

SOCIALIZATION AND PROBLEM-SOLVING IN DOMESTIC CATS (*FELIS CATUS*)

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## ABSTRACT

There is evidence that an animal's socialization towards humans and rearing environment can enhance their problem-solving ability. According to the social intelligence hypothesis, which states that intelligence evolved due to complex social environments, an animal's social life should result in higher cognitive abilities. Domestic cats are capable of leading both solitary and social lives in their natural habitat, as well as in captive environments. I assessed both general problem-solving ability and the relationship between socialization and problem-solving ability, problem-solving speed, and latency to approach a novel apparatus in domestic cats. Twenty-four out of 86 cats solved the problem-solving task. There was also a significant relationship between the cats' socialization with their problem-solving abilities, latency to solve, and latency to approach the apparatus. These results provide evidence that domestic cats are not only capable of problem-solving, but that their socialization towards humans influences their abilities.

## DEDICATION

I dedicate this thesis to my amazing support system, including my family and significant other, Harley Burt. My family continuously checked up on me, offered their emotional support, and showed interest in my project. Harley provided me with unconditional love and motivated me when I needed it most. Thank you so much.

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## CHAPTER I

### INTRODUCTION

Animal intelligence has intrigued scientists and lay people for centuries; some researchers want to understand how animals perceive and experience the world, while others want to understand how animal and human intelligence evolved (Cook, 1993). No matter the motivation, animal researchers have provided evidence of many different cognitive capabilities, such as learning and problem-solving, for a wide range of species (Reznikova, 2007). Much of the research has focused on large-brained mammals, such as primates and cetaceans (dolphins and whales; Reznikova, 2007), while considerably less has focused on smaller mammals, like domestic cats (*Felis catus*; Shreve & Udell, 2015).

When scientists conduct studies involving intelligence, there are many contributing factors to consider, such as age, sex, personality, and socialization, that may affect an animal's cognitive performance (Carere & Locurto, 2011). More specifically, an animal's socialization, defined as a process to determine an animal's comfort level or social character towards other conspecifics and people (Kessler & Turner, 1999), may affect cognitive performance due to the challenges of social living (Humphrey, 1976; Jolly, 1966). Research has shown that animals reared by humans are more curious and therefore better at problem-solving than wild animals (Damerius, Graber, Willems, & van Schaik, 2017). Domestic cats can vary tremendously in how well they are socialized to humans, ranging from feral to lap cats, (Bradshaw, Casey, & Brown, 2012; Kessler & Turner, 1999; Weiss, Gramann, Drain, Dolan, & Slater, 2015) and their

cognitive abilities have been assessed in a handful of studies (Bateson, 2000; Merola, Lazzaroni, Marshall-Pescini, & Prato-Previde, 2015; Sherman et al., 2013; Thorndike, 1898). However, research has not yet shown if there is a relationship between problem-solving ability and socialization levels in domestic cats.

## **Problem-Solving**

Problem-solving is a primary method of measuring animals' learning, cognitive, and innovative abilities (Boogert, Monceau, & Lefebvre, 2010; Griffin & Guez, 2014; Thornton & Samson, 2012). Boogert et al. (2008) and Overington et al. (2011) found a positive correlation between problem-solving ability and a general learning capacity. Problem-solving can be tested using an extractive foraging task, which measures differences in ability to solve the task and gain access to a reward, most typically food (Griffin & Guez, 2014). For example, Thornton and Samson (2012) created three unique puzzle boxes as extractive foraging tasks, which required meerkats (*Suricata suricatta*) to manipulate functional components on the apparatuses to obtain a highly desirable food reward. These types of problem-solving tasks can motivate innovation, which is indicated by using a new or modified behavior not previously found in a population (Griffin & Guez, 2014). Innovation and problem-solving have important implications for animals' abilities to use new resources and adapt to environmental changes. Although problem-solving is not the sole indication of an animal's cognitive ability, it does encompass important factors of behavioral flexibility (Boogert et al., 2010). For example, encountering a novel problem, such as finding food that is out of reach, and being able to adjust to the environment is essential for survival in the wild (Griffin & Guez, 2014). Considering the abilities that problem-solving sheds light on, easy and efficient methods are important to identify.

A common method used to test animal cognition and learning is the puzzle box, which Edward Thorndike pioneered in 1898 (Reznikova, 2007; Thorndike, 1898). While Thorndike's puzzle box required the animal to escape from a box to eat a reward, current methods require an animal to obtain a food reward that is inside of a puzzle box. When using the current methods, intelligence is defined as the animal modifying their behaviors based on previous experiences, showing that they have at least some understanding that their prior behaviors are related to the following outcomes (Reznikova, 2007). Therefore, puzzle boxes are quick and reliable tests of problem-solving ability and cognitive functioning (Nada et al., 2011). There are a multitude of studies utilizing puzzle boxes to measure different aspects of animal cognition (Griffin & Guez, 2014). For example, Benson-Amram and Holekamp (2012) found that spotted hyenas (*Crocuta crocuta*) solve puzzle boxes by trial-and-error learning and Overington et al. (2011) measured the personality trait, neophobia, by observing Carib grackles' (*Quiscalus lugubris*) reactions to a new object (puzzle box) in their environment. Studies like these show the importance of acknowledging different factors that could potentially affect an animal's cognition, such as socialization.

## **Socialization**

Socialization refers to a process that determines an animal's comfort level or social character towards other animals and people (Kessler & Turner, 1999). Many animals have a sensitive period, implying it is easiest to socialize an animal to others during a specific time in their early development (Ahola, Vapalahti, & Lohi, 2017; Damerius, Forss, et al., 2017; Hoppe, Milton, & Simmel, 1970). If the socialization process is attempted after the sensitive period, it can often take much time and effort or be impossible (Ahola et al., 2017; Woolpy & Ginsburg,

1967). Animals can be socialized to humans by domestication (Hare et al., 2010), rearing environment (Hoppe et al., 1970), or a combination of both (Kaminski, Riedel, Call, & Tomasello, 2005; Topál et al., 2005).

The domestication hypothesis posits that attachment to humans is dependent on genetic changes that fostered dependence on humans (Hare, Brown, Williamson, & Tomasello, 2002; Ádám Miklósi et al., 2003). Topál (2005) studied the attachment differences using the Strange Situation Test between hand-reared wolves, hand-reared dogs, and pet-reared dogs. The hand-rearing required the puppies to be separated from their moms after three to five days and spend the first 16 weeks of their lives in intensive human care by the same group of women. Pet-reared puppies stayed with their mothers until seven to nine weeks old and then lived in human households. They found that wolves were less responsive to both their owner and an unfamiliar human when compared to the hand-reared and pet-reared dogs. This attachment difference showed that there are species-specific genetic differences in how wolves and dogs make human attachments (Topál et al., 2005). Further support for the domestication hypothesis comes from a study by Miklósi et al. (2003), who showed that domestic dogs look at their owners for help more than socialized wolves, which implies dogs have developed different communicative abilities with humans through domestication.

On the other hand, the socialization hypothesis states that attachment to humans is dependent on rearing environment during the critical period (Freedman, King, & Elliot, 1961). Rearing environment can drastically affect how animals respond to humans and other animals. For example, dogs isolated from their mothers and human contact between three to fifteen weeks interact less with other dogs, people, and toys than pet-reared dogs (Hoppe et al., 1970). Haslam (2013) coined the term “captivity bias,” which means that captive or lab animals, typically

primates, outperform their wild counterparts in tool-use defined as an animal manipulating an object in a proper and efficient manner to achieve a goal (Shumaker, Walkup, Benjamin, & Burghardt, 2011). For example, an Asian elephant (*Elephas maximus*) displayed tool-using behavior when he manipulated a large box to obtain a previously out-of-reach food reward (Foerder, Galloway, Barthel, Moore III, & Reiss, 2011). Haslam (2013) argues that the proximity to tool-using humans is one of the main factors that contribute to their increased tool-using abilities. As Topál et al. (2005) noted, these two hypotheses might not be mutually exclusive; both rearing environment and domestication can influence how and why animals form attachments and relationships towards humans. Kaminski (2005) suggest that it depends on the specific species one is investigating whether or not domestication or socialization will matter more in their formation of relationships with humans.

