JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 2008, **89,** 247–261 NUMBER 2 (MARCH)

*A REVIEW OF DOMESTIC DOGS' (*CANIS FAMILIARIS*) HUMAN-LIKE BEHAVIORS: OR WHY BEHAVIOR ANALYSTS SHOULD STOP WORRYING AND LOVE THEIR DOGS*

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Dogs likely were the first animals to be domesticated and as such have shared a common environment with humans for over ten thousand years. Only recently, however, has this species' behavior been subject to scientific scrutiny. Most of this work has been inspired by research in human cognitive psychology and suggests that in many ways dogs are more human-like than any other species, including nonhuman primates. Behavior analysts should add their expertise to the study of dog behavior, both to add objective behavioral analyses of experimental data and to effectively integrate this new knowledge into applied work with dogs.

Key words: gestures, object permanence, theory of mind, social cognition, dogs

DOGS IN HUMAN SOCIETY

"That the dog is a loyal, true, and affectionate friend must be gratefully admitted, but when we come to consider the psychical nature of the animal, the limits of our knowledge are almost immediately reached" – Sir John Lubbock. (1889, p. 272)

Our Intertwined Past

Sir John Lubbock's opinion, outdated though its language may be, is not an inappropriate summary of the state of research on dog behavior today. Domestic dogs are never far away from most people's lives, but objective understanding of their behavior is still surprisingly scarce.

A better understanding of the variables controlling dog (*Canis familiaris*) behavior could have practical importance for the growing number of industries that utilize the behavior of domestic dogs—not only in formal training settings, such as police dogs, drug-sniffer dogs, guide dogs, and so forth—but also in the public realm, where the line between the love of man's best friend and the fear of so-called ''bad dogs'' is a source of great anxiety. In addition, a more complete understanding of the role of social stimuli, which develops as a result of a natural history of operant and classical conditioning within the domestic dogs' home environment, could play a crucial role in maximizing the quality of our interactions with dogs in a variety of settings.

Humans and dogs share a long intertwined history. DNA evidence suggests domestic dogs most likely diverged from wolves in different places at different times beginning as long as 135,000 years ago (Vila et al., 1997). This is when the morphological structure of certain groups of wolves began to change to more closely resemble the modern domestic dog. Anthropologists and archaeologists have argued that this is an overestimate, claiming that the best way to determine the time of domestication is to look for signs of a close association between dogs and humans (Morey, 2006). One way this has been done is by looking for evidence of dog burials. The earliest burial remains of a domestic dog are 14,000 years old and were found in Bonn-Oberkassel, Germany (Nobis, 1979). The dimensions of the well-preserved lower jaw and teeth suggest that this animal was domesticated and could be compared to a small sheep dog, making it the oldest known domesticated animal and a companion of the Cro-Magnon Man in the late Paleolithic age (Nobis, 1979). The time line of dog burials around the globe indicates the spread of dog domestication at different geographic areas (Morey, 2006).

Role of Dogs in Human Society

The exact location and lineage of the first domesticated dog are still under debate, but the impact that humans have had on the

We thank Ray Coppinger, Leonard Green, Bill Roberts, and John Staddon for most helpful comments on a previous draft.

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doi: 10.1901/jeab.2008.89-247

domestic dog as a species is undeniable. Dogs play an astonishing range of roles in human society. Many individuals put their faith in rescue dogs when stranded in the wilderness or capsized in cold water. Others rely on guide dogs to get them safely to multiple destinations on a daily basis. Drug dogs, de-mining dogs, police dogs, termite- and even cancer-detecting dogs are trained and utilized as substance detectors even in the face of competition from the latest technology. There are herding dogs, hunting dogs, sled dogs, and various other specializations that are crucial to the livelihoods of many individuals, not to mention the role dogs play in entertainment and the pleasures of individual dog ownership—sufficiently reinforcing to sustain 74.8 million dogs in the United States, at a cost to their owners of over $100 billion (American Pet Products Manufacturers Association, 2007).

However, qualities desired in one specialization may not be appropriate in dogs filling another capacity. For example, the dependency on human guidance and direction sought in companion dogs may inhibit a rescue dog's ability to problem solve and function independently in situations when its handler is out of sight (Miklósi, Pongracz, Lakatos, Topál, & Csányi, 2005). It is important, therefore, to take breed specializations and individual history into account when selecting dogs for specific tasks. The more that is known about dog behavior, the more that can be done to make the training of working dogs as efficient as possible.

A greater understanding of dog behavior also would be beneficial in a society that perceives dog attacks and consequent deaths to be a growing problem. The Humane Society of the United States estimates that 2% of the population is bitten by a dog each year (over six million people) and ten to twenty of these bites are fatal—with the victim usually a child (Humane Society of the United States, 2007). Recently, the Minnesota Department of Health (2007) reported a 40% increase in the number of hospital treated dog bites between 1998 and 2005. According to attorney Kenneth Phillips this increase in medically treated dog bites is representative of an increase in the dog population at large, which rose 36% from 1986 to 1994 (Phillips, 2007). The public response to increased media reporting of dog attacks has been to label certain breeds as ''bad dogs.'' Malcolm Gladwell (2006) in the *New Yorker* likened the profiling of ''dangerous dog'' breeds to the racial profiling that has dominated the search for terrorists since September 11th, 2001. As with most forms of prejudice and profiling, the banning of specific breeds of dogs from municipalities (most commonly at present the pit bull), fails to effectively identify the environmental causes of undesired behavior so that positive behavior can be reinforced and aggressive behavior controlled with more enlightened methods. Breed profiling may lead not only to a misguided fear of well-behaved dogs identified with a ''bad'' breed, but may also offer a false sense of security around a dog showing warning signs of aggression just because it comes from a breed with a good reputation.

