Social Interaction, Food, Scent or Toys? A Formal Assessment of Domestic Pet and Shelter Cat (*Felis silvestris catus*) Preferences

Kristyn R. Vitale Shreve[1], Lindsay R. Mehrkam[2], Monique A. R. Udell[1]

1. Department of Animal and Rangeland Sciences, Oregon State University 112 Withycombe Hall, 2921 Southwest Campus Way, Corvallis, OR 97331, USA

2. Department of Psychology, Monmouth University 142 Howard Hall, 400 Cedar Avenue, West Long Branch, NJ 07764, USA

Corresponding author- Kristyn Vitale Shreve, Email: kristyn.shreve@oregonstate.edu Phone: (541) 737-3431, Fax (541) 737-4174

Abstract

Domestic cats (*Felis silvestris catus)* engage in a variety of relationships with humans and can be conditioned to engage in numerous behaviors using Pavlovian and operant methods. Increasingly cat cognition research is providing evidence of their complex socio-cognitive and problem solving abilities. Nonetheless, it is still common belief that cats are not especially sociable or trainable. This disconnect may be due, in part, to a lack of knowledge of what stimuli cats prefer, and thus may be most motivated to work for. The current study investigated domestic cat preferences at the individual and population level using a free operant preference assessment. Adult cats from two populations (pet and shelter) were presented with three stimuli within each of the following four categories: human social interaction, food, toy, and scent. Proportion of time interacting with each stimulus was recorded. The single most-preferred stimulus from each of the four categories were simultaneously presented in a final session to determine each cat's most-preferred stimulus overall. Although there was clear individual variability in cat preference, social interaction with humans was the most-preferred stimulus category for the majority of cats, followed by food. This was true for cats in both the pet and shelter population. Future research can examine the use of preferred stimuli as enrichment in applied settings and assess individual cats' motivation to work for their most-preferred stimulus as a measure of reinforcer efficacy.

Keywords: Domestic cat; *Felis sylvestris catus;* Human-cat bond; Human interaction; Preference assessment

1. Introduction

With over 85 million domestic cats (*Felis silvestris catus***)** living in U.S. homes (APPA, 2015), over 3.4 million cats entering U.S. shelters each year (ASPCA, 2016), and an unknown number of free-roaming cats sharing human spaces (Miller et al., 2014) the domestic cat has displayed amazing flexibility in social living. Despite this adaptable nature cats are still often thought to be more independent than social (Potter and Mills, 2015; Spotte, 2014). Additionally, many still perceive the domestic cat as difficult to train, with kitten and cat training classes rare compared to the variety of these classes offered to dogs (Seksel, 2008). However, cats have been successfully trained on a variety of auditory (Witte and Kipke, 2005), visual (Pisa and Agrillo, 2009; Sasaki et al., 2010; Wilkinson and Dodwell, 1980), and olfactory (Mayes et al., 2015) discrimination tasks in scientific settings and are also regularly trained for entertainment outlets worldwide. Significant species continuity has also been demonstrated with respect to Pavlovian and operant conditioning (Skinner, 1938). Therefore the cat's untrainable reputation may have more to do with lack of knowledge of which stimuli individual cats most prefer and what items those cats may be most motivated to work for, an important aspect of operant conditioning (Powell et al., 2012).

Several forms of preference assessment have been developed to examine individual preference, originally for use with non-verbal humans with disabilities (Cannella et al., 2005). In a paired-stimulus preference test, two items are concurrently presented and the stimuli which produces the highest percentage of approach behavior recorded as the preferred item (DeLeon and Iwata, 1996; Fisher et al., 1992). In another type of preference assessment, the multiple-stimulus assessment, an individual is able to choose from an array of several items that are presented simultaneously. Two versions of the multiple stimulus test exist, including the replacement of the chosen stimulus back into the array, making the preferred item available for selection during the next trial, and without replacement of the chosen stimulus, comparing only previously not selected stimuli during the next trial (DeLeon and Iwata, 1996). Finally, in free operant preference assessments, an individual has noncontingent access to an array of stimuli for a set period of time, allowing free interaction with all items (Roane et al., 1998). Rather than measuring discrete trials, the free operant method assesses preference based on duration of interaction with various stimuli. The free operant method provides a potential advantage with certain human and non-human animal populations; as the length of the assessment is often shorter than methods requiring discrete trials, allowing for preference testing to be used with individuals where brief assessments with less repetition may improve efficacy (Rush et al., 2010). Additionally, items in a free-operant test can be laid out in a square, reducing potential issues with side-bias, a problem seen in research with dogs (Gácsi et al., 2009).

More recently, preference tests have been extended to several non-human animal species including the domestic dog (*Canis lupus familiaris*) (Feuerbacher and Wynne, 2015, 2014; Protopopova et al., 2016; Vicars et al., 2014), Galapagos tortoise (*Chelonoidis nigra*) (Mehrkam and Dorey, 2014), Cotton-Top Tamarin (*Saguinus oedipus*) (Fernandez et al., 2004), giant panda (*Ailuropoda melanoleuca*) and African elephant (*Loxodonta Africana*) (Gaalema et al., 2011). However, to date no formal preference assessment comparing several different categories of stimuli has been conducted with the domestic cat. A formal assessment in cats has several applied benefits and can be used to identify stimuli that are most likely to function as a reinforcer in training settings, to evaluate the palatability of food or attractiveness of other stimuli, and could be used to inform the use of specific stimuli for environmental enrichment.

Studies that have been conducted with cats have examined preference for various types of food. Church and colleagues (1996) examined cat food preference by concurrently presenting hard dry foods in varying ratios to two populations of domestic cat; a farm and rescue cat population that had a history of scavenging on a variety of foods and a population of more nutritionally inexperienced indoor-only pet cats. Cats in the farm and rescue population showed a stronger individual preference for the novel food while the more nutritionally inexperienced pet cats only showed a weak individual preference (Church et al., 1996). Additionally, Bradshaw et al. (2000) found housecats, which were fed raw meat less often in their diet, preferred raw beef less than free-roaming cats, which most likely often eat raw meat as part of their diet. The food preferences of young kittens are also known to be heavily influenced by experience with their mother (Bradshaw, 2006) as kittens tend to imitate their mother's food preferences, even if the mother's food is atypical for their species (e.g. mother has been trained to eat bananas or potatoes) (Wyrwicka, 1978).

Finally, although not a formal preference assessment, Ellis and Wells conducted studies into attention and behavioral response to visual stimuli (2008) and olfactory stimuli (2010) as enrichment for shelter cats. They found that although shelter cats spent relatively low amounts of time looking at the visual conditions presented on the television screen, they spent more time directing their gaze at the screen and less resting behaviors during the conditions with animate movement. This indicates the use of video images with live prey species may serve as an effective form of enrichment, although there is habituation to this stimulus over time (Ellis and Wells, 2008). Additionally, the researchers found that although shelter cats spent relatively little time with the scent stimuli overall, catnip elicited the most interest indicating this scent could also be a useful form of enrichment, especially in captive settings (Ellis and Wells, 2010).