Another aspect of animal socialization to consider is their social relationships with conspecifics. Different species can vary greatly on how social they are, ranging from mostly solitary leopards (*Panthera pardus*) and tigers (*Panthera tigris*) to extremely social spotted hyenas (*Crocuta crocuta*) and lions (*Panthera leo*). Asocial animals typically only associate with dependent offspring or conspecifics during mating, while social animals live and interact regularly with conspecifics (Borrego & Gaines, 2016). Borrego and Gaines also note that group living requires social animals to form and keep relationships, anticipate and respond to others' behaviors, and both cooperate and compete with other members. One way this concept has been identified in animals is to measure their sociability, which is a personality trait defined as an individual's reaction to the presence of conspecifics (Gartner, 2015; Réale, Reader, Sol, McDougall, & Dingemanse, 2007; Vonk, Weiss, & Kuczaj, 2017). More sociable animals seek out the presence of conspecifics while less sociable individuals avoid them (Réale et al., 2007).

When sociability is measured in animals, it can help organizations place them in appropriate housing conditions to decrease stress and therefore physical illness (Kessler & Turner, 1997, 1999; Slater et al., 2013). Socialization towards humans and other animals has a large impact on animals' lives. The varying social issues that relate to an animals' socialization can have many implications for their overall wellbeing, which has led many researchers to investigate how it affects their mental capabilities.

### **Social Intelligence Hypothesis**

Researchers have studied and observed social species displaying many complex cognitive capabilities, leading many to hypothesize that cognitive complexity has evolved with sociality (Borrego & Gaines, 2016). Sociality refers to individuals living and interacting with one another and forming complex relationships (Wey, Blumstein, Shen, & Jordán, 2008). Based on primate research by Alison Jolly (1966) and Nicholas Humphrey (1976), the social intelligence hypothesis posits that intelligence evolved due to the challenges of dealing with complex social relationships formed between animals. In other words, the social intelligence hypothesis suggests that social animals will have higher cognitive abilities than less social animals (Borrego & Gaines, 2016; Jolly, 1966; Whiten & Byrne, 1997).

Jolly's (1966) research focused on comparing lemur (*Lemur catta*) societies to other primates and the possible effect primate social behavior had on the evolution of intelligence. She concluded that primate social life provided the necessary evolutionary context for primate intelligence. Later, Humphrey (1976) explored why animals and humans seem to possess apparently unnecessary cognitive abilities that are displayed under laboratory conditions. For example, he noted that Einstein did not need his genius to survive in the world and that monkeys

seemed to not have any use of conditional oddity discrimination in their natural environment. He noted that these needless abilities should not have evolved through natural selection. Later, he realized that the intelligence more than likely evolved from problematic social lives and has allowed animals to excel in the laboratory. Humphrey's observations led him to come to a similar conclusion as Jolly (1966), hypothesizing that primate social environment might have influenced the evolution of primate intelligence.

Since Jolly (1966) and Humphrey's (1976) findings, there has been debate on how accurate it is, whether it pertains to social or general intelligence, and if it can be applied at the individual level. There are researchers who have found no relationship between sociality and intelligence (Holekamp, 2007). For example, Benson-Amram, Dantzer, Stricker, Swanson, and Holekamp (2016) found that there was no relationship between social complexity and problem-solving success in 39 carnivore species. Due to contradictory findings, Holekamp (2007) suggests that there may be multiple variables that interacted with social complexity and allowed for the evolution of increased cognitive abilities.

Further debate concerns whether the hypothesis only pertains to social intelligence or if it encompasses nonsocial intelligence as well (Borrego & Gaines, 2016). The domain-general social intelligence hypothesis states that sociality convergently evolved with general intelligence, while the domain-specific social intelligence hypothesis argues that sociality only evolved with social cognition (Byrne & Whiten, 1988). Therefore, an animal's sociality, including socialization, could be an important factor that may affect problem-solving ability (Borrego & Gaines, 2016; Damerius, Forss, et al., 2017; Damerius, Graber, et al., 2017). More speculation related to the social intelligence hypothesis is whether it could also apply at the individual level, rather than the only the species level (Ashton, Ridley, Edwards, & Thornton, 2018). To



investigate this, Ashton et al. decided to look at the effects of sociality within Australian magpies (*Cracticus tibicen dorsalis*). Using group size as the measure of sociality, they tested the magpies' abilities on four cognitive tasks, including inhibitory control, associative learning, reversal learning and spatial memory. Their findings provided evidence that individuals living in larger groups performed better on all four tasks than individuals living in smaller groups. They also showed that individual performance was highly correlated with the tasks. Ashton et al.'s recent results sets a precedent for other researchers to also investigate if the social intelligence hypothesis is relevant within different species.

### **Factors That Affect Problem-Solving**

Social animals live extremely complex lives, which has theoretically allowed for more complex cognitive abilities to evolve in social species (Ashton et al., 2018; Byrne & Whiten, 1988; Humphrey, 1976; Jolly, 1966; Whiten & Byrne, 1997). Two factors that can affect cognition are an animal's sociality and socialization (Borrego & Gaines, 2016; Damerius, Forss, et al., 2017; Damerius, Graber, et al., 2017). Studies investigating sociality are typically interested in the cognitive effects of animals forming complex relationships with each other (Borrego & Gaines, 2016; Wey et al., 2008), while studies looking at socialization want to understand how humans can affect animals' cognition (Damerius, Forss, et al., 2017; Damerius, Graber, et al., 2017; Tomasello & Call, 2004). Therefore, a common goal of studies researching the effects of socialization is to understand the consequences of animal captivity. On the other hand, studies investigating sociality are typically focused on providing evidence for the social intelligence hypothesis.

Studies that aim to investigate the social intelligence hypothesis typically use group size as their measure of sociality (Borrego & Gaines, 2016; Byrne & Bates, 2007). Borrego and Gaines (2016) chose socially distinct, but closely related species with similar ecological challenges to examine the relationship between sociality and nonsocial problem-solving abilities. They concluded that the social animals (lions and hyenas), determined by group size, were more successful at innovating and were more persistent than their asocial counterparts (leopards and tigers). This article provides support for the domain-general social intelligence hypothesis, which states that the complexities of social living allowed for the evolution of higher general cognitive abilities.

Although animal's social lives have been extensively researched, the effect humans have on animals' cognitive capabilities are beginning to be studied more. It is known that human cognitive capabilities are deeply affected by environmental and developmental influences in their early years, but these influences in animals have received less attention comparatively (Damerius, Forss, et al., 2017). Great apes reared with humans in enriching environments have increased socio-cognitive, and communicative abilities (Call & Tomasello, 1996; Tomasello & Call, 2004). For example, human-reared great apes are better at attending to both intentional and referential actions of humans than wild great apes. Similarly, Damerius and Forss et al. (2017) studied 103 orangutans (*Pongo abelii* & *Pongo pygmaeus*) and found that orientation towards humans, defined as an animal's reaction to an unfamiliar human, predicted both exploration and problem-solving success. They also found that the orangutans that showed the most apparatus exploration were significantly better at problem-solving.

Damerius, Graber, Willems, and van Schaik (2017) investigated how rearing environment affects problem-solving ability. They found that curiosity was the sole predictor of

problem-solving performance in orangutans. Considering wild orangutans rarely display curiosity, they suggest that curiosity is a byproduct of being raised by humans. The effect humans have on animal's cognitive capabilities has been mostly explored in primate species, leaving much room for future studies. One study looking at this effect on spotted hyenas found that captive hyenas were significantly better at problem-solving and exploration than their wild counterparts (Benson-Amram, Weldele, & Holekamp, 2013). Considering this effect was found in a non-primate species, more studies need to investigate the effect humans have on non-primate animals' cognitive capabilities. For example, the domestic cat could be an interesting species to investigate this question due to the large gap in research focusing on the factors affecting their cognition (Shreve & Udell, 2015).

### **Feline Cognition**

Even though research on cat cognition is sparse compared to other species, the field is growing (Shreve & Udell, 2015). Bradshaw, Casey, and Brown (2012) discuss how domestic cats are extremely adaptable animals because they can function and survive in many different environments. They contend that having extensive learning abilities allows an animal to adapt to new environments rapidly. Domestic cats are capable of multiple types of associative learning, such as classical conditioning and instrumental learning. Classical conditioning requires an animal to understand stimuli relationships in their environment, while instrumental learning requires animals to predict the consequences of their own actions and modify their behaviors based on failures (Bradshaw et al., 2012). Thorndike's (1898) classic learning research was one of the first studies investigating how animals learn from their previous behaviors. One of his experiments assessed learning abilities in domestic cats using puzzle boxes. He placed cats inside

a puzzle box and measured their latency to escape and gain access to a food reward. He noted that the cats did not experience insight to correctly escape but learned through trial-and-error learning.

