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Canine Curiosity: What We Do and Don't Know, and What Human Infants Could Teach Us

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Abstract – The phenomenon of domesticated dogs looking to humans for information is ubiquitous, yet infrequently observed among other interspecies interactions. Dogs' inclination to solicit information from humans is in large part a result of the two species' shared social evolution and niche. Perhaps a more compelling aspect of this relationship is how dogs respond in the face of unexpected, uncertain, and/or novel cues from humans, from whom they frequently solicit information. The influence of human presence on canines' curiosity about and engagement with their immediate environment is understudied, in part due to challenges in study design. Some of these challenges are common to working with and learning from babies of our own species. And, as dogs have developed many mental processes and behaviors similar to preverbal human infants, illuminating strategies for understanding curiosity in babies may prove useful in learning more about how dogs experience the world, with and without people.

Keywords – Curiosity, Comparative cognition, Child development, Human-animal interactions, Canine cognition, Novelty-seeking behavior

We're all familiar with the supposed fate of the curious cat. But what does curiosity do for, or to, a dog, and how much do humans matter when it comes to curiosity in the canine mind? Curiosity is broadly defined as the drive to acquire new information (Gottlieb et al., 2013). Researchers are just beginning to dissect how circumstances provoke curiosity-related traits and behaviors in dogs — such as neophilia, creativity, and innovation — and how these may subsequently alter canine cognitive development (Bray, Gruen, et al., 2021; Lazzaroni et al., 2019; Pelgrim et al., 2023; Piotti et al., 2022). In this paper, we first provide a working definition of curiosity, describing what is known about its function and development in humans. We then outline what is known about the various factors shown to influence curiosity in canines, paying particular attention to the role that humans may play, and highlight new insights about canine cognition that can be gained from studying curiosity. We also suggest that drawing on insights from human cognitive development could provide fodder for testing hypotheses about canine curiosity, both in the presence and absence of humans. We end with a proposal for mapping the future of canine curiosity research.

Hallmarks of Curiosity

Curiosity is a powerful driver of human learning and behavior. Our individual curiosities shape the kinds of experiences we have, the careers we pursue, and the social networks we build. Curiosity is motivated by a variety of factors, including the desire to seek out novelty (Ivancovsky et al., 2023), reduce uncertainty (Berlyne, 1954), and fill knowledge gaps (Loewenstein, 1994). The scientific study of curiosity has operationalized curiosity as both a trait that is relatively stable within individuals over time, and a state governed by specific contextual factors. Curiosity, broadly, is conceptualized as a complex construct involving several cognitive processes, including memory, cognitive control, attention, and the reward system (Ivancovsky et al., 2023).

Curiosity comes in many forms. Most notably, Litman and Silvia (2006) argue that curiosity falls along a continuum of interest-deprivation— curiosity can either be motivated by an interest in acquiring new information (Interest, or I-, type curiosity) or the drive to reduce unpleasant states of uncertainty (Deprivation, or D-, type curiosity). Building on this idea, Kashdan and colleagues (2018) further expanded the conceptualization of curiosity by proposing a multidimensional model of curiosity that treats curiosity as a multifaceted construct comprised of distinct subtypes, including Joyous Exploration (i.e., rewarding nature of acquiring new information), Deprivation Sensitivity (i.e., discomfort in uncertainty), Stress Tolerance (i.e., ability to withstand stressors), Social Curiosity (i.e., joy in learning about others), and Thrill Seeking (i.e., seeking out new experiences). These different types of curiosity are driven by distinct cognitive processes and relate to different behavioral outcomes (e.g., thrill seeking tends to be correlated with anxiety (Kashdan et al., 2018)), and recent work has shown that similar distinctions among subtypes of curiosity are present as early as the first year of life in humans (Lee et al., 2022).

Curiosity, in large part due to its complex nature, is notoriously difficult to study in lab-based settings. The clearest, and most widely used, marker of curiosity is information-seeking behaviors, such as question asking, or the degree to which an individual is willing to incur a cost, forgo resources, or wait in exchange for information (Brydevall et al., 2018; Marvin & Shohamy, 2016). Research using these types of curiosity measures, combined with self-report measures of curiosity, has found that curiosity serves a useful function for humans. The most well-known function of curiosity in humans is its ability to support learning.

Where Does Curiosity Come From in Humans?

Apart from general information-seeking, curiosity in humans is distinct in that it is driven by the desire to acquire new knowledge for the sake of knowledge alone, not as a means to an end (e.g., to obtain a reward) (Kidd & Hayden, 2015; Loewenstein, 1994). Though developmentalists have long been interested in processes and behaviors related to curiosity (e.g., motivation, play), it has been historically assumed that human infants do not possess the cognitive foundations required for epistemic curiosity. Similar assumptions have been made for other animals with heightened socio-cognitive capacities, dogs among them.

One of the reasons for the long-held belief that human infants (and other species as well) don't possess epistemic curiosity is due to their limited verbal skills— it's hard to know if an individual is curious, let alone what they might be curious about, without language. However, recent human development work with human infants has debunked this notion (Begus & Southgate, 2012; Goupil et al., 2016; Lucca et al., 2020; Lucca & Wilbourn, 2019, 2018; Stahl & Feigenson, 2015), shedding new light on the sophistication of early metacognitive reasoning and information-seeking abilities, and documenting that individual