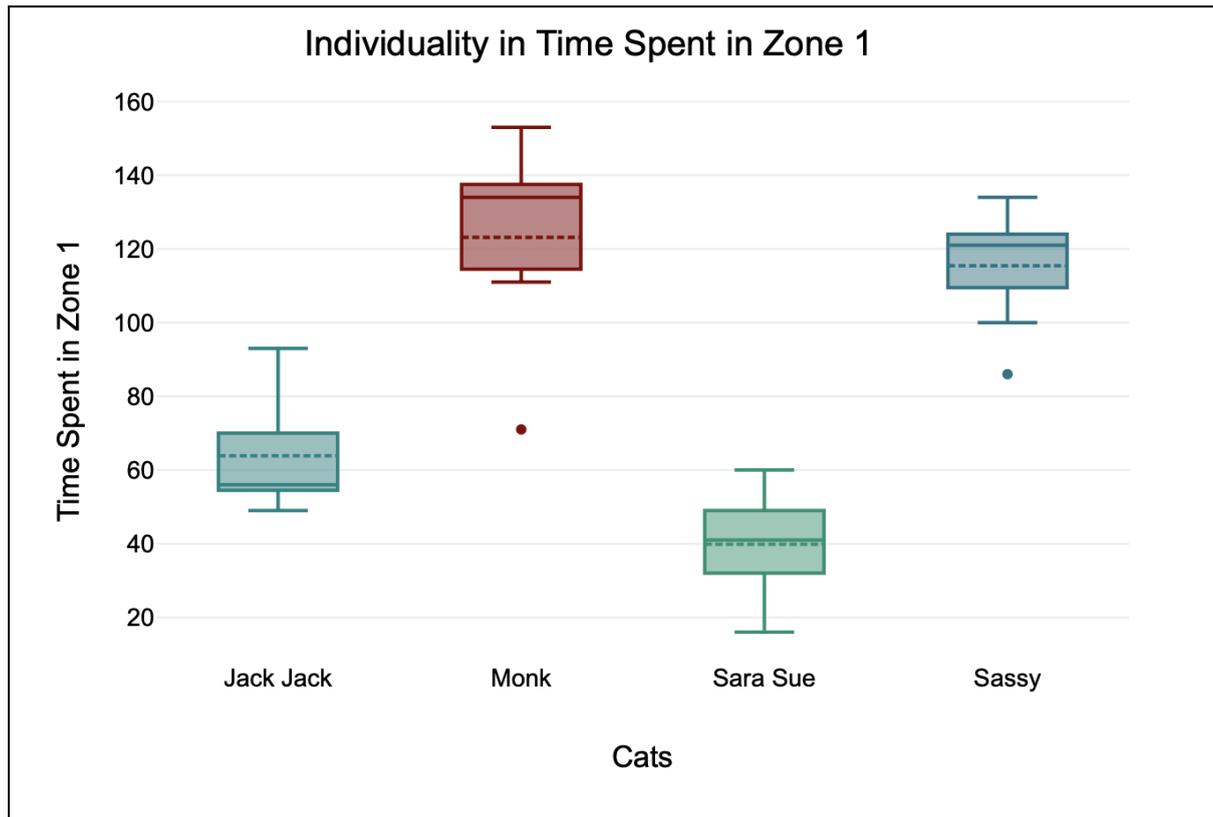

Figure 7. Individual differences in time allocation for Zone 1 (within 1 inch from the food) among feline subjects during the study. Over a seven-day trial period, cats displayed varied levels of engagement in this closest zone, reflecting differences in motivation or frustration. The graph shows the range of time spent by each cat per day (n = 7 days), indicating the degree to which each individual prioritized proximity to the food despite its inaccessibility.
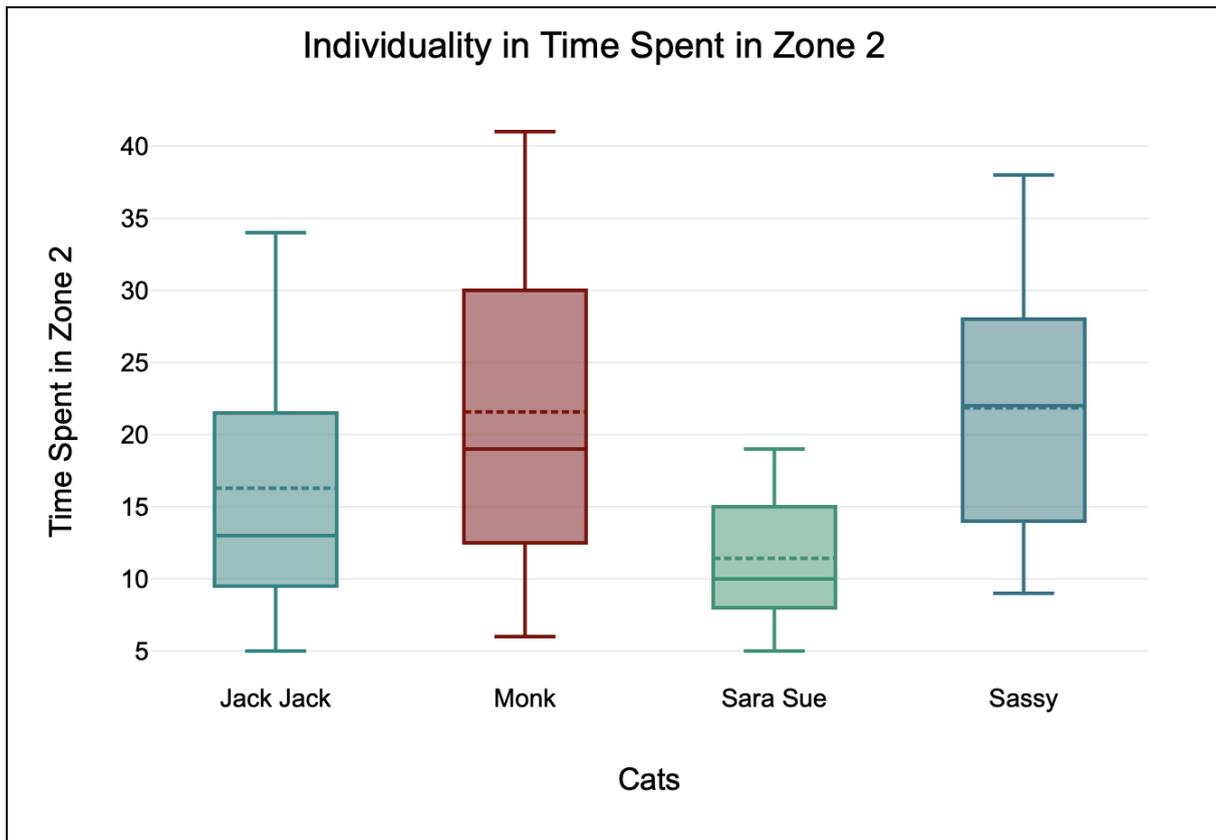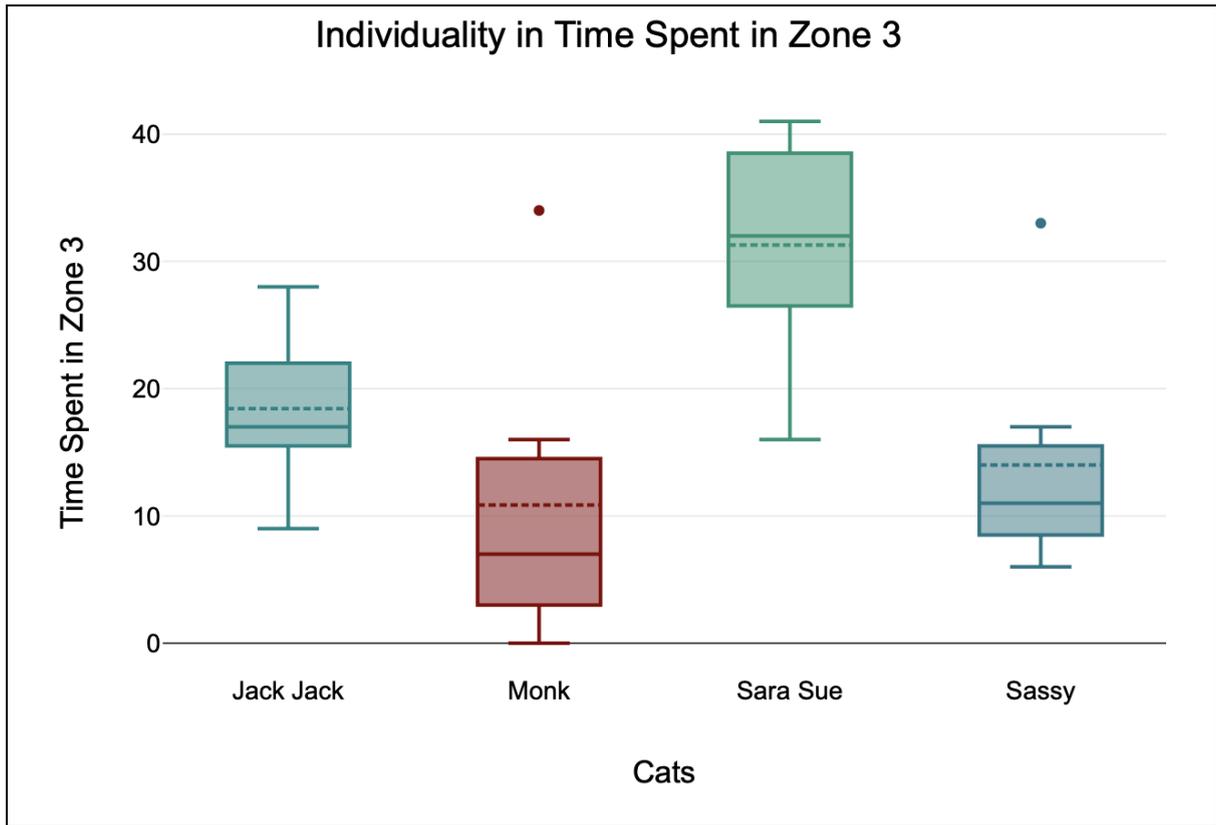
Figure 8. Individual differences in time allocation for Zone 2 (within 1 to 5 inches from the food) among feline subjects during the study. Over a seven-day trial period, cats displayed varied levels of engagement in this intermediate zone, reflecting differences in motivation or frustration. The graph shows the range of time spent by each cat per day (n = 7 days), indicating the degree to which each individual maintained proximity to the food within this distance, despite its inaccessibility.