Phylogeny vs. Ontogeny

Despite the omnipresence of dogs in human lives, scientific study of the factors that have allowed dogs to thrive in human environments has until recently been surprisingly meager.

The causes of the characteristic behaviors of dogs can be understood at two levels. First are the phylogenetic influences on behavior that arise as a result of the unique evolutionary past of domestic dogs. Second, and perhaps more importantly (at least in the sense that they are available for modification in real time), are the ontogenetic causes that are the history of contingencies of reinforcement each domestic dog experiences within human society during its lifetime.

The phylogeny of dogs is particularly interesting because, instead of natural selection by the environment, artificial selection by humans is responsible for the hundreds of breeds of domestic dog that exist today. There is also evidence that selection for desirable physical and behavioral traits has led to many changes in social behavior as unexpected byproducts (Hare & Tomasello, 2005). This has led some scientists to attribute the propensity of dogs for human social interaction to convergent evolution, where the two genetically distinct species were shaped by similar selective pressures (Hare & Tomasello, 2005).

There is, of course, no question that genes play a role in the behavior of domestic dogs, but a dog's individual environmental history

plays a major role in shaping its behavior over its lifetime. From the time a puppy is brought into a human household it is completely dependent on human caretakers for all of its needs. The majority of reinforcers a dog will have access to throughout its life are controlled, either directly or indirectly, by humans. This is comparable to the situation of young human children, and may explain in part the similarities in sensitivity to human social stimuli shown by dogs and children. However, unlike children, domestic dogs remain dependent on humans for primary reinforcers, such as food, water, access to mates, and even touch, throughout their lifetimes. Consequently, their access to reinforcers is contingent upon appropriate behavioral responses within the human social environment. Furthermore, behavior directly related to subordinance and dependency is often shaped in dogs from a young age. A puppy that sits by its bowl and whines for food will usually have a greater chance of reinforcement than one who seeks out a source of food on its own, such as from a closet or off a table. Similarly, a dog that gets its leash or goes to the door and barks when it has to relieve itself will likely be praised and be given the opportunity to mark its territory, in addition to lessening the pressure in its bladder. A dog that urinates in the house, in contrast, is likely to receive punishment in the form of scolding and in having its owner clean away its territorial scent. In this way, dependence and sensitivity to human contingencies are shaped quickly in domestic dogs in human households. In many cases reinforcement depends on the dog's ability to recognize social stimuli presented by humans, both subtle human gestures that may serve as discriminative stimuli for certain behaviors and overt mands which command a direct and specific response from the dog.

THE STUDY OF DOG BEHAVIOR IN HISTORICAL PERSPECTIVE

The behavior of dogs was very important in the early history of comparative psychology. Darwin wrote extensively about dog behavior, intelligence and emotions, often using his own dogs as examples. He believed that dogs had emotions such as love, fear, shame, and rage, as well as dreams, and the ability to imitate and reason (Darwin, 1871). Darwin also commented on how domestication impacted the behavior of domestic dogs, decreasing their fear of humans, and he even argued for the evolution of distinct barks with various meanings.

Darwin's neighbor in Downe, Sir John Lubbock, was one of the first to carry out experimental tests of the intelligence of dogs. In the first recorded experiment on nonhuman language abilities, Lubbock trained his dog, Van, to bring him a card labeled ''food'' by reinforcing this response with the presentation of bread and milk upon retrieval. Once Van could readily discriminate between the ''food'' card and a blank card, Lubbock added more cards containing words such as ''out,'' ''bone,'' ''water,'' and ''tea,'' and reinforcing their retrieval with the action or item on the card. Although his data were, by his own admission, preliminary at best, Lubbock reported that out of 113 card retrievals, Van selected the ''food'' card 80 times and the ''tea'' card 31 times. Since the dog consumed these items with alacrity, Lubbock concluded that the dog had learned to communicate his wants effectively (Lubbock, 1889). Van's successes inspired Lubbock to attempt to use this method to test the dog's color discrimination abilities as well as its ability to count, but no results were published.

The most famous early researcher to use dogs was, of course, Ivan Pavlov. As is widely known, he discovered the form of conditioning now associated with his name using domestic dogs as experimental subjects. Pavlov exploited this phenomenon to explore dogs' sensitivity to scents, touch, temperature, and musical tones (Pavlov, 1906/1966). Less well known is that he speculated on the role of Pavlovian conditioning in the training of domestic dogs: ''You lift the dog's paw saying 'give me your paw' or even 'paw,' and then give the dog something to eat. After repetition of this procedure the dog gives its paw at these words; it does so without any word of command when it has a keen appetite'' (Pavlov, 1936/1966, p. 309).

CURRENT DIRECTIONS IN DOG RESEARCH

The last twenty years have seen a resurgence of research into the behavior of domestic dogs. Most of the studies reviewed here have drawn

their inspiration from work on developmental and cognitive questions in humans and nonhuman primates. This search for common psychological processes in humans and dogs has been motivated by the fact that humans and domestic dogs have shared a common environment and similar selective pressures for tens of thousands of years.

