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The development of problem-solving behaviors in canines, including persistence, has implications for canine training, welfare, and the human-dog bond. Past research has shown that a variety of factors, including genetics (domestication) and training experience, play a role in a how a canine might behave during a problem-solving task. Less well understood is how certain populations of dogs may behave differently during a problem-solving task or how the actions of the human during the test and the dog's relationship with or perception of humans may affect a dog's behavior during a problem-solving task; in particular, one that the dog must solve independently of a human. To evaluate these questions, three experiments were conducted utilizing an independent task to compare the performance and persistence of wolves and domestic dogs from different populations, and under different environmental and testing contexts. Experiment one compared the problem-solving behavior of socialized wolves, pet dogs and free-ranging dogs from India. In experiment two, trained search and rescue dogs and untrained pet dogs were compared performing the same independent task under three conditions: a neutral, human-present condition; an alone condition; and an encouragement condition. In experiment three, pet dogs were compared for their ability to solve the task when they were presented with the testing apparatus in one of three conditions: a neutral condition, followed by encouragement; an encouragement condition followed by a neutral condition; and a neutral condition followed by a neutral condition. Results demonstrated that factors such as lifetime experience, relationship with humans, testing environment, and actions of the human during testing all influence a canine's behavior during an independent task. Further research is needed to better understand the impact of genetic and lifetime factors that affect persistence in canines and to identify ways that this information can be used to increase the persistence of dogs in working and training contexts. Promising areas of future research include investigations into possible breed differences and the influence of the human-canine relationship on problem solving behavior.

Factors Affecting Persistence of Canines at an Independent Task

by
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CHAPTER 1

Introduction

Understanding an animal's capacity for learning and problem solving (behavioral flexibility), and the factors that influence this capacity, have significant implications for theoretical knowledge about species cognitive abilities and animal welfare. The tendency to persist at certain tasks is thought to influence learning ability and, therefore, behavioral flexibility: i.e. the longer an individual persists at problem solving tasks, the better they perform, suggesting that time and motivation are important factors in learning (Chow et al., 2016). In addition, a past history of reinforcement and early life experience can also affect persistence and behavioral flexibility (Bandura, 1977; Jones, 2005; Nevin, 2012).

Canis lupus familiaris, the domestic dog, is one of mankind's oldest companions. Today there are as many as 700 million dogs worldwide, a tenth of the total human population (Macpherson et al., 2013). The domestic dog has roles in companion and working environments. Pet dogs come from a variety of breeds and mixes, but often experience training, or hold a unique place in human homes, which presents them with many opportunities to learn about human actions and environments. Many working breeds have been bred and trained to perform certain tasks at the highest level possible (Svartberg, 2001; Svartberg, 2006; Udell and Wynne, 2008; Shimabukuro et al., 2015). To date the majority of canine cognition research has focused on these populations. However, the majority of the world's dogs are stray, free-roaming, and village dogs, which share a very different relationship with humans and fill different ecological niches around the world (Coppinger and Coppinger, 2001). Traditionally, these groups have received less scientific attention.

Researchers have investigated the learning (including persistence) and behavioral flexibility of the domestic dog (Udell and Wynne, 2008), with a special focus on pet and working populations. The learning ability of certain dog breeds has, in the past, been shown to differ, suggesting that breeding (and therefore genetics) may have an impact on the trainability and behavior of the domestic dog (Svartberg, 2006; Marshall-Pescini et al., 2009; Mehrkam and Wynne, 2014). Research has also shown that lifetime experience, including early developmental experiences and current living conditions, influence the trainability and behavior of an individual (Clarke et al., 1951; Svartberg, 2001; Marshall-Pescini et al., 2008; Udell and Wynne, 2010). Testing conditions (in particular, the behavior of the human during a learning task and the relationship the dog has to the human) can also influence how the dog behaves (Marshall-Pescini et al., 2013; Shimabukuro et al., 2015; Udell, 2015).

Tasks can be designed to test the persistence level of individuals and this information can be used to advance our knowledge of the propensity for behavioral flexibility (Miller et al., 2010). Studying persistence levels can allow researchers to measure how an animal solves problems in its environment and, therefore, can inform us of potential reasons for differences between populations of animals. Knowledge of those differences can be used to select and train the best individuals for working tasks as well as increase the welfare and management of these animals. For example, understanding what factors influence a dog's trainability can increase the efficacy of training programs.

The mechanisms that affect the domestic dog's ability to engage in problem-solving behavior, particularly when humans are involved, is an area of particular interest. A pet or working dog's ability to be trained by and to communicate with humans is an important aspect of their welfare. Most dogs that live in conjunction with humans will acquire some type of training during their lifetime as a result of human actions, regardless of whether they are enrolled in a formal training program (Bekoff and Byers, 1998; Hiby et al., 2004; Udell et al., 2010; Plec, 2013).

Scientists have suggested a range of possibilities as to why a dog may or may not persist when confronted with a novel task. A study done by Udell (2015) tested the problem solving ability and persistence of ten shelter dogs, ten pet dogs, and ten wolves. The animals were presented with a plastic container with a rope through the lid and a food reward inside. They could solve the task by breaking it or opening the container to obtain the food reward inside. The canines were presented the apparatus under three conditions: an alone condition (in which the animal was alone in the testing room with the container), a human-in condition (in which the animal's caretaker remained in the testing room but was neutral during the test), and an encouragement condition (in which the animals could be encouraged to open the container if they did not do so in either of the other two conditions). The researchers found that the wolves were the most successful at opening the container, regardless of the condition, and dogs spent more time gazing at the human during the human-in condition than wolves. Only one pet dog and one shelter dog solved the task during the human-in and alone conditions, respectively. They found, however, that four additional shelter dogs and one additional pet dog solved the task in the encouragement condition. The amount of time spent looking at the apparatus also increased during this condition. They concluded that domestic dogs may be initially less inclined to independently problem-solve than wolves and that this was greatly influenced by the dogs' lifetime experience of living with humans, such as the dog's role in the household (i.e. a pet or family dog), any major changes in the dog's lifestyle, such as being surrendered to a shelter after living in a home, and the current living environment of the dog, such as the stress and variability of a shelter environment versus the relative consistency of a home environment (Udell, 2015).

Gazing towards humans has been considered indicative of purposeful communication between dog and human, at least in some contexts (Udell et al., 2011; Marshall-Pescini et al., 2013). The exact meaning and motivation behind this behavior, however, is less clear. Gazing at a nearby human when presented with a solvable or unsolvable task may be a way for dogs to "request" for help or to acquire social information (Kaminski et al., 2011). However, gazing can be heavily manipulated by learning experience. For example, a study done by Bentosela et al. (2008) found that the rate of human-directed gazing behavior in dogs is predicted by reinforcement schedules. Thirteen dogs were reinforced for looking at an experimenter's face; then seven of the dogs underwent an extinction phase (in which gazing behavior was not rewarded) and six underwent an omission phase (in which the dog was given a food reward for directing its gaze anywhere but at the experimenter). In the extinction and omission groups, there was a significant decrease in gazing behavior, and during the extinction phase the dogs also lay down more, turned their back on the experimenter, and increased the distance between themselves and the experimenter (Bentosela et al., 2008). The researchers concluded that there is evidence that dogs learn to gaze at the human face as a result of previous reinforcement for doing so, and that this is not necessarily a purposeful communicative tactic (Bentosela et al., 2008; Bentosela et al., 2009). A study by Jakovcevic et al. (2012) found that dogs that touch an unfamiliar person more often during a sociability test show increased gazing behavior towards that person during a cognitive task. They suggested that this is due to the fact that human presence is inherently rewarding for more social dogs, thus gazing may be an inherently rewarding behavior for some, but not all, domestic dogs (Jakovcevic et al., 2012). Conversely, while non-pet dogs have often been underrepresented in canine cognition studies of this type, dogs that have reason to be cautious or fearful of humans (e.g. some feral, free roaming, stray dogs or even pets with negative past experiences) might be expected to gaze towards humans for different reasons, for example to ensure that the human remains at a safe distance or is not responding negatively to their actions (Ortolani et al., 2009; Gibson et al., 2014). Regardless, the longer the time a dog spends gazing at a human during a solvable or unsolvable task (attentional bias towards social stimuli) the less time the dog spends persisting at independently solving the object task. Therefore, increased gazing time at the human typically predicts decreased persistence on independent problem solving tasks (or, conversely, an increased persistence towards getting the human's attention or help), while gazing at or touching the apparatus suggests increased persistence at an independent task (Udell, 2015).

Another area of debate is what role domestication plays in a dog's prosocial behavior, particularly in the human-dog bond and a dog's ability to respond to human gestures. For thousands of years humans have contributed to the genetic modification and, eventually, breeding of certain species, in the process known as domestication (Darwin, 2010). Domestication began when humans attempted to utilize other animals and plants in a way that was mutually beneficial and may have eventually resulted in genetic and behavioral changes in the species in question (Belyaev, 1979; Wilson, 1988). Some scientists suggest that the apparent sensitivity that dogs have to humans, including communicative abilities and the ability to socialize and bond with people, is due to the genetic changes that took place during the domestication process (Miklósi et al., 2003; Hare and Tomasello, 2005; Kubinyi et al., 2007).

Miklósi et al. (2003) studied the propensity for dogs and socialized wolves to gaze at humans in a way that appears to be communicative when presented with six solvable "training" trials that were followed by an "unsolvable trial." Nine domestic dogs and seven socialized wolves were presented with a bin that they could open for food reward and a rope that could be pulled through a fence for a food reward. In the unsolvable trial, the bin was mechanically closed and the rope was fixed. Domestic dogs gazed more often, had a shorter latency to gaze at the human, and gazed for longer during the unsolvable trial; in contrast, only two of the seven wolves tested gazed at their caretaker during the unsolvable task and had much larger latencies to gaze (Miklósi et al., 2003). The study found that wolves persisted on the independent task for longer during the unsolvable trials, whereas domestic dogs persisted for an average of one minute before looking back at their owners. They concluded that wolves are less likely than dogs to look at humans during a problem solving test as a result of "…a genetic predisposition in dogs, as it is difficult to induce this behavior in wolves even after intensive socialization" (Miklósi et al., 2003, pg 764-765); that is, they predicted that difference between domestic dogs and wolves could be explained by an increased sensitivity and communicative ability in domestic dogs that resulted from the domestication process (Miklósi et al., 2003). Further research has shown that a preparedness for engaging in human-directed social behaviors (in particular, eye contact with humans) may be partially heritable but is also affected by the sex of the dog, the dog's age, and the experience the dog has had with humans (Persson et al., 2015).