Figure 9. Individual differences in time allocation for Zone 3 (within 5 to 10 inches from the food) among feline subjects during the study. Over a seven-day trial period, cats displayed varied levels of engagement in this mid-range zone, reflecting differences in motivation or potential loss of interest. The graph shows the range of time spent by each cat per day (n = 7 days), indicating the degree to which each individual maintained proximity to the food at this distance, despite its inaccessibility.
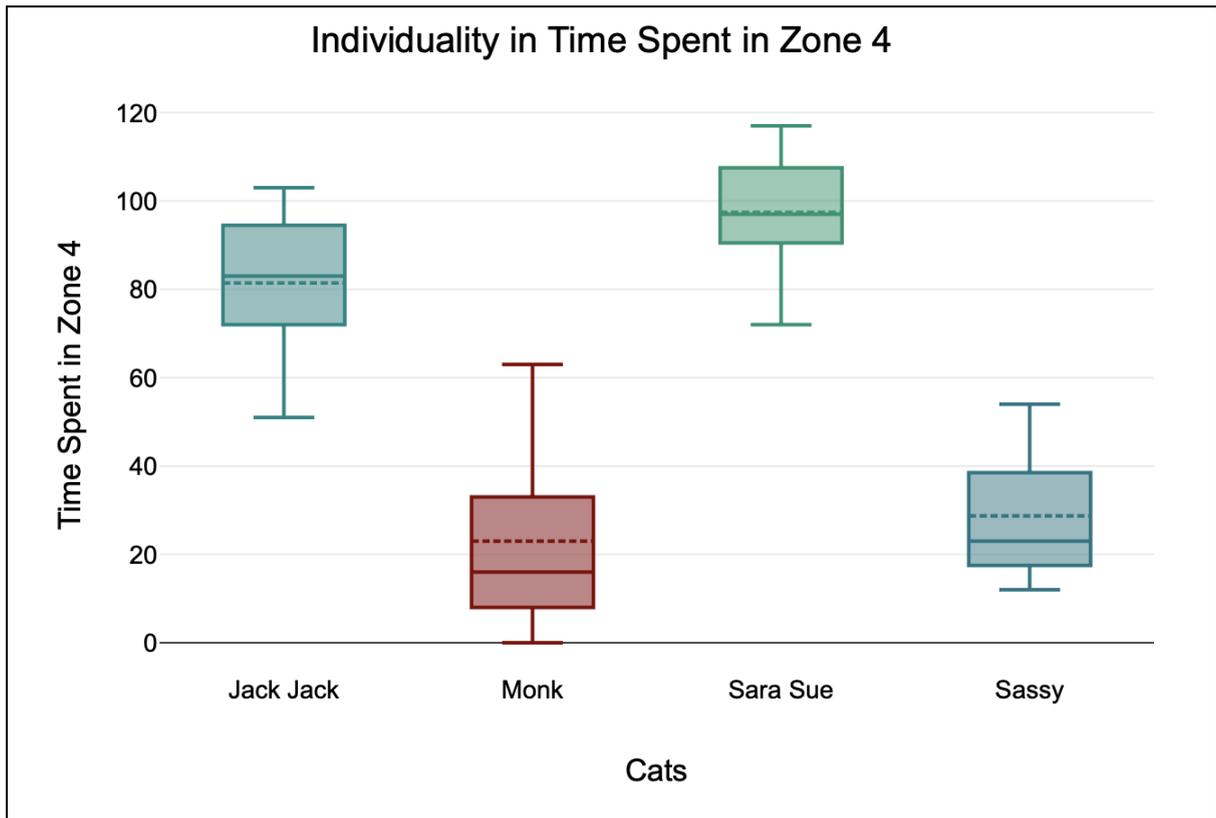
Figure 10. Individual differences in time allocation for Zone 4 (farther than 10 inches from the food, the farthest zone) among feline subjects during the study. Over a seven-day trial period, cats displayed varied levels of engagement in this distant zone, reflecting differences in motivation or disengagement. The graph shows the range of time spent by each cat per day (n = 7 days), indicating the degree to which each individual chose to remain farther away from the inaccessible food, potentially as a response to frustration or loss of interest.