More recently, Sherman et al. (2013) examined learning abilities in domestic cats by using an adaptive T-maze. T-mazes are apparatuses that contain a food reward in one of two areas, which requires a subject to choose between two directions to find the reward. They are standard tools used to measure cognitive processes in many different species of animals. The goal of the study was to develop a sensitive measurement of learning that could potentially be used to identify cats with feline immunodeficiency virus (FIV) related cognitive and motor declines. The cats were trained to find the food reward going in only one direction. Two reversal tests, in which the food was moved to different locations, were used to measure the cat's speed at figuring out a new food reward location. The cats were able to reliably learn the T-maze in all tests, with mean learning curves significantly slower in each reversal test. Therefore, Sherman et al. concluded that their assessment should be a useful baseline in future studies wanting to assess cats' declining cognitive functioning.

One study examined problem-solving in 39 different carnivore species, including three smaller Felidae species (Benson-Amram et al., 2016). They wanted to investigate the assertions that animals with larger brains or from larger groups possess more cognitive capabilities than animals with smaller brains or from smaller groups. For the Felidae species, 13 out of the 20 Bobcats (*Lynx rufus*), 5 out of the 12 Fishing cats (*Pronailurus viverrinus*), and 1 out of the 8 Pallas cats (*Otocolobus manul*) solved the puzzle box and obtained their food rewards. Their findings showed that animals with larger brain volumes in relation to their body masses performed better than the others. They also found that there was no relationship between social

group size and problem-solving ability. They also found that most of the animals showed learning in their efforts to open the puzzle box as opposed to insightful behavior.

Specific abilities that have been investigated in domestic cats are teaching and observational learning. For example, domestic cat mothers are one of the few animals that overtly teach their kittens, specifically predatory behaviors (Caro, 1980; Hoppitt et al., 2008). Teaching in animals is compared to altruism in humans because it is costly to the teacher and benefits others (Hoppitt et al., 2008). Caro (1980) studied the predatory behavior of mother cats and found that they do not kill and eat their prey in the same way as cats without kittens. The mother cat will bring the captured prey back to their young and let them practice hunting behaviors. The prey is let loose near the kitten, while the mother waits back for the kitten to begin hunting. The mother only interacts with the prey when the kitten has stopped interacting with the prey. While this is an example of mother cats teaching their young, kittens also learn from their mothers by simply watching them. Kittens use observational learning from a very young age to learn how to eat and behave from their mothers (Bateson, 2000). For example, Wyrwicka (1978) trained mother cats to eat novel foods, such as bananas or mashed potatoes, and tested kittens' food choice between the novel foods and meat pellets after observing their mothers eat the novel foods. They found that most of the kittens imitated their mothers and chose to eat the novel foods over the meat pellets. This finding was consistent both when the mothers were present and when the kittens were tested alone. Chesler (1969) also examined observational learning and found that kittens learned to press a lever to obtain food better when watching their mother perform the task than when they observed a stranger cat. Kittens exposed to the task, without observing another cat, never solved the task.

While observational learning with other cats has been noted in many studies, the ability for cats to learn from observing humans is less understood (Shreve & Udell, 2015). For example, Merola et al. (2015) tested the human-cat communicative relationship by exposing cats to their owners having either a positive or negative response to a potentially frightening stimuli. They found that close to 80 percent of cats looked to their owner for reference, but only a few modified their behaviors based on their response. Similarly, Miklósi et al. (2005) examined cats' sensitivity to human cues and found that cats were able to follow human pointing cues to a hidden food reward. On the other hand, cats did not look towards humans when they were presented with an unsolvable task. These studies show that cats' relationships with other cats and humans have varying effects on their cognitive abilities.

### **Feline Socialization**

Domestic cats have varying levels of social lives with conspecifics and humans. They can either be solitary and live away from other cats or humans or be social and live amongst other cats or humans (Bradshaw et al., 2012; Kessler & Turner, 1999; Weiss et al., 2015). Group living with other cats in the wild depends on food source and proximity (Bos & Buning, 1994; Bradshaw et al., 2012). They do not need to live in groups to succeed as a species, but group-living does provide additional protection for their offspring (Serpell, 2000). Bateson (2000) notes that kittens are allowed to nurse from other cats in their group. He also discussed how kittens form social relationships with other cats most easily during the first two months of their lives. Considering the domestic cat's ancestor, the African wildcat (*Felis silvestris libyca*), does not live in large groups, it can be assumed that domestication has allowed cats to live together

(Bradshaw, 2016; Macdonald, Yamaguchi, & Kerby, 2000). Domestication refers to a gradual, dynamic process where a wild species is adapted to live with humans (Zawistowski, 2008).

Domestic cats are the only members of the Felidae family that are able to form social relationships with humans (Bradshaw, 2016). However, interspecies relationships typically only occur if kittens are exposed to another species during their early life (Bateson, 2000). The sensitive period in which it is easiest for kittens to form interspecies relationships happens between two and seven weeks (Karsh & Turner, 1988). Also, Turner (2000) reports that the more human handlers a kitten has, the friendlier and more socialized that kitten will be towards humans later in their life. Since attempting to socialize a cat outside of its sensitive period can be quite challenging, it is important for shelters to identify or measure a cat's socialization towards other cats and humans to provide the best care for them (Kessler & Turner, 1997, 1999).

The ASPCA examined socialization levels of cats when they were first brought into the shelter. The purpose of this research was to identify which cats were ready to be displayed for adoption and to separate the feral cats from the lost pet cats. Sometimes lost pet cats are too frightened by the unfamiliar shelter environment to exhibit their typical behaviors, which can cause them to be mislabeled as feral. Since differentiating lost, scared pets from feral cats is difficult, the Feline Spectrum Assessment was developed to determine the socialization of new cats. This assessment involves a trained employee to observe the range of socialized behaviors displayed by cats in a cage. Feral cats are expected to display no socialized behaviors since they would not have been exposed to humans during their sensitive period. The results showed that the owned, scared cats displayed more and different behaviors than the less socialized, feral cats. For example, the owned cats were more likely to be at the front of the cage with their tail up, while the feral cats were more likely to stay at the back of the cage intensely focused on the

human doing the assessment. Their study shows that their assessment is fairly accurate at differentiating between lost and feral cats, but it may be improved by more research (Slater et al., 2013).

Kessler and Turner (1997) also examined how long it takes new cats to adjust to a shelter environment compared to cats that had lived in group-housing conditions at the shelter for several weeks. They housed the experimental cats in single-, pair-, or group-housing conditions for a two-week period and measured their stress with a Cat-Stress-Score they developed from a pilot study. The test required observers to rate the body posture of cats on a seven-point Likert scale of 1 (*Fully relaxed*) to 7 (*Terrorized*) while in their cage. The test was conducted four times within a 14-day period by either trained or non-trained observers. The inter-rater reliability for the trained observers was high ( $\kappa = .90$ ), while it was acceptable for the non-trained observers ( $\kappa = .75$ ). Their results showed that the new cats' stress did decrease over the two-week period, regardless of housing condition, but their stress never decreased to the level of the cats that had lived there for several weeks.

In a follow up study, Kessler and Turner (1999) investigated the effect cats' socialization levels towards other cats and people has on their stress in single- and group- housing conditions at shelters. They used the same Cat-Stress-Score as the previous study (Kessler & Turner, 1997). They measured the cats' socialization toward humans and conspecifics with a Human-Approach-Test, a Cat-Approach test, and a Socialization-Questionnaire. The approach tests were behavioral assessments, which required observers to rate on a six-point Likert scale of 1 (*Extremely friendly*) to 6 (*Extremely unfriendly*) how the cats reacted to either an unknown human or cat. The Socialization-Questionnaire was filled out by the previous cat owner. Only cats that received the same socialization score (socialized or non-socialized) in both the questionnaire and



approach tests were analyzed. Their results found that cats not socialized to other cats in the group-housing condition experienced more stress than the cats who were more socialized to other cats. Non-socialized cats experienced less stress in the single-housing condition. They also found that cats not socialized to humans were more stressed in all housing conditions than the cats that were socialized to humans. This study emphasizes the importance of shelters identifying cats' socialization levels so that they can adjust their housing protocols to better control cats' overall health and well-being.

### **Present Study**

Domestic cats have wide variation in the type of social lifestyle in which they inhabit and flourish (Bateson, 2000; Bradshaw et al., 2012; Slater et al., 2013) and have many different cognitive and learning abilities (Merola et al., 2015; Thorndike, 1898; Wyrwicka, 1978). However, there is a lack of research on how socialization relates to cat problem-solving performance. The social intelligence hypothesis implies that the more social an animal is, the better they should be at problem-solving since intelligence evolved due to social factors (Carere & Locurto, 2011; Humphrey, 1976; Jolly, 1966).