However, more recent findings have been contradictory. When the study was replicated with twelve dingoes, a group of scientists found mixed results: half the dingoes tested looked back during the unsolvable trial, and the average latency to look back was less than one minute. When the scientists changed the definition of "gazing" (from the dingoes orienting their heads and noses toward the human at any point during the study to dingoes orienting their noses and heads towards the object and then orienting their nose and head towards the human's head or face for at least half of a second) they found that only three of the dingoes "looked back" during the unsolvable task. The scientists suggested that in the absence of a consistent operational definition, gazing behavior may be incorrectly identified and/or interpreted (Smith and Litchfield, 2013). They asserted, "…although dogs might quickly seek help from a human nearby, wild canids often continue to seek solutions independently. A look back is most likely to occur after all strategies have been exhausted" (Smith and Litchfield, 2013, pg 968-969).

While the domestication process may play a role in the overall training and communication ability of domestic dogs, factors such as lifetime experience may play an equal or even greater role in a dog's overall performance on certain tasks (Udell et al., 2010). In a study by Udell, Dorey, and Wynne (2008), eight wolves, eight shelter dogs, sixteen pet dogs (eight with a familiar experimenter, eight with an unfamiliar experimenter) tested outdoors and sixteen pet dogs tested indoors were given the task of following a human point to a bucket and ignoring an identical bucket. The animal was rewarded for approaching the bucket that the experimenter was pointing to and was not rewarded for going to the other bucket. The experimenter stood between the two buckets and pointed at the correct bucket for four seconds while the subject watched. If the subject went to the correct bucket (i.e., the one the experimenter pointed to), the experimenter would click and reward the animal with food. If the animal made an incorrect choice, the experimenter would remain neutral. The researchers found that, in contrast to previous studies, wolves on average outperformed dogs in choosing the correct bucket. Domestic dogs tested in a home environment with an unfamiliar experimenter outperformed dogs in an outdoor environment, while shelter dogs performed the worst out of all the groups. The researchers concluded that, when properly socialized and given experience with humans, wolves can perform on par with or even better than domestic dogs in following human social cues – suggesting that domestication is not as important to the problem-solving ability in a human guided task as previously thought (Udell et al., 2008).

Following this, a study by Passalacqua et. al. (2011) arranged dogs based on genomic analysis into three groups: primitive, hunting/herding, and molossoid (mastiff). They tested these dogs at 2 months or age, 4.5 months, and as adults. The dogs were presented with three warm-up trials (in which the dog could manipulate a container on a board to obtain the food inside) followed by an unsolvable task trial (in which the container was fixed to the board). The researchers found that dogs at 2 months of age only briefly gazed at the human, if at all, during the trials, and no breed differences were found. At 4.5 months, some breed differences began to emerge, and as adults these differences were much more pronounced, with dogs in the hunting/herding group gazing significantly more at the human during the trials than dogs in the other two groups. The researchers suggested that these results indicated that domestication may play a role in a dog's communicative abilities, but that breeding and/or life experiences may serve to refine and shape those abilities so they become more pronounced (Passalacqua et al., 2011).

While there is no question that dog breeds are different in terms of their physiology and physical appearance, the tendency for any given dog to persist at a difficult task based on the breeding of that dog is less clear. In a meta-analysis by Dorey, Udell, and Wynne (2009), researchers found that very little difference existed between different dog breeds performing on human pointing tasks (where an experimenter points to the location of a food reward). They suggested that this could be due to a lack of breed diversity in studies or a problem with the analysis itself due to the fact that they were only total proportions rather than acquisition rates were analyzed (Dorey et al., 2009).

In a study by Protopopova et al. (2014), a group of 13 pet dogs with stereotypy and 13 controls dogs (matched by breed) were trained to touch a researcher's hand with their nose during an acquisition phase. The dogs then underwent an extinction phase in which this nose-touch behavior was no longer rewarded. The researchers found that dogs with stereotypy were more resistant to extinction (i.e., showed greater persistence in the absence of reinforcement) than the control, and that dogs in the herding and terrier groups persisted less during the extinction phase than dogs in the hound or working dog groups (Protopopova et al., 2014).

As suggested by Udell et al. (2009), past training experience plays a large role in determining how an animal will behave when presented with a problem-solving task. In a study by Marshall-Pescini et al (2008), 118 dogs were assigned to one of two groups: one in which dogs were highly trained and one in which dogs received little or no training. The experimenters presented the dogs with an apparatus that the dog could potentially open ("solve") by lifting the lid or pressing on a paw-pad for a food reward. The researchers found that dogs in the trained group were more successful at opening the apparatus and would interact with the apparatus significantly more than the untrained dogs. The team suggested that the trained dogs' histories with the apparatus created a "learning to learn" mentality and led to an increased willingness to try new problem-solving methods and to interact with novel items. According to the researchers, "…the highly trained dogs were used to the idea of trying out a number of behaviours to obtain a reward. This kind of experience may induce a more proactive type of approach to novel problems" (Marshall-Pescini et al., 2008, pg 453).

Osthaus, Lea, and Slater (2003) tested eight dogs that were clicker trained and eight dogs that had no clicker training on a rope-pulling task. During the task, the dogs had to pull a rope to acquire a food reward that was in plain sight under a glass board. The researchers gave the dogs a total of 30 trials, 10 with a short rope, 10 with a long rope, and 10 with a long rope that was angled to the front of the box. They found that clicker trained dogs were able to learn the rope-pulling behavior in roughly half the time of the non-clicker trained dogs and that non-clicker trained dogs engaged in significantly more proximity error (in which they pawed at the box instead of the rope) than the clicker trained dogs. Osthaus et al. (2003) concluded that the clicker trained dogs had learnt to learn, resulting in their faster learning time during the rope-pulling task (Osthaus et al., 2003).

In another study by Marshall-Pescini et. al. (2009), thirteen search and rescue dogs, thirteen agility dogs, and thirteen pet dogs were presented with a solvable task for three trials followed by an unsolvable task in the presence of an owner and a stranger. No significant differences in the behavior towards the task were found, however differences emerged in the gazing behavior of the groups. The agility group gazed at the owner significantly more than either the other groups, with the search and rescue group gazing towards the owner the least amount; they would only gaze at their owner when the task was unsolvable. Researchers also noted that the agility group gazed at the owner for longer than they gazed at the stranger (in contrast to the rescue dogs), and that the search and rescue dog group barked during the unsolvable task considerably more than the other two groups, but only barked while looking at the apparatus or the owner. Further, they found that the search and rescue dogs alternated their gaze between their owner and the apparatus much more frequently than the other two groups. The researchers suggested that the behavior seen during the test mirrored what the dogs were taught to do in training, and therefore past training experience (and the type of training received) seemed to play a large role in how the dogs problem-solved (Marshall-Pescini et al., 2009).

These studies paint a complicated picture of what factors affect persistence in canines. It is clear that past training experience, genetics, breeding, and the home and immediate environment all affect a dog's behavior when presented with a problem-solving task. Of special interest, however, is the notion that increased human gazing but decreased persistence at an independent task may not indicate a lack of trainability, but rather a lack of willingness to engage in independent task especially when in physical proximity to humans. There may be several "types" of persistence, such as the ability to persist at social behaviors (gazing at humans) versus behaviors that are object-oriented (such as solving a task), but the question remains as to the factors that best predict observed individual, population and species differences in this domain. Individual dogs or breeds may be more inclined to gaze towards their owner when presented with an unsolvable task (such as agility dogs versus search and rescue dogs), but it is less understood whether this difference is a result of their past training, their owner's expectations, their breeding, or, more likely, some combination of those factors.

CHAPTER 2

Differences in independent problem-solving ability between canid populations: Do domestication and lifetime experience affect persistence?

Introduction

Studies have shown that dogs and wolves tend to "look back" at human handlers at drastically different rates when presented with a task that is impossible or very difficult to solve for a food reward; dogs tend to look back at the handlers more, while wolves tend to persist at the task (Miklósi et al., 2003; Udell et al., 2009). Looking back at the caretaker during such a scenario may be indicative of attempting to ask for help or guidance during a task that has proven difficult (Marshall-Pescini et al., 2013). This was initially proposed to be an inherent difference in the social communication abilities of dogs and wolves, with dogs appearing more human-oriented and more likely to engage in communication (in the form of gazing) with humans (Miklósi et al., 2003).

However, later research found that wolves were more successful than dogs at a human-oriented task, such as a human pointing to the location of a hidden food reward, indicating that wolves can understand communicative gestures given by people; this suggests that wolves do have the ability to socially communicate with humans and that domestication may not be entirely responsible for the gazing difference between wolves and dogs (Udell et al., 2008).

Other studies have attempted to better understand how domestication may have influenced how animals interact with humans on a regular basis. A study with captive foxes attempted to replicate a typical domestication process by only breeding foxes that showed a tendency towards human interaction. These foxes were less aggressive, more docile when handled, and appeared to warm up to people much faster than their unselected (genetic control) match. Over the course of several generations, the researchers found that the propensity for their foxes to seek out human contact and their sociability towards humans increased (Belyaev, 1979; Hare et al., 2005). This research also showed that the "domesticated" foxes were able to learn human-based cues much faster than their wild counterparts, suggesting that there is at least some genetic basis for cross-species communication, at least in the case of humans and foxes (Hare et al., 2005). In addition, the research suggested that domestication results in an increased sensitivity period (Belyaev, 1979), meaning that domestication may result in prolonged development and this may be the source of differences in the social behavior between domestic and wild animals (Belyaev, 1979; Wynne et al., 2008; Udell et al., 2009). Still, other researchers have argued that while modern breeding of domesticated populations is common, the assumption that early domestication was a deliberate process (i.e., human hunter-gatherers deliberately selected "friendly" animals to breed) is not supported by scientific evidence (Price, 1999; Diamond, 2002; Udell et al., 2009; Coppinger et al., 2016).

