Insight into the Factors of Human-Canine Relationships in Shaping Canine Personalities

By

Kaitlyn Stephanie Sudowsky

Ecology and Evolutionary Biology, University of Colorado Boulder

Defense Date: April 3, 2023

Thesis Advisor:

Dr. Ambika Kamath, Ecology and Evolutionary Biology

Defense Committee:

Dr. Ambika Kamath, Ecology and Evolutionary Biology

Dr. Pieter Johnson, Ecology and Evolutionary Biology

Dr. William Lindsay, School of Education

I. Abstract

Dogs, *Canis familiaris*, have been under artificial selection by humans since 8,000 BC, with some evidence of selection taking place up to 28,000 BC. The unique domestication of dogs has created a diverse assortment of phenotypes, behavior, and traits. This process has generated dogs that many people consider companions. Dogs are suitable companions because there is evidence of personality alignment between owner and dog. Because of this personality alignment, what influences personality in dogs? And if the environment is a major influence, what hypotheses are present in research? In this literature review, the CU library database was used to qualitatively synthesize research literature, and information from textbooks relating to dog domestication. Information was organized and presented to come to a preliminary conclusion regarding whether and how dog personalities develop and if they are aligned with the personalities of their owners. Due to the high level of past artificial selection, there is little room for further additive genetics effects, and thus dog personality is highly influenced by environment. Three hypotheses from Chopik and Weaver (2019) are considered: selection effect, dog's personalities are alike to humans because humans select similar behaving dogs; socialization effect, more social humans will have more social dogs; and anthropomorphism, humans have idiosyncratic ways of evaluating dog's behaviors. I propose veterinarian insight is necessary to come to a definite conclusion because they are professionals in the field with knowledgeable first-hand experience, and present a set of interview questions and preliminary data on which future research can be based. By understanding the basis of dog behavior and personality, owners can create spaces that are more shaped towards their dog's welfare.

II. Introduction

Within populations of any species, there is continuous variation among individuals in response to environmental and social challenges. Common challenges that organisms face include locating food sources, interacting with predators and competition with conspecifics. Social environments and challenges present opportunities for species to cope with problems. The different social conditions for individuals in the same group or population result from two influences: ecological parameters (e.g. distribution of resources like food, shelter and breeding sites), and social conditions (e.g. hierarchy structure or variation among individuals in resource holding potential; Bermuller & Taborsky, 2010).

Social environment is a critical factor that shapes behavioral traits and animal personality. Personality traits, like all other behavioral traits, are produced by the interaction of genetic factors and environmental factors, with a particularly large impact during development. Individuals with different genotypes experience different environments, and as a result there is variation among individuals in behavior. This variation undergoes selection and thus there is feedback on genotype structure in a population due to behavior phenotypes (Dingemanse & Réale, 2005).

Personality traits are shaped by both selective forces and natural environmental fluctuations. Different personalities coexist in the same population because multiple approaches or strategies in the face of challenges can be equally successful. It is beneficial for individuals to possess social cognition because they can understand members of a group and predict their actions due to their personality. Thus, personality and social cognition has utility and survival value (Breed & Moore, 2016a).

Domestication is defined as artificial selection to adapt species to human preferences. Animals that are domesticated experience strong artificial selection. The combination of

domestication and diversity of artificial selection across different breeds of dogs make the species' personality especially interesting to evaluate. Two modes of evolution have been identified for dogs: preservation of discrete mutations of large effect and diversification involving selection breeding within distinct phenotypic or functional groups. These modes have produced enhanced attributes of highly phenotypic diversity from a small number of major genes (vonHoldt et al., 2011).

Through these selective pressures, dogs have socially adapted to live with humans and participate in social interactions with humans. Indeed, dogs are thought to be especially perceptive to humans because of their unique domestication process. There is evidence of social contagion. Dogs recognize and integrate emotional information from humans and adjust their behavior these communicative signals (Schöberl et al., 2017). Humans and dogs can even experience hormonal synchronization under psychological stress (Sümegi et al., 2014).

The inter-specific type of social competence allow for dogs to have a range of social relationships with humans, including personality alignment between dogs and humans. In this thesis, I analyzed the human-dog interaction, a social effect on dog personality, through a literature synthesis. My methods included using CU Boulder Library search engines to find and synthesize major reviews of animal personality, dog domestication and personality, and human-dog interactions. This compilation of qualitative research led me to a preliminary conclusion. From this review, individual dog personality appears to be influenced more by the environment than by genetics; furthermore, an important environmental influence on dogs is their owners, whose personalities dogs morph to match.

Through this qualitative research, the foundation of a more quantitative study is established, but veterinarian insight is necessary to come to a higher-level conclusion. If dog personality is

highly influenced by the environment, what are the major influences? The three most prominent hypotheses, as proposed by Chopik and Weaver (2019), are: (1) selection effect, humans pick dogs that behave similarly to them; (2) socialization effect, more social humans will raise more social dogs; (3) anthropomorphism, humans view their dogs in idiosyncratic ways to analyze or understand their pets. The selection effect has the most data supporting this, followed by socialization, and then anthropomorphism. While there are other effects, most research can be categorized under one of the three hypotheses. Future directions include interviewing veterinarians for their opinions to get professional insight as well as quantitative data. The origin of dog personality and factors that can shape it are important to understand so owners and veterinarians can better the environment for dog, and animal, welfare.