Movement Around the Room

The Chi-square statistic for the "exploring the room" behavior was X^2=58.361 with 3 degrees of freedom and the two-tailed p-value was below 0.0001. This finding suggests that the amount of time in the room exploring was not evenly split between cats and might reflect a variety of individuals' preferences (see Figure 11). Likewise, in the case of "circling the strainer", the Chi-square value was X^2=36.354 with 3 degrees of freedom, and the two-tailed p-value was also below 0.0001. According to this finding, each cat spent different amounts of time circling the strainer, possibly revealing different degrees of frustration or excitement

about the unobtainable food (see Figure 12). Such results demonstrate large variability in the movement of each cat over the course of the experiment.
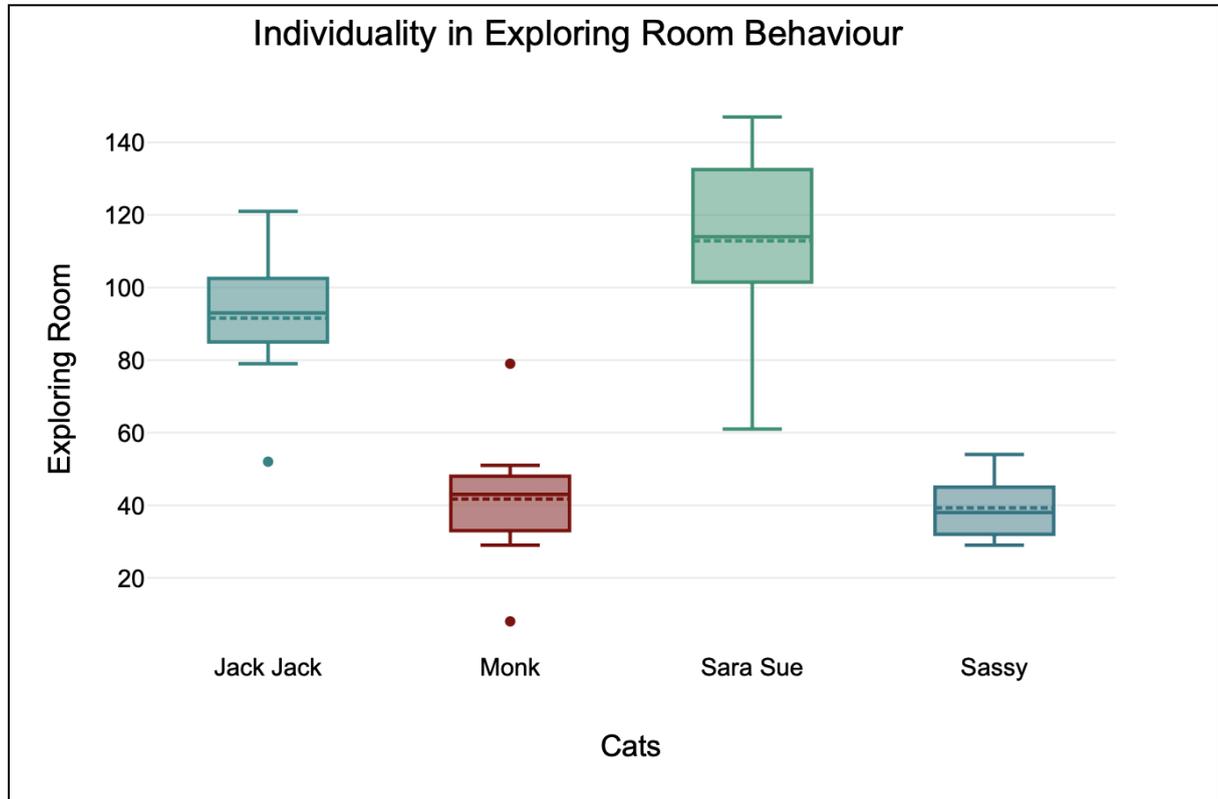

Figure 11. Individual differences in time spent exploring the room among feline subjects during the study. Over a seven-day trial period, cats displayed varied levels of exploration, reflecting differences in curiosity or attempts to cope with frustration. The graph shows the range of time each cat dedicated to exploring the room per day (n = 7 days), highlighting individual variations in engagement with the environment outside of direct interaction with the food source.
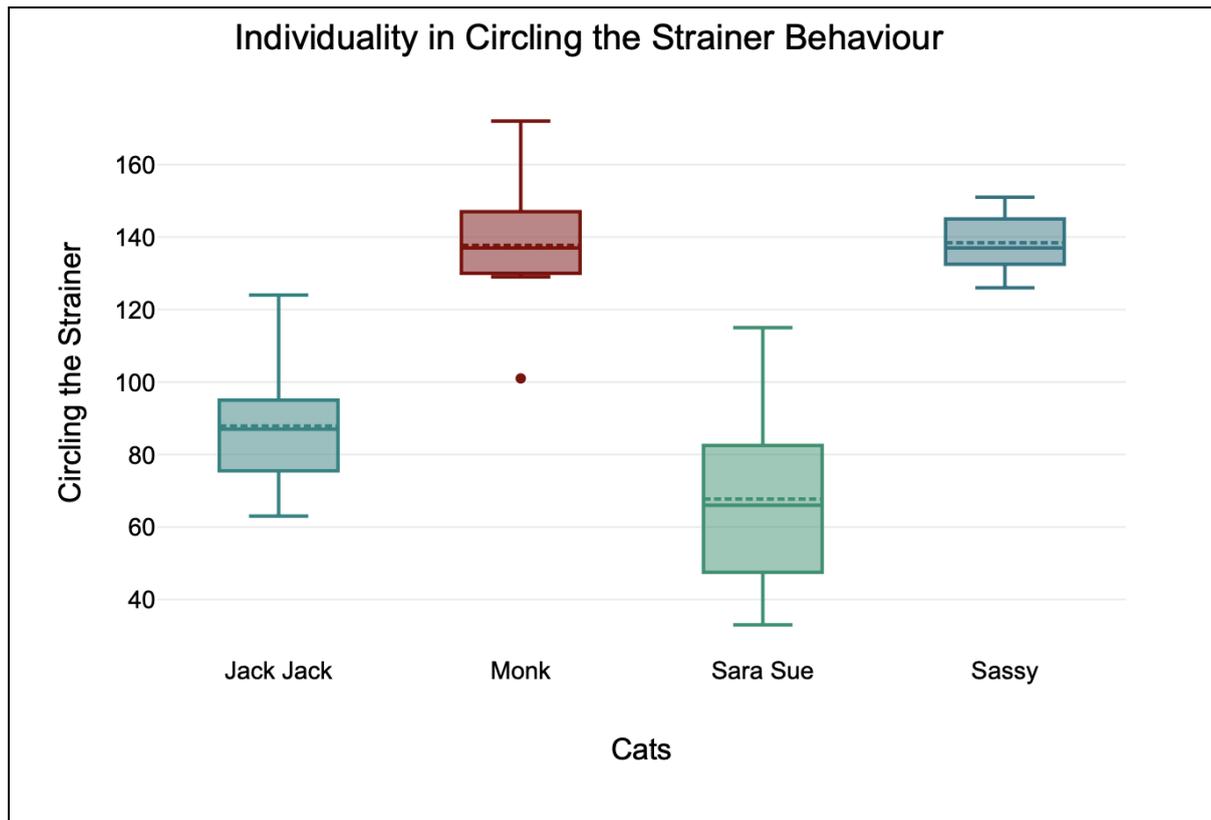
Figure 12. Individual differences in time spent circling the strainer among feline subjects during the study. Over a seven-day trial period, cats displayed varied levels of engagement in circling behavior, reflecting differences in frustration or motivation to access the inaccessible food. The graph shows the range of time each cat spent circling the strainer per day (n = 7 days), indicating the degree to which each individual persisted in this focused behavior as a response to the food being out of reach.