Although previous studies provide a foundation in understanding some cat preferences, no study has yet conducted formal cat preference assessments for triads of stimuli across human social, food, scent, and toy categories. There is also a great need to consider a wider range of stimuli in

general, especially biologically relevant stimuli and other stimuli that are common in domestic cat environments and could be used in enrichment, training or behavior modification settings. Therefore, the aim of this study was to examine individual cat preferences within and between items in human social, food, scent, and toy categories in two populations (shelter and pet) of domestic cats.

2. Material and methods

2.1 Subjects

Twenty-five adult (>1-year-old) pet cats and twenty-five adult (>1-year-old) shelter cats were selected for this study. Pet cats ranged in age from 1-16 years old with an average age of 5.5 (SD +-3.8) and had a sex distribution of 13 males and 12 females. None of the pet cats had been recently acquired from a shelter prior to the study. Shelter cats were tested from 3 shelters- 9 cats from Willamette Humane Society in Salem, OR, 9 cats from Heartland Humane Society in Corvallis, OR, and 7 cats from SafeHaven Humane Society in Tangent, OR. Shelter cats ranged in age from 1-20 years old, with and average age of 6.3 (SD +-5.4). Shelter cats had a sex distribution of 12 males and 13 females. Shelter cats had been residing in the shelters for an average of 46.5 days, with stays ranging from 1 day to 163 days prior to the date of testing.

Of these fifty cats, 5 (2 pet, 3 shelter) did not undergo the full assessment due to nervous behavior (hiding, shaking, dilated pupils) and 6 other cats (4 pet, 2 shelter) underwent the full assessment but did not interact with any of the items, often sitting away from the stimuli. Nineteen pet cats interacted with stimuli during the assessment and were included in the full dataset. Twenty shelter cats interacted with stimuli during the assessment and were included in the within-category comparisons (N = 39). However 1 shelter cat did not interact with any stimuli during the between-category (most-preferred) comparison and so 19 shelter cats were included in the full dataset (N = 38).

2.2 General Procedure

In order to control for motivational state, food and social attention were withheld from subjects for 2.5 hrs prior to testing. The other specific stimuli used for this study were novel to the cats at the time of testing, although cats may have had prior experience with similar stimuli in each category (e.g. the scent of other unfamiliar cats, or exposure to a variety of toys). For pet cats, testing occurred in a room in the owner's home. Shelter cats were tested in a room within the shelter. A free-operant preference assessment was conducted with human social, food, toy, and biologically relevant scent categories.

Stimulus Categories:

In the within-category social condition, preference for (1) human vocalization, (2) petting and (3) playing with feather toy was compared serially so that the human's identity could be held consistent. Each human interaction type was presented for one minute and associated with an identifiable cue.

Before the petting condition, the human pet the cat, showed the cat a closed fist, and sat on the ground as indicated by tape marking on the testing floor while still presenting the closed fist as a cue for petting. If the cat approached, the human could freely pet the cat. After each 1 min session, the human got up and moved to a different spot on the ground (i.e. once the 1 min of play is over, the human gets up and moves to another tape marking before beginning the 1 min of vocalizing). Vocalizing served as its own discriminative stimulus, and the presence of the toy indicated the availability of play. The feather toy used in this condition utilized the same brand of feathers from the toy condition, *GoCat Da Bird Feather Toy*, however this feather was attached to a rod. In total, the within category social condition lasted three minutes to match the other within-category assessments.

For the food condition, (1) chicken, (2) tuna, and (3) chicken flavored meat soft cat treat were compared simultaneously for three minutes. Approximately a tablespoon of each food item was placed in 3 locations- in front of, on top of and inside of an unsolvable task previously used with cats (Miklósi et al., 2005). The food task is a small stool (9.5 cm in height, 25.5 cm in length, 12.5 cm in width) with a plastic see-through cup connected via a string (50 cm long), which can be wrapped around the stool so the cat cannot access the food inside the dish. Because some of the cats broke open the unsolvable version as described by Miklósi et al. (2005) we added a second string that could be tied to the first string in order to more securely fasten the cup to the top of the food task. This ensured the cats could taste a chosen food, but not consume all of it within the three-minute period, which could otherwise remove the motivation to stay in a particular testing quadrant past initial consumption.

For the biologically relevant scent category, the scents of a (1) gerbil (potential prey item), (2) catnip, and (3) unfamiliar conspecific were compared simultaneously for three minutes. Each scent stimuli was impregnated into a square cotton cloth (15 cm x 15 cm) for at least 24 hrs prior to the assessment (Ellis and Wells, 2010). The conspecific cloth was rubbed onto the scent glands of an unfamiliar cat and left in the unfamiliar cat's resting area. The gerbil cloth was left inside the cage with the experimenter's gerbils. Experimenters wore gloves when placing the cloths to avoid scent contamination.

The toy condition compared a (1) movement toy, (2) mouse toy, and (3) feather toy simultaneously for three minutes. The movement toy was a wire feather toy with erratic movement that was moved by the experimenter while outside of the room (the experimenter was out of view of the cat). To make this toy the *Cat Dancer 101 Cat Dancer Interactive Cat Toy*™ was attached to a 2x4 wooden board so the wire would stand up on its own. A feather was attached to the top of the toy and clear fishing line attached to the wire so the toy could be moved by the experimenter. Both feathers used in the toy condition were the same brand as used in the social play condition, *GoCat Da Bird Feather Toy*™. The mouse toy was small and fuzzy with a short tail and a shaker inside.

Stimulus Presentation and Behavior Assessment:

In food, toy, and scent categories, the cat had free access to all available stimuli in the category during the 3 min session (Hagopian, 2004). The presentation order of stimuli category and location of stimuli in the testing session were randomly arranged (Roane et al., 1998) in a square with the center of each stimulus (marked with an X) 1.5 m from the center of the other stimulus around the square (Feuerbacher and Wynne, 2015). The experimenter presented the stimulus to each cat briefly before it was placed in the testing area. For the social interaction category, an owner (for pet cats) or experimenter (for shelter cats) provided each type of interaction singly for a period of 1 min each (Hagopian, 2004) in order to hold the 'individual human' constant and still maintain a total of 3 minutes of testing within the social interaction category. Because preference for an item can be measured by an individual's approach to and maintenance of proximity with a stimulus (Zajonc and Markus, 1982), stimuli in each within-category comparison with the highest proportion of interaction were compared in a final between-category comparison to determine each cat's most-preferred stimulus category.

In each of the 4 within-stimuli categories, the proportion of time spent engaging in physical interaction with each stimuli was live coded by experimenters using *Countee*, a mobile device application for analysis of behavioral data (Hernández and Peić, 2016). Physical interaction was defined as a cat making contact with any part of the stimulus (touching, eating, sniffing, playing, licking, etc.), Once the cat completed the within-stimuli categories, a final comparison was made between the items from each of the 4 categories with the highest proportion of interaction. If there was a tie within a category (i.e. playing and petting were equally preferred in the human interaction category) a coin was flipped to decide which item was presented in the final between-category comparison.