III. Animal Personality

The foundation of behavioral consistency defines animal personality. Behavioral consistency is the behavior of individuals which remain stable over time and space; the behavior is reflected in intra-individual correlations when subjects are measured repeatedly in the same context. These consistencies come from social conflict and social options that affect development and evolution. In this thesis, I define animal personality as consistent individual differences in behavioral tendencies (Konno, 2014; Bermüller & Tabosky, 2010; Breed & Moore, 2016a).

The analogy of a scaffold is used to describe the different components that contribute to personality. At the base of the scaffold, there are genetically determined behavioral traits, commonly known as an innate behavior. Next is developmental, ontogenetic, influences. For example, prenatal exposure to testosterone can make individuals bolder on a bold-shy

continuum. Lastly, experiences and current events, the social environment, will also factor into an individual's personality (Breed & Moore, 2016a).

The social environment is a crucial element that shapes behavioral traits in general and animal personalities in particular. Social environments include within-species interactions such as competition, cooperation, and reproductive interactions, and across-species interactions such as host-parasite, predator-prey, and interspecific mutualism interactions. Animal personality is influenced by multiple components such as role choice, character displacement, temporal consistency, and conflict reduction. Personality traits tend to be unchanging within life stages but variable between stages, especially critical developmental events such as early stages of development (Bermüller & Tabosky, 2010) and sexual maturation (Cabrera et al., 2021). Traits are considered on a spectrum since animals at both extremes of the continuum have evolutionarily succeeded. At one time or another, one end may be favored by the selective forces, but natural fluctuations in environmental conditions allow both phenotypes to persist (Breed & Moore, 2016a).

Animal personality could be viewed as maladaptive. One might think that the most fit animals will only be bold or aggressive when it senses it should be because consistently bold animals have a higher chance of being preyed upon. Bell (2007) argues that not only does consistent behavior make evolutionary sense, but there are also mechanisms from life-history tradeoffs which can explain the success. If an environment is variable, being an intermediate is beneficial; however, if the environment is uncertain, avoiding a personality transformation is more favored because it requires less resource or energy use. This hypothesis answers why an individual may behave consistently but with different individuals' personalities occurring on a spectrum of variation.

Variation of personality is evident across individuals, but stable within individuals. The individual consistencies can be explained by growth-mortality tradeoff. Stamps (2007) suggest individuals vary physiologically and morphologically, and thus develop differences in behavioral traits that can increase growth rate but also increase risk of mortality, known as the growth-mortality tradeoffs. Long term, selection for high growth rates will increase bold behaviors across the population.

Personality traits evolve in response to selective forces in the context of natural environmental fluctuations. The most investigated proximate mechanism that influences personality is the role of neurotransmitters, because they modulate behavior in the nervous system and play a key role in behavioral systems. However, neurotransmitters' effects vary across species. For example, selective serotonin reuptake inhibitor (SSRIs), antidepressants used by humans that increase serotonin levels, have been found to have a similar response across mammals such as dogs and mice. In dogs, anxiety induced aggression are given SSRI's, such as Clomipramine, is used as treatment. Contrarily, serotonin has been shown to increase anxiety behaviors such as hiding and reduced exploratory behaviors in crustaceans. (Breed & Moore, 2016a). This evidence shows that we cannot assume that function is across different animal species. By understanding the role and mechanics of personality in more species, species interactions and persistence can be better explained.

IV. Domestication of Canines

Because dogs have been domesticated and bred through artificial selection, dog personality is especially interesting to analyze. I considered dog's most common ancestor, wolves, to help understand dog personality. Wolf pack social behavior is variable across

environmental and social contexts, specifically looking at the interactions to form a social order. However, wolves and dogs have diverged over thousands of years, due to domestication, primarily artificial selection on behavior. Because this process must be taken into consideration, we cannot completely turn to wolf behavior to understand dog behavior (Van Kerkhove, 2004). Selective breeding has resulted in breeds with characteristic and stereotypical personality traits; however, breed specific individuals still vary within their stereotypes. Dogs vary in their individual personality due to innate responses, social interactions, and environments.

Hare et al. (2002) found a correlation between domestication and social cognition in dogs. The hypotheses reported provide support for not focusing heavily on dog and wolf similarities. There were three hypotheses reported: (1) canids in general are unusually flexible in the types of social information they are capable of exploiting because of their cooperative social behavior in hunting and packs; (2) domestic dogs have much more experience with humans, compared to a close human relative of primates, and so they have learned skills during individual ontogenies; (3) there has been selection pressure on dogs during the process of domestication for skills of social cognition and communication with humans. Four different types of social tests were performed between dogs and primates, dogs and wolves, and among puppies. The results supported the hypothesis of domestication and selection for social cognition. In other words, the unique social communicative skills dogs possess is a result of domestication. This further supports the claim that wolves cannot be looked to for information on personality because dogs hold special cognitive and behavioral traits from the effects of domestication.

Humans selectively bred dogs that had behaviors that would make them easier to manage, better to work with, or had reduced predatory behaviors. Differences in temperament and abilities have been associated with the purposes for which the breed was selected for. Evidence

of different alleles in catecholamine synthesis—a biochemical pathway used to produce dopamine, norepinephrine, and epinephrine—have been associated with behavioral difference between ancient and modern dogs. This suggests that this pathway played an important role in the domestication (Cagan & Blass, 2016).

Today, trade-mark behaviors that differ among breeds are well known. “Breeding true”, also known as “pure bred breeding”, is accomplished through reducing genetic variation through breeding among those with the breed-specific traits. With this type of breeding in practice, most or all the additive genetic variation in the breed will be eliminated (Breed & Moore, 2016a).