Interaction with the Strainer

For "pawing", the Chi-square statistic was $X^2=47.371$ (3 degrees of freedom) and the two-tailed p-value was less than 0.0001, which indicates a highly significant difference between the cats' pawing behavior (see Figure 16). That means that there was significant individual variation in the frequency with which each cat pawed at the strainer. The "sniffing" category also showed substantial variation, with a Chi-square of $X^2=15.293$, 3 degrees of freedom, and a p-value of 0.0016, suggesting that cats varied significantly in their frequency of this activity (see Figure 15). For "licking", the Chi-square was $X^2=19.308$ (3 degrees of

freedom) and the p-value was 0.0002, again revealing large variability between cats in this interaction (see Figure 14). However there was no significant difference in "biting" (X^2 =2.000, 3 degrees of freedom, p = 0.5724), indicating that it was less common across the cats (see Figure 13). In general, these findings indicate pronounced individual differences in certain behaviors when they interact with the strainer, including pawing, sniffing and licking more than biting.
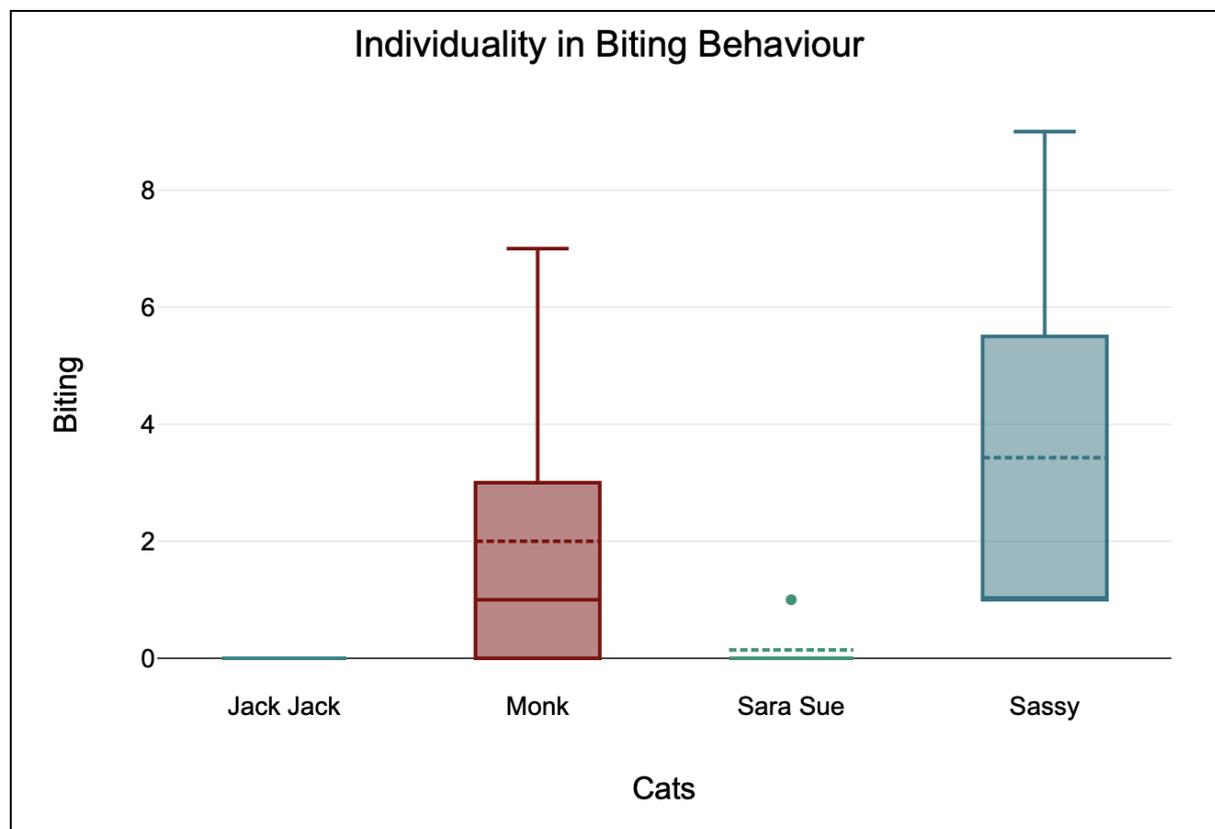