Research has suggested that dogs increase their gazing at humans when they are reinforced for doing so, and several researchers have suggested that humans may be more responsive to dogs who look at them, bark at them, or otherwise engage in behaviors to get their attention (Jakovcevic et al., 2010; Udell and Wynne, 2010). Overtime the dogs may learn to engage in these human oriented social behaviors simply because they have been reinforced for doing so throughout their lifetime (Hare and Tomasello, 2005; Udell et al., 2009). At least one study has shown, however, that there are breed differences in the amount of time dogs will spend gazing at their owners face; in particular, retrievers maintained their gaze towards an experimenter for longer durations compared to shepherds and poodles. The researchers suggested that genetics may be a component in this difference; however, owners will have different expectations for different breeds, so life experiences cannot be discounted (Jakovcevic et al., 2010).

Dogs that spend a disproportionate amount of time gazing towards a human during a testing trial, or a dog that appears to rely on social cues when presented with a difficult problem to solve, may be less likely to excel at independent problem solving (Udell, 2015). Therefore, given the propensity for domestic dogs to gaze at their owner rather than attempting to solve a problem independently, it seems reasonable to assert that wolves are more persistent at independent tasks than domestic dogs (Udell, 2015). However, what is less clear is whether or not these differences exist because of domestication, lifetime experience, testing environment, or all of the above. The role of ecological niche has been especially difficult to address in prior studies, since typically only the performances of pet and working dogs have been directly compared to that of wolves. Feral and free roaming dogs, which might be expected to perform more independently, have never previously been evaluated on these problem-solving tasks.

Therefore the present study examined four groups of canines: socialized wolves, pet dogs in an indoor environment with a familiar experimenter, pet dogs in an outdoor environment with an unfamiliar experimenter, and free-roaming dogs.

Given that wolves tend to outperform domestic pet dogs on independent tasks (Udell, 2015), it was hypothesized that wolves would persist at tasks more than any of the domestic dog groups. However, due to the fact that life experience, including relationship with humans and environment, can play a role in how dogs perform on problem solving tasks (Marshall-Pescini et al., 2008; Udell and Wynne, 2010; Udell, 2015) and that the life experience and relationship with humans of free-roaming dogs may be distinct from the experiences of a pet dog, it was also hypothesized that free-roaming dogs would be intermediate between wolves and pet dogs and would persist more at the task than either of the pet dog groups. However it is also predicted that free-roaming and pet dogs would gaze more at the human than wolves.

Methods

Four groups of canines were compared for this experiment: 13 wolves (hand-reared and socialized to people from two weeks of age - for methods see Klinghammer & Goodman, 1987) tested with a familiar experimenter (their human caretaker) in their home environment (outdoors); 20 pet dogs with a familiar experimenter (their human caretaker) in their home environment (indoors); 20 pet dogs tested with an unfamiliar experimenter in an outdoor environment; and 20 free-roaming dogs (living on the streets of Kolkata, India) tested with an unfamiliar experimenter in an outdoor environment. The median age of the wolves was seven years, with five females and eight males; the familiar/indoor pet dogs was six years, with 11 females and 10 males; the unfamiliar/outdoor pet dogs was 4 years, with nine females and 11 males; and the free-roaming dogs were of unknown age and sex. A variety of breeds were tested.

The methods used replicated the human-in solvable task procedure from Udell (2015). Raw data for ten of the wolves was taken from Udell (2015) to avoid any repeat testing effects; these wolves were naïve to the task at the time they were tested. The additional three wolves and all 60 dogs were also naïve to the task, and were tested with matched methods during the course of this study. Canines were given a puzzle box (the "object"): a Rubbermaid deep squares TakeAlongs**®** tupperware container with a thick rope measuring approximately 18 inches long threaded through the lid. A preferred chunk of meat (summer sausage or chicken) cut into one-inch pieces was the reward. The food could be obtained by shaking the rope and dislodging the lid or by breaking through the container by biting through the plastic. While this puzzle task is considered challenging, it has been verified as physically solvable in the allotted trial time (2 minutes) by wolves and dogs, including small dogs and puppies, given adequate persistence (Udell, 2015).

The experimenter called the animal's attention and allowed it to sniff the food in the container. Then the experimenter snapped the lid closed, set the container on the ground, and stepped back approximately one meter. The experimenter remained neutral with their gaze directed down for the remainder of the test. The subjects were given two minutes from the time the container was placed on the ground to open the container and get the food reward. The task was considered complete when the subject opened the box and the food left the container or after two minutes, whichever came first.

Each test was video recorded. Behavior was coded for percent of trial time spent gazing at the human (defined as looking at the human at any time during the test once the container was placed on the ground), percent of time gazing at the puzzle box (defined as looking at the object at any point during the test), and time spent touching the puzzle box (defined as making contact with the object with any part of their body). Whether the animal solved the test or not and amount of time it took to solve was also recorded. Inter-rater reliability was tested by double coding 30% of the videos. Using a weighted Cohen-kappa test, the kappa coefficient was 0.98 (95% confidence interval: $0.97 \leq k \leq 1.0$) and 1.0 for whether the task was solved. The data from coder one was used for statistical analysis, and data from coder two was used to test the inter-rater reliability.

Statistical Analysis

Shapiro tests of the residuals revealed that the data were not normal (Touch: $W = 0.8699$, $p = 0.000002$; Gaze at the object: $W = 0.89525$, $p = 0.000018$; Gaze at the human: $W = 0.74241$, $p < 0.01$); thus, non-parametric statistical methods were used in the analysis. Kruskal-Wallis tests were used for comparisons for all four groups in time spent touching the object, gazing at the object, and gazing at the human. Mann-Whitney U tests were used for post-hoc comparisons. For all Mann-Whitney U tests, a Bonferroni-correction (alpha = 0.01) was used. All statistics were run using R Studio.

Results

A total of 2/20 pet dogs in the familiar/indoor group, 0/20 pet dogs in the unfamiliar/outdoor group, and 1/20 free-roaming dogs solved the puzzle. Conversely, wolves were much more successful with 11/13 wolves opening the container (*Figure 1*). Persistence at the task (touching the object) differed significantly between the four groups (Kruskal-Wallis test, H_2= 23.31, p = 0.0000349) as did time spent gazing at the object (Kruskal-Wallis test, H_2 = 23.02, p = 0.000040) and human (Kruskal-Wallis test, H_2 = 31.81, p = 0.00000058) (*Figure 2*).

Significant differences were found between the wolves and all other groups for amount of time spent touching the object, with wolves spending more time touching the object (wolves and unfamiliar/outdoor pet dogs: Mann-Whitney U Test, U = 33, p = 0.0004; wolves and familiar/indoor pet dogs: Mann-Whitney U Test, U = 40.5, p = 0.001; wolves and free-roaming dogs: Mann-Whitney U Test, U = 25, p = 0.00012). Significant differences were also found in gazing at the object, with wolves spending more time gazing at the object (wolves and unfamiliar/outdoor pet dogs: Mann-Whitney U Test, U = 26.5, p = 0.00014; wolves and familiar/indoor pet dogs: Mann-Whitney U Test, U = 38.5, p = 0.0008; wolves and free-roaming dogs: Mann-Whitney U Test, U = 20, p = 0.00005).

No significant differences were found between the two domestic pet dog groups in regards to the percent of time spent touching the object (familiar, indoor and unfamiliar pet dogs: Mann-Whitney U Test, U = 252.5, p = 0.1592) or gazing at the object (familiar, indoor and unfamiliar, outdoor pet dogs: Mann-Whitney U Test, U = 266.5, p = 0.074). In comparisons of free roaming and domestic pet dogs, no significant difference was found between pet dogs in the unfamiliar/outdoor group and free roaming dogs in amount of time spent touching the object (free roaming and unfamiliar, outdoor pet dogs: Mann-Whitney U Test, U = 158 $p = 0.2615$) or gazing at the object (free roaming and unfamiliar, outdoor pet dogs: Mann-Whitney U Test, U = 215, $p = 0.70$). There was significant difference between the familiar/indoor pet dogs and free roaming dogs in time spent touching the object, with pet dogs touching the object more (free roaming and familiar/indoor pet dogs: Mann-Whitney U Test, U = 96, $p = 0.005$), but not for amount of time spent gazing at the object (free roaming and familiar/indoor pet dogs: Mann-Whitney U Test, U = 129, $p = 0.057$)

In regards to the proportion of time spent gazing at the human, wolves spent the least amount of time of each group gazing at the human (wolves and unfamiliar/outdoor pet dogs: Mann-Whitney U Test, U = 222, $p = 0.0005$; wolves and familiar/indoor pet dogs: Mann-Whitney U Test, U = 248, $p < 0.0001$; wolves and free-roaming dogs: Mann-Whitney U Test, U = 20, $p = 0.00005$).

Pet dogs in the familiar/indoor group spent more time gazing at the human during the test compared to pet dogs in the unfamiliar/outdoor group (familiar, indoor and unfamiliar, outdoor pet dogs: Mann-Whitney U Test, U = 303.5, $p = 0.005$). No significant difference was found between free roaming and familiar/indoor pet dogs in proportion of time spent gazing at the human (free roaming and familiar, indoor pet dogs: Mann-Whitney U Test, U = 201, $p = 0.99$). When comparing the free roaming dogs to the unfamiliar/outdoor pet group, there was significant difference in amount of time spent gazing at the human, with the free roaming dogs gazing more (free roaming and unfamiliar, outdoor pet dogs: Mann-Whitney U Test, U = 305, $p = 0.005$).

Discussion

As past studies have demonstrated, wolves spent more time touching and gazing at the object and less time gazing at the human when compared to domestic dogs (Miklósi et al., 2003; Udell, 2015). However this is the first study to demonstrate that this holds true even when wolves were compared to free-roaming dogs, a population living as scavengers that might be expected to show greater persistence on independent food-acquisition tasks than pets. Wolves were overall more successful at solving the task than any of the domestic dog groups, a finding that suggests that even when dogs may be highly motivated to attempt to solve the task for food (in the case of the free-roaming dogs), dogs were much less persistent and thus less successful across populations, at least in part due to the greater amount of time spent gazing at the human.