V. Dog personality

The absence of additive genetic variation in breeds will lead to more behaviorally stable offspring. There is also the opportunity for higher heritability for complex behavior systems (Reuterwall & Ryman, 1973, as cited in Wilsson & Sungren, 1997b). Wilsson & Sungren (1997a) found that there is a difference in mentality between German shepherds and Labrador retrievers. This mentality difference can be attributed to the fact Labrador retrievers and German shepherds are a highly selected breed, thus, there is little additive genetic variation and complex behavior systems can diverge. Selection and heritability of behavior were evaluated in Labrador retrievers and German shepherds. Behavior tests have been used for 87 years to aid in the selection of service dogs for various types of work and breeding, but there were little studies prior to 1996 that took the approach of evaluating both different breeds and different work. 10 characteristics were scored based on dog’s reactions in 7 different test situations. Observational data concluded that there was a significant difference when comparing males and females separately in 3 of the 10 categories, and a significant difference among breeds, combining the

sexes, in 8 of the categories. German shepherds scored higher for sharpness and defense drive, while Labrador retrievers scored higher for nerve stability, reacted less to gunfire, and cooperation. Notably, Labrador retriever males were less cooperative than German shepherd males, and Labrador retriever females were more cooperative than German shepherd females. The lack of cooperation that male Labrador retrievers present has been found to be hormonally regulated because the noncooperation disappears if the dogs are castrated before they are one year old.

The difference in mentality between the two breeds can be attributed to the original work the breeds were meant for, which suggests some degree of heritability. Wilsson and Sungren (1997b) calculated heritability for the characteristics evaluated in behavioral tests discussed above. 1469 puppies bred by Swedish Dog Training Centre (1002 German shepherds and 467 Labrador retrievers) and 637 puppies from private breeders (308 German shepherd and 330 Labrador retrievers) were used to estimate heritability between siblings within groups of full and half siblings. Heritability estimated for the four factors—mental stability, willingness to please, affability, and ardour—were between 0.15 and 0.32. A higher heritability is found for complex behavior systems rather than specific behavior systems. The higher heritability could be explained since the evaluated characteristics could overlap, and thus that evaluated characteristics could mechanistically overlap and result in this higher degree of confidence. There are other estimates of heritability for behavioral traits in guide dogs such as: success, 0.44 (Goddard and Beilharz, 1982); fearfulness, 0.50 (Barlett, 1976); and temperament, 0.51 (Mackenzie et al. 1985).

Like Wilsson and Sungren (1997), Ilaska et al. (2017) used the Canine Behavioral Assessment and Research Questionnaire (C-BARQ) which was developed at the University of

Pennsylvania as a way for evaluating and predicting the success of guide dogs. Combined with genomic data, results from the questionnaire yielded a significant genetic variance present for behavioral traits for Labrador Retrievers, ranging from 0.11 (excitability) to 0.28 (fetching). In 9 of out the 12 evaluated traits, genomic heritability was lower than pedigree-based estimates; however, genome-wide association analysis identified several genomic regions showing associations with the traits under evaluation. Low heritability shows that the gene has gone under strong selection; any of the variation is due to the environment because most of the dogs are hardwired with the traits. An important consideration is organization of data for analysis. Grouping into behavioral factors could influence estimates of heritability and the dog breeds may differ in the "meaningfulness" of any aspect of personality for their lives.

Dog aggression has been identified as being both genetically rooted and influenced by their owners. Using the Dog Mentality Assessment (DMA) test of 16 behavioral traits, breeds of German Shepherds and Rottweilers were tested to understand the genetic component to personality. There was a strong genetic correlation in personality traits for playfulness, chase-proneness, and aggressiveness; the mechanics of the genetic correlation was also found to be similar between German Shepherds and Rottweilers (Saetre et al., 2005). Similarly, ancestral lines of Springer Spaniels and English Cocker Spaniels were more aggressive; however, reports indicate that dogs needed to display protection because their owners showed higher territorial aggression. However, dogs that are obedience trained or used as a household family pet showed lower levels of aggression (Daye, 2011). Younger dogs are more excitable and less aggressive towards people compared to older middle-aged dogs who were 6-8 years older; specifically older, male dogs have higher aggression rates compared to other groups (Chopik & Weaver, 2019).

VI. Human-Canine Interaction

Personality alignment between dogs and humans is supported by data as well. Jones (2008) was able to characterize dog personalities into five dimensions: fearfulness, aggression towards people, aggression towards other animals, excitability, and responsiveness to training. The classification was built from guidelines for measuring personality traits in humans. A critical aspect of an owner-dog relationship is personality consistency; through a meta-analysis of dog temperament, it was found that adult dogs have a more consistent personality in comparison to puppies. Puppy personality fluctuates much into adult period, especially on an aggression-submission spectrum (Fratkin et al., 2013). While dogs do not choose the environment they live in, social interactions throughout their development such as training and socialization can reinforce behaviors via a positive feedback loop (Howell et al., 2015).