Figure 13. Individual differences in occurrences of biting behavior directed at the strainer among feline subjects during the study. Over a seven-day trial period, cats displayed varied frequencies of biting, reflecting differences in frustration levels or attempts to access the inaccessible food. The graph shows the range of occurrences per day for each cat (n = 7 days), highlighting individual variability in using biting as a behavioral response to the challenge presented.
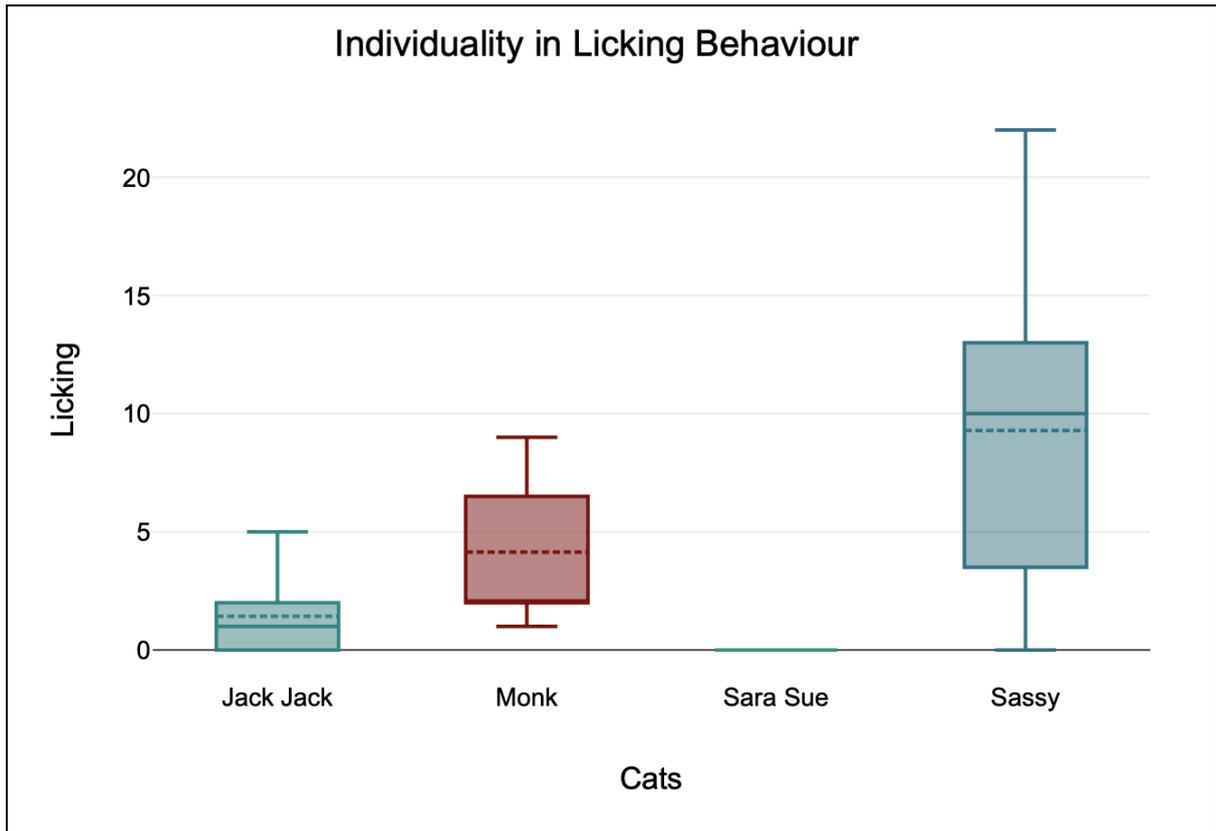
Figure 14. Individual differences in occurrences of licking behavior directed at the strainer among feline subjects during the study. Over a seven-day trial period, cats displayed varied frequencies of licking, which may reflect differences in frustration, exploration, or attempts to interact with the inaccessible food. The graph shows the range of occurrences per day for each cat (n = 7 days), highlighting individual variability in using licking as a response to the experimental setup.
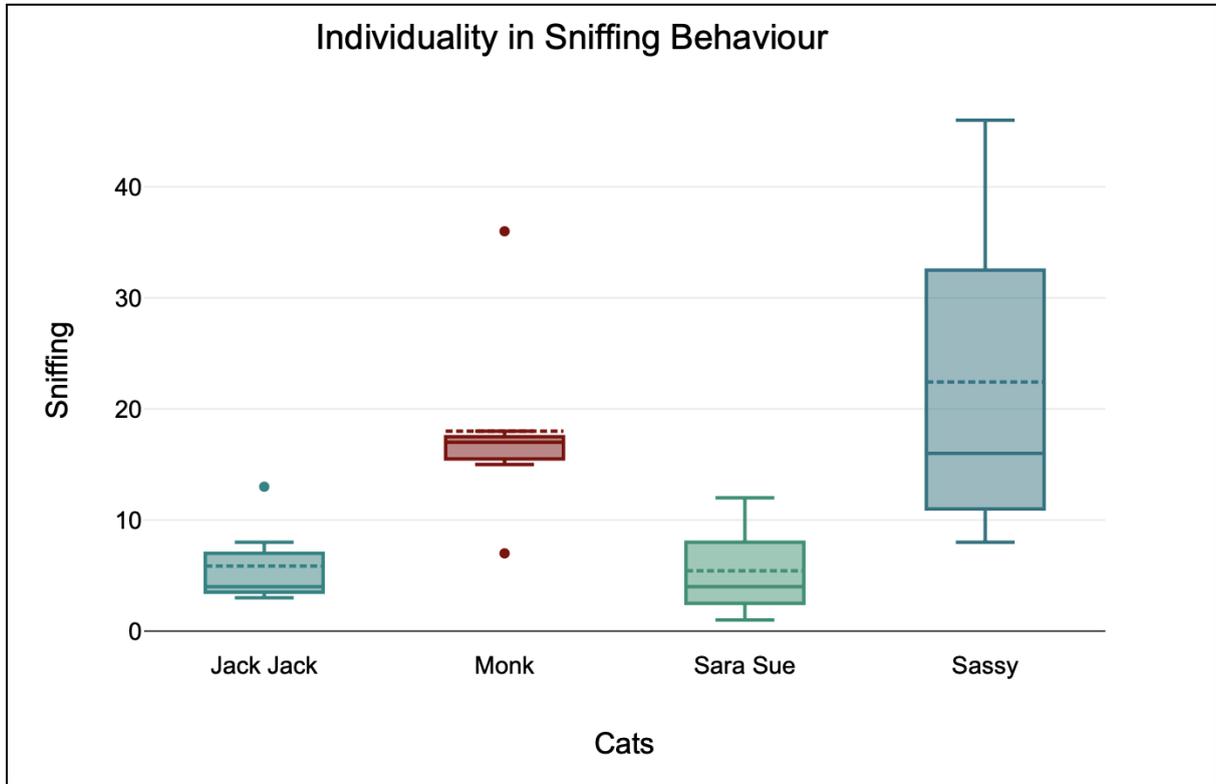
Figure 15. Individual differences in occurrences of sniffing behavior directed at the strainer among feline subjects during the study. Over a seven-day trial period, cats displayed varied frequencies of sniffing, reflecting differences in curiosity, exploratory behavior, or attempts to gather more information about the inaccessible food. The graph shows the range of occurrences per day for each cat (n = 7 days), highlighting individual variability in using sniffing as a behavioral response during the trials.
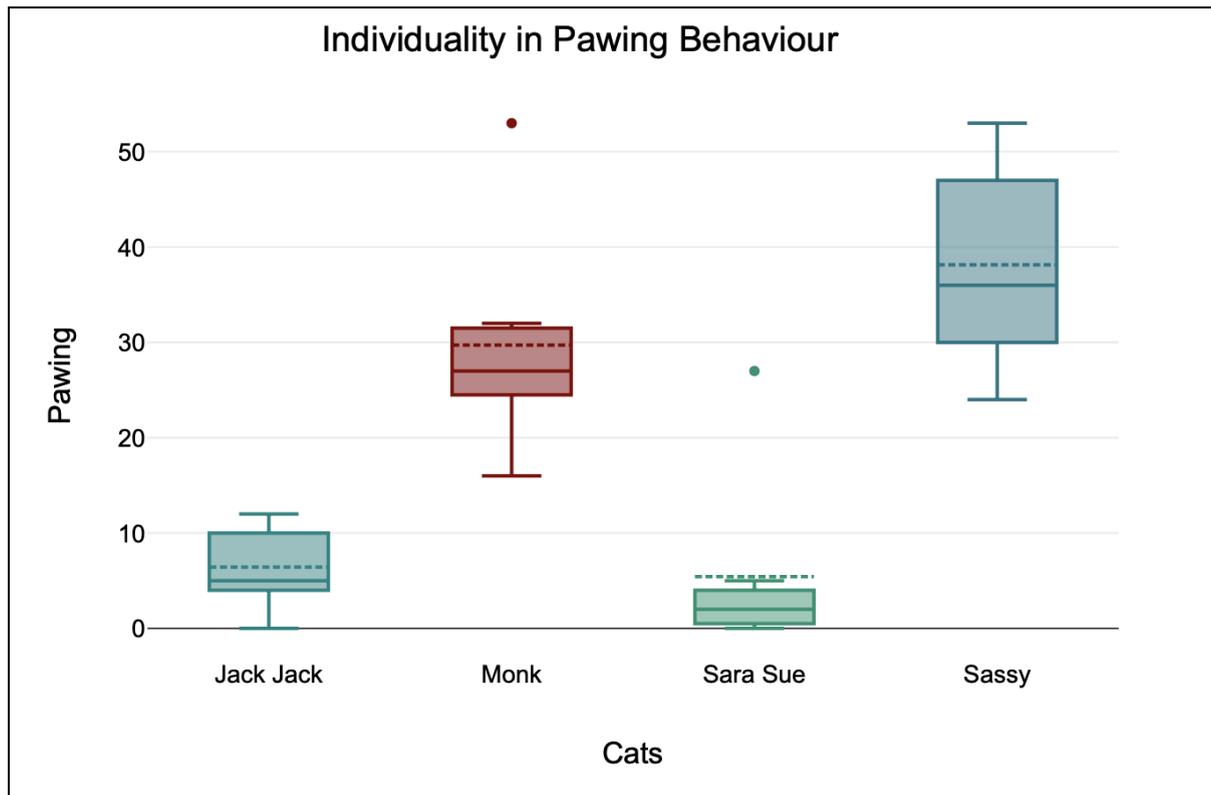
Figure 16. Individual differences in occurrences of pawing behavior directed at the strainer among feline subjects during the study. Over a seven-day trial period, cats displayed varied frequencies of pawing, indicating differences in frustration, determination, or attempts to access the inaccessible food. The graph shows the range of occurrences per day for each cat (n = 7 days), highlighting individual variability in using pawing as an active response to the experimental challenge.