Responsiveness to Human Social Cues

One of the most interesting behavioral characteristics of the modern domestic dog is its predisposition to attend and respond to human social gestures and cues. Skinner (1953) noted that the behavior of other individuals can be an important source of social stimuli. Gestures and cues are social stimuli that likely started out as behaviors that directly impacted the behavior of another individual in a reinforcing or punishing way. Skinner gives the example of a policeman's ''stop'' signal, which could have originated from the action of a man putting out his hand against another man's chest forcing him to stop. If this were aversive, the second man might learn to stop before he reached the first man's upheld hand in future presentations (Skinner, 1986). Once a gesture is established, an individual's history with the stimulus shapes his or her behavior in its presence. Thus, if the social contingencies are established already for behavioral responses to a particular gesture, contact with the original behavior that evolved into the gesture is not essential. Other examples of common human gestures include pointing, nodding, reaching towards something, or glancing between an object and another individual. Skinner focused on how gestures might come to act as social stimuli in humans, but the basic principles could easily be applied to dogs as well. For example, if a human throws a dog's ball in a game of fetch, the throwing motion or outstretched arm serves as a discriminative stimulus to chase something in the direction of the release. This reaction most likely ties into the reinforcing effects of chasing a ball or catching prey along with the social reinforcers received for retrieving the object. This behavior, of following the direction of an outstretched arm, may generalize to less dynamic forms of the stimulus, and the dog may begin to follow gestures such as pointing or fake tosses to static objects to be retrieved. The use of gestures could undoubtedly be shaped in many species through this process over time, but dogs appear to demonstrate a sensitivity for human gestures that many other nonhuman species lack (Brauer, Kaminski, Riedel, Call, & Tomasello, 2006; Hare, Brown, Williamson, & Tomasello, 2002).

Responses to gestures usually are tested in an object-choice paradigm. In this test, a reinforcing object is hidden in one of two or more locations or containers. The subject enters the test area, and a gesture is given to indicate the location of the object. Alternative hiding places are equated for smell and other cues and are usually sham-baited to control for the effects of noise and human scent. The dog is then allowed to approach the containers and indicate a choice by touching or coming within a required distance of one of the locations.

Miklósi, Polgárdi, Topál, and Csányi (1998) carried out the first study investigating the use of human social cues by domestic dogs. Modeled primarily on studies with humans and nonhuman primates, two bowls were used to hide food items in an object-choice paradigm. One of the bowls was baited out of sight of the subject; the location of the food was determined by a coin toss with no bowl being baited more than twice in a row. The dog then was led back into the room and was held 3 meters from the bowls. The experimenter, who stood behind the bowls, made eye contact with the dog and then gave the predetermined gesture. The experimenter then returned to a neutral position and the dog was allowed to indicate its choice by approaching one bowl. A correct choice resulted in food reinforcement and an incorrect choice ended the trial with no reinforcement. Five gestures were used in this study: pointing, bowing (bending the upper torso), nodding, head-turning, and glancing with the eyes only. Each gesture was presented a minimum of 30 times before the next was introduced. All dogs experienced the gestures in the order given here. To progress to the next gesture, 80% accuracy had to be met for the previous condition.

All 6 pet dogs in this study were able to use pointing, head nodding, bowing, and head turning to identify the target bowl without explicit training in the first fifteen trials, and the only significant initial difference among dogs was the ability to use gazing as a discriminative stimulus (Miklósi et al., 1998).

Subsequent studies have analyzed a wider set of gestures and found dogs that can use, or be trained to use, various types of pointing with the arm or extensions of the arm (Hare & Tomasello, 1999; Miklósi et al., 2005; Miklósi et al. 1998; Soproni, Miklósi, Topál, & Csányi, 2001; Soproni, Miklósi, Topál, & Csányi, 2002; Udell, Giglio & Wynne, 2008), glancing (Miklósi et al. 1998; Soproni et al. 2001; Udell et al., 2007), local enhancement by a human's presence near the target (Hare & Tomasello, 1999), and a human placing a token on a target (Hare & Tomasello, 2005; Udell et al., 2008).

Other studies of the exploitation of human gestures by dogs have varied the way in which conditions are presented. Instead of a hierarchical series of gestures in which one gesture must be learned to criterion before the next is introduced, some studies have presented conditions in orders that vary across subjects and thus control for the effects of generalization from one gesture to another (Brauer et al., 2006). Others have used probe methods to insert novel gestures into a series of trained or familiar gestures such as pointing (Soproni et al., 2002). These studies have largely supported the conclusions from the pioneering work of Miklósi et al. (1998), suggesting that Miklósi et al.'s positive conclusions were not artifacts of having the dogs master one gesture type before proceeding to the next.

Particularly noteworthy in these studies of dog responsiveness to human gestural cues, is that some of the successful dogs in these studies had only had minimal contact with humans or did not live as pets in human households. Miklósi et al.'s (1998) study included 5 assistant or guide dogs that did not reside in a typical household setting and yet still performed above baseline in the pointing and bowing conditions in the first 15 trials.

The degree to which individual dogs attend to human social cues and their tendency to rapidly integrate new behaviors into their repertoire based on the consequences that follow from them, says something about both their development and their environment. For dogs to provide adaptive responses to human gestures requires not only attentiveness and close proximity to human action, indicative of some sort of social attachment to humans, but also sensitivity to context within a human environment.

This conclusion gains strength from recent research on the role of context in the training of basic commands, such as ''sit'' and ''come.'' Fukuzawa, Mills, and Cooper (2005) demonstrated that unintentional human cues influence how dogs respond after training. Dogs who responded to the commands ''sit'' and ''come'' reliably when a human was giving the command, showed declines in performance when the command was given by tape recorder in the human's presence, and declined further when the human wore tinted sunglasses. Furthermore, when the human experimenter gave the two commands from behind a screen, out of sight of the dog, the dogs responded dependably to the ''come'' command but not to the ''sit'' command (Fukuzawa et al., 2005). This finding makes sense when the context of training and previous exposure is considered. ''Come'' is often applied and reinforced when presented from a greater distance or when the dog is out of sight, whereas the ''sit'' command is usually given and reinforced only when the dog is in close proximity to the human issuing the command.