Chopik and Weaver (2019) used human interactions as a basis to explain why owners and dog personalities may be correlated. Based on a selection effect, owners may pick dogs whose personalities and temperament align with theirs. This is observed in humans, where couples can accurately predict one's personality traits and attitudes after only being with someone for a short amount of time (Tidewell et al., 2013). Humans and dogs may also share a similar personality because they share activities and environments, as shown in studies with human relationships with emotional convergence (Anderson et al., 2003). And finally, owners might evaluate the personality of their dogs in their lives in anthropomorphized, idiosyncratic ways (Kwan et al., 2008)

A. Selection Effect

Owners and dogs might have similar personalities based on a selection effect. Because owners align their personalities and lifestyles to other humans, they may consciously or unconsciously choose dogs that match their personality. Chopik and Weaver (2019) proposed this hypothesis because there is evidence in speed-dating simulations that individuals can predict some personality traits and attitudes with impressive amounts of accuracy after being exposed to another person for a short amount of time (Tidewell et al., 2013).

Most research on selecting dogs specifically for their personality, behavior, or temperament has been done with working dogs, specifically those in assistance, protection, or detection. Working dogs have diverse roles in hunting and agriculture, transportation, public health, and environmental protection (Bray et al., 2021). Because of this advanced, and more available research, I will be focusing heavily on selection of working dogs, but the phenomena should translate to selecting a pet dog.

When selecting a working dog, individuals need to be able to identify a dog, most commonly a puppy 8-10 weeks of age, with the potential physical and behavioral characteristics necessary for their future role. Two approaches working dog programs use is identifying breeders with a history of success or trial-and-error approach with individual dogs. Even from a young age, performance on tasks could be predicted from a set of cognitive measures collected in early development (Bray et al., 2021).

A common assessment used in the United States is the C-BARQ. This is a standardized, behavioral evaluation tool developed in 2003 and is used by Penn Vet Working Dog Center, Guiding Eyes for the Blind, Best Friends Animal Society, and Canine Companions for Independence, among other programs. C-BARQ measures 14 different categories of dog behavior while also providing information on 22 miscellaneous behavior problems (University of

Pennsylvania School of Veterinary Medicine). The C-BARQ in working dogs has shown great success. 27 traits explained significant proportions of the variation in success. Traits at 6 months old were the same in those associated with successful working dog traits. These included: high trainability, high energy, low stranger-directed aggression, low owner-directed aggression, low dog-directed aggression, low non-social fear, low stranger-directed fear, and low chasing.

Researchers have found a relationship between C-BARQ behavior traits and successful training as a service dog. At both a young age and a mature age, these successes and traits were similar. This means it is possible to use C-BARQ to screen and select dogs for working dogs as early as 6 months (Hare et al., 2018). Penn Vet claims that C-BARQ can be utilized by everyday individuals for comparing their dog to the general data. More broadly this means that through careful evaluation, non-working dogs can also be selected to meet the personalities of owners.

B. Socialization Effect

Owners and dogs might have similar personalities based on a socialization effect. The shared activities and environments of humans and dogs can influence the dog's personality and relationship. Chopik and Weaver (2019) proposed this hypothesis based on emotional convergence between humans. People in relationships become emotionally similar over time leading to psychological coordination of thoughts and behaviors that increase understanding and increase social cohesion (Anderson et al., 2003). Individuals may also meet their emotional needs through a canine relationship, and this relationship may be enhanced when receiving their dog as a puppy since puppies require more time and care (Barker & Barker, 1988).

Experiences and handling in a dog's early life can have profound effects on later behavior. The early experiences influence the developing neuroendocrine system. Fox (1970)

emphasized the importance of socialization for dogs. He claimed that an innately timid dog, if carefully handled and exposed to stimuli during early life, can adapt to reduce over-reaction to stimuli. In contrast, dogs with restricted socialization early on will experience an "overload effect" when emerging from isolation.

Dogs recognize emotions and sense the environment. In a study conducted using quantified heart rate variability (HRV) of Border Collies and Labrador Retrievers- male, female, intact and neutered morphologies, researchers found that dogs were more active, lower HRV, during emotional stimulation. Low HRV means high emotional arousal, while high HRV means low emotional response. The researchers claim that quality of dog owner relationship could be measured using heart rate variability. Dogs with a closer bond to owners will have higher arousal. (Somppi et al., 2022). This further supports the idea that shared activities and experiences is a factor that shapes dog personality to match their owners.

Similar experiences during early life, to a certain extent, lead to dogs behaving similarly, whereas any behavior differences appear during maturation (Fox, 1970). Bray et al. 2021 assessed 160 dogs at two distinct ages. The first assessment was at 8-10 weeks old and the second was ~21 months. The assessments included two categories: executive function, including inhibitory control, reversal learning, and memory; and sensory discrimination such as vision, audition, and olfactory. Their results showed that task performance increased with age, and the largest effects were observed for measures in executive function. The differences in dogs were evident early on, and they persisted throughout the research time. There was evidence for rank-order stability between the two time points. This means, the puppies who performed high continued to perform high as adults, and the puppies who performed low continued to perform low as adults.

These performances could be a reflection on behavioral synchronization with their owners. Pet dogs exhibit a social preference for people who synchronize with them, and working dogs also have strong bonds with owners, though the type and strength of the bond can differ by breed. For example, when comparing the social preference between shepherd dogs, known for herding, and molossoid dogs, known for guarding, molossoid dogs exhibited a stronger preference for people who synchronized. This is because they are the boldest breeds of dogs, so these dogs have increased affiliation with strangers. Shepherds exhibited a random choice. When humans did not provide any type of interaction, both types of dogs turned to characteristic behaviors for their breeds, such as herding for shepherds (Duranton et al., 2019).