Free-roaming dogs spent more time than wolves gazing at the humans during the task, a finding that may not be surprising given that free-roaming dogs are scavengers that rely on humans for food (Paul et al., 2015). There may be multiple explanations for why the free-roaming dogs spent more time gazing at the human when compared to the unfamiliar/outdoor pet dogs. Past studies have indicated that gazing behavior can be reinforced, leading to increases in the behavior after only a few learning trials (Jakovcevic et al., 2010). Given that these dogs are scavengers (Mech, 2012; Coppinger et al., 2016) free-roaming dogs may have learned through their life experience that humans are the primary providers of food. Unlike pet dogs, whose experiences and resources are primarily controlled by their owner (Udell and Wynne, 2008), this may be more strongly generalized to any human (not just the primary caretaker) and, because food may be scarce in their environment, an increase in gazing behavior could have survival benefits for them. Given that there is no difference in gazing behavior between the familiar/indoor pet dogs and the free-roaming dogs; pet dogs may associate food with a familiar caretaker in the same way that free-roaming dogs associate food with a stranger, and the indoor testing environment of these pet dogs would provide very little distractions. Thus, they may be more motivated to engage in communicative behaviors with any human as this may have been previously rewarding for them, similar to pet dogs and their caretakers. Alternatively, gazing behavior during this test may reflect a more cautious approach on the part of the free-roaming dogs to engage with an object that a human has presented, indicating that the dog may be wary of humans due to past aversive experiences.

Familiar/indoor pet dogs gaze more at the human and show a slight trend of gazing more at the object when compared to unfamiliar/outdoor pet dogs. An indoor environment is less distracting for pet dogs, and they may be more willing to engage in communicative gestures (such as gazing) with their owners than with strangers. This has been found in a previous study with pointing, wherein dogs tested in an outdoor environment did not follow pointing cues (Udell et al., 2008).

Conclusion

These findings all indicated that the behavior of these canines during the solvable task test may be reflective of their respective lifetime experiences and influenced by the testing environment. Free-roaming dogs, which have a unique relationship with humans, gaze more towards the human than any other group tested in this study, a finding that may be reflective of their past experiences with humans. However, further research is needed to better understand why this population of dogs gazed more towards the human during this independent task. Given the amount of individual variation within these populations, there is still much to learn about the factors that affect the tendency for canines to independently problem solve, especially in free-roaming dog populations.

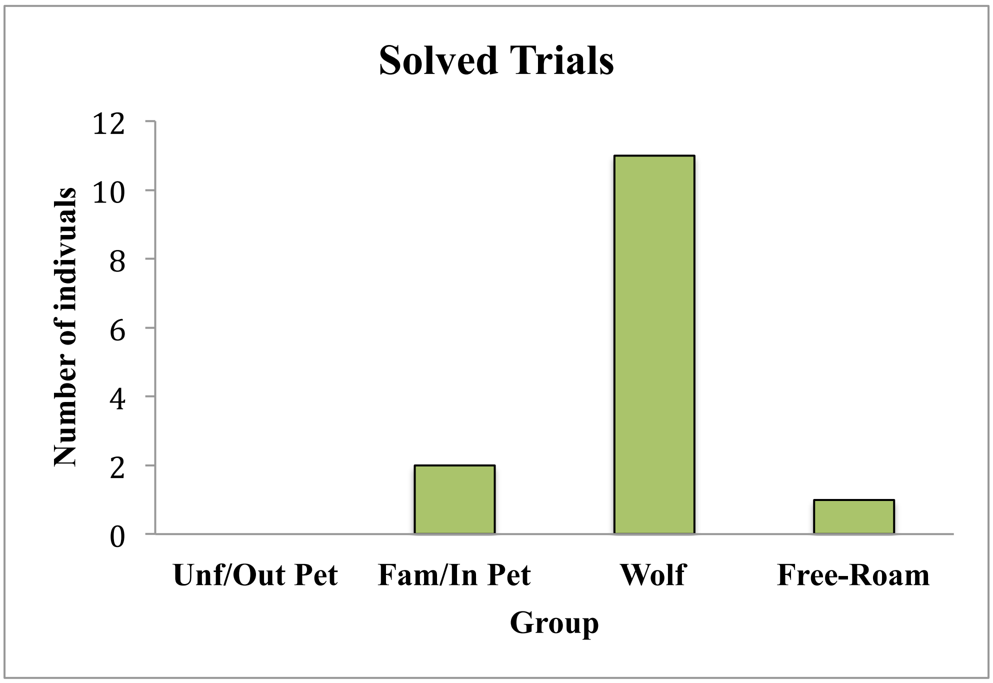

Figure 1: *Number of individuals that successfully opened the container within two minutes.*

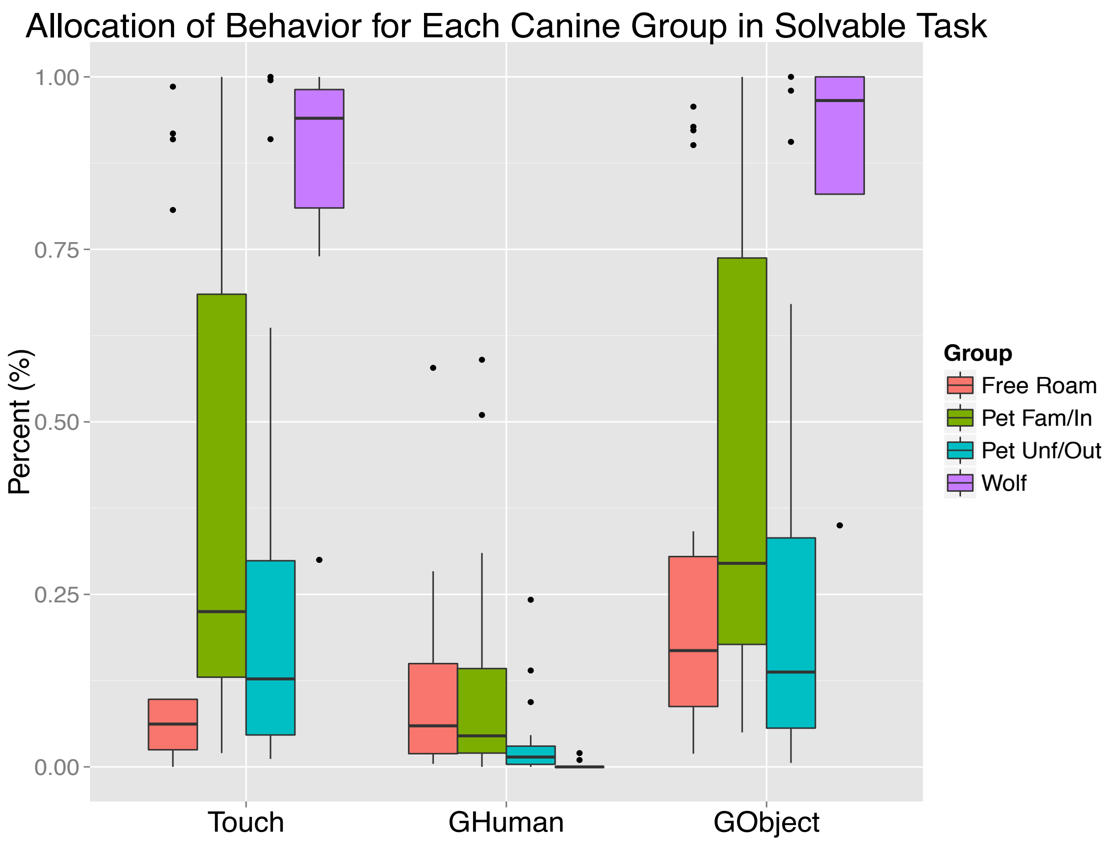

Figure 2: Box and whisker plot of proportion of time each group spent touching the object (Touch), gazing at the human (GHuman), and gazing at the object (GObject) for the trial time. Dots represent individual outliers and the horizontal black lines represent median values.

CHAPTER 3

The effects of past training experience and human behavior on a dog's tendency to persist at an independent task

Introduction

Past research has shown that a number of factors affect how a dog problem-solves, including prior training experience (Marshall-Pescini et al., 2008; Marshall-Pescini et al., 2009; Scandurra et al., 2015) and the relationship the dog has with humans (O'Farrell, 1997; Marshall-Pescini et al., 2008; Passalacqua et al., 2013; Shimabukuro et al., 2015). Marshall-Pescini et al. (2008) showed that when dogs are presented with a container that they were previously able to open for a food reward, their behavior when the container can no longer be opened mimics their previous training history; agility dogs gazed at their owners more often and search and rescue dogs vocalized more often than pet dogs during the test. The researchers suggested that this was likely due to the dogs having learned that this is a way to communicate with their owners in problem solving contexts (Marshall-Pescini et al., 2008). Other research using water rescue dogs has supported this finding (D'Aniello et al., 2015). Research has also shown that the immediate behavior of the experimenter can heavily influence a dogs behavior during an empirical test, particularly if the experimenter is familiar to the dog (Prato-Previde et al., 2007; Udell et al., 2008; Kerepesi et al., 2015; Udell, 2015).

To better understand how past training experience and owner behavior during a problem-solving task influence a dog's success and persistence on an independent task the performance and persistence of 20 search and rescue dogs and 20 pet dogs on an independent task were compared across three conditions: when alone, when the owner was in the room but neutral, and when encouraged by their owner to solve the task.

Given that search and rescue dogs are trained to work independently, it is likely that they will excel at an independent task compared to pet dogs, regardless of what their caretaker is doing during the task. However, past research has shown that the amount of time spent touching the object and gazing at the object increases when a dog is encouraged (Udell, 2015); thus, this will likely be true of all dogs, showing the most persistence during encouragement and the least persistence when alone.