In a final phase to determine most-preferred category, four stimuli (the individual's most preferred item from each category as determined by the within-category assessment) were presented simultaneously for 3 min in the same manner as previously described, however this time social interaction was presented concurrently with the other stimuli, not singly as before. Figure 1 shows the set-up of the final most-preferred stimulus comparison phase, with the most-preferred stimulus from each category presented simultaneously (the within-category comparison would look similar, with the exception only 3 of the quadrants would hold stimuli, and all stimuli would be from the same category). If a cat showed no interaction with any stimulus in a within-stimulus category, a stimulus from that category was not included in the final comparison (e.g. if cat never investigated any of the scent cloths, no scent item would be in final comparison).

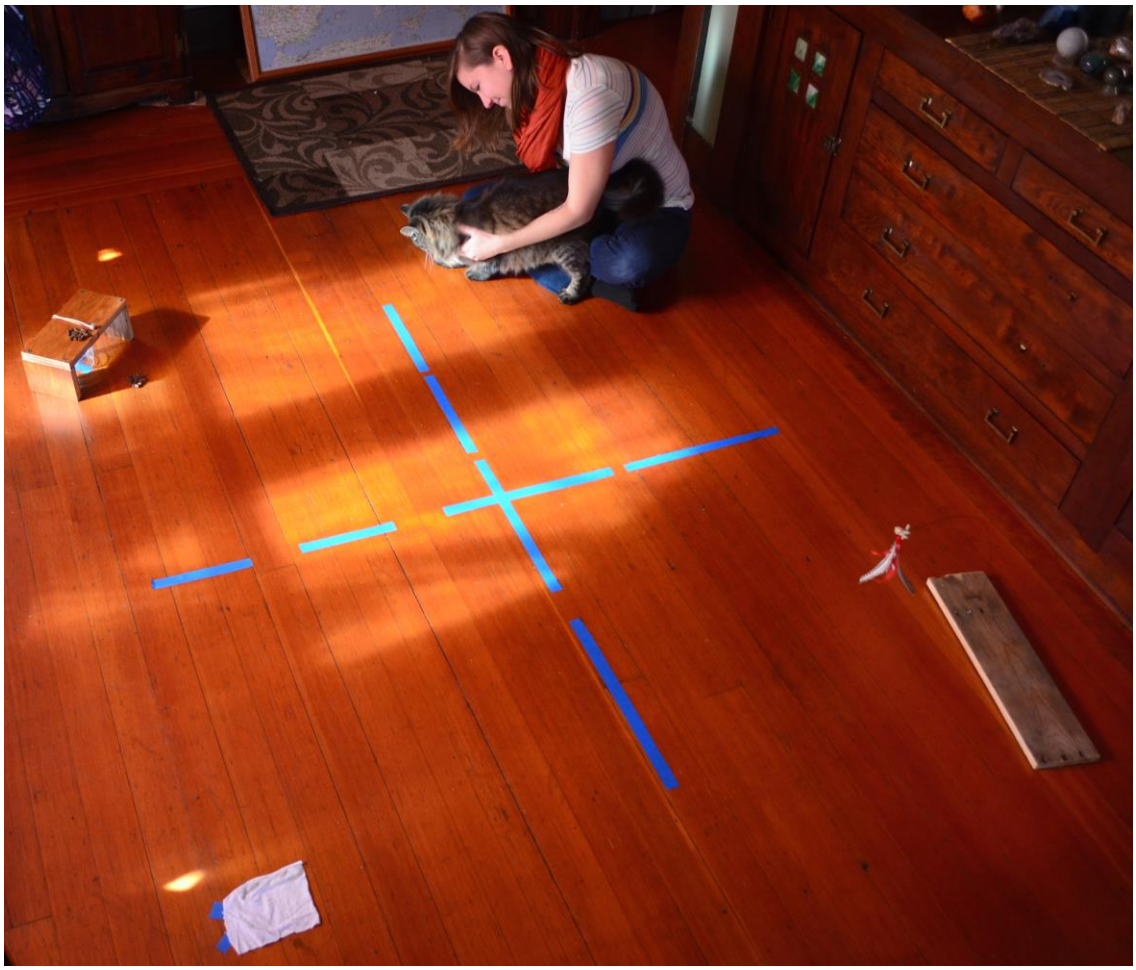

Figure 1

Set up of the between-category comparison to determine most-preferred stimulus category. The most-preferred stimuli from the food, scent, toy, and human interaction conditions were randomly placed in a square with the center of each stimulus (marked with X on the floor) 1.5 m from the center of the other stimulus around the square.

2.3 Statistical Methods

Shapiro-Wilk normality tests were run and data did not follow a normal distribution (all $p > 0.05$) therefore non-parametric statistics were used to analyze study data. Two-tailed Fisher's Exact Tests were run to compare the number of pet and shelter cats preferring stimuli in each within-stimulus category comparison and the most-preferred category comparison. All tests were two-tailed and used an alpha of 0.05, with the exception of cases where multiple pairwise comparisons were conducted in which case a Bonferroni Corrected alpha of 0.008 was used as indicated. To calculate inter-observer reliability, 30% of videos were double coded using *Countee*, applying an 8% range of tolerance for proportion of interacting with each stimuli (i.e. if two observer scores were within 8% of each other in terms of total duration they were considered in agreement). An inter-observer reliability score of 88% was calculated for proportion of interaction with stimuli.

3. Results

3.1 Overview

When comparing pet and shelter cats, there were no significant differences between the two populations in terms of the number of individuals preferring stimuli within each category or in the number of individuals preferring each stimulus category in the final comparison (all $p > 0.06$). Therefore these populations were combined when analyzing overall cat preferences.

3.2 Within-Category Most Preferred Comparison

Two-tailed Fisher's Exact Tests were run to compare the number of cats that preferred items within each category type (e.g. number of individuals that preferred vocalization vs. playing vs. petting) using the Bonferroni-corrected alpha. The preferred item was the stimulus with the highest proportion of interaction during the session. If a cat showed equal preference for multiple stimuli within the category (e.g. spent 100% of time with the human in all 3 human interaction conditions) each of those conditions were considered most-preferred for that cat. Therefore, in some cases, the number of preferred stimuli recorded for within-category testing was greater than the number of cats tested. As seen in Figure 2, in the human interaction category significantly more cats preferred playing to vocalization (25 and 8 respectively, $p = 0.0002$) however there was no significant difference in cat preference between petting and vocalization (17 and 8, $p = 0.05$) or playing and petting (25 and 17, $p = 0.1$). In the food category, significantly more cats preferred tuna to the chicken meat soft treat (22 and 4, $p = 0.0001$) however there was no significant difference in cat preference between tuna and chicken (22 and 11, $p = 0.02$) or chicken and meat soft treat (11 and 4, $p = 0.08$). In the toy condition, significantly more cats preferred interacting with the movement toy over both the mouse (23 and 3, $p = 0.0001$) and the feather (23 and 2, $p = 0.0001$), however there was no significant difference in preference between the mouse and feather toy (3 and 2). Finally, in the scent category, significantly more cats preferred the catnip scent to the gerbil scent (22 and 6, $p = 0.0003$) and conspecific scent (22 and 6, $p = 0.0003$), however there was no difference in preference between the gerbil and conspecific scent (6 and 6, $p = 1$).