I conducted a study to examine the relationship between socialization and problem-solving skills in domestic cats. My subjects were domestic cats from the McKamey Animal Shelter in Chattanooga, Tennessee. Many of the cats were already assigned socialization grades with McKamey's Feline Behavior Assessment, which is based on aspects of the American Society for the Prevention of Cruelty to Animals' (ASPCA) Feline Spectrum Assessment Protocol. This protocol measures the level of socialization in each cat to humans. I administered a problem-solving task to each cat individually to investigate the relationship between their

problem-solving abilities and their socialization scores. I hypothesized that 1) the more socialized cats would be more likely to solve the problem-solving task than the less socialized cats; 2) the more socialized cats would approach the apparatus sooner than the less socialized cats; and 3) the more socialized cats would complete the task more quickly than the less socialized cats.

## CHAPTER II

### METHOD

#### **Pilot Study**

##### Subjects and Housing

Twenty cats from the McKamey Animal Shelter in Chattanooga, TN were used as subjects. Age ranged from 1 to 10 years ( $M = 3.639$ ,  $SD = 2.49$ ) and number of days at the shelter ranged from 14.20 to 76.20 ( $M = 44.23$ ,  $SD = 16.89$ ). Demographic information was collected on all cats (see Table 2.1). Three of the cats that were tested on the constructed apparatus were previously assessed at McKamey's discretion using their Feline Behavior Assessment, which noted how many socialized behaviors the cats displayed during an observational four-step test (see Appendix A). Selection criteria used in the study was their estimated age, cage condition (housed alone and clean), and alertness. All cats were vaccinated and checked for health issues prior to participation. Following the restrictions of the Feline Behavior Assessment, cats who met any of the following categories: younger than 9 months, older than 15 years, or in heat, were not included. Kittens and females in heat were excluded because they do not display consistent socialized behaviors (Slater et al., 2013).

Table 2.1 Pilot Study Demographic Information by Apparatus

Variable	Homemade		Nina Ottosson	
	N	%	N	%
Sex				
Female	4	40	7	70
Male	6	60	3	30
Breed				
Short-hair	9	90	10	100
Medium-hair	1	10	0	0
Source				
Stray	4	40	0	0
Owner Surrender	4	40	8	80
Transfer	2	20	0	0
Returned	0	0	2	20
Spay Status				
Spayed	9	90	10	100
Not Spayed	1	10	0	0

All cats were housed in McKamey’s Cat Quarters room. The cat’s home cage was used in this study. Each cat had access to one other adjacent cage via an opening. However, during the study the opening was closed. Both cages the cats have access to were 20” x 24” x 30” (length x width x height). The walls of the cage were wood, while the doors were metal, with gaps for the potential adopters/staff to physically interact with the cats. The cages were stacked three high and six wide against a wall. The cages contained a litter box, a towel for sleeping, a food dish, and a water dish.

#### Materials

The pilot study was conducted to test the appropriateness of two puzzle boxes to measure the cats’ problem-solving abilities in the main study (see Figure 2.1) and choice of food reward (Orijen six fish, Orijen wild boar, Orijen lamb, liver, and tripe, Meow Mix irresistible salmon, Meow Mix irresistible tuna, and VitalCat duck liver). The first puzzle box (see Figure 2.1a) was

constructed based on an apparatus used with meerkats (*Suricata suricatta*; Thornton & Samson, 2012). This puzzle box was a transparent, plastic container with perforations so that the cat could see and smell the food reward that was placed inside. It had two levels that were separated by a sheet of plastic that had a tab the cats could pull with either their paws or teeth to obtain the treat. The top level had the treat sitting on top of the sheet of plastic. The bottom level of the apparatus had an opening for the cat to eat the reward when it fell. To successfully obtain the food reward, the cats had to pull on the tab separating the two levels, which allowed the treat to fall and be available for the cat to eat.

The second puzzle box (see Figure 2.1b) was the “Cat MixMax A” puzzle donated from Nina Ottosson pet games and toys (<http://www.nina-ottosson.com/products/great-for-cats/mixmax-puzzle-a-level-1.html>). In this puzzle, the treat was contained in circular blocks with perforations that allowed the cat to smell the food. To obtain the treat, the cat had to move the block around the center and push it off the puzzle.

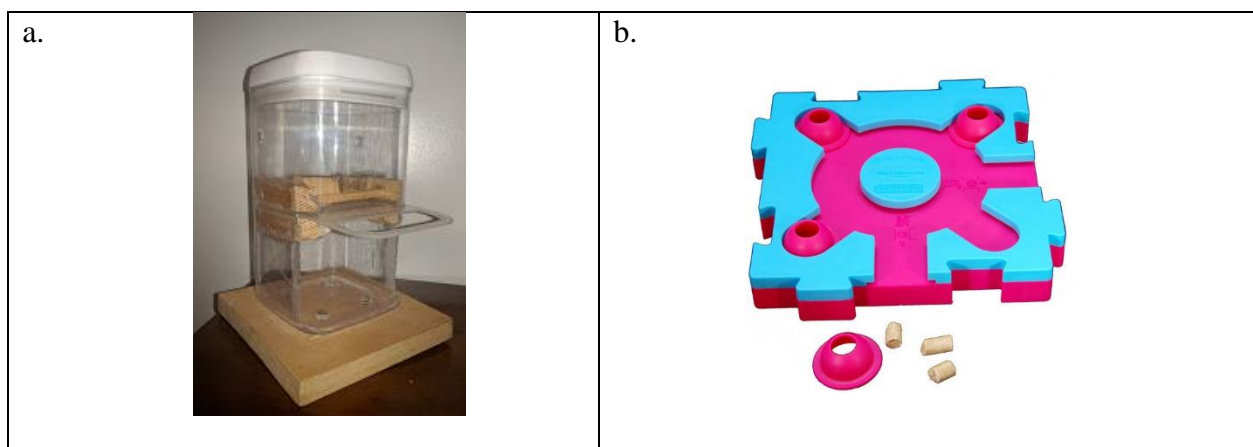


Figure 2.1 Pilot study apparatuses: a) constructed apparatus, b) Nina Ottosson

All cat interactions with the puzzle box were recorded with a HD Canon Vixia HF R400 video recorder attached to a tripod. During testing, all cat interactions were monitored with a DBPower EX5000 camera connected to an iPad 4 MD528LL/A via Wi-Fi.

## Procedure

Prior to the first session, an informal assessment of food reward preference was conducted. Each of the treats were given to a handful of cats. The food reward chosen was based on the level of interest displayed in the treat and how quickly the cats ate the treats. For example, cats given Orijen six fish treats ate the treat almost immediately, while cats given the other treats sniffed and took longer than a few seconds to eat them. Therefore, Orijen six fish treats were chosen to be used in the study. To assess apparatus appropriateness, ten cats were tested with the constructed apparatus and ten cats were tested with the Nina Ottosson apparatus (see Figure 2.1). The first ten cats were tested on the Nina Ottosson apparatus and the following ten were tested on the constructed apparatus. Data was collected between the dates of October 7<sup>th</sup>, 2017 to October 13<sup>th</sup>, 2017 on a set schedule of Friday, Saturday, Sunday 1 to 3 p.m. This time frame was designated by McKamey personnel as being the best time since it was in between feeding times and the cages should be clean.

Prior to testing, I noted the cat's name and session number. The video camera and DBPower camera was set up outside each cat's cage to record and monitor the session. During testing, the cat's food and water dishes were removed to give the cat more space and ensure the treat was the only source of food during the 10-minute session. Once I started recording, I got the attention of the cat by showing them the treat. When they engaged, I placed the treat inside of the apparatus and placed it in their cage. As soon as the cage door closed, I started a 10-minute timer

and left the room with an iPad and clip board. I monitored and noted each cat's behavior to know when they interacted with and solved the puzzle. Either when the cat solved and ate the treat or after 10 minutes, the video recorder was stopped, and the apparatus was removed from the cage. Following testing, their food and water were returned to their cage. If the cat did not either solve the task or find the food reward on their own, the treat was given to them. Whether or not they ate the treat was noted. After each session, the apparatus was cleaned with disinfectant wipes commonly used by McKamey. The data on the cats was associated with each cat's demographic information compiled by the shelter.

## **Main Study**

### **Subjects and Housing**

Seventy-eight cats from the McKamey Animal Shelter in Chattanooga, TN were used in the main study. Age ranged from 1 to 10 years ( $M = 3.44$ ,  $SD = 2.32$ ) and number of days at the shelter ranged from 8.70 to 153 days ( $M = 59.90$ ,  $SD = 31.47$ ). Demographic information was collected on all cats (see Table 2.2). Forty-eight of the cats were previously assessed at McKamey's discretion using their Feline Behavior Assessment, which noted how many socialized behaviors the cats displayed during an observational four-step test (see Appendix A). Selection criteria used in the study, as well as participation restrictions, were the same as the pilot study. All cats were vaccinated and checked for health issues prior to participation.