Methods

Domestic dogs were compared in their persistence at a task in the presence, absence, and with the encouragement of their primary caretaker. In addition, two distinct groups of domestic dogs were compared: a working group of active search and rescue dogs (median age four years, 13 females and seven males) and a pet dog group (median age four years, nine females and 11 males). Search and rescue dogs were used because they are traditionally trained to work independently of their owner. All dogs were given a puzzle box (the “object”): a Rubbermaid deep square TakeAlongs® tupperware container with a thick rope measuring approximately 18 inches long threaded through the lid. Summer sausage, cut into 1-inch pieces, was the food reward. The food could be obtained by shaking the rope and dislodging the lid or by breaking through the container by biting through the plastic.

In phase one of the experiment, the dogs were given the container under two conditions (two minutes each): alone in the room, and with their owner in the room standing neutrally. To account for any order effects, the order of each condition was counterbalanced across dogs such that a total of ten dogs in each group began by being alone first and ten dogs began with the human-in condition first. Each condition immediately followed the next. Before each condition the owner was instructed to “bait” the container by picking the container up, placing the food inside the container while the dog watched, and showing it to the dog to allow the dog to see that the container had food in it. If the dog failed to open the container in either of these conditions (phase one), they moved to phase two, during which the owner encouraged the dog to solve the task using verbal praise or gestures, but without touching the dog or the container.

The task was considered solved if the dog opened the container and the food was removed. The dogs were given two minutes in each condition or until they opened the container (whichever came first) and each session was video recorded. Behavior was coded for percent of trial time spent gazing at the human (defined as looking at the human at any time during the test once the container was placed on the ground), percent of time gazing at the apparatus (defined as looking at the object at any point during the test), and time spent touching the apparatus (defined as making contact with the object with any part of their body). The groups were then compared to find if there were differences in these behavioral measures across dog categories or testing conditions. Inter-rater reliability was tested by double coding 30% of the videos. Using a weighted Cohen-kappa test, the kappa coefficient was 0.89 (95% confidence interval: $0.79 \leq k \leq 0.98$) and 1.0 for whether the task was solved. The data from coder one was used for statistical analysis.

Statistical Analysis

Shapiro-Wilk tests of the residuals revealed that the data were not normal for all conditions but one (Human in, touch: $W = 0.8131$, $p = 0.0000129$; Human in, gazing at the object: $W = 0.76374$, $p = 0.0000013$; Human in, gazing at the human: $W = 0.84672$, $p = 0.000075$; Alone, touch: $W = 0.67443$, $p < 0.0001$; Alone, gazing at the object: $W = 0.55517$, $p < 0.0001$; Alone, gazing at the human: $W = 0.89231$, $p = 0.0012$); Encouragement, touch: $W = 0.8645$, $p = 0.00042$; Encouragement, gazing at the object: $W = 0.9024$, $p = 0.0040$). Shapiro-

Wilk test revealed that in the encouragement condition, gazing at the human was normal (W = 0.9712, p = 0.4583). A Mann-Whitney U test was used for all comparisons between groups. All within group comparisons were performed using the Wilcoxon Signed Rank test (comparing human-in and alone conditions) or Mann-Whitney U test (comparing human-in and encouragement conditions) with a Bonferroni corrected alpha of 0.02. Fisher's exact tests were used to compare the number of dogs who solved the puzzle. All statistical measures were run using R Studio.

Results

No statistical difference was found between the search and rescue group and the pet dog group in any of the conditions for percent of time spent touching the object (Mann-Whitney U Test: human-in, U = 191.5, p = 0.8286; alone, U = 172.5, p = 0.4648; encouragement, U = 152, p = 0.764), percent of time spent gazing at the object (Mann-Whitney U Test: human-in, U = 202, p = 0.9676; alone, U = 195.5, p = 0.9137; encouragement, U = 201, p = 0.2231), or percent of time spent gazing at the human (Mann-Whitney U Test: human-in, U = 176, p = 0.5249; encouragement, U = 173, p = 0.7397) (*Figures 3, 4, and 5*). An equal number of dogs in each group solved the task during the human-in condition. Two pet dogs (compared to no search and rescue dogs) solved it during the alone condition, however this was not statistically significant (Fisher's exact test, p = 0.4872). Four search and rescue dogs (compared to one pet dog) solved it during the encouragement condition, however this was not statistically significant (Fisher's exact test, p = 0.3377).

Significant differences were found between the human-in and alone condition for pet dogs for touching the object (Wilcoxon Signed Rank, V = 174, p = 0.0083) and gazing at the object (Wilcoxon Signed Rank, V = 178, p = 0.0049), with pet dogs touching and gazing at the object more often during the human-in condition. Two dogs (one that was in the human-in condition first and one that was alone first) solved the puzzle during both conditions for phase one. No statistical difference was found with pet dogs between the human-in and encouragement conditions for touching the object (Mann Whitney U Test, U = 125, p = 0.1118). However, statistical differences were found in proportion of time spent gazing at the object (Mann-Whitney U Test, U = 76, p = 0.002478) and gazing at the human (Mann Whitney U Test, U = 89, p = 0.00707), with dogs gazing at the human and gazing at the object more often during the encouragement condition. One pet dog solved the task during the encouragement condition.

Within the search and rescue dog group, significant differences were not found in the percentage of time spent gazing at the object in the human-in and alone conditions (Wilcoxon Signed Rank, V = 145, p = 0.0442), however search and rescue dogs do display a trend in gazing at the object more during the human-in condition. No significant differences were found in time spent touching the object during the human-in condition versus alone (Wilcoxon Signed Rank, V = 96, p = 0.3558). Two search and rescue dogs solved the puzzle during the human-in condition; however, interestingly, no dogs solved it during the alone condition – despite the fact that both dogs that solved it during the human-in condition experienced that condition first and the alone condition second. No significant differences were found between the human-in condition and encouragement for percentage of time spent touching the object (Mann Whitney U test, U = 136, p = 0.2031). A slight trend was found for gazing at the object, with search and rescue dogs gazing at the object more during the encouragement condition (Mann Whitney U test, U = 122, p = 0.0925). A trend was also found for a difference between the human-in and encouragement conditions for amount of time spent gazing at the human, with dogs gazing at the human slightly more during encouragement (Mann-Whitney U test, $U = 117$, $p = 0.0675$). Four dogs solved it during the encouragement condition.

Discussion

Past research has shown that dogs will often mimic their training during a cognitive task (Marshall-Pescini et al., 2009). Because search and rescue dogs are trained to work independently, it is surprising that they do not out-perform pet dogs on an independent cognitive task. However, because search and rescue dog training often relies on human-oriented behavior, such as increased awareness of humans and human voices (D'Aniello et al., 2015), this could explain why there were no significant differences in the human-in and alone condition for these dogs, and why they appeared to attend to (in the form of gazing) but do not attempt to solve the task while their owner is out of the room.

In addition, given that past training experience can have an impact on the relationship between human and dog (Clark and Boyer, 1993; Marshall-Pescini et al., 2008), it is intriguing that the encouragement condition did not have a greater impact on the search and rescue dogs. However, the overall behavior of the search and rescue dogs during the encouragement condition does seem to be more effective in solving the task given the increased number of dogs who solved it during this condition when compared to pet dogs. There may be a variety of reasons for this. Search and rescue dog owners may be more effective at their ability to communicate with the dog, leading to a decreased effort but increased effectiveness at solving the task. As suggested by Marshall-Pescini et al. (2009), the effect of training on dogs appears to lie in the communicative styles and inclination to communicate with a human during a cognitive task (Marshall-Pescini et al., 2009) rather than a decrease or increase in the overall tendency to perform on that task. This may also explain why no differences were found between groups, except for the number of dogs that solved the task.

Search and rescue dogs are selected by their owners specifically for search and rescue training, so genetic differences between the two groups cannot be ruled out. Although a wide variety of breeds were present in both groups for this study, there may be some genetically linked behavioral traits that an ideal search and rescue dog possesses which may or may not be present in a pet dog group. Although it seems clear that humans can and do impact a dog's performance on cognitive tasks, more research is needed to better understand what traits make a dog more trainable than others and how these traits may present themselves during a cognitive task such as solvable task.

Conclusion

These findings indicate that past search and rescue training experience does not seem to significantly impact a dog's performance on an independent task when compared to pet dogs; however, there are differences among individuals within the groups, with search and rescue dogs showing slightly less variation in their behavior during human-in and alone conditions overall. Encouragement increased gazing behavior for both groups and greatly increased the number of dogs who solved the task for the search and rescue group. Overall, training does seem to result in some differences within groups, but this difference is not statistically significant when comparing pet and search and rescue dogs at an independent task.