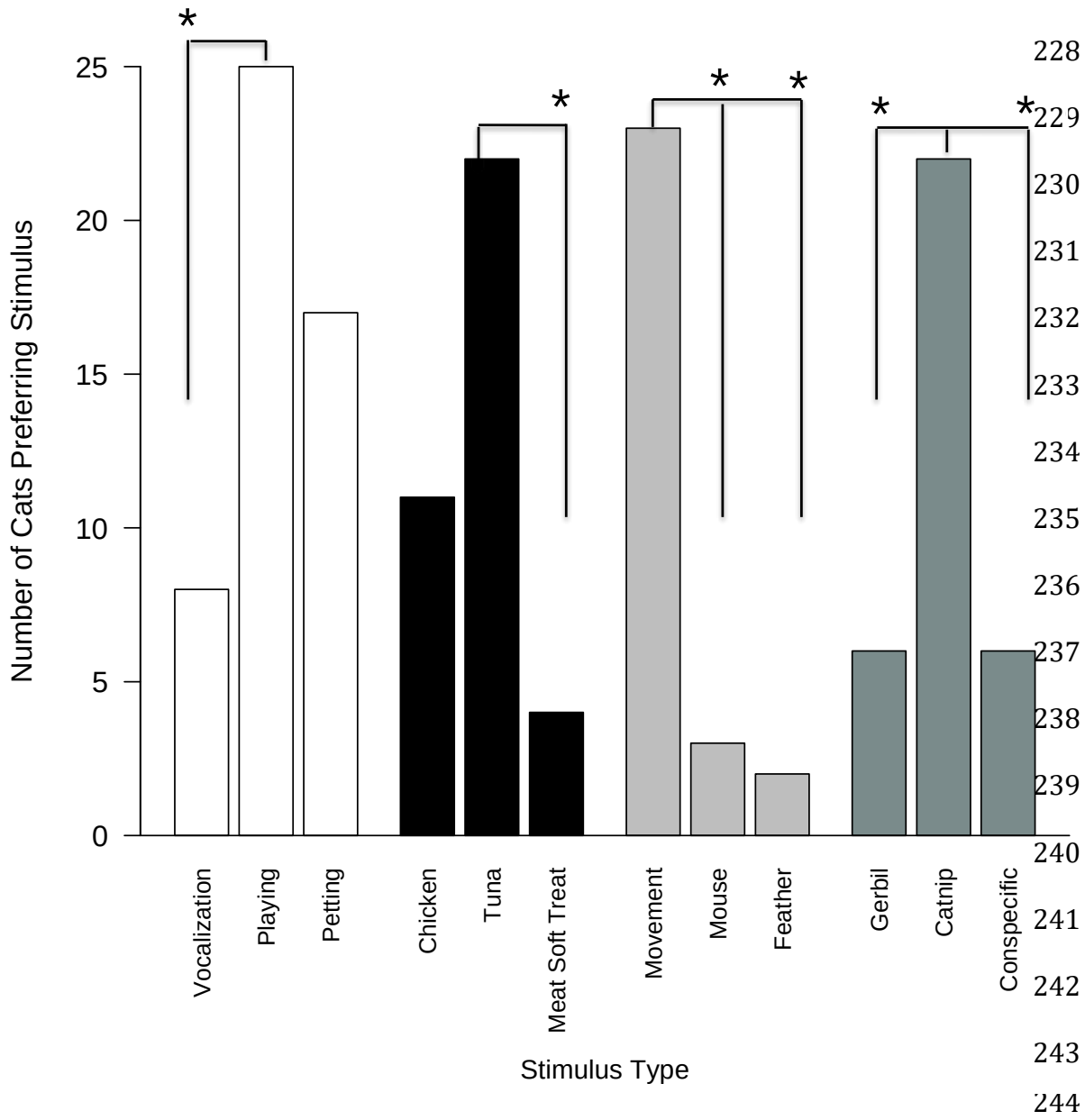

Fig. 2

Number of pet and shelter cats (N=38) preferring each stimulus across the four categories in the within-category most preferred comparison. * $p > 0.001$. White bars indicate items in the human social interaction category, black bars indicate food, gray indicate toys, and green indicate scent items.

3.3 Between-Category Final Most-Preferred Comparison

Data for the most-preferred stimuli comparison (final comparison in which the stimulus with the highest proportion of interaction from the within-category comparison were compared against one another) were analyzed using two-tailed Fisher's Exact Tests and a Bonferroni correction. The stimulus category receiving the highest proportion of interaction in this final comparison was categorized as the most-preferred category. As seen in Figure 3, 19 cats (50%) most preferred social interaction, 14 cats (37%) most preferred food, 4 cats (11%) most preferred toys, and 1 cat (2%) most

preferred scent. Significantly more individuals preferred social interaction to toys (19 and 4 respectively, $p = 0.0003$) and scent (19 and 1, $p = 0.0001$), however there was no significant difference between individuals preferring social interaction and food (19 and 14, $p = 0.35$). In addition, significantly more individuals preferred food to scent (14 and 1, $p = 0.0003$) but there was no difference between individuals preferring food and toys (14 and 4, $p = 0.014$) or toys and scent (4 and 1, $p = 0.36$).

In terms of time interacting in each stimulus category, 19 cats spent on average of 65% of the time interacting in the social category, 14 cats spent an average of 69% of the time interacting in the food category, 4 cats spent on average 50% of the time interacting with toy stimuli, and 1 cat spent 52% of the three minute session interacting with the scent stimuli. The majority (70%) of cats engaged with the most-preferred stimuli for at least half the session time. Additionally, individual cats showed substantial variability in preference (Fig. 4), suggesting that use of a preference assessment to identify individually preferred items or motivational state in research or training contexts could be beneficial.