C. Anthropomorphism

Owners and dogs have similar personalities because owners have idiosyncratic ways of evaluating things in their lives or even project their personality on things they evaluate, including dogs. Anthropomorphism is attributing human characteristics to nonhuman animals (Breed & Moore, 2016b). Kwan et al. (2008) identifies two types of anthropomorphism. The first is egocentric anthropomorphism which is the degree which humans misperceive dogs as similar to themselves. The second is homocentric anthropomorphism which is the degree which humans inappropriately perceive dogs similar to other humans in general. There is a high level of consensus reached when judging dogs, and perceivers generally did not use appearance-based stereotypes to judge dogs.

There are stereotypical views of person-pet combinations, and this can affect pet selection. When asked to pair 10 pictures of owner and dog, there was a significant pairing trend for nine of the ten target persons. Sex is a major determining component. Males are generally associated

with larger dogs while females are associated with smaller dogs. In addition to human sex, other factors were taken into consideration during the pairing such as age, personality attributes and appearance (Budge et al., 1997). Owners are generally seen to resemble their dogs.

Owners are considered similar to their dogs and commonly will "alloparent" dogs. Because owners adopt and raise dogs, a parental role is fulfilled in owners. There are similarities between owner-dog relationship and huma infant-caregiver relationship. Both have been described within the framework of human attachment theory. With the use of fMRI brain scans, there are reports of substantial overlap in brain activation patterns in regions involved in reward, emotion, and affiliation when a mother's own child and dog images are shown. There is less of a response when shown images of other children and dogs (Stoeckel et al., 2014). This means that humans have an emotional attachment to dogs comparable to their attachment to a family member; thus, there might be human actions or attributes forced onto dog behavior. Anthropomorphism is seen as a large issue in western countries compared to Asia, Africa, and Oceania (Endenburg et al., 2022).

VII. Discussion

Dogs, especially pure breeds, have undergone high artificial selection for appearance, temperament, and instincts. This leaves little room for further additive genetic effects, and thus, many breeds are behaviorally stereotyped, but individual variation in behavior is unlikely to be genetically based. Because of the close relationship humans and dogs share, there is evidence of personality alignment; this phenomenon likely results from environmental effects and social interactions. Three main hypotheses have been identified by Chopik and Weaver (2019): the selection effect, the socialization effect, and anthropomorphism.

All three hypotheses have the potential to contribute to human-dog personality alignment. The degree of effect that each of these factors have on individual dog personality is unknown. The most compelling evidence of personality alignment is categorized under the socialization effect. From personal experience working with many types of dogs and clients at veterinarian practices and informal discussions with veterinarians, I think socialization effect is the biggest contributor to dog personality. For example, it is recommended that puppies experience proper socialization, training, and desensitization for maximum combability. After completing this research and coming to a preliminary conclusion, veterinarian insight would be the next steps to take.

An issue that I battled with is that the basis of the hypotheses is from human interaction and psychology. As discussed in "domestication of canines" section, I argued that we cannot look to wolves, dog's closest ancestor, because the behavior is too divergent. I think it is a stretch to assume that human psychology is applicable in this context. However, I understand and witnessed that research in human-dog personality and relationship is lacking.

I was intending to get veterinarian opinions to bring this synthesis to a more concrete conclusion. This was my biggest struggle and limitation. They are professionals in the field, and they interact with dogs and clients on a regular basis. To standardize the veterinarian's opinions, I created a document with twelve questions, found in the appendix. Examples are very important to ask for so we can understand where their insight is coming from. In a preliminary study, I received answers from two practicing vets. The phrasing and terminology they used were strikingly similar despite them being from separate practices and having different veterinarian school experiences. Both veterinarians think that spending a short amount of time with a dog is not enough to completely predict the dog, and that they "morph" to the environment they are

placed into. I intended to increase this sample size but after reaching out to multiple practices and social media platforms, I got a handful of responses, but not enough to come to any significant deductions.

The ways that an owner interacts with their dog will shape the relationship. All dogs have the potential to be trained to perform and act a certain way. Socialization effect has the greatest and most significant research, followed by the selection effect, and then anthropomorphizing. Because dogs are highly domesticated animals, they have the capacity to morph to their environment. Understanding a dog's personality origins more concretely will be significant for a better relationship between owners and dogs, for shelters to help place dogs with appropriate owners, and to create better environments for pets to live in.

VIII. Acknowledgements

I would like to thank my thesis advisor Dr. Kamath for the large amount of support she has given me throughout the writing process. Dr. Kamath's teachings in her animal behavior class inspired me to pursue this topic in the first place. Our meetings continued to inspire and encourage me to become a creative thinker, to question the world around me, and analyze research from a new perspective. Dr. Lindsay has always been a positive mentor to have, and he has shown me the power of being an educator. I appreciate Dr. Johnson's contributions in preparing me for my defense and aiding me to finish my thesis. Lastly, I would like to give an overwhelming thank you to my parents who have always supported my aspirations as a student; they have taught me that hard work brings the best rewards.

IX. References

Anderson, C., Keltner, D., & John, O. P. (2003). Emotional convergence between people over time. *Journal of Personality and Social Psychology* 84: 1054-1068.

Barker, S. B., & Barker, R. T. (1998) The human-canine bond: closer than family ties?. *J Mental Health Counsel* 10:46–56.

Barlett, C.R. (1976) Heritability and genetic correlation between hip dysplasia and temperament traits of seeing-eye dogs. Master Thesis. Rutgers University, New Brunswick, NJ.

Bell, A. M. (2007). Animal personalities. *Nature* 447: 539-540.