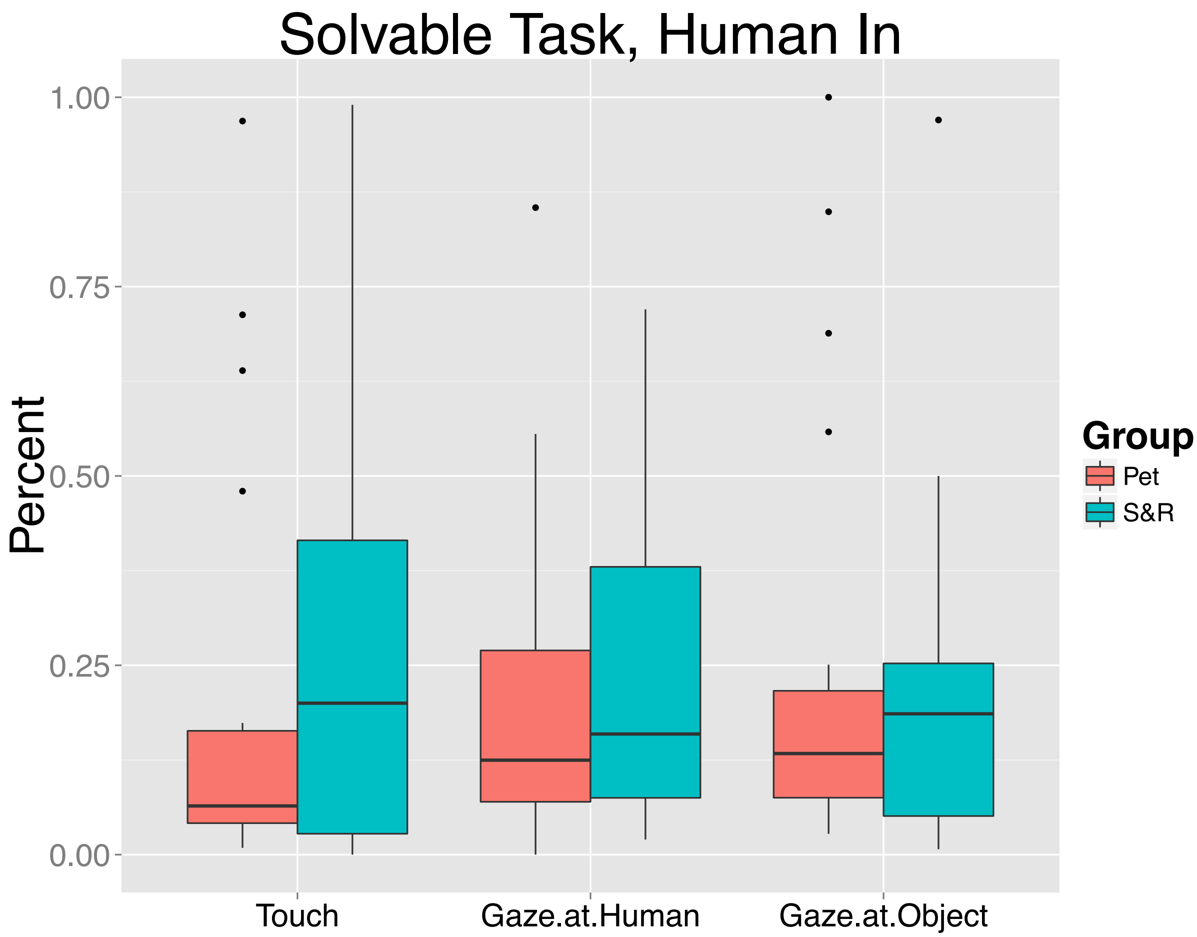

Figure 3: Percentage of time spent touching the object, gazing at the human, and gazing at the object during the human-in condition. Black dots represent outliers and horizontal black lines represent medians.

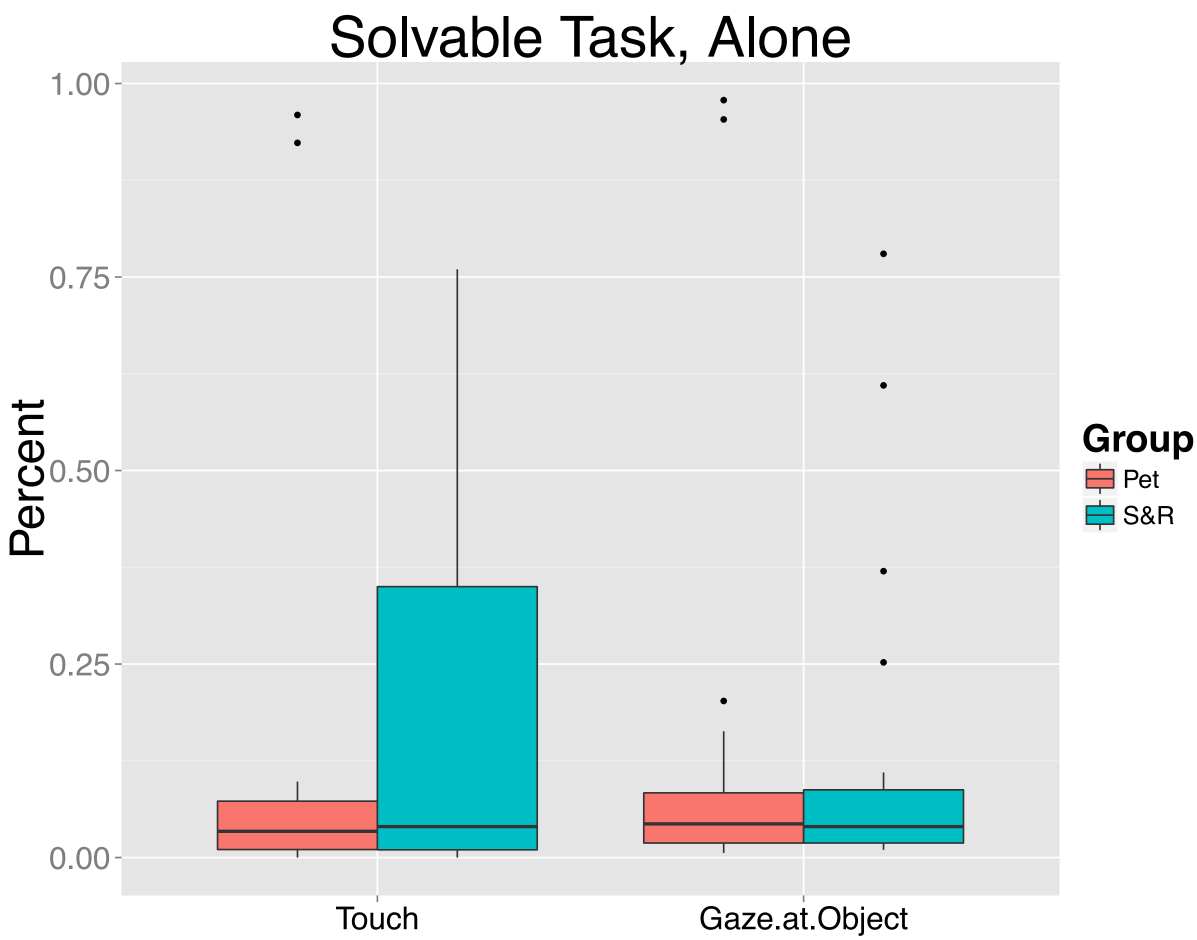

Figure 4: *Percentage of time spent touching the object and gazing at the object during the alone condition. Black dots represent outliers and horizontal black lines represent medians.*

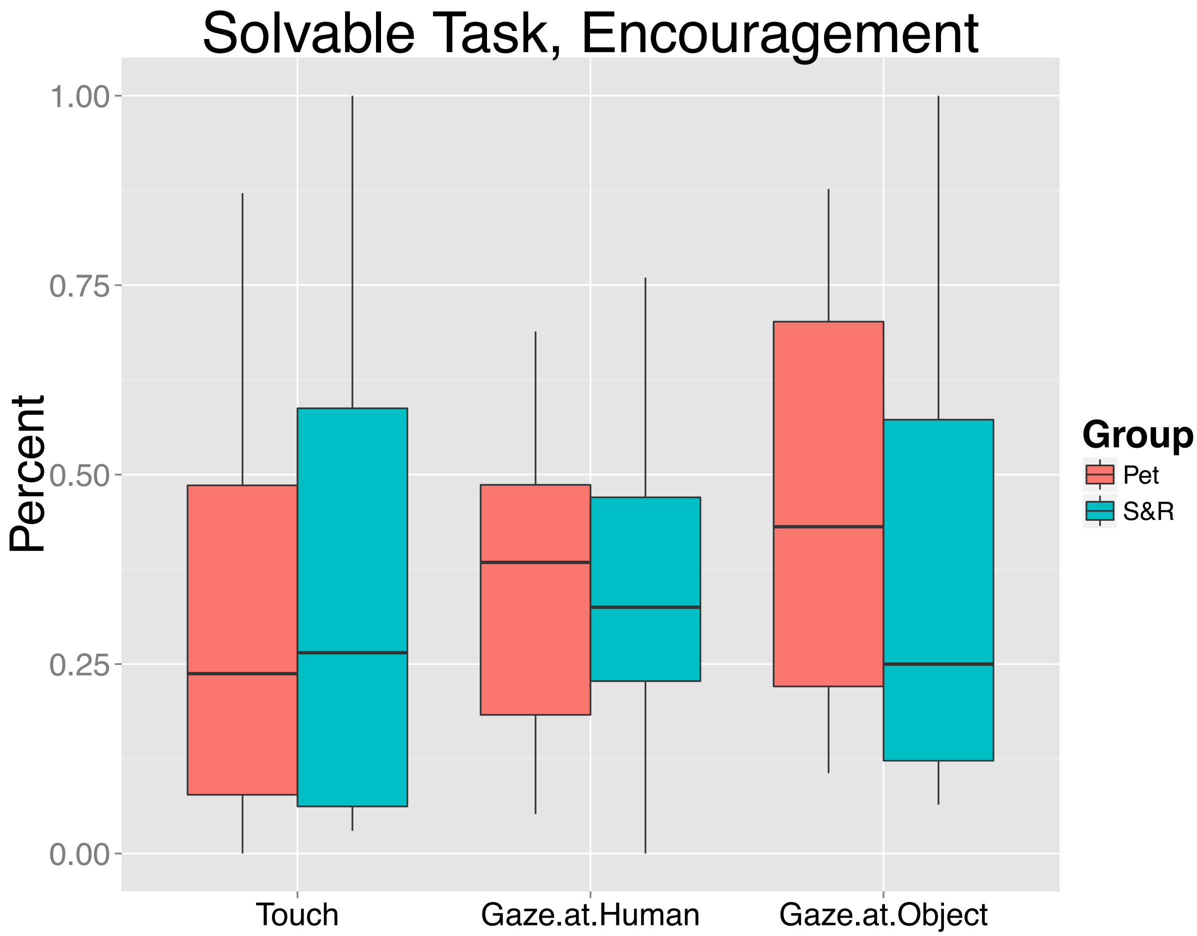

Figure 5: *Percentage of time spent touching the object, gazing at the human, and gazing at the object during the encouragement condition. Black dots represent outliers and horizontal black lines represent medians.*

CHAPTER 4

Order effects: does encouragement have an immediate effect on a dog's performance on future problem-solving tasks?