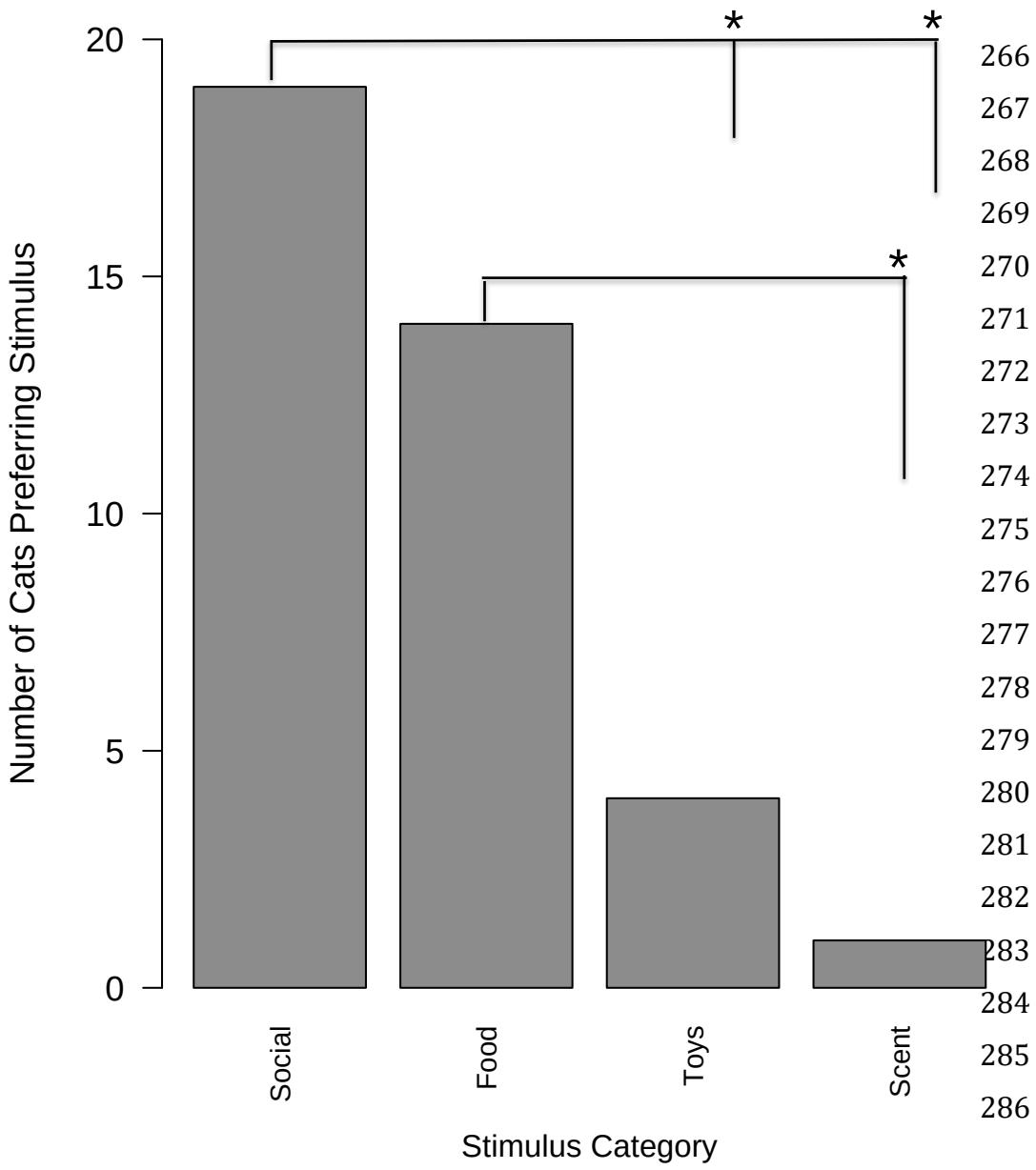

Fig. 3

Number of both pet and shelter cats (N=38) preferring each stimulus category in the final between-category most-preferred comparison * $p > 0.001$.

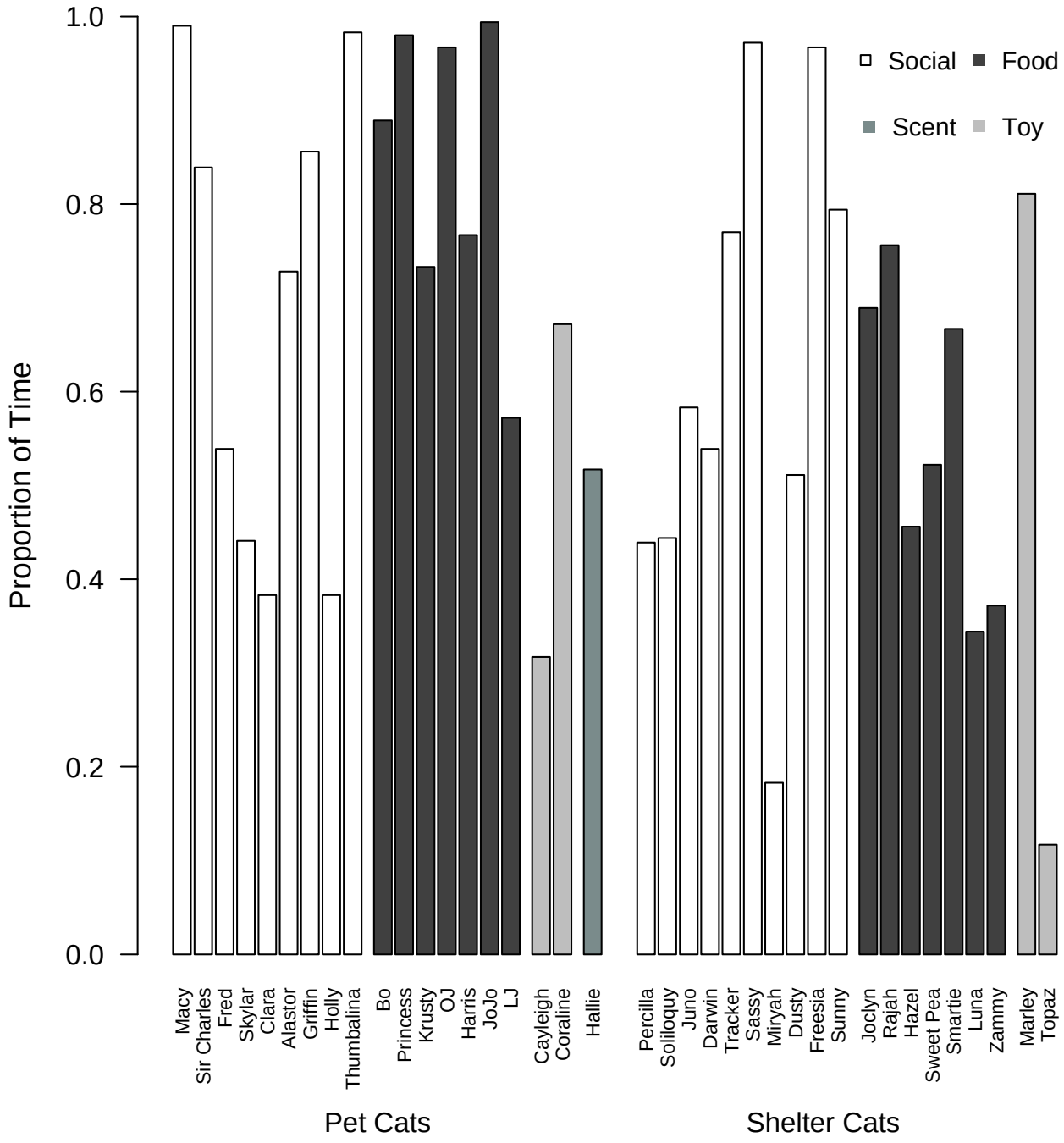

Fig. 4

The proportion of time each cat in the pet and shelter populations spent interacting with their most-preferred stimulus in the final between-category most-preferred comparison. White bars indicate human social interaction as the most-preferred category, black bars indicate food, gray indicate toys, and green indicate scent category.