Table 2.2 Main Study Demographic Information

Variable	N	%
Sex		
Female	42	53.8
Male	36	46.2
Breed		
Short-hair	67	85.9
Medium-hair	5	6.4
Long-hair	6	7.7
Source		
Stray	36	46.2
Owner Surrender	30	38.5
Transfer	4	5.1
Returned	4	5.1
Ambulance	3	3.8
Abandoned	1	1.3
Spay Status		
Spayed	71	91.0
Not Spayed	7	9.0

Fifty cats resided in the Cat Quarters room, 25 resided in the Vet Quarters room, and three resided in the front adoption room. The cat's home cage was used in this study. The cats in Cat Quarters and the front adoption room were the same as described in the pilot study. In Vet Quarters, the walls of the cage and door were metal, with similar gaps for the potential adopter and staff to physically interact with the cats. These cages were stacked two high and eight wide against a wall. All cages had a litter box, a towel for sleeping, a food dish, and a water dish.

## Materials

The main study was conducted to examine the relationship between cats' socialization and their problem-solving ability. Problem-solving ability was measured using an appropriate puzzle box (see Figure 2.1a) and food reward (Orijen six fish), which were chosen from the pilot study. Towards the beginning of data collection, the apparatus had to be fixed after a cat broke



off an important piece. Fixing the broken piece allowed the food reward to fall in a consistent manner once again.

The McKamey Animal Shelter used their own version of the ASPCA's Feline Spectrum Assessment titled the Feline Behavior Assessment (see Appendix A) which they have altered to fit their needs. The ASPCA's assessment used two slightly different protocols for morning and afternoon assessments, while McKamey only had one protocol for all assessments. Despite the alterations, McKamey has seen no change in return rates or adopter satisfaction. They have used the assessment to measure cat behavior since 2015. McKamey's feline care employees are instructed to follow four rules when assessing cats: 1) at least two hours after processing; 2) by at least two different employees; 3) not right before or after feeding times; and 4) use a four-step observational method to note how many socialized behaviors are displayed. Steps one to three occurred while the cat was in their cage and step four occurred outside of their cage.

Step one was the observation test, which lasted about 30 seconds. The assessor was instructed to observe the cat's behaviors when they approached their cage in a non-threatening manner. The goal for this step was to see how the cat responded to the approach of a human. Step two was the door test, which also lasted about 30 seconds. The assessor cracked the cage door open and placed their palm in the cage, out of reach of the cat, so that the cat must initiate an interaction. The purpose of this step was to identify how the cat responded to the invitation of human touch. Once step two was complete, the cage door was kept closed. Step three was the stroke and push test, which had no specified time limit. The assessor used a backscratcher to reach in the cage and held it in front of the cat's nose to let it sniff. Next, they needed to slowly move the backscratcher to stroke their cheek, chin, and back. When they scratched their back, they made sure to gently push down between the cat's shoulder blades. The goal of this step was

to see how the cat responded to a gentle touch and if they had sensitivity to restraint. Step four was the cat test, which was only tested on cats they are unsure of. The assessor removed the cat from their cage and brought them in front of another cat's cage for approximately 15 seconds. The purpose of this step was to identify if the cat was suitable to live in a home with multiple animals.

The socialized behaviors were broken down into "A" behaviors and "B" behaviors. The "A" behaviors were: chirps, rubs on bars, kneads, touches bars, at the front of cage, and tail is up. The "B" behaviors were: yawns, grooms, shakes, approaches front, sniffs, rolls, reaches, and still standing or moving at the end. "A" behaviors were considered to be distance-reducing behaviors and "B" behaviors may be indicative of socialization (Christie, 2015). Distance-reducing or "A" behaviors showed that the cat was socialized enough to humans to adjust to the stressful environment of a shelter. Cats needed to display at least four "B" behaviors to be considered socialized. If they did not display at least four, then it could mean they were not very socialized or that it could take them longer to adjust to their new environment than more socialized cats. The cats received a score of total "A" behaviors, ranging from 0-54, and "B" behaviors, ranging from 0-72. A high number in each category indicated that the cat was very socialized. To create one variable, the cats' total "A" and "B" behaviors were weighted together ( $A + B \cdot .25$ ). The "B" behaviors were designated as a fourth of the "A" behaviors in accordance with how the Feline Behavior Assessment differentiates between them.

All cat interactions with the puzzle box were recorded in the same way as the pilot study.

## Procedure

Data were collected between the dates of October 27<sup>th</sup>, 2017 to December 22<sup>nd</sup>, 2017 on the same schedule as the pilot study. The procedure for the main study was identical to the pilot study, except only one apparatus – the constructed apparatus (see Figure 2.1a) – was administered to the cats, instead of two.

## CHAPTER III

### RESULTS

#### **Interrater Reliability**

The Behavioral Observational Research Interactive Software (BORIS; Friard & Gamba, 2016) was used to create an ethogram and to code all videos. Videos were analyzed by two raters. One was a blind rater and the other was the primary researcher. The blind rater was unaware of the cats' socialization scores to minimize any bias towards the cats' behaviors. BORIS was used to compute a Cohen's  $\kappa$  to determine the interrater reliability between the blind rater and researcher. Cohen's  $\kappa$  was used as opposed to other measures of interrater reliability because it controls for agreement that may have occurred by chance and because the raters were judged on their level of agreement on categorical variables. Results indicated acceptable agreement between raters ( $\kappa = .82$ ).

#### **Feline Behavior Assessment Intrarater Reliability**

SPSS (IBM, 2017) was used to assess intrarater reliability with the assessors. The raters' double observations, meaning they rated a cat two out of the three times the assessment was conducted, were correlated with each other. Correlations below .7 indicate questionable reliability (Cohen, 2001). There were four McKamey personnel (Rater 1, 2, 3, and 4) who conducted the behavioral assessments. Only personnel who had more than 10 double observations were included in the analyses. Therefore, Rater 4's intrarater reliability was not

assessed due to only having two double observations. Rater 2 was the only assessor that conducted the assessment by themselves for a small number of cats. Due to this, Kendall's  $W$  was used to assess intrarater reliability for Rater 2. Rater 2 displayed good intrarater reliability,  $T_w = .81, p = .02$ . Rater 1 showed low intrarater reliability,  $r = .44$ . Rater 3 also showed low intrarater reliability,  $r = .41$ .

### **Feline Behavior Assessment Interrater Reliability**

SPSS' Kendall's  $W$  was used to conduct interrater reliability between assessors. Each time two raters assessed a cat together, their time 1, 2, and 3 scores were inputted to assess the amount of agreement between the raters. The same four McKamey personnel conducted the assessments. Rater 4 only assessed cats with Rater 1, meaning interrater reliability was only assessed between them. Rater 1 displayed good interrater reliability with Rater 2, Rater 3, and Rater 4, while Rater 2 and Rater 3 did not display acceptable interrater reliability (see Table 3.1).

Table 3.1 Feline Behavior Assessment Interrater Reliability

	Rater 1	Rater 2	Rater 3	Rater 4
<b>Rater 1</b>				
N	-	18	10	11
$W$	-	.65	.73	.81
$p$	-	.01	.02	.007
<b>Rater 2</b>				
N	-	-	19	-
$W$	-	-	.67	-
$p$	-	-	.153	-

## **Pilot Study**

The pilot study was conducted to assess the appropriateness of two puzzle boxes. The two apparatuses were compared on success rate, duration of interaction, and solve time. SPSS 25 was used to analyze the data. The homemade apparatus was solved 6 times, while the Nina Ottosson puzzle was only solved 3 times. The cats interacted with the homemade apparatus slightly more ( $M = 71.89$ ,  $SD = 52.44$ ) than the Nina Ottosson apparatus ( $M = 71.25$ ,  $SD = 32.37$ ). The cats also took longer to solve the homemade apparatus ( $M = 69.23$ ,  $SD = 56.11$ ) than the Nina Ottosson apparatus ( $M = 61.77$ ,  $SD = 57.28$ ). Therefore, I chose to use the homemade apparatus for the main study.

## **Main Study**

The purpose of the main study was to assess overall problem-solving ability and the relationship between problem-solving ability and a domestic cat's socialization towards humans. A total of 24 out of 86 cats solved the chosen apparatus from the pilot study. I had three hypotheses: 1) the more socialized cats would be more likely to solve the problem-solving task than the less socialized cats; 2) the more socialized cats would approach the problem-solving apparatus sooner than the less socialized cats; and 3) the more socialized cats would complete the task more quickly than the less socialized cats.