Bergmüller, R., & Taborsky, M. (2010). Animal personality due to social niche specialisation. *Trends in Ecology and Evolution* 25*:* 504-511.

Bray, E. E., Gruen, M. E., Gnanadesikan, G. E., Horschler, D. J., Levy, K. M., Kennedy, B. S., Hare, B. A., & MacLean, E. L. (2021) Dog cognitive development: a longitudinal study across the first 2 years of life. *Animal Cognition* 24: 311-328.

Breed, M. D., & Moore, J. (2016a). Homeostasis and time budget. In 2nd ed. *Animal Behavior* (pp. 109-144). Academic Press.

Breed, M. D., & Moore, J. (2016b). Cognition. In 2nd ed. *Animal Behavior* (pp.175-209). Academic Press.

Budge, C. R., Spicer, J., St. George, R., & Jones, B. R. (1997). Compatibility stereotypes of people and pets: a photograph matching study. *Anthrozöös* 10: 37-46.

Cabrera, D., Nilsson, J. R., & Blaine, D. (2021). The development of animal personality across ontogeny: a cross-species review. *Animal Behaviour* 173: 137-144.

Cagan, A., & Blass, T. (2016). Identification of genomic variants putatively targeted by selection during dog domestication. *BMC Evolutionary Biology* 16: 10.

Chopik, W. J., & Weaver, J. R. (2019). Old dog, new tricks: Age differences in dog personality traits, associations with human personality traits, and links to important outcomes. *Journal of Research in Personality* 79: 94-108.

Daye, M. (2011). Dog owner personality, owner interaction with dog, and dog aggression. *Alliant International University ProQuest Dissertations Publishing* 3450373.

Dingemanse, N. J., & Réale, D. (2005). Natural selection and animal personality. *Behaviour* 142: 1159-1184.

Duranton, C., Bedossa, T., Gaunet, F. (2019). Pet dogs exhibit social preference for people who synchronize with them. *Animal Cognition* 22: 243-250.

Endenburg, N., Trakashima, G., van Lith, H. A., Bacon, H., Hazel, S. J., Jouppi, R., Lee, N. Y. P., Seksel, K., & Ryan, S. (2021). Animal welfare worldwide, the opinion of practicing veterinarians. *Journal of Applied Animal Welfare Science* 24: 215-237.

Fratkin, J. L., Sinn, D. L., Patall, E. A., & Gosling, S. D. (2013). Personality Consistency in Dogs: A Meta-Analysis. *PLoS ONE* 8.

Fox, M. W. (1970). Neurobehavioral development and the genotype-environment interaction. *The Quarterly Review of Biology* 45: 131-147.

Goddard, M. E., & Beilharz, R. G. (1982). Genetic and environmental factors affecting the suitability of dogs as guide dogs for the blind. *Theoretical and Applied Genetics* 62: 97-102.

Hare, B., Brown, M., Williamson, C., & Tomasello, M. (2002). The domestication of social cognition in dogs. *Science* 298: 1634-1636.

Hare, E., Kelsey, K. M., Serpell, J, A., & Otto, C. M. (2018). Behavior differences between search-and-rescue and pet dogs. *Frontiers in Veterinary Science* 5: 118.

Howell, T. J., King, T., & Bennett, P. C. (2015). Puppy parties and beyond: the role of early age socialization practice on adult dog behavior. *Veterinary medicine (Auckland, N.Z.)* 6: 143-153.

Ilska, J., Haskell, M. J., Blott, S. C., Sánchez-Molano, E., Polgar, Z., Lofgren, S. E., Clements, D. N., & Wiener, P. (2017). Genetic Characterization of Dog Personality Traits. *Genetics* 206:1101-1111.

Konno, A., Hasegawa, T., Inoue-Murayamama, M. (2014). An integrated understanding of the personality concepts in animal personality psychology and behavioral syndrome research. *Japanese Journal of Animal Psychology* 64: 19-35.

Kwan, V.S.Y., Gosling, S. D., & John, O.P. (2008). Anthropomorphism as a special case of social perception: A cross-species social relations model analysis of humans and dogs. *Social Cognition* 26: 129-142.

Mackenzie, S. A., Olenacu, E. A. B., & Leighton, E. (1985). Heritability estimate for temperament scores in German shepherd dogs and its genetic correlation with hip dysplasia. *Behavioral Genetics* 15: 475-482.

Saetre, P., Strandberg, E., Sundgren, P. E., Pettersson, U., Jazin, E., & Bergstrom, T.F. (2005). The genetic contribution to canine personality. *Genes, Brain and Behavior* 5: 240-248.

University of Pennsylvania School of Veterinary Medicine. (2023 March 1) *Canine Behavioral Assessment & Research Questionnaire*. https://vetapps.vet.upenn.edu/cbarq/about.cfm

Schöberl, I., Wedl, M., Beetz, A., & Kotrschal, K. (2017). Psychobiological factors affecting cortisol variability in human-dogs dyads. *PLOS ONE* 12: e0170707.

Somppi, S., Tornqvist, H., Koskela, A., Vehkaoka, A., Tiira, K., Vaataja, H., Surakka, V., Vainio, O., & Kujala, M.V. (2022). Dog-Owner Relationship, Owner Interpretations and Dog Personality Are Connected with the Emotional Reactivity of Dogs. *Animals* 12:1338.

Stamps, J. A. (2007). Growth-morality tradeoffs and 'personality traits' in animals. *Ecology letter* 10: 355-363.