4. Discussion

Our results indicate that although there is individual variation in cat preference for the various items, certain stimuli were preferred significantly more both within and between categories. Social interaction was the most-preferred stimulus category overall for the majority of cats followed by food (Fig. 3). While it has been suggested that cat sociality exists on a continuum, perhaps skewed toward independency (Potter and Mills, 2015), we have found that 50% of cats tested preferred interaction with the social stimulus even though they had a direct choice between social interaction with a human and their other most preferred stimuli from the three other stimulus categories. Therefore, the idea that cats have not been domesticated long enough to show preference toward human interaction is not supported by these data (Potter and Mills, 2015). However, cat sociality may instead be influenced by a combination of factors including biological predispositions and lifetime experiences (Vitale Shreve & Udell, 2015) resulting in the individual variation seen within and between studies on cat social behavior. It is therefore possible some populations of cats may display greater preference for social interaction than others.

These findings are also important to the study of operant conditioning in cats, as knowing what stimuli individual cats most prefer and are most motivated to work for is a necessary prerequisite to effectively shaping behavior (Powell et al., 2012). Although study cats interacted with all 12 stimuli to some extent, our results indicate certain stimuli were preferred significantly more within their categories than the other stimuli presented (Fig. 2). In the social interaction category, significantly more cats preferred to interact in the play condition than the human vocalization condition. In the food category, significantly more cats preferred tuna to the meat soft treat. In the toy category, significantly more cats preferred to interact with the movement toy over both the mouse and feather toys. Finally, in the scent category significantly more cats interacted with the catnip cloth over either the gerbil or conspecific scent cloths. Additionally, in the final between-category comparison there was no significant difference between the number of cats most preferring the social stimulus category (19 individuals) and the number of cats most preferring the food category (14 individuals). Although presenting food and non-food items concurrently has been found to lead to a displacement of non-food items and preference for food in children with disabilities (Deleon et al., 1997), this did not appear to be an issue in the present study, with both groups spending a similar amount of time interacting with their most-preferred stimulus (65% in the social category and 69% in the food category).Overall, these findings suggest both social interaction and food could function as reinforcers, providing useful data for behavior modification or cognitive testing. Future research should build on the current findings by pairing a free-operant preference test with an operant conditioning procedure (e.g. training a cat to touch an object and observing the change in behavior frequency in response to the most-preferred stimulus) to directly assess the ability of that item to

serve as a reinforcer (Deleon et al., 1997; Fisher et al., 1992; Tobie et al., 2015; Vicars et al., 2014), informing further applied uses of these stimuli in training situations.

Given that human play and the movement toy were preferred by many cats, with both stimuli being preferred by the majority within each category (Fig. 2) this may indicate cats prefer to engage with toy stimuli with erratic movement. When comparing between the feather toys used in the toy condition, one of the feathers was stationary and one of the feathers moved erratically (as controlled by the experimenter from outside the room). Only 2 cats preferred to interact with the stationary feather toy in the within-toy category as compared to the 23 cats that preferred the movement feather toy. Only 3 cats preferred to interact with the mouse toy, which similar to the feather toy, was presented on the ground and had no movement (unless engaged in by the cat). Hall and colleagues (2002) suggest adult cat object play is derived from predatory behavior, indicating a prey-like stimulus (appropriate size, shape, sound, furry/feather texture) that mimics a prey's erratic movement would be expected to produce the most interaction from cats. This is further supported by the finding that shelter cats spend more time looking at a screen playing images of animate movement, such as movement of prey (Ellis and Wells, 2008). Future research should build upon this finding to examine what characteristics of toy stimuli are most enriching for cats and potentially pair these toys with scent enrichment (catnip or prey scent) to examine factors influencing preference to interact with toys.

As can be seen in Figure 4, there were also individual differences in preference across categories and individual stimuli within each category. This highlights the importance of considering the individual in research on preference. Average results may provide a guide about the types of stimuli or interactions that most cats prefer, providing an evidence based starting point for selecting an array of potentially preferred items. However, the use of single-subject design or individual analysis is also critical to our understanding of preference; in applied settings it is the preference of the individual, not the preference of cats on average, that would best facilitate optimal matching of enrichment items or reinforcers intended to achieve behavior modification or welfare goals. Factors influencing the formation of individual preferences in cats are not well studied but may be explained by a combination of several possible mechanisms. Genetics, as well as life experience, are known to influence a cat's personality (for review see Vitale Shreve & Udell, 2015) and personality may influence a cat's behavior toward stimuli (Gosling, 2001). Reinforcement history may also influence an individual organism's behavior toward a stimulus (Freeman and Lattal, 1992). Bradshaw and colleagues (2000) found that previous experience with a food item influenced the cat's preference for that food; housecats, which were fed raw meat less often in their diet, preferred raw beef less than free-roaming cats, which most likely eat raw meat as part of their diet. Therefore, cat preference for a

stimulus or stimulus category may in part be due to the individuality of the cat, their previous experience with the stimuli, and their motivation state (e.g. more/less hungry).

As stated, an individual's preference for a stimulus can be influenced by their motivational state (deprived/satiated) (Van den Bos, Meijer, & Spruijt, 2000). In the present study we tried to account for motivational state to some extent by withholding food and social attention from subjects for 2.5 hours prior to testing. Although all of the specific stimuli used in testing (except interactions with the pet cat's owner) were brought by the experimenter ensuring some degree of novelty, we could not control for all variables that may have contributed to motivational state. For example, the cats' exposure other toy and scent stimuli in the home environment were not controlled for prior to testing which could have influenced the lower preference for these stimulus categories, even though they would not have had prior access to the exact scents or toys used in testing. However, lack of access to specific stimuli within these categories (e.g. gerbil scent) did not systematically result in higher preference for these items, therefore recent exposure to similar stimuli may be an important factor to explore further in the future, but is likely only one factor of many. Given our results are consistent with that of Ellis and Wells (2010), who also found cats spent relatively little time with scent stimuli, this could indicate that for many cats scent is simply a less preferred stimulus when other options are available- except in the case of catnip which significantly more preferred than gerbil or conspecific scent within-category (Fig. 2) and also produced the highest amounts of interaction for Ellis and Wells. Future studies could further control for or manipulate motivational states across stimuli, or the individual's expectation for rewards (optimism/pessimism or reinforcement history), to better understand what proximate factors most readily influence cat motivation and preference in different settings.

It is interesting to note that although previous research has found differences in food preferences of dogs in different populations (dogs housed in kennels compared to homes, two groups that may differ in life experience) (Griffin et al., 1984), the present study did not find any significant difference between the preferences of pet and shelter cats. This may be partially due to the relatively short stay of the shelter cats participating in the study, with cats being at the shelter for an average of 46.5 days, or a little over 1 month, prior to testing. It may be this is not a sufficient amount of time to develop differences between the two populations. However similar levels of preference in the social interaction category are especially interesting given the relationship with the human providing social interaction differed between the pet and shelter populations. Owners provided social interaction for pet cats whereas an unfamiliar human (experimenters) provided social interaction for shelter cats (given the lack of an owner). Similar findings have been found in dogs, for example dogs living in a shelter have been found to form attachment like behavior towards previously unfamiliar individuals very quickly (Gácsi et al., 2001). Therefore it may be shelter cats spend more time interacting with an

unfamiliar human than pet cats would, as found in research comparing pet and shelter dogs (Barrera et al., 2010). Future research should therefore also explore the use of an unfamiliar human in preference assessments conducted with pet populations to determine if shelter and pet cats significantly differ in their preference for a novel human versus a familiar one.