Displacement Behaviors

For "grooming," Chi-square was X^2=3.667 with 3 degrees of freedom and the p-value was 0.2998. This implies that the grooming behavior was not significantly different between the cats, and there was a similarity in how much each cat was displaced by grooming (see Figure 17). The same applies to "scratching at ground surface" where X^2=3.000 with 3 degrees of freedom, and p=0.3916, with no significant difference in behavior among the cats (see Figure 18). On the other hand, "rolling" was somewhat variable among the cats (X^2=8.600, 3 degrees of freedom, p-value 0.0351, statistically significant). This finding indicates

that rolling was used almost equally as a displacement behavior between individual cats (see Figure 19). Lastly, "chewing non-food" had zero-inflated data suggesting that it was either rare or absent from the majority of cats and thus could not be directly compared. While rolling was slightly variable on an individual basis, grooming and scratching remained fairly uniform, and chewing food was too rare to be evaluated.
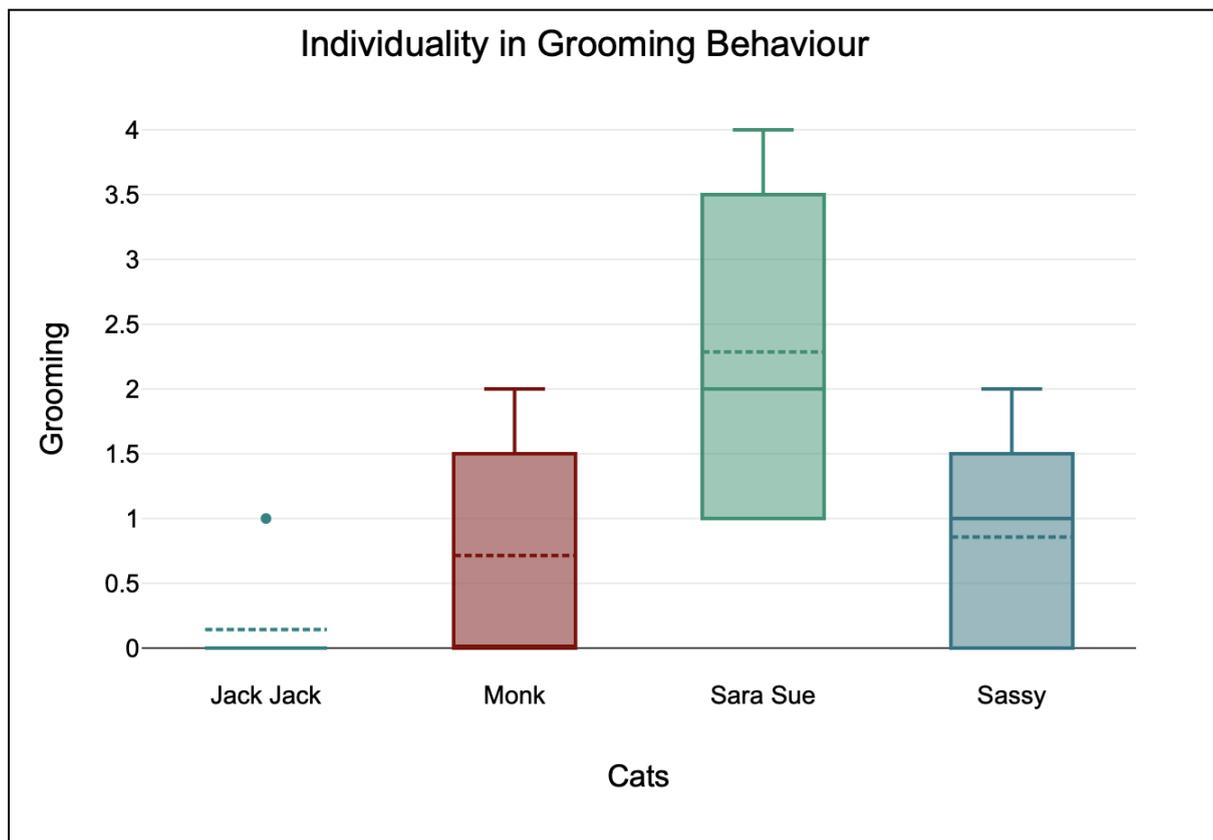