### **Hypothesis 1**

To assess the relationship between socialization and problem-solving, the socialization scores were weighted to create one independent variable. The scores were the same as described in the main study's materials. SPSS 25 was used to conduct a Logistic Regression with problem-solving status (Yes/No) and the weighted socialization scores ( $N = 51$ ). The cats that solved the

puzzle box had a higher mean score ( $M = 24.92$ ,  $SD = 9.85$ ) than the cats who did not solve the apparatus ( $M = 18.60$ ,  $SD = 10.91$ ). Results indicated that there was a significant relationship between weighted socialization scores and problem-solving status ( $p = .05$ ). There is an upward linear trend, indicating that the cats who solved the apparatus tended to have higher socialization scores than the cats who did not solve the apparatus (see Figure 3.1).

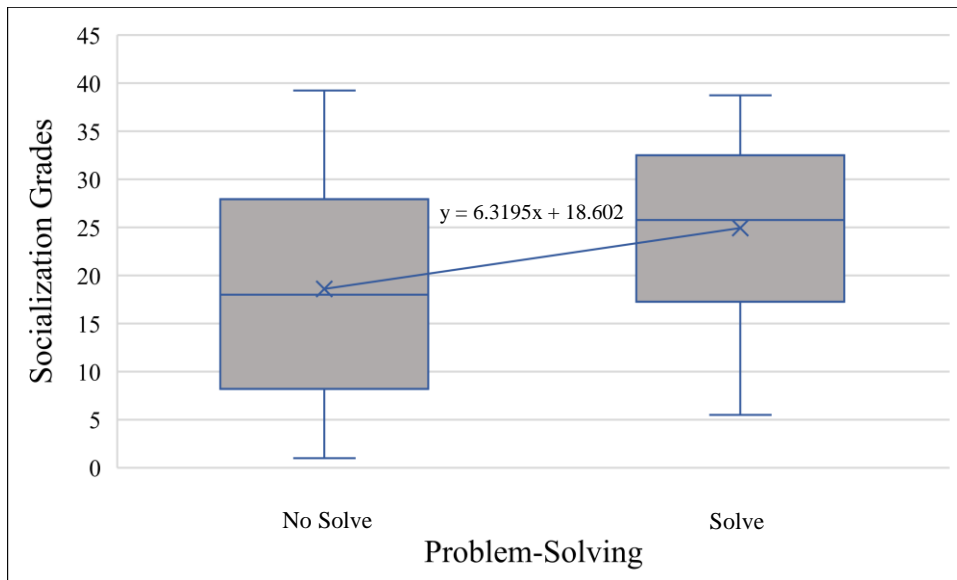


Figure 3.1 Box and whisker plot of problem-solving with socialization scores

### Hypothesis 2

To assess the relationship between socialization scores and solve times, the logarithm of solve time was computed to ensure it was symmetric. Also, there was one outlier that was excluded from the analysis because it had a z score greater than 3.0 ( $z = 3.08$ ). The average time the cats solved the apparatus was 83 seconds ( $M = 82.45$ ,  $SD = 58.11$ ) after the apparatus was placed inside of their cage. SPSS 25 was used to conduct a correlation analysis between socialization scores and solve times ( $N = 19$ ). The results indicated that there was a significant

negative relationship between the variables,  $r(16) = -.51, p = .032$ . The cats with higher scores did have quicker solve times (see Figure 3.2). When including the outlier, the results indicated that there was not a significant relationship between the socialization scores and solve time,  $r(17) = -.31, p = .194$  (see Figure 3.3).



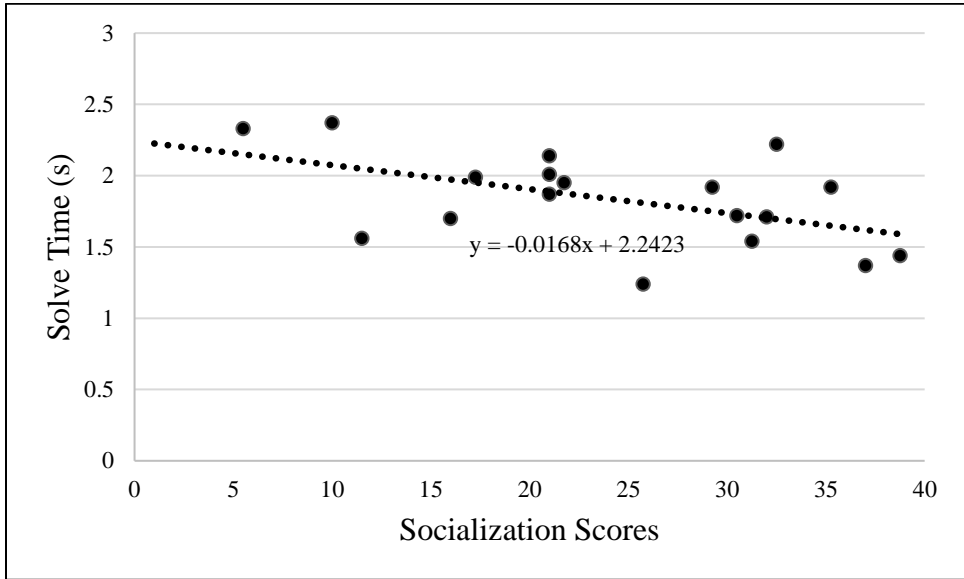


Figure 3.2 Scatterplot of socialization score with the logarithm of solve time

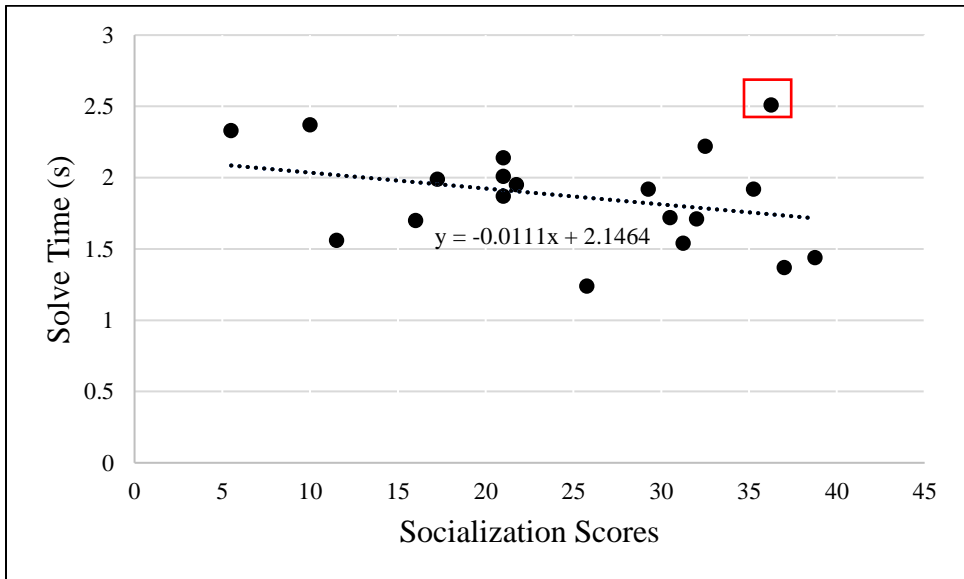


Figure 3.3 Scatterplot of socialization score with logarithm of solve time with outlier (indicated by square)

### Hypothesis 3

To assess the relationship between socialization scores and time of first touch, the logarithm of first touch was computed to ensure it was symmetric. Also, there was one outlier that was excluded from the analysis because it had a z score greater than 3.0 ( $z = 8.70$ ). The average time the cats first touched the apparatus was four seconds ( $M = 3.96$ ,  $SD = 8.69$ ) after the apparatus was placed inside of their cage. SPSS 25 was used to conduct a correlation analysis between socialization scores and time of first touch ( $N = 50$ ). The results indicated that there was a negative relationship that was trending towards significance between the socialization scores and time of first touch,  $r(48) = -.28$ ,  $p = .052$ . The cats with higher socialization scores did have slightly shorter first touch times (see Figure 3.4). When including the outlier, the results indicated that there was a stronger significant negative relationship between the socialization scores and time of first touch,  $r(49) = -.35$ ,  $p = .013$  (see Figure 3.5). To further assess how first touch times varied, the relationship between solve status and first touch time was examined. Cats who solved the puzzle box on average first touched the apparatus in 2 seconds ( $M = 2.13$ ;  $SD = 2.85$ ), while cats who did not solve the puzzle box on average first touched the apparatus in 5 seconds ( $M = 4.70$ ;  $SD = 10.06$ ; see Figure 3.6).