Our findings are also interesting from an enrichment perspective. Although prior studies have investigated cat preferences for different scents (for review see Vitale Shreve and Udell, 2017) and visual stimuli for use as enrichment (Ellis and Wells, 2010, 2008), to our knowledge interactions with humans has never formally been included in a cat enrichment study. However, the current data suggests interaction with humans may serve as a highly preferred stimulus with enrichment potential. Future studies could assess whether interaction with humans increases domestic cat welfare and/or species typical behaviors. Finally, even though all stimuli had already been presented to the cat prior to the final most-preferred comparison (in the within-category comparisons) most cats still spent a high proportion of the time interacting with their most-preferred item, with 70% spending at least half the final session interacting with their most-preferred stimulus. This may further support the idea of using these stimuli for enrichment purposes, as interaction with stimuli that retain salience and interest over multiple presentations may further reduce stereotypic behaviors. However habituation to these stimuli over time, and factors influencing the salience of these stimuli over time, must still be considered and measured (Ellis and Wells, 2010; Hall et al., 2002).

5. ***Conclusions***

The results of our study indicate cat preferences are highly individual, spanning across all four stimuli categories. However, cats display significant preference for certain stimuli, both within categories and in the most-preferred test. These results expand upon the findings of prior research assessing cat preference, including Bradshaw et al. (2000) who found that cats (both pet and free-roaming) display a spectrum of individual, but relatively stable, food preferences. The finding that most cats in both pet and shelter populations prefer social interactions with humans, followed by food, may indicate that these stimuli may be a useful starting point when considering potential reinforcers (for cognitive/behavior testing or training) or enrichment items for cats. Free operant preference assessments represent a reliable way of identifying individual preferences within and between these categories. Factors influencing the formation of these individual preferences in cats are not well researched but could be explained by a combination of genetic, experiential, and motivational mechanisms. Although it is often thought cats prefer solitude to social interaction, the data of this study indicate otherwise. In sessions comparing types of social interaction, cats displayed a preference for all three types of human interaction and the majority of cats most preferred human interaction in the final session comparing preferred stimuli in all four categories. Much work remains to be done in this area, however consideration of the most-preferred stimulus in each category and

implementation of human petting protocols may inform the use of these items as enrichment, especially for shelter cats. Finally, a future study pairing the free-operant preference test with an operant conditioning procedure would further assess the strength of the cat's motivation to work for access to that item and its effectiveness as a reinforcer.

Acknowledgements

KVS and a portion of this work was supported by the National Science Foundation Graduate Research Fellowship Program under Grant No. (1314109-DGE). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. This research complies with the Oregon State University Institutional Animal Care and Use Committee policies (ACUP #4767). We would like to thank all of the cats, owners, the Heartland Humane Society, Willamette Humane Society, and SafeHaven Humane Society, who have all graciously participated in this research. We would also like to thank our research assistants that assisted with data collection or video analysis, especially Eric Tam, Lauren Thielke, Lauren Brubaker, Rachel Webber and Ashley Carlberg.

References

APPA, 2015. National pet owners survey: industry statistics & trends. [WWW Document]. URL http://www.americanpetproducts.org/press_industrytrends.asp (accessed 10.15.14).

ASPCA [WWW Document], 2016. . Shelter Intake Surrender Pet Stat. URL https://www.aspca.org/about-us/faq/pet-statistics (accessed 4.30.15).

Barrera, G., Jakovcevic, A., Elgier, A.M., Mustaca, A., Bentosela, M., 2010. Responses of shelter and pet dogs to an unknown human. J. Vet. Behav. Clin. Appl. Res. 5, 339–344. doi:10.1016/j.jveb.2010.08.012

Bradshaw, J.W.S., 2006. The evolutionary basis for the feeding behavior of domestic dogs (Canis familiaris) and cats (Felis catus). J. Nutr. 136, 1927S–1931S.

Bradshaw, J.W.S., Healey, L.M., Thorne, C.J., Macdonald, D.W., Arden-Clark, C., 2000. Differences in food preferences between individuals and populations of domestic cats Felis silvestris catus. Appl. Anim. Behav. Sci. 68, 257–268. doi:10.1016/S0168-1591(00)00102-7

Cannella, H.I., O'Reilly, M.F., Lancioni, G.E., 2005. Choice and preference assessment research with people with severe to profound developmental disabilities: a review of the literature. Res. Dev. Disabil. 26, 1–15. doi:10.1016/j.ridd.2004.01.006

Church, S.C., Allen, J.A., Bradshaw, J.W.S., 1996. Frequency-dependent Food Selection by Domestic Cats: A Comparative Study. Ethology 102, 495–509. doi:10.1111/j.1439-0310.1996.tb01142.x

DeLeon, I.G., Iwata, B.A., 1996. Evaluation of a multiple-stimulus presentation format for assessing reinforcer preferences. J. Appl. Behav. Anal. 29, 519–533. doi:10.1901/jaba.1996.29-519

Deleon, I.G., Iwata, B.A., Roscoe, E.M., 1997. Displacement of Leisure Reinforcers by Food During Preference Assessments. J. Appl. Behav. Anal. 30, 475–484. doi:10.1901/jaba.1997.30-475

Ellis, S.L.H., Wells, D.L., 2010. The influence of olfactory stimulation on the behaviour of cats housed in a rescue shelter. Appl. Anim. Behav. Sci. 123, 56–62. doi:10.1016/j.applanim.2009.12.011

Ellis, S.L.H., Wells, D.L., 2008. The influence of visual stimulation on the behaviour of cats housed in a rescue shelter. Appl. Anim. Behav. Sci. 113, 166–174. doi:10.1016/j.applanim.2007.11.002

Fernandez, E.J., Dorey, N., Rosales-Ruiz, J., 2004. A Two-Choice Preference Assessment With Five Cotton-Top Tamarins (Saguinus oedipus). J. Appl. Anim. Welf. Sci. 7, 163–169. doi:10.1207/s15327604jaws0703_2

Feuerbacher, E.N., Wynne, C.D.L., 2015. Shut up and pet me! Domestic dogs (Canis lupus familiaris) prefer petting to vocal praise in concurrent and single-alternative choice procedures. Behav. Processes 110, 47–59. doi:10.1016/j.beproc.2014.08.019

Feuerbacher, E.N., Wynne, C.D.L., 2014. Most domestic dogs (*Canis lupus familiaris*) prefer food to petting: population, context, and schedule effects in concurrent choice: Concurrent choice in dogs. J. Exp. Anal. Behav. 101, 385–405. doi:10.1002/jeab.81

Fisher, W., Piazza, C.C., Bowman, L.G., Hagopian, L.P., Owens, J.C., Slevin, I., 1992. A comparison of two approaches for identifying reinforcers for persons with severe and profound disabilities. J. Appl. Behav. Anal. 25, 491–498. doi:10.1901/jaba.1992.25-491