Figure 17. Individual differences in occurrences of grooming behavior among feline subjects during the study. Over a seven-day trial period, cats exhibited varied frequencies of grooming, suggesting individual differences in stress coping, self-soothing, or displacement behavior in response to the experimental challenge. The graph illustrates the range of occurrences per day for each cat (n = 7 days), highlighting the variability in using grooming as a behavioral response to frustration or discomfort.
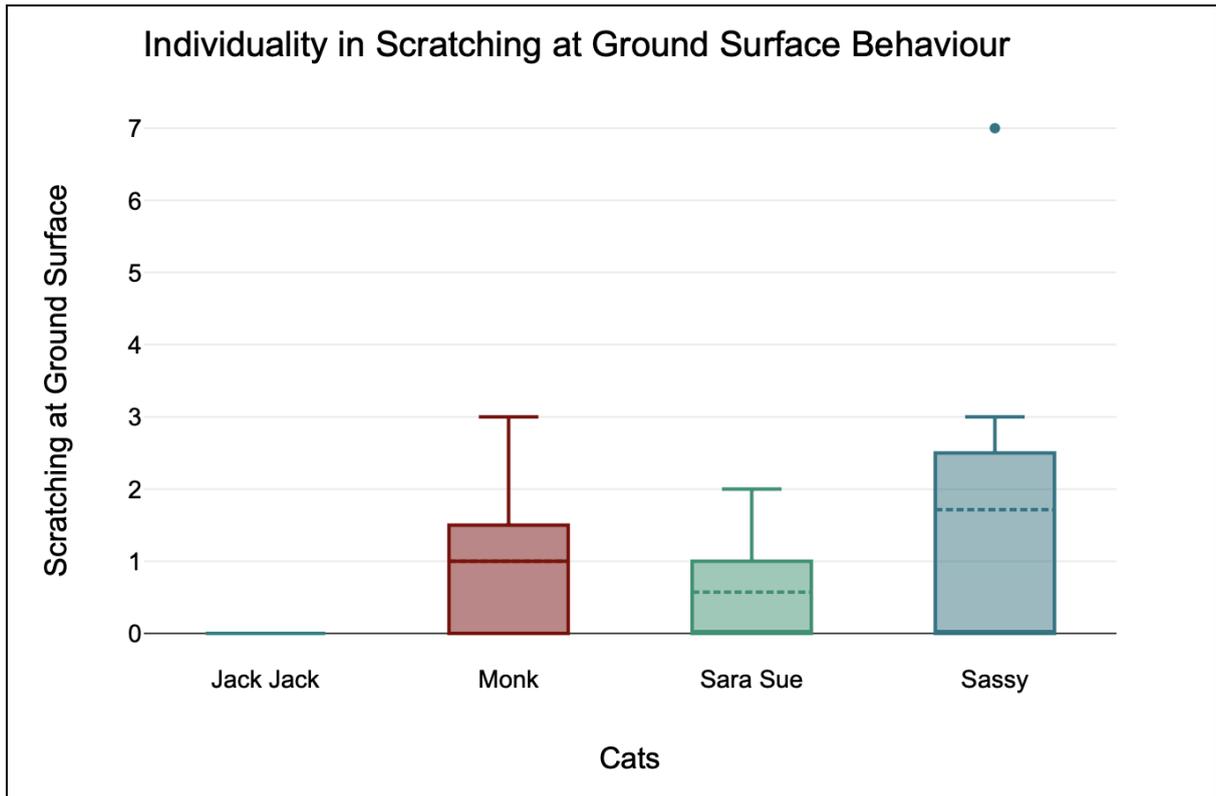
Figure 18. Individual differences in occurrences of scratching at the ground surface behavior among feline subjects during the study. Over a seven-day trial period, cats showed varied frequencies of scratching, indicating differences in their response to frustration, stress, or attempts to alleviate discomfort. The graph displays the range of occurrences per day for each cat (n = 7 days), emphasizing individual variability in using scratching as a coping mechanism during the experimental challenge.
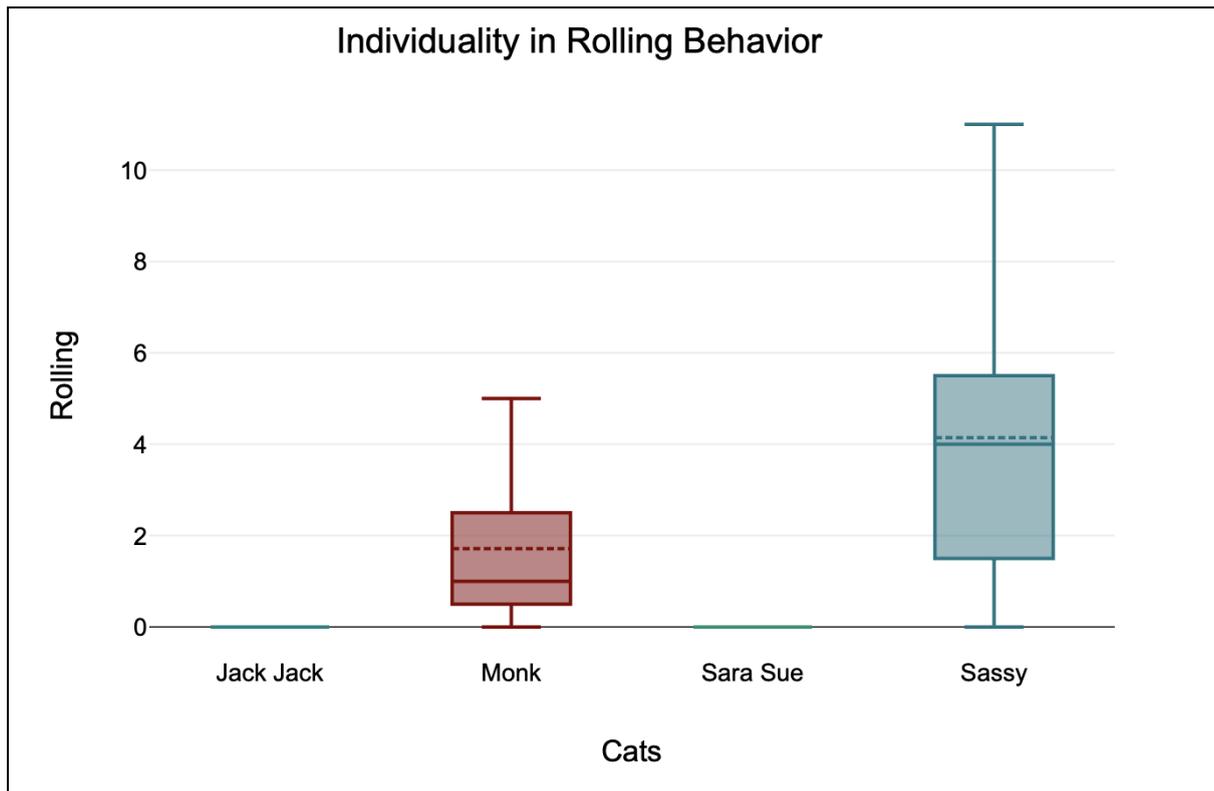
Figure 19. Individual differences in occurrences of rolling behavior among feline subjects during the study. Over a seven-day trial period, cats exhibited varied frequencies of rolling, suggesting individual differences in response to frustration, stress, or as a displacement activity. The graph illustrates the range of occurrences per day for each cat (n = 7 days), highlighting the variability in using rolling as a behavioral response to the experimental challenge.

Vocalizations

Within the Vocalizations subclass, both categories ("meowing") and ("growling/hissing") had zero-inflated values. That is, such vocalizations were very rare or even nonexistent in most cats during the experiment. Therefore, it was not possible to properly do a statistical analysis of differences in vocalizations between cats because the numbers were insufficient. The relatively low frequency of vocalizations suggests that meowing and growling/hissing were not routine responses among the cats to the unsettling conditions of the experiment. Such a lack of vocalization could indicate that these

vocalizations are not typical cat behaviors under stressful conditions where their food cannot be reached.

Discussion

The purpose of this study was to detect frustration responses in domestic cats when presented with an unattainable food item, using an ethogram that included different behavioral categories to quantify this emotion. The categories included proximity to food, interaction with the strainer, movement in the room, vocalization, and other displacement behaviors such as grooming and scratching, chewing non-food items and rolling. These types of behavioral markers can be used to understand how cats display frustration, and better understand their way of coping with a frustrating situation.