Ability to Cue Humans

Most research in the area of social cues has focused on the dog's response to human gestures, but a study by Miklósi, Polgárdi, Topál, and Csányi (2000) found that dogs that had seen a food item or a toy hidden in a specific bowl placed out of their reach while their owner was out of the room, were able to communicate to their owner the location of the hidden target item when he or she returned. These dogs showed a significant increase in mouth licking, vocalization, sniffing, looking at the owner, and looking at the location of the hidden object after the toy had been hidden and the owner returned. Vocalizations and gaze directed at the location of the hidden object were also higher when the owner was present than when the dog was left alone after hiding, although both behaviors occurred in both conditions (Miklósi et al., 2000). Gazing between the owner and the location of the food or toy occurred an average of three times in the first minute, with 8 out of 10 dogs looking first at their owner and then at the location of the hidden item (Miklósi et al., 2000). This suggests that the dogs remem-

bered where the desired object was hidden after the person who hid it had left the room, and that the dogs displayed behaviors, such as glancing between the naive owner and the location of the object, specifically instrumental in getting the owner to uncover the target object.

Dogs also follow the behavioral cues of other dogs in object-choice tasks. In one study, dogs could find a hidden item at above-chance levels when a trained demonstrator dog oriented towards the correct location while gazing at it, or presented a local enhance cue such as sitting by the correct location (Hare & Tomasello, 1999). The specifics of this study will be discussed later, but these findings may suggest that this kind of ''showing'' or cuing behavior is part of the everyday behavioral repertoire of the domestic dog.

Object Permanence

''Object permanence'' is a Piagetian term for an individual's continued interest in a stimulus after it has disappeared from sight. Children go through several stages of object permanence during development, from a complete disregard for obscured objects at the earliest ages of testing, to sustained search for hidden objects starting around age 2 years. Dogs have been tested for object permanence of varying levels. Gagnon and Doré (1992) completed a series of eight tests with 30 dogs of different breeds. The first four tests made up the visible displacement task. In these tests a toy was placed behind a screen in full view of the dog, and subsequently moved from screen to screen—but always so that the dog could easily observe the movements. The last four tests made up the invisible displacement task. In these tests the toy was first placed in a container before it was moved. The container with toy was then placed behind a screen, the toy was inconspicuously removed from the container and left behind the screen, and finally the now-empty container was shifted behind a different screen. The dog could not know that the container was empty and would naturally go to the container first. An individual that has mastered invisible displacements is one that, on finding the container to be empty, returns to the last place the container stopped to search for the toy. Reinforcement in this study consisted of the opportunity to play with the toy once it was found.

Gagnon and Doré (1992) found that their dogs were more successful on the visible displacement tasks than on the invisible tasks, but some dogs—those that experienced all four visible displacement tasks first before moving on to the invisible displacements—were then successful on the invisible displacement tasks. Unlike the studies of dogs following human gestures, the data in most cases showed improvements across trials rather than a spontaneous ability to follow the cues offered.

This study is important within a Piagetian framework because it showed that domestic dogs could display behaviors characteristic of the sixth, and most advanced, stage of object permanence (Gagnon & Doré, 1992).This conclusion, however, is not universally accepted. Other research has suggested that although dogs still search for the toy in invisible displacement tasks, they are not truly demonstrating stage six behavior because their search patterns do not match those of children in that stage (Watson et al., 2001). Furthermore, a follow-up study provides evidence that dogs in these types of experiments are not showing object permanence at all. Collier-Baker, Davis, and Suddendorf (2004) demonstrated that it was the final resting place of the pole used to move the target ball that cued successful responding, not object permanence after all.

Theory of Mind

Dogs appear to be sensitive to the attentional state of humans and this in turn has an impact on their behavior in a variety of situations. For example, in conditions where taking a piece of food has been forbidden, domestic dogs are much more likely to take the food if the human experimenter does not have a direct view of the food or of the dog approaching the food (Brauer, Call, & Tomasello, 2004; Call, Brauer, Kaminski, & Tomasello, 2003). In conditions where the experimenter has a clear view of the dog and the food, dogs typically obey the wait command given by the experimenter. However, dogs instructed not to take the food often disobey if the human's eyes are closed, if the human's back is turned, if the human is distracted, if the human leaves the room, or if some barrier blocks the human's view of the food and the dog's approach to the food (Brauer et al., 2004; Call et al., 2003).

Gacsi, Miklósi, Varga, Topál, and Csányi (2004) concluded that the body orientation and eye visibility of a human also has an effect on the begging behavior of dogs. Dogs were given the opportunity to approach and beg from one of two women holding sandwiches. In one condition the two women faced the dog: One with a blindfold on her head, and the other with a blindfold over her eyes. In the other condition one woman faced the dog and tried to maintain eye contact without moving her head or body, whereas the other woman faced away from the dog and ignored it. Dogs were given a piece of food no matter whom they begged from in each trial. Nevertheless, in both conditions, dogs begged significantly more from the seeing or attentive individuals than from the other woman.