Introduction

Given that past life experiences, such as training experiences, can influence how a dog behaves during a cognitive task (Marshall-Pescini et al., 2008; Marshall-Pescini et al., 2009; Scandurra et al., 2015), there is some question as to how an encouragement condition during a solvable task paradigm might influence a dog's behavior in the absence of encouragement. This is particularly true when considering that Udell (2015) showed that a higher number of domestic dogs solved the task in an encouragement condition when compared to a human-in condition (Udell, 2015). This effect was observed in experiment two of the current project (see chapter 2). Therefore, when an owner encourages a dog to solve the task, the dog's persistence appears to increase and they are more likely to be successful on the task.

However, what is less clear is how encouragement may affect the behavior of the dog when followed by a more ambiguous situation, such as a neutral human-in condition. Given a dog's increased performance during the encouragement condition, the behavior of the dog during a human-in condition (in which the dog is not encouraged) immediately following encouragement should show evidence of learning effects.

Methods

In experiment three, three groups of ten pet dogs were each presented with the same object as described in experiment two (see chapter 2). Each dog was randomly assigned to one group of conditions: an encouragement (as described in experiment two) followed immediately by a human-in but neutral condition (E/H); a human-in but neutral condition followed by a human-in but neutral condition (the control group, H1/H2) to control for the effects of repeated experience with the box independent of encouragement; and a human-in but neutral followed by an encouragement condition (H/E). A variety of breeds were included and the median ages of each group were: five years, with six females and four males (for the H/H group); six years, with seven females and three males (for the H/E group); and 4 years, with four females and six males (for the E/H group). Each condition ran for two minutes or until the dog opened the container and the food was dislodged, whichever came first. Before each condition the owner was instructed to pick up the container, open it, and show the dog the task and food reward. Each session was video recorded and behavior was coded according to the guidelines in experiment two. The groups were then compared to find how the encouragement condition influences the dog's persistence in subsequent conditions. Inter-rater reliability was tested by double coding 30% of the videos. Using a weighted Cohen-kappa test, the kappa coefficient was 0.93 (95% confidence interval: $0.80 \leq k \leq 1.0$) and 1.0 for whether the task was solved. The data from coder one was used for statistical analysis.

Statistical Analysis

A Shapiro-Wilk test revealed the data were not normal across any of the parameters (Touch: $W = 0.92522$, $p = 0.0013$, gazing at the object: $W = 0.9114$, $p = 0.0004$; gazing at the human: $W = 0.8848$, $p = 0.00004$). Therefore, non-parametric statistics were used. All data was analyzed using R Studio.

Results

A Wilcoxon Rank sum test was used to compare the human-in conditions of the control (H1/H2) to the E/H group. No significant differences were found with percent of time spent touching the object (H2 and H, $W=43.5$, $p = 0.6495$), gazing at the object (H2 and H, $W=41$, $p =$

0.5172), or gazing at the human (H2 and H, W = 62, p = 0.3809). Further, no significant differences were found when the encouragement conditions were compared for touching the object (W = 48, p = 0.9118), gazing at the object (W = 45.5, p = 0.7623), or gazing at the human (W = 40, p = 0.472) (*Figure 6*).

Within group differences were compared using a Wilcoxon Signed Rank test. Significant differences were found when comparing H/E for gazing at the object (V = 7, p = 0.03711) and a trend was found for touching the object (V = 9, p = 0.06445) (*Figure 7*) with increased touching and gazing behavior in the encouragement condition. No significant difference was found for gazing at the human (V = 13, p = 0.153). When comparing E/H, no significant differences were found with touching (V = 35, p = 0.4922) (*Figure 8*), a slight trend was found for gazing at the object (V = 35, p = 0.0840), and no significant differences found for gazing at the human (V= 33.5, p = 0.5748), When H/H was compared to find whether simply presenting the task twice in a row under the same conditions affected the dogs behavior, no significant differences were found in touching (V = 0.20, p = 0.4922) (*Figure 9*), gazing at the object (V = 27, p = 1.0), or gazing at the human (V = 24, p = 0.9060).

Discussion

These findings suggest that there are some order effects when a test is presented multiple times, but this effect is only slight and is only present when the dog is encouraged to solve the task first. This may not be surprising when considering that, when presented with an ambiguous situation, dogs may need encouragement as a way of determining how they should act or to give context to the situation. Alternatively, a dog may have a history of scolding that could result in them hesitating to interact with a testing apparatus. By encouraging them to interact, owners may be reassuring the dog and, as a result, the dog learns to interact with the apparatus even when not encouraged to do so.

Conclusion

This study shows evidence that encouragement does impact a dog's performance on an independent task when compared to a human-in but neutral condition. This effect may also be carried over into a neutral condition, as no significant difference in touching or gazing was found when dogs were encouraged to solve the task first. This suggests that dogs had increased overall touching and gazing behaviors after being encouraged to solve the task.

The effect, however, does not seem to be substantial, as when compared to a control condition no significant difference was found. Further, when the two human-in conditions in H/H were compared, no significant differences were found. This provides evidence that there may be slight order effects if encouragement is given first, and that encouragement affects the way a dog performs on an independent task.

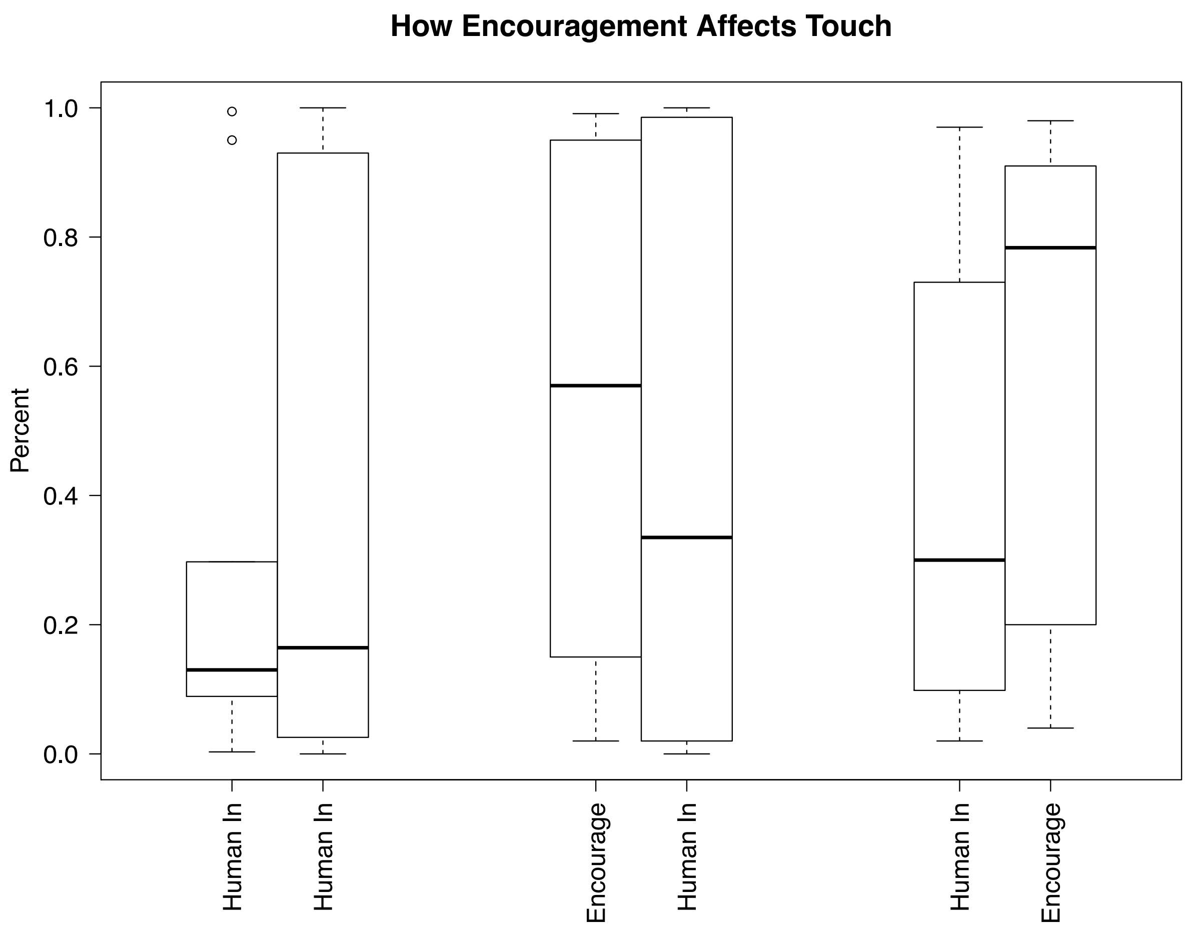

Figure 6: Percentage of time spent touching the object in the control (H/H), E/H, and H/E conditions. Dots indicate outliers and horizontal black lines indicate medians.

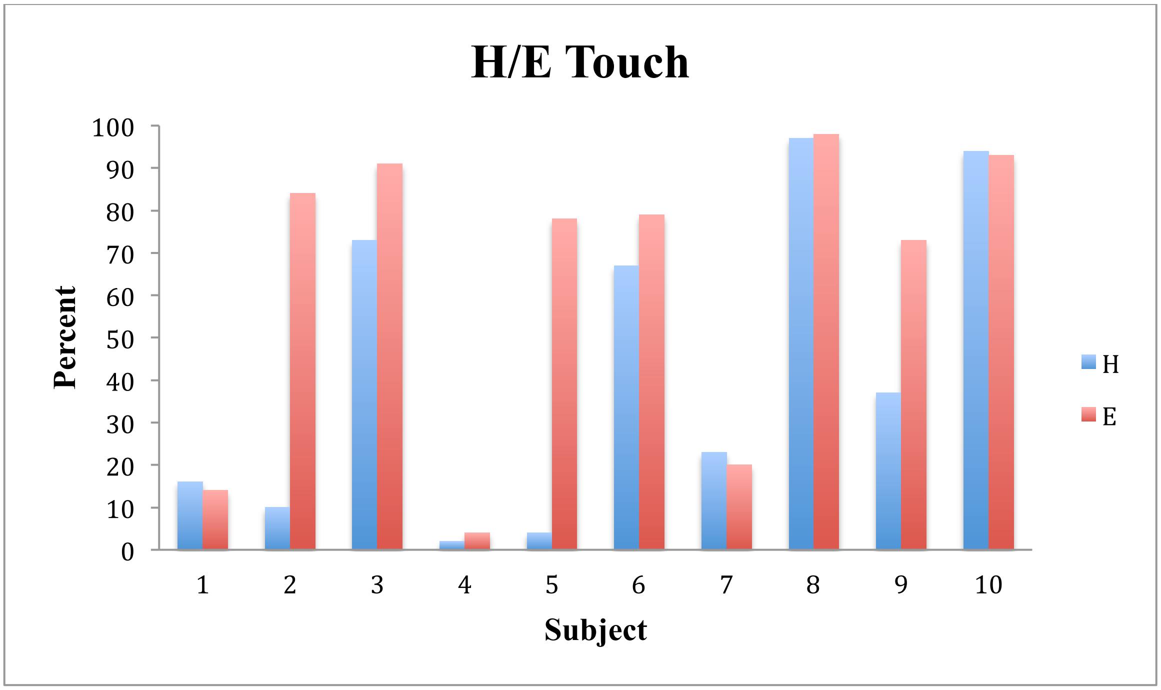

Figure 7: Percent of time spent touching the object in the human-in followed by encouragement (H/E) group. H denotes the human-in condition (in blue) and E denotes the encouragement condition (in red).