The primary behavioral trend noticed in this study were the cats' inclination to spend more time around the food, specifically inside Zone 1 (the closest area to the food). Over the first four days, the cats spent an average of 83-95 seconds near their food. This discovery provides support to the idea that cats have a strong motive to stay close to food when it is within reach, even if they are unable to obtain it directly due to the strainer. The rise in activity in this zone on Days 1 and 4 shows that cats were more persistent in staying physically near the food in the early days, maybe due to increased frustration or a strong desire to get the reward.

In contrast, Zone 2 (1-5 inches from the food) data showed greater fluctuation. The average time spent in this zone varied dramatically across days, which could represent the cats' emotional state and fluctuating levels of frustration. On certain days, such as Day 5, the time spent in this zone increased, implying that as the cats became more comfortable with their tasks, they may have altered their technique or met additional frustration cues, causing them to spend more time in this intermediate zone. The low levels of engagement seen in

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Zone 3 suggest that the cats were generally not motivated to stay away from the food, which could imply a direct concentration on the reward when they became frustrated. The continuous decrease in time spent in Zone 4 (the furthest from the food) reflects this tendency, with the cats becoming less likely to stay on the edge of the room and more focused on the food reward itself as the experiment progressed.

Vocalizations (particularly meowing) occurred on only two days – Days 3 and 4. The limited meowing in this context seems to suggest that meowing is not the typical behavior that cats engage in when frustrated. In the case of not being able to reach a reward, cats might resort to non-vocal coping mechanisms. These could be more subtle than vocalization, such as displacement activities including exploring, grooming, or even chewing non-food items that they were able to reach. The lack of growling or hissing seems to indicate that frustration is unlikely to have escalated into aggression or overt signs of distress.

Displacement behaviors (grooming, scratching at the ground, chewing non-food items, and rolling) were elevated more or less throughout the trials but spiked on particular days. For example, the sharp elevation in rolling and chewing non-food items on Day 5 likely reflects an increased degree of frustration and coping attempts as a way to mitigate the frustration coming from an inability to access the food. This mirrors previous research, which explains displacement behaviors in cats as stress and frustration-related release outlets (Amat et al., 2015; Hargrave, 2015). The spike and subsequent decrease in these behaviors suggests that as the trials proceed the cats may have habituated thereby reducing their frustrated responses.

The spike in rolling on Day 5 might reflect cats engaging in self-soothing behaviors due to increased frustration, while the peak in chewing on non-food items on the same day might reflect the phenomenon of redirected energy to an alternative behavior when the desired food was too difficult to obtain. This interpretation is consistent with previous

research that showed that cognitive enrichment, by providing cats with alternative tasks, reduces frustration behaviors by bridging ongoing motivational states and diverting their focus elsewhere (Gourkow & Phillips, 2016).

There was evidence of cats interacting directly with the strainer, which declined over the course of the trials. This could be because, after a few attempts, the cats learned that it wasn't worth the energy to try to complete the task. This response might also reflect learned helplessness: a psychological state in which, after repeatedly being exposed to an unsolvable task, animals stop trying to solve it altogether (Dantas et al., 2016). Alternatively, it could reflect the cats' not attempting the task anymore but instead performing other sorts of behaviors that are mostly likely to produce a sense of control over the environment, such as displacement behaviors or exploration of the room.

Mostly, movement about the room decreased over the course of trials, indicating a habituation effect, whereby the cats became less and less active in finding a way to access the food-reward. Alternatively, energy conservation might reflect a loss of interest once the cats figured out that the movement would not help them achieve their objective. This behavioral pattern related well to findings by Bennett et al. (2017) who found that repeated attempts to discover a solution to insurmountable problems, led to cats not working quite as hard at the tasks. It seemed that there was simply no point in expending too much energy when the problem couldn't be solved.

Such findings unveil intriguing insights about how cats respond to frustration in various settings and offer a benchmark against which we can understand feline frustration and coping mechanisms in real life. The cats living in animal shelters or multi-cat homes routinely experience frustration, for example when sharing a home or more simply their space, or fighting over food or toys. The recurrence of rolling and chewing non-food items, as

primary features of frustrated behavior, highlights the necessity of having alternative outlets to translate frustration into these displacement behaviors. Hence, appropriate environmental enrichment should be used to facilitate cats' coping with stress (Ellis, 2018).

These behavioral patterns could also be useful in developing tools for assessing the welfare of cats kept in limited and enclosed environments. Specifically, displacement behaviors could indicate frustration and, as such, they could be used as 'early warning signs' to indicate if a cat is beginning to experience stress. This would allow caregivers to intervene before the cat's frustration manifests as a certain threshold for more serious welfare concerns, like aggression or chronic stress.

There are also limitations in the level of generality of the findings because the sample size was very small and because the trials all took place at the same location and in the same room. While this high degree of standardization of the experimental conditions might compensate in some way for the fact that the cats were kept in unfamiliar surroundings, it does seem to have prevented them from expressing their frustration via normal behaviors, as there was no possibility for them to engage in activities that are part of their repertoire when faced with stress (such as running, climbing or hiding). More complex environments could allow the cats to express a broader range of responses in the future.

Secondly, though it was helpful to develop a personalized ethogram, expansion of the list to encompass more subtle indicators of emotion, for example, ear position or tail movement, has the potential to enrich future assessments of feline frustration. It would also be interesting to explore, for example, if repeated frustration over time would cause changes in cat behavior, and ultimately their welfare, in terms of chronic stress and its consequences for physical health.

The overall pattern of behavior in this study indicates that frustration in cats results in a complicated combination of persistent actions (proximity to food, strainer interaction) and more passive methods of coping (displacement behaviors). The combination of these responses suggests a variety of approaches to frustration in cats, in which the animals initially proceed in seeking to gain access to the food but eventually turn to different coping behaviors when the goal remains unachievable. The decrease in goal-directed activities (e.g., pawing) and increase in displacement behaviors (e.g., rolling) during the trial suggests that the cats were able to adapt to the frustrating circumstance, presumably through a learning process or habituation.

Importantly, the individual differences in the cats' responses indicate that frustration tolerance may differ between individuals. Some cats engaged with the strainer more intensely and persistently, while others were more prone to displacement behaviors at first. This heterogeneity could be attributable to characteristics like temperament, prior experiences, or individual coping techniques, emphasizing the importance of taking individual differences into account when studying animal behavior in experimental situations.

Conclusion

In conclusion, this study advances knowledge of feline frustration behaviors regarding unobtainable food with nuanced insight into how they cope with this challenge by exhibiting displacement behaviors, vocalization and engagement of the object, self, and room. These findings underscore the necessity of recognizing and understanding frustration behaviors in experimental set-ups and the real-world context, providing feline caretakers and veterinarians with the understanding necessary to promote the welfare of cats.Ensuring that cats have regular environmental stimulation, such as food puzzles or other cognitive toys, can help to avoid stressful circumstances and behavioral concerns. Given the widespread prevalence of

frustration behaviors observed in experimental studies and real-world settings, and the likely distinction between domestic and natural environments, future research on feline frustration behaviors and using more complex and larger environments to investigate the role of frustration in addressing real-world challenges, as cats likely cope with in natural and home environments, will most definitely be required.

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