Research of this kind often has been used in support of the possibility that dogs possess a ''theory of mind'' or ability to adopt the perspective of others (e.g., Brauer et al., 2004; Gacsi et al., 2004). However, such performances also could be due to past experience with similar contingencies. When food is forbidden, taking the food while a human's face is oriented to the food and visible to the dog would likely be punished. However, taking food in situations where the human's face is not appropriately oriented is more likely reinforced by obtaining the food and less likely to be punished. Furthermore, if begging from a person who is looking at a dog usually leads to reinforcement and begging from someone who is not oriented towards the dog does not (as might occur at a family dinner table), then reinforced begging behavior directed towards attentive individuals should increase whereas nonreinforced behavior towards nonattentive individuals should decrease. Despite the fact that reinforcement was available for begging from either woman in Gacsi's study, a long history of begging would increase the probability of begging from an attentive person in the first place, and the dog may never come into contact with the new contingencies. Furthermore, it is possible that a dog reared with different contingencies in place, for example one that only successfully obtains food when humans are not looking, would show the exact opposite behavior. In this case it is not the individual's ''theory of mind'' which is at stake, but rather the development of a foraging strategy based on the greatest chance of reinforcement.

Word Learning

In 2004 *Science* published a report of an exceptional border collie named Rico. Rico could recognize vocal labels for over 200 items, mostly toys, which he retrieved by name. Kaminski, Call, and Fischer (2004) demonstrated that Rico also was able to identify a novel item from a group of familiar items and would retrieve the novel item in response to an unfamiliar item name in 70% of trials. Exclusion learning and fast mapping were said to occur, and Rico was credited with not only pairing an unfamiliar name with a novel item but remembering the new name for the novel item in later testing sessions.

Rico's vocabulary is certainly impressive and suggests the potential dogs may have for learning associations between items and human vocal cues. However, Rico's ability to fast map—or pair items with a novel name after one association—was far from perfect. When he was given the name of one of the previously novel items ten minutes after the first pairing, Rico retrieved the correct item out of a pile of nine toys in four out of six trials. However, when tested an hour after the first pairings, using a different set of items, his performance dropped to retrieving the correct item in three out of six trials (Kaminski et al., 2004).

The study with Rico raises interesting questions about the capacity dogs have for name learning and the amount of exposure required to learn the names of new objects. But more research is needed before the implications of his performance become clear. Questions that remain open include: Is Rico an exceptional dog, or could his achievements be replicated in other dogs given appropriate training? What might the necessary and sufficient training regimen be to train a dog to respond to vocal labels in this way? What is the limit of a dog's vocabulary? How does a dog generalize to words pronounced in different ways and by different individuals?

Individual and Breed Differences

It is a widely accepted part of the common lore that different breeds of dogs show characteristic behavioral patterns and aptitudes, and that individual dogs differ in their

temperaments. In an attempt to quantify these lay impressions, Svartberg (2004) developed the dog mentality assessment (DMA). The assessment consists of a battery of tests, such as the dog's reaction to social contact, play, chase games, passive situations, strangers, sudden appearances of objects, and loud noises. Factor analysis on these scores led to the identification of six traits: playfulness, chase-proneness, curiosity/fearlessness, sociability, aggressiveness, and distance-playfulness. Follow-up questionnaires indicated the stability and value of the DMA for predicting broader personality dimensions, such as a placement along a shyness–boldness continuum (Svartberg, Tapper, Temrin, Radesater, & Thorman, 2005). However, the DMA has been less successful at identifying and predicting long-lasting aggressiveness and nonsocial behavioral problems (Svartberg, 2004; Svartberg et al., 2005).

Evidence for inherent breed and sex differences, as measured with the DMA, is limited. One study indicated that high scores on the boldness scale do not correlate with the breed or sex of a dog. However, breed and sex appear to play some role for the lower scoring dogs, of which female German Shepherds and the other tested breed of working dog, Belgian Tervurens, scored lower than male German Shepherds (Svartberg, 2002). Furthermore, a later study (Svartberg et al., 2005) indicated that scores on all six personality traits did not vary significantly by breed types divided into herding dogs, guarding dogs, and gun dogs. This is not to say that differences do not exist between individual breeds; however, the source of these differences does not seem to be explained by the current personality tests or models. More tightly controlled behavioral methods, focusing on individual differences and specific behavior problems, may have more success at getting to the root of the environmental influences that shape these differences in behavior.

DISCUSSION

Social vs. Causal Cues: The Difference Between Dogs and Nonhuman Primates

Ever since Darwin (1859), the search for human-like social cognition (i.e., behavior controlled by human and conspecific social cues similar to that observed in humans) has focused on our closest genetic relatives, particularly chimpanzees. Though much remains controversial in this field, it seems clear that chimps and several other species of primates are only modestly successful on many tasks designed to test for human-like social reasoning. Thus, chimpanzees are only able to follow gaze and show joint attention under a limited set of conditions (Barth, Reaux, & Povinelli, 2005). In the object-choice task described above, few chimpanzees or other nonhuman primates are able to use gaze or other social cues such as pointing to identify the location of a hidden object (Call, Hare, & Tomasello, 1998; Call & Tomasello, 1998; Itakura, Agnetta, Hare, & Tomasello, 1999; Povinelli, Reaux, Bierschwale, Allain, & Simon, 1997; Tomasello, Call, & Gluckman, 1997). Successful individuals typically need dozens of repeated exposures to the cue, and show poor transfer after even small changes to the testing environment (Brauer et al., 2006; Call, Agnetta, & Tomasello, 2000; Itakura et al., 1999).

Dogs, in contrast, though they share much less of our genetic material than do chimpanzees, nonetheless show a spontaneous ability to follow human gestures to find reinforcing objects, even in the absence of training in the laboratory. Most remarkably, even dogs raised with minimal human contact can follow a human point and gaze gesture without explicit training (Hare et al., 2005).