Freeman, T.J., Lattal, K.A., 1992. Stimulus control of behavioral history. J. Exp. Anal. Behav. 57, 5–15. doi:10.1901/jeab.1992.57-5

Gaalema, D.E., Perdue, B.M., Kelling, A.S., 2011. Food preference, keeper ratings, and reinforcer effectiveness in exotic animals: the value of systematic testing. J. Appl. Anim. Welf. Sci. JAAWS 14, 33–41. doi:10.1080/10888705.2011.527602

Gácsi, M., Kara, E., Belényi, B., Topál, J., Miklósi, Á., 2009. The effect of development and individual differences in pointing comprehension of dogs. Anim. Cogn. 12, 471–479. doi:10.1007/s10071-008-0208-6

Gácsi, M., Topál, J., Miklósi, Á., Dóka, A., Csányi, V., 2001. Attachment behavior of adult dogs (Canis familiaris) living at rescue centers: Forming new bonds. J. Comp. Psychol. 115, 423.

Gosling, S.D., 2001. From mice to men: what can we learn about personality from animal research? Psychol. Bull. 127, 45–86. doi:10.1037//0033-2909.127.1.45

Griffin, R.W., Scott, G.C., Cante, C.J., 1984. Food preferences of dogs housed in testing-kennels and in consumers' homes: some comparisons. Neurosci. Biobehav. Rev. 8, 253–259.

Hagopian, L.P., 2004. Preference Assessment Procedures for Individuals with Developmental Disabilities. Behav. Modif. 28, 668–677. doi:10.1177/0145445503259836

Hall, S.L., Bradshaw, J.W.S., Robinson, I.H., 2002. Object play in adult domestic cats: the roles of habituation and disinhibition. Appl. Anim. Behav. Sci. 79, 263–271. doi:10.1016/S0168-1591(02)00153-3

Hernández, V., Peić, D., 2016. Countee - Data collection system [WWW Document]. URL https://www.counteeapp.com (accessed 2.27.17).

Mayes, E.-R.E., Wilkinson, A., Pike, T.W., Mills, D.S., 2015. Individual differences in visual and olfactory cue preference and use by cats (Felis catus). Appl. Anim. Behav. Sci. doi:10.1016/j.applanim.2015.01.003

Mehrkam, L.R., Dorey, N.R., 2014. Is preference a predictor of enrichment efficacy in Galapagos tortoises (Chelonoidis nigra)? Zoo Biol. 33, 275–284. doi:10.1002/zoo.21151

Miklósi, Á., Pongrácz, P., Lakatos, G., Topál, J., Csányi, V., 2005. A comparative study of the use of visual communicative signals in interactions between dogs *(Canis familiaris)* and humans and cats *(Felis catus)* and humans. J. Comp. Psychol. 119, 179–186. doi:10.1037/0735-7036.119.2.179

Miller, P.S., Boone, J.D., Briggs, J.R., Lawler, D.F., Levy, J.K., Nutter, F.B., Slater, M., Zawistowski, S., 2014. Simulating free-roaming cat population management options in open demographic environments. PloS One 9, e113553.

Pisa, P.E., Agrillo, C., 2009. Quantity discrimination in felines: a preliminary investigation of the domestic cat *(Felis silvestris catus)*. J. Ethol. 27, 289–293. doi:10.1007/s10164-008-0121-0

Potter, A., Mills, D.S., 2015. Domestic Cats (Felis silvestris catus) Do Not Show Signs of Secure Attachment to Their Owners. PLOS ONE 10, e0135109. doi:10.1371/journal.pone.0135109

Powell, R.., Honey, P.L., Symbaluk, D.G., 2012. Operant Conditioning, in: Introduction to Learning and Behavior. Wadsworth Publishing, Belmont, CA, p. 234.

Protopopova, A., Brandifino, M., Wynne, C.D.L., 2016. Preference assessments and structured potential adopter-dog interactions increase adoptions. Appl. Anim. Behav. Sci. 176, 87–95. doi:10.1016/j.applanim.2015.12.003

Roane, H.S., Vollmer, T.R., Ringdahl, J.E., Marcus, B.A., 1998. Evaluation of a brief stimulus preference assessment. J. Appl. Behav. Anal. 31, 605–620.

Rush, K.S., Mortenson, B.P., Birch, S.E., 2010. Evaluation of preference assessment procedures for use with infants and toddlers. Int. J. Behav. Consult. Ther. 6, 2.

Sasaki, Y., Gold, J., Watanabe, T., 2010. Perceptual learning: cortical changes when cats learn a new trick. Curr. Biol. 20, R557–R558.

Seksel, K., 2008. Preventing Behavior Problems in Puppies and Kittens. Vet. Clin. North Am. Small Anim. Pract. 38, 971–982. doi:10.1016/j.cvsm.2008.04.003

Skinner, B.F., 1938. The behavior of organisms; an experimental analysis,. D. Appleton-Century Company, Incorporated, New York, London.

Spotte, S., 2014. Free-ranging Cats Behavior, Ecology, Management. Wiley, Hoboken.

Tobie, C., Péron, F., Larose, C., 2015. Assessing Food Preferences in Dogs and Cats: A Review of the Current Methods. Animals 5, 126–137. doi:10.3390/ani5010126

Van den Bos R, null, Meijer, null, Spruijt, null, 2000. Taste reactivity patterns in domestic cats (Felis silvestris catus). Appl. Anim. Behav. Sci. 69, 149–168.

Vicars, S.M., Miguel, C.F., Sobie, J.L., 2014. Assessing preference and reinforcer effectiveness in dogs. Behav. Processes 103, 75–83. doi:10.1016/j.beproc.2013.11.006

Vitale Shreve, K.R., Udell, M.A.R., 2017. Stress, security, and scent: The influence of chemical signals on the social lives of domestic cats and implications for applied settings. Appl. Anim. Behav. Sci. 187, 69–76. doi:10.1016/j.applanim.2016.11.011

Vitale Shreve, K.R., Udell, M.A.R., 2015. What's inside your cat's head? A review of cat (Felis silvestris catus) cognition research past, present and future. Anim. Cogn. 18, 1195–1206. doi:10.1007/s10071-015-0897-6

Wilkinson, F., Dodwell, P.C., 1980. Young kittens can learn complex visual pattern discriminations. Nature 284, 258–259. doi:10.1038/284258a0

Witte, R.S., Kipke, D.R., 2005. Enhanced contrast sensitivity in auditory cortex as cats learn to discriminate sound frequencies. Cogn. Brain Res. 23, 171–184. doi:10.1016/j.cogbrainres.2004.10.018

Wyrwicka, W., 1978. Imitation of mother's inappropriate food preference in weanling kittens. Pavlov. J. Biol. Sci. Off. J. Pavlov. 13, 55–72. doi:10.1007/BF03000667

Zajonc, R.B., Markus, H., 1982. Affective and Cognitive Factors in Preferences. J. Consum. Res. 9, 123–131. doi:10.1086/208905