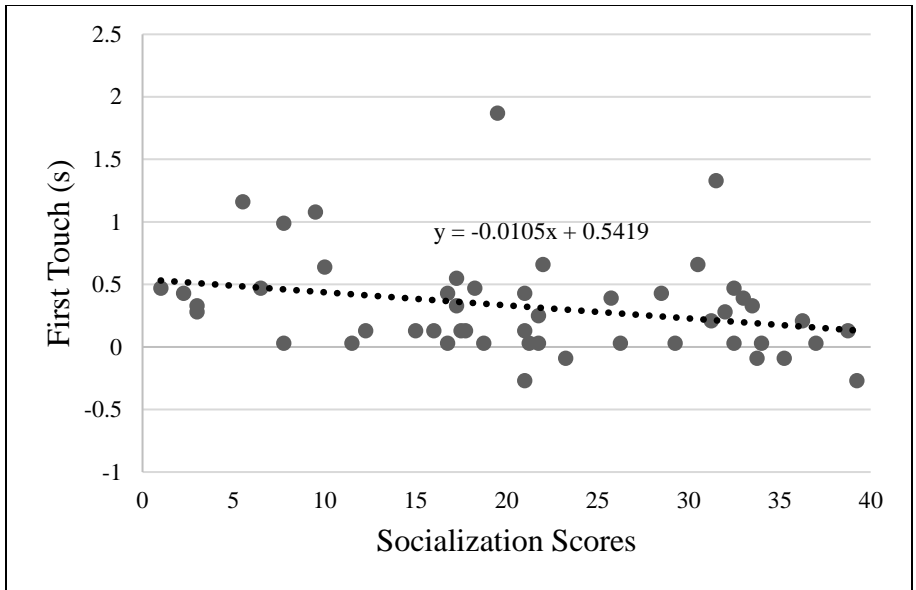


Figure 3.4 Scatterplot of socialization score with the logarithm of first touch time

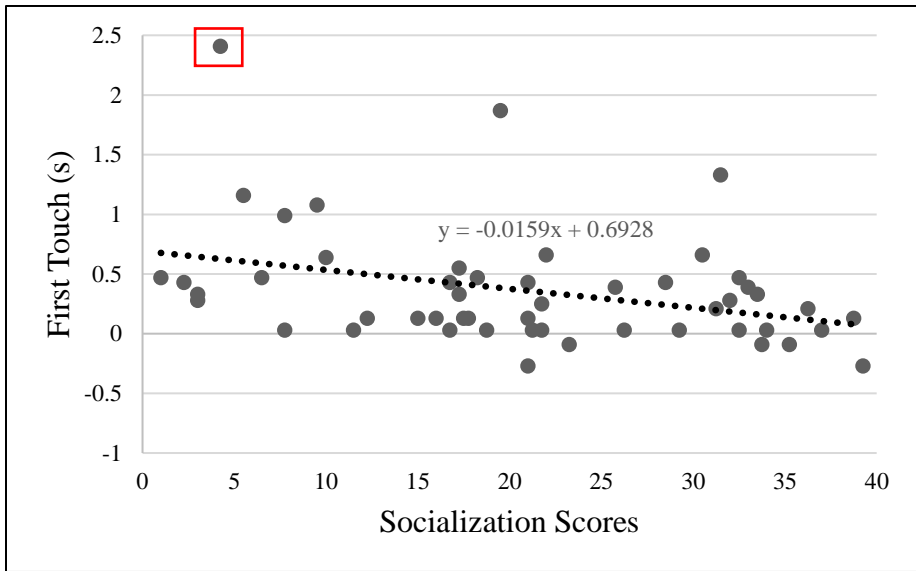


Figure 3.5 Scatterplot of socialization score with the logarithm of first touch time with outlier (indicated by square)

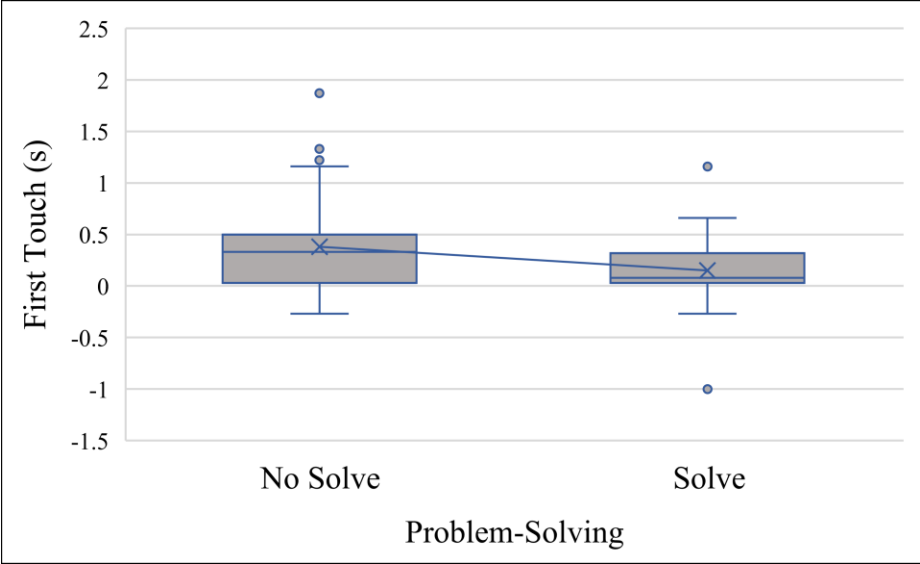


Figure 3.6 Box and whisker plot of problem-solving with the logarithm of first touch time

## CHAPTER IV

### DISCUSSION

My research provides evidence that domestic cats are capable of problem-solving and that their socialization towards humans is related to their problem-solving abilities, latency to solve, and latency to approach a novel object. Twenty-four of the 86 cats presented with a novel puzzle box solved the task.

One purpose of the current study was to fill a gap in research concerning problem-solving abilities in domestic cats. While cats' cognitive abilities have been examined with maze performance (Sherman et al., 2013) and observational learning (Merola et al., 2015; Wyrwicka, 1978), there has been a lack of research concerning their overt problem-solving abilities with an extractive foraging task. The closest research related to their problem-solving abilities was Thorndike's (1898) classic experiment in which cats had to learn to escape from a puzzle box to obtain a food reward. The current study's findings provide evidence for domestic cat problem-solving abilities.

One objective of my research was to examine the relationship between cat socialization towards humans and their problem-solving ability. My results showed that cats with higher socialization scores solved the problem-solving task more than cats with lower socialization scores. This shows evidence that cats' orientation towards humans has a positive influence on their problem-solving abilities. Similarly, Damerius, Forss, and colleagues (2017) found that orangutans who were accustomed to humans through captivity showed greater capability in

cognitive testing as opposed to wild orangutans. Damerius, Forss, and colleagues (2017), Damerius and Graber (2017), and Haslam (2013) all provide evidence that animals' relationships with humans have a positive influence on their cognitive abilities. Furthermore, the social intelligence hypothesis states that more social animals should have higher cognitive abilities due to their challenging social environments.

As a secondary objective, I studied the relationship between the cats' socialization scores and latency to solve the apparatus. My hypothesis that the cats with higher socialization scores would have shorter solve times did have statistical support when the outlier was excluded. This finding indicates that as a cat's socialization towards humans increases, their speed of solving an apparatus decreases. On the other hand, Benson-Amram, Weldele, and Holekamp (2013) found no differences in solve time between wild and captive hyenas; both developed quick learning curves over multiple trials. The captive hyenas were born into captivity, meaning they had a significant amount of human interaction compared to the wild hyenas who had minimal to no human interaction.

I also researched the relationship between the cats' socialization scores and latency to approach the apparatus. When the outlier was excluded, I found statistical support indicating that cats with higher socialization scores had shorter approach times. Even with the outlier included in the analysis, I found that the relationship between socialization scores and first touch times trended towards significance. This finding provides evidence that the domestic cats' comfortability with humans may influence their problem-solving abilities. Damerius and Forss (2017) investigated the relationship between orangutans' reactions to unfamiliar humans and problem-solving and found the orangutan's orientation towards humans was a good predictor of orangutan problem-solving success. In a follow-up study, Damerius and Graber (2017) provided

evidence that a rearing environment with humans causes animals to become more curious about their surroundings. They hypothesized that this increase in curiosity caused them to explore a novel apparatus more with greater success.