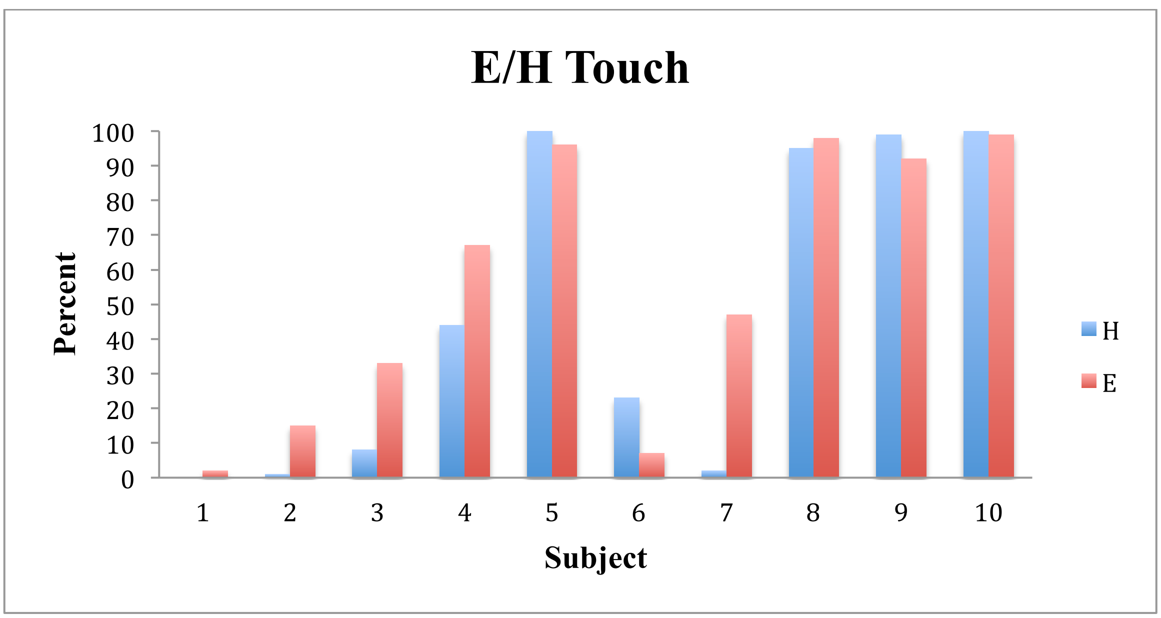

Figure 8: Percent of time spent touching the object in the encouragement followed by human-in (E/H) group. E denotes the encouragement condition (in blue) and H denotes the human-in condition (in red).

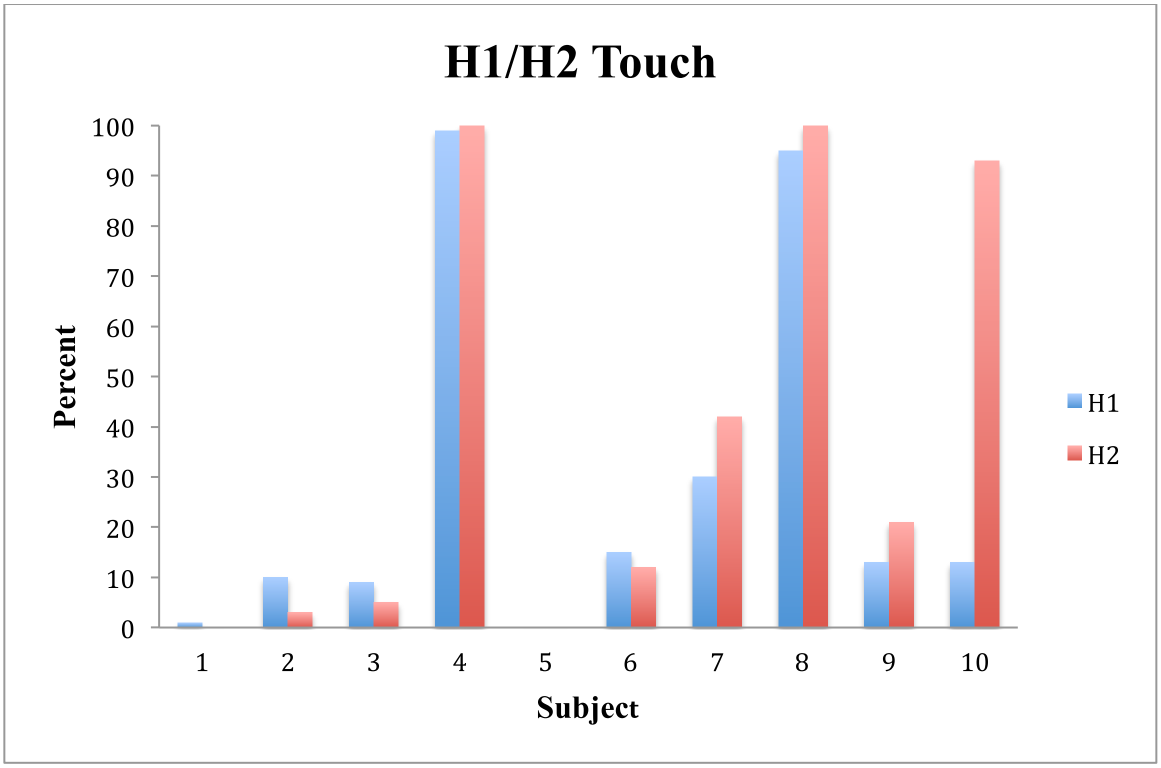

Figure 9: Percent of time spent touching the object in the control condition (H/H). H1 denotes the first human-in condition (in blue) and H2 denotes the second human-in condition (in red).

CHAPTER 5

Conclusion

Many factors, including genetics, life experiences, relationship with humans, environment, and domestication can all affect how a canine problem solves and, in particular, how persistent they are when presented with an independent task. These studies show that each of these factors is relevant to the overall tendency that an animal has to problem-solve.

Experiment one demonstrated that wolves appear to persist more on independent problem solving tasks and look back at the human the least amount. While all dogs gazed at the human significantly more than wolves, contrary to predictions free-roaming dogs gazed at the human the most during the test. This may suggest that increased gaze towards humans is related to domestication. However given that free-roaming dogs are not subject to breeding or the same level of genetic control that some purebred domestic dogs are (Coppinger et al., 2016), this may also be a result of unintended selection and/or learning on the part of the dog. Free-roaming dogs may have learned to gaze at passing humans for food scraps, or conversely may be wary of nearby humans when foraging (in this case interacting with an apparatus containing food) as a result of past aversive experiences with humans, either of which could result in prolonged gazing towards a human during solvable task.

Further research is needed to better understand free-roaming dog behavior and what, exactly, may be “meant” by gazing behaviors across dog and other canine populations. To better understand the origins and motivation behind gazing behavior, better definitions of gazing and gazing coded with other relevant behaviors (such as vocalizations, crouching, stalking, biting, etc.) may shed light on how and why free-roaming dogs differ from their pet dog counterparts, and why wolves do not tend to engage in this behavior during solvable task.

The effects of training on the persistence and problem solving behavior of the domestic dog has also received research attention, including how the type of training effects gazing and persistence (Marshall-Pescini et al., 2009; D'Aniello et al., 2015; Scandurra et al., 2015). Past research regarding breed differences has suggested that these differences seem to develop over time (Passalacqua et al., 2011), and other researchers have suggested that any breed differences may be due to owner expectation (Jakovcevic et al., 2010). This suggests that the behavior of the owner, including their expectation of their dog and how they engage with their dog on a day-to-day basis, may heavily influence the dog during a solvable task. This would be a result of lifetime learning that is not necessarily connected to a formal training program. Rescue dogs of all types have expectations about how they react to humans even before their training begins, for example the need for the dog to focus on humans even when the human is unfamiliar to them (D'Aniello et al., 2015). Therefore, it is possible that differences found when comparing trained groups of dogs to pet dogs may be the result of differences between the owner's expectation and treatment of the dog throughout the dog's lifetime. Further research is needed to better understand how the relationship between the owner and the dog affect the dog's behavior during a cognitive task, including how and why the owner chose the dog, the dog' personality traits, the owner's personality traits, and the nature of the owner/dog relationship.

Overall, these studies support previous findings that wolves and domestic dogs differ in their behavior at independent tasks, especially with regard to persistence, and that free-roaming dogs differ from both domestic dogs and wolves, particularly in the duration of gazing behavior towards humans. In addition, this research shows that lifetime and environmental factors impact a domestic dog's performance on independent tasks, including the testing environment, human presence during testing, relationship and perception of the human, and human behavior during testing. Supporting past research, search and rescue dog behavior appears to reflect their overall training; however this did not result in statistically significant differences when compared to pet dogs in this study. More research is needed to better clarify why these differences exist and how humans influence them.

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