Chimpanzees also have been the species most intensely studied for any ability to respond to the attentional state of humans or conspecifics—so-called ''Theory of Mind'' abilities. However, several published studies have failed to find any evidence of a sensitivity to another's knowledge (e.g., Brauer et al., 2006; Povinelli & Eddy, 1996), and studies that do suggest this ability (e.g., Hare & Tomasello, 2004) have been subject to extensive criticism (e.g., Boesch, 2007; Heyes, 1998; Penn, Holyoak, & Povinelli, in press). Dogs, in contrast, respond readily to human cues in these kinds of tests (e.g., Brauer et al., 2004; Call et al., 2003; Gacsi et al., 2004).

Chimpanzees have been by far the most intensively studied species for the comprehension of human language (including seminal studies by Gardner & Gardner, 1969; Savage-Rumbaugh et al., 1993; Terrace, 1979), but no peer reviewed paper has ever claimed the rapid ''fast-mapping'' of language acquisition

found by Kaminski et al. (2004) in the dog Rico.

Several theories have been proposed to explain why dogs perform so well on tasks involving socially mediated stimuli. The possibility that dogs learn to attend to human social cues simply because of the intensity of their interactions with humans appears to be refuted by the observation that even puppies and domesticated fox kits that have had only minimal exposure to human beings, nonetheless respond very accurately to human cues in choice paradigms (Hare et al., 2005).

Hare and Tomasello (2005) considered the possibility that domestic dogs' high sensitivity to social cues is an evolutionary legacy inherited from wolves, the dog's closest wild relative and progenitor. If general social traits common to wild canids have simply been inherited by domestic dogs, then wolves also should do well on tasks involving social cues. However, when compared to wolves and wild foxes, domestic dogs (including puppies) make significantly more correct responses on choice paradigms where social cues serve as the discriminative stimuli (Hare et al., 2002; Hare & Tomasello, 2005). This is true even though the wolves tested had been socialized and raised by humans in their homes as pets. Thus, it does not seem that domestic dogs simply inherited the predisposition to attend to social stimuli from wolves.

Hare and Tomasello's (2005) study included, alongside tests on domestic dogs, comparison tests on fox kits that had been selectively bred over 46 years for nonaggressive behavior towards humans. These fox kits were compared to others reared under the same conditions but not selectively bred for low aggression. Neither group of foxes had been raised in human homes (nor had the earlier generations from which they were descended). Hare and Tomasello found that the fox kits bred for nonaggressive reactions to people performed just like domestic dog puppies on pointing and gazing tasks. The fox kits that had not been selectively bred performed poorly on these tasks, at a level similar to that seen in wolves (Miklósi et al., 2003).

These results suggest that during domestication, traits that were often selected by humans, such as lack of aggression and fearlessness towards people, may have carried with them other genetic traits that led to a heightened responsiveness to human social stimuli (Hare et al., 2002; Hare & Tomasello, 2005). It also is possible that by removing genetic tendencies towards aggression and fear towards humans, other preexisting social behaviors were no longer blocked and thus could increase in frequency.

If selective breeding and domestication serve as a likely explanation for the success of domestic dogs on tasks involving human social cues, then that begs the question—Why don't other domesticated animals share these abilities? In fact, domestic cats have been shown to be only slightly less successful than dogs in using basic pointing cues to find a hidden food item in a simple choice test (Miklósi et al., 2005). However, when presented with an unsolvable task, where food was hidden in a butter pot but tied to a stool in such a way that retrieval was impossible, dogs looked between the problem and their owner more often and for longer periods of time, whereas cats only occasionally looked towards their owners and spent much more time trying to get the food themselves. This may indicate that: (1) During domestication cats were selected for traits less tied to the approach of humans and fear reduction, or (2) less stringent contingencies exist for cats in their home environment leading to behavior that is more independent of human action, or both.

The lower responsiveness and less frequent orientation of cats to human cues may in fact be related to the fact that domestic cats are closer to their wild relatives than dogs are to wolves. The domestic cat (*Felis catus*) shows only a low level of genetic divergence from its two nearest wild relatives (the European wildcat, *F. silvestris*, and African wildcat, *F. libyca*), and the earliest evidence for cat domestication is only around 8,000–9,500 years BP—considerably more recent than that for dogs (between 14,000 and 135,000 years BP) (Driscoll et al., 2007; Serpell, 2000; Vigne, Guilaine, Debue, Haye, & Gérard, 2004). The traits selected for in the domestication of the two species also may have led to differences in the responsiveness and attentiveness each has towards humans. Even today, many dog breeds are selectively bred to work in close association with humans, filling specific roles in industries such as farming, therapy, police, and search-and-rescue. Even with earlier partnerships such as hunting it is quite probable that a

dog that stayed close to its owner or was quick to respond to its owner's actions would have been a more beneficial working companion, securing its place in the group and ultimately in the gene pool.

Cats were likely used as mousers and kept as pets from early in their domestication (Vigne et al., 2004), but they are not typically bred for purposes that require a close partnership with humans, even today. Thus, a house cat's independence could have actually been a beneficial trait that increased the chances of its survival in the same environment. Furthermore, cats are often chosen as pets because they are considered low maintenance compared to dogs. They do not require walking, they sleep or entertain themselves most of the day, and they are typically small and quiet enough to go unnoticed much of the time. Thus, there are many more opportunities for cats to engage in independent behaviors without immediate human consequences within the home environment.

Several studies have looked for key similarities and differences between wolves and dogs. Perhaps the most striking developmental difference between dogs and wolves is that, whereas dogs can be socialized to humans within the first sixteen weeks of life, wolves must be removed from their mother for human socialization before fourteen days of age, or acceptance of humans is very unlikely (Klinghammer & Goodman, 1985).