Stoeckel, L. E., Palley, L. S., Gollub, R. L., Niemi, S. M., Evins, A. E. (2014). Patterns of brain activation when mothers view their own child and dog: an fMRI study. *PLOS ONE* 9: e107205.

Sümegi, Z., Oláh, K., & Topál, J. (2014). Emotional contagion in dogs as measured by change in cognitive task performance. *Applied Animal Behaviour Science* 160: 106-115.

Tidewell, N., Eastwick, P., & Finkel, E. (2013). Perceived, not actual, similarity predicts initial attraction in a live romantic context: Evidence from the speed-dating paradigm. *Personal Relationships* 20: 199-215.

Wilsson, E., & Sungren, P.E.(1997a). The use of a behaviour test for the selection of dogs for service and breeding, I: method of testing and evaluating test results in the adult dog, demands on different kinds of service dogs, sex and breed differences. *Applied Animal Behaviour Science* 54: 279-295.

Wilsson, E., & Sungren, P.E. (1997b). The use of a behaviour test for selection of dogs for service and breeding, II: heritability for tested parameters and effect of selection based on service dog characteristics. *Applied Animal Behaviour Science,* 54: 235-241.

Van Kerkhove, W. (2004). A fresh Look at the Wolf-Pack Theory of Companion-Animal Dog Social Behavior. *Journal of Applied Animal Welfare Science* 7: 279-285.

vonHoldt, B. M., Pollinger, J. P., Earl, D. A., Knowles, J. C., Boyoko, A. R., Parker, H., Geffen, E., Pilot, M., Jedrzejewski, W., Jedrzejewska, B., Sidorovich, V., Greco, C., Randi, E., Musiani, M., Kays, R., Bustamante, C. D., Ostrander, E. A., Novembre, J., & Wayne, R. K (2011). A genome-wide perspective on the evolutionary history of enigmatic wolf-like canids. *Genome Research* 21: 1294-1305.

X. Appendix

A. Preview of Potential Questions

1. Please tell me about yourself. Where are you from, where did you go to veterinary school, how long have you been in veterinary medicine, and what do you find most interesting about what you practice?

2. Do you think domesticated animals, pets, in general have personalities? More specifically, do you think canines do? If so, how would you define personality?

Chopik and Weaver proposed in a study called "Old dog, New Tricks: Age differences in dog personality traits, associations with human personality traits, and links to important outcomes" that there are 3 hypothesizes that can explain dog personality and a possible alignment that dogs and humans share. As explained in the paper, all of the hypotheses originate from human interactions and human psychology but have been modified to understand dog and human interaction.

HYPOTHESIS I: Selection Effect (Tidwell et al., 2013).

3. This hypothesis is that owners and dogs might have similar personalities based on a selection effect. Because owners align their personalities and lifestyles to other humans, they may purposely choose dogs that match their personality. Can you describe a specific example that supports or opposes this idea?

4. There is evidence in speed-dating simulations that individuals can predict some personality traits and attitudes with impressive amounts of accuracy after being exposed to another person for a short amount of time. We can compare that setting to being able to

pick out a dog since you only have a short interaction with a dog before picking him/her out. Do you think that owners have a sense of a dog personality in a short interaction?

5. It has been found that puppies do not have consistent personality or behavioral traits. Because of these findings, an owner's initial interaction and perception of a dog may change throughout the dog's lifetime. With your experience in the field, what is your opinion of this? Can you give an example of that support and/or oppose this?

HYPOTHESIS II: Socialization Effect (Anderson et al., 2003)

6. The second hypothesis is the idea that owners and dogs might have similar personalities based on a socialization effect. The shared activities and environments of humans and dogs can influence the dog's personality and relationship. Can you describe to me a specific example that supports or opposes this idea?

7. Humans share a process called emotional convergence: people in relationships become emotionally similar over time so there is psychological coordination of thoughts and behaviors to increase understanding and increase social cohesion. Do you think that emotional convergence can happen between owner and dogs, if so can you provide an example? Additionally, do you think that the emotions of owners and/or the environment they raise their dog in is significant? Why or why not?

8. Do you find puppies, middle aged, or older dogs to have more variable personalities? (ie breaking their usual behaviors) Why do you think this is?

HYPOTHESIS III: Anthropomorphism (Kwan et al., 2008)

9. The third hypothesis is that owners and dogs have similar personalities because owners have idiosyncratic ways of evaluating things in their lives or even project their personality on things they evaluate, including dogs. Do you see owners anthropomorphizing pet interactions? If so, why?

10. To what extent do you feel perceptions of animals reflect real attributes of the animals and to what extent do they reflect the projections of the human perceivers?

11. “In the absence of other behavioral information, owners rely on physical stereotypes in judgments of dogs. Clearly, such physical stereotypes could be adaptive to the extent they allow individuals to predict dogs’ behaviors under conditions of minimal information” (p. 139). Namely, people assume the meaning of dog behavior when they lack information. What are your thoughts on the statement being a professional in the field?

12. Do you have any concluding thoughts or observations you would like to share?

B. Sample Response from Veterinarian A

Please note the questions are from an earlier, version. Revisions to the question document have been made since then, as seen above.

1. Tell me about yourself. Where are you from, where did you go to veterinary school, how long have you been in the practice, how did you end up in Colorado?
    a. My name is [Veterinarian A]. I am a veterinarian in Fort Collins, CO. I have practiced as an ER veterinarian for over 20 years. I am originally from New Jersey. I went to veterinary school at the University of Pennsylvania in Philadelphia. I did an internship at Red Bank Veterinary Hospital in New Jersey.