A byproduct of this study was to analyze the Feline Behavior Assessment and determine how reliable it is. The reliability assessment provides evidence that the first measurement is conducted is not reliable with the second or third time it is conducted. The reliability assessment did show that the measure is reliable from the second time to third time. One possible explanation is that the third rater could see the results of the first and second rater's assessments. To counteract this effect, the assessment could be conducted so that the raters are not able to see the results of the other raters' assessments or, perhaps, the first time might not be included in the cats' final scores. Considering the assessment is conducted soon after a cat is brought to McKamey, another possibility is that the cat's heightened stress could be influencing the reliability of the first assessment. My suggestions to improve the measure would be either to wait an additional day to start the assessment or, as suggested above, to use the first assessment as a trial run to allow the cat to adjust.

My results echo other studies' findings that animals' social lives have a positive influence on their cognitive abilities. More specifically, I have shown that cats' relationships with humans are related to their problem-solving abilities. These findings may be useful in many different settings, including shelters and the home. Understanding the cognitive abilities of domestic cats can increase the ability of welfare programs to offer challenging enrichment activities. Also, shelters could potentially display cats capable of problem-solving to increase the likelihood of adoption. Furthermore, the relationship between socialization towards humans and problem-solving ability can also be used to increase adoptions in a shelter setting. The relationship

between cats' socialization towards humans and problem-solving ability may also be of interest to cat owners. Owners with social cats could purchase puzzle boxes from sites like Nina Ottosson (<http://www.nina-ottosson.com/products/great-for-cats/>) and test their own cat's problem-solving to potentially provide a more stimulating environment. Overall, my findings can potentially improve the lives of domestic cats in both the home and shelter environments.

### **Limitations**

The current study contained multiple limitations that could have potentially affected the results. One major limitation was that the Feline Behavior Assessment did not have an acceptable level of reliability between the first application of the assessment with the second and third applications of the assessment. A limitation that could have potentially suppressed more cats from displaying their problem-solving abilities is that I did not control the cats' environment throughout the study. For most of the sessions, there was a radio playing and McKamey employees or volunteers present in the testing rooms, typically cleaning other cages. While this limitation may have affected the cats' focus, my goal was to examine the cats' problem-solving abilities in their typical shelter environments.

### **Future Research**

My findings provide evidence that the domestic cats' socialization towards humans affects their problem-solving abilities. Therefore, a suggestion for future research is to investigate what other factors, i.e. personality or curiosity, could have an influence on cat's problem-solving abilities. I plan to analyze the current data to identify whether age, sex, length of stay at the shelter, or source (owner-surrendered, stray, and return) have any effect on



problem-solving success. Another suggestion for future research is to compare problem-solving abilities of feral or low-socialized cats to socialized cats to give a broader range of socialization. Finally, future research should investigate how the relationship between domestic cats' socialization towards humans and problem-solving ability could potentially benefit welfare efforts in shelter settings.

## **Conclusions**

My research provides evidence that domestic cats are capable of problem-solving, specifically in obtaining food from this specific puzzle box, and that their socialization towards humans is related to their problem-solving abilities. More specifically, cats with higher socialization scores are more likely to solve the apparatus than cats with lower socialization scores. I also show that there is a relationship between cats' socialization scores and both latency to approach and solve a novel apparatus; cats with higher scores approached and solved the apparatus more quickly than cats with lower scores. My findings address a gap in research on domestic cat problem-solving and how their socialization towards human is related to their abilities.

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APPENDIX A  
IACUC APPROVAL LETTERS

Institutional Animal Care and Use Committee  
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615 McCallie Avenue  
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Phone: (423) 425-5867  
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**MEMORANDUM**

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TO: Dr. Preston Foerder

FROM: Dr. Ethan Carver, IACUC Chair  
Lindsay Pardue, Director of Research Integrity

DATE: September 19, 2017

SUBJECT: **IACUC #: 17-07: Sociality and Problem-Solving in Cats (*Felis catus*)**

The UTC Institutional Animal Care and Use Committee has reviewed and approved your application and assigned you the IACUC number listed above.

**Reminder:** Approved protocols must be reviewed at least annually. It is the responsibility of the principal investigator to submit an Application for Protocol Annual Continuation form to the IACUC before the anniversary date of the approved protocol. However, the Office of Research Integrity shall make every effort to send reminders 30 days prior to the anniversary date. The annual review form must be completed and submitted to the IACUC Committee before the first day of the anniversary month. New protocols must be submitted and approved every three years.

Please remember to submit a Protocol Modification Form if significant changes occur in your research design or in any instruments used in conducting the study. You should also contact the IACUC immediately if you encounter any adverse effects during your protocol.

For additional information, please consult our webpage <http://www.utc.edu/iacuc> or email [iacucpro@utc.edu](mailto:iacucpro@utc.edu).

Best wishes for a successful research project.



**Institutional Animal Care and Use Committee**

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**MEMORANDUM**

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TO: Dr. Preston Foerder

FROM: Dr. Ethan Carver, Chair, Institutional Animal Care and Use Committee

DATE: December 11, 2017

SUBJECT: **IACUC #: 17-07: Sociality and Problem-Solving in Cats (*Felis catus*)**

The UTC Institutional Animal Care and Use Committee has reviewed and approved the modifications requested on 12/04/2017 for the IACUC number listed above.

- The number of animal subjects has been increased from 85 to 96.

For additional information, please consult our webpage <http://www.utc.edu/iacuc> or email [iacucpro@utc.edu](mailto:iacucpro@utc.edu).

Best wishes for a successful research project.

APPENDIX B  
FELINE BEHAVIOR ASSESSMENT SCORE SHEET STEPS 1-4

(Feline Behavior Assessment Score Sheet, 2015)

Cat Temperament Test

ID: \_\_\_\_\_ Cat's Name: \_\_\_\_\_ Final Grade: \_\_\_\_\_  
Dates: \_\_\_\_\_ Assessors: \_\_\_\_\_

<b>Step 1: The Observation Test (30 seconds)</b> Approach the cage and, speaking in a soft, gentle voice, and slow-blinking, extend your hand			
A	A	A	Chirps
A	A	A	Rubs on bars
A	A	A	Kneads
A	A	A	Touches bars
A	A	A	At the front
A	A	A	Tail is up
B	B	B	Yawns
B	B	B	Grooms
B	B	B	Shakes
B	B	B	Approaches front
B	B	B	Sniffs
B	B	B	Rolls
B	B	B	Reaches
B	B	B	Still standing or moving at the end
<b>Notes:</b>			

<b>Step 2: The Door Test (30 seconds)</b> Crack the cage door open and observe the cat, then close the door			
A	A	A	Chirps
A	A	A	Rubs on bars
A	A	A	Kneads
A	A	A	Touches bars
A	A	A	At the front
A	A	A	Tail is up
B	B	B	Yawns
B	B	B	Grooms
B	B	B	Shakes
B	B	B	Approaches front
B	B	B	Sniffs
B	B	B	Rolls
B	B	B	Reaches
B	B	B	Still standing or moving at the end
<b>Notes:</b>			

<b>Step 3: The Stroke and Push Test (No Time Limit)</b> Reach the backscratcher through the bars and hold in front of the cat's nose to let him sniff. Stroke the cat gently under the chin. Allow him to sniff it again, then stroke again, then gently push down between his shoulder blades.			
A	A	A	Chirps
A	A	A	Rubs on bars
A	A	A	Kneads
A	A	A	Touches bars
A	A	A	At the front
A	A	A	Tail is up
B	B	B	Yawns
B	B	B	Grooms
B	B	B	Shakes
B	B	B	Approaches front
B	B	B	Sniffs
B	B	B	Rolls
B	B	B	Reaches
B	B	B	Still standing or moving at the end
Notes:			

<b>Step 4: The Cat Test</b> Perform <i>ONLY</i> on cats that score in the adoptable rage. Remove the cat from the cage and hold him up to 3 cats.			
A	A	A	Sniffs, reaches, meows, chirps
B	B	B	No reaction
F	F	F	Hisses/growls
N/A	N/A	N/A	Struggles through entire hold (RETEST)
Cat 1	Cat 2	Cat 3	(Circle one) Ok w/ cats      No cats

Time1 Total A's	Time2 Total A's	Time3 Total A's	Overall Total A's
Time1 Total B's	Time2 Total B's	Time3 Total B's	Overall Total B's

## VITA

Mary Howard was born in Chattanooga, TN to Connie and Richard Howard. She is the fourth of six children: Genna, Ben, David, Daniel, and Sammy Howard. She attended St. Jude Catholic School from kindergarten to eighth grade and continued to Notre Dame High School. After graduation, she attended Maryville College in Maryville, TN, where she became interested in Psychology. She graduated *cum laude* with a Bachelor of Arts degree in May 2016 in Psychology. She continued her education at The University of Tennessee–Chattanooga where she pursued a graduate degree. Mary will graduate with a Master of Science degree in May 2018 in Psychology with a focus in Research.