Implications for Phylogeny and Ontogeny

In a study by Frank and Frank (1982), domesticated dogs (Alaskan malamutes) and wolf pups that were raised in identical conditions in a home environment showed distinct differences in both physical and social development. Conducted as a two-stage experiment, 2 malamutes acquired at 10 days old were compared to 2 wolf pups acquired at 11 days old a year before. The wolf and dog pups did not interact, but the conditions were kept almost identical for the two groups during the experiment. Interestingly the two major differences were that wolves were given more socialization to humans, as they were required to sleep with their human foster parent two out of every three nights as pups, and the malamutes, who did not receive this extra socialization, were given slightly more frequent exposure to the outdoor enclosure. All pups were nursed by the same wolf mother until weaning, at which point they were hand raised and fed by humans.

The wolves reached several physical developmental landmarks days ahead of the malamutes. For example, the wolf pups began climbing over their 45-cm pen wall at only 19 days, whereas the malamute pups could not climb over their 15-cm den box opening at 32 days old. However, socialization of the wolves was much more difficult than of the malamutes. At 2 weeks of age the wolf pups avoided the human handlers whenever possible and hid behind the wolf dam when humans approached. At 6 weeks they became less fearful but somewhat indifferent to the human presence, preferring to be around adult wolves or dogs in the enclosure. The malamutes, in contrast, became more independent of the nursing wolf, and actively approached nearby humans and engaged in ''greeting frenzies'' on a regular basis (Frank & Frank, 1982).

However, this study has some potential flaws. First, all of the pups were raised by a wolf foster mother, which could have potentially impacted the behavior of the mother to the foster pups or the behavior of the growing pups toward the foster mother. Without a comparison using a Malamute foster mother for both species it is impossible to say that having a same-species foster mother would not produce a closer bond to that individual and therefore less of a bond towards humans. Second, since the two groups of pups were raised at different times, other factors may have been present in one study that were not accounted for in the next, for example, the age of the foster mother or other canine group members and the previous experience of the experimenters raising wolfs before raising the Malamutes.

To address some of these concerns, Kubinyi, Viranyi and Miklósi (2007) conducted a similar study comparing the development and behavior of wolf pups and mongrel dog pups in foster homes with human caretakers. In this study, all pups were individually assigned to a human caretaker who hand raised and fed his or her pup from 4 to 6 days old. Both sets of pups participated in multiple behavioral tests from 3 to 9 weeks of age. When the wolves reached 9 weeks of age they had to be integrated into a captive wolf pack, but were still visited by their caretakers at least

once or twice a week. Unfortunately the mongrel dogs in the study continued to live in a human household at this point, so testing later in their lives could have been impacted by different home environments. Nevertheless, the study found that the wolves could be handled by their caretakers similarly to dogs when tested between 1 and 2 years of age. This included coming when called, sitting and lying down on cue, allowing dog accessories such as a muzzle to be put on, and minimal social and physical neophobia. The level of attachment, measured by the length of time the wolves spent in close proximity to their caretaker at 1 to 2 years of age, however, was less for wolves than it was for the dogs. The domestic dogs also out-performed the wolves on tasks involving more complex human social cues, such as momentary distal pointing. The wolves could be taught to use the same level cues as the dogs at 11 months, but only after extensive training (Kubinyi et al., 2007).

Studies comparing domestic animals and their closest genetic relatives are a good step in the direction of identifying the role phylogeny and ontogeny play in key behaviors that seemingly make the species behaviorally distinct. However, much care needs to be taken to make sure both species are treated equivalently and that the behavior that results is not a byproduct of some unintended aspect of the experimental environment. This includes taking into account genetic and developmental differences that may impact how different species respond to stimuli when presented at the same age or in different environments.

The fact that various domesticated animals do better than their nondomesticated relatives on tasks requiring the use of human social stimuli indicates that selective breeding and domestication play some role in this class of behavior. These genetic traits or predispositions may have been a result of artificial selection in some species, but they are still a product of the evolutionary history of that species. Instead of mountains creating the geographic isolation of a pack of wolves, stone walls and chains may have determined which individuals could breed. In place of a natural distribution of ecological resources, a human hand may have determined which individuals would live or die within a pack.

Dogs may have developed at least some behaviors similar to those of humans because the two species lived in such close proximity over 10,000 years. It also is the case that it would have been beneficial to humans to create similar or complementary social traits in these animals through selective breeding. Of course, over most of this history of artificial selection, the human breeders would have understood nothing of genetics or selective breeding. Simple operant conditioning would be sufficient to explain the selection of dogs with desirable traits. Dogs that bit or attacked a human may have been killed, whereas ones that worked well with humans on the hunt and were nonviolent to their owners were taken care of and had a greater chance of reproductive success. Over time, people would have learned to recognize traits in puppies that had typically led to aggressiveness in older dogs in the past, and the process of selecting desired individuals and rejecting ones with undesirable traits would have become more efficient. In other words, the selection of particular traits in dogs would be reinforced with the presence of cooperative, nonaggressive dogs, whereas the tolerance or selection of other traits might be punished with aggressive attacks or a lost investment of food and energy if a fearful dog runs away.