2. Do vets think dogs "have" personalities? How do you define it?
    a. I don’t speak for all vets, but most believe there are distinct breed predilections. For instance – working breeds (German shepherds, Malinois, Border collins). Those breeds tend to have more drive and energy. Each breed tends to have its own traits after many many decades of “purpose” breeding. Traits like aggression are hard to predict.

Chopik and Weaver proposed in a study called Old dog, New Tricks that there are at least 3 reasons why owner and dog personality might be similar in psychological contexts. All of these ideas stem from human interactions and human psychology but have been modified to understand dog and human interaction.

HYPOTHESIS I (Tidwell et al. 2012 & Fratkin et al. 2013)

3. The first is that owners and dogs might have similar personalities based on a selection effect. Because owners align their personalities and lifestyles to other humans, they may purposely choose dogs that match their personality. Can you describe to me a specific example that supports or opposes this idea?

    a. Certainly. A police officer will select a patrol dog based on his/her drive to catch and bite. This is more of a selection use than a personality match, but the officer will reward certain behaviors associated with the dogs work. In this case, the dog's natural tendency is selected for by the human.

4. There is evidence in speed-dating simulations that individuals can predict some personality traits and attitudes with impressive amounts of accuracy after being exposed to another person for a short amount of time. We can compare that setting to being able to pick out a dog since you only have a short interaction with a puppy before picking him/her out. Do you think that owners have a sense of a dog personality in a short interaction?
    a. Absolutely. There is a lot of evidence that traits are heritable. Things like "braveness, fearfulness, resilience, willing to play" can be tested and are very predictable. Natural events will change an animal throughout it's life but good breeders can help "pick a personality". For instance – Guide dogs are tested for traits that would make them successful as an assistance for from only a few days old. Those traits are then rewarded with positive conditioning.
5. Another variable that is interesting is that initial interaction and perception an owner may understand about their dog may change throughout the dog's lifetime. It has been found that puppies do not have consistent personality or behavioral characteristics. Throughout your work in the field, how do you feel about this? Can you give an example of this?
    a. Dogs are unpredictable. Some puppies may develop aggressions or anxieties. One example is food aggression. A normal puppy may begin to growl or even snap at its owner around food. This is typically a behavior that can be fixed. Phobias can develop as well. Some dogs develop fear of loud noises (fireworks, thunder, etc.)

HYPOTHESIS II (Anderson et al. 2003)

6. The second hypothesis is the idea that owners and dogs might have similar personalities based on a socialization effect. The shared activities and environments of humans and dogs can influence the dog's personality and relationship. Can you describe to me a specific example that supports or opposes this idea?
    a. This is well illustrated with an owner who is very active. Let's say – an avid hiker. They are likely to have a fitter dog since they exercise with their dog frequently. The opposite of this is a poorly matched owner-pet situation. A sedentary person with a very active or high drive pet is a difficult situation. Often the pet will develop anxiety or even destructive behavior from lack of exercise or boredom.
7. People express emotions through facial, vocal, and postural behavior and in response we quickly and automatically detect and interrupt the emotional expression of others. This process is called emotional convergence; do you think that the emotions of owners and the environment they raise their dog in is significant? Why or why not?

a. Sure. Dogs are very intuitive. There is an entire language of dogs. It's way more complicated than just wagging a tail. Yawning, whining, ear position, pacing, licking, etc. are well documented expressions of emotion from a dog. Dogs are also very intuitive regarding their human's emotions. This is why assistance dogs can detect and deter anxious behavior and even detect medical events (seizures, hypoglycemia, etc.) more accurately than people can.

8. Do you find puppies, middle aged, or older dogs to have more variable personalities? (ie breaking their usual behaviors) Why do you think this is?
    a. Puppies are more malleable generally than older dogs. There is a socialization period for puppies. Older dogs are certainly trainable as well, but puppies tend to be more receptive to positive and negative influences. On the other hand, most working dogs (police K9s, search and rescue dogs, even guide dogs) that do not begin their definitive careers until they are 2 or 3 years old.

HYPOTHESIS III (Kwan et al. 2008)

9. The third hypothesis is that owners and dogs have similar personalities because owners have idiosyncratic ways of evaluating things in their lives or even project their personality on things they evaluate, including dogs. Do you see humans anthropomorphising pet interactions? If so, why?
    a. Definietly. People will interpret their dog's behavior (even justify it) according to their own frame of reference.
10. What extent do you feel perceptions of animals reflect real attributes of the animals and to what extent do they reflect the projections of the human perceivers?
    a. I think people probably convey more of their own emotions and attributes onto dogs.
11. In the absence of other behavioral information, people rely on physical stereotypes in judgments of dogs. Clearly, such physical stereotypes could be adaptive to the extent they allow individuals to predict dogs' behaviors under conditions of minimal information. (pg133) What are your thoughts on this being a professional in the field?
    a. Im sorry? I don't understand the question? Do you mean breed stereotypes? Or human characteristics? I can attest my Bulldog is stubborn. That is a breed characteristic. But not necessarily a stereotype.

12. Do you have any concluding thoughts or observations you would like to share?
    a. These are interesting questions. Ultimately we are a combination of nature and nurture. Herding dogs herd. Guard and patrol dogs bite. Sighthounds chase things. The nurture issue comes into play when a pet owner adopts a dog and either encourages those behaviors, or discourages them. Sometimes it's a bad fit.