Of course, phylogeny may set the limits of what is possible in behavior, but it is ontogeny—the personal history of reinforcement—that determines what an animal actually does. In a study by Hare and Tomasello (1999), domestic pet dogs demonstrated the ability to use the location and gestures of both humans and other dogs to help locate hidden food. Four conditions were used: human–local enhance (the human squatted by the correct location); dog–local enhance (another dog sat by the location); human–gaze- and-point; and dog–gaze-and-point (the other dog faced and looked towards the location). When performance was assessed as a group, the 10 subject dogs in the study found food significantly more often in each of the experimental conditions than in the control or baseline condition where no cue was provided. As a group, no one condition appeared to be more helpful than another. However, individual dogs differed greatly in which stimulus they were most successful in using to find the target location. Only 2 dogs were successful in all four conditions, 1 dog was successful in three conditions, 2 dogs were successful only with

the human communicator, 2 only with the dog communicator, 1 during both the human– and dog–local enhancement conditions only, and 2 during the human–local enhancement condition only. These differences are most likely due to different levels of experience in the home with situations similar to the ones the experimenters set up in the laboratory.

Dog Profiling Revisited

If, then, there is a genetic component to some aspects of behavior that have a clear impact on human–dog interaction, can bans targeting ''bad dog'' breeds such as pit bulls, or profiling based on genes in general, be justified by maintaining the position that behavior is a product of genetic tendencies as well? Evidence suggests that the answer is no. Although bites and deaths attributed to pit bulls are up in recent years (Sacks, Sinclair, Gilcrist, Golab, & Lockwood, 2000), other breeds have been number one for aggression against humans at other times. German shepherds and St. Bernards were estimated to be responsible for the majority of deadly dog attacks, not including police dogs, from 1975 through 1980 (Pinckney & Kennedy, 1982). In the 1970s, Dobermans were on the top of the list (Randall Lockwood of the ASPCA, as cited in Gladwell, 2006), and between 1993 and 1998 Rottweilers were the most dangerous dog breed (Sacks et al., 2000). However, these estimates are imperfect because they do not take into account the baseline populations of each breed in the U.S. at any given time, and identifying an individual as a specific breed is not always clear cut. Therefore, breeds that have a larger population may be involved in more attacks than less popular breeds but proportionally may be less aggressive; and aggressive dogs that do not fall clearly into a breed category are often labeled as a breed that is already deemed aggressive, thereby inflating the numbers for that breed. However, even in times where one breed may show proportionally higher levels of aggressive behavior, there is evidence that this is not solely due to an inherited ''bad dog'' gene. In fact, the type of owner, not the breed of the dog, is the best predictor for dog attacks (Gladwell, 2006; Siebert, 2004). In a quarter of fatal dog attacks, the owners previously had been arrested for illegal fighting, and many aggressive dogs are ones that have been abused, starved, or deprived of medical attention. In addition, some owners seek out breeds that have a reputation as ''bad dogs'' and then shape the aggressive behaviors that later seal their fate. According to Randall Lockwood, a senior vice-president of the ASPCA, ''A fatal dog attack is not just a dog bite by a big or aggressive dog. It is usually a perfect storm of bad human–canine interactions—the wrong dog, the wrong background, the wrong history in the hands of the wrong person in the wrong environmental situation'' (cited in Gladwell, 2006, p. 26).

Dogs may become problems in human society because their owners may also respond in unconventional ways to social stimuli within the environment because of their own history—possibly exposing their dog to contingencies governed by an abusive, isolated, or neglectful home environment. Therefore, to fully address these and other types of behaviors demonstrated by domestic dogs, the specific contingencies that surround the operant and the specific properties of social stimuli that serve as effective discriminative stimuli need to be identified and defined.

Dogs: Our Closest Relatives?

It may sound strange, but it is not unreasonable to view dogs and humans as subject to convergent evolution (Hare & Tomasello, 2005). Over the last 100,000 years, the social environments of domestic dog pups and human children have become more and more similar to each other, and less like those of either species' closer genetic kin.

It is as a consequence of this intense cohabitation that dogs have come to emulate some behaviors that are commonly viewed as uniquely human, such as the recognition of another's attentional state. These kinds of complex behaviors are commonly structured in relatively vague cognitive terminology. We hope this review will inspire behavior analysts to use the empirical tools of our field to investigate just how closely dog social behavior maps onto human use of social cues. Such research could answer fascinating questions in the evolution of complex behavior, as well as enabling us to live more safely and profitably with our ''best friends.''

To Shape, Lead, Catch, or Click?

The study of dog behavior may seem new to experimental behavior analysis, but the inter-

est in applying behaviorist technology to dog training dates back to Skinner's own writings. Skinner wrote: ''Since nearly everyone at some time or other has tried, or wished he knew how, to train a dog, a cat, or some other animal, perhaps the most useful way to explain the learning process is to describe some simple experiments which the reader can perform himself'' (Skinner, 1951/1999, p. 605). He went on to provide techniques to shape the behavior of any animal the reader could ''catch'' using the basic principles of positive reinforcement (Skinner, 1951/1999). Three decades later, Karen Pryor reintroduced behavioral methods of dog training to a new generation of animal trainers and pet owners (Pryor, 1984).

Notwithstanding Skinner's and Pryor's encouragement to behavior analysts to become involved in dog training, and even a paper in the psychological literature calling on behavioral scientists to become more involved in the scientific development of dog training methods (Tuber, Miller, Caris, Halter, Linden, & Hennessy, 1999), the two flagship journals of the field, the *Journal of the Experimental Analysis of Behavior* and the *Journal of Applied Behavior Analysis*, have published surprisingly few empirical papers involving dogs as subjects, the most recent (Cohen, 1970) having a publication date of over 35 years ago.

Surely there would be no better way to convince people of the effectiveness of scientific behavioral techniques than to provide them with the technology that they desire to address their current needs. Now is the time to provide the research that will help behaviorists, and in turn society, better understand the behavior of domestic dogs as a species, and to devise refined and easily applied methods of training and evaluation grounded in empirical and testable approaches to behavior.

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Received: July 12, 2007
Final acceptance: October 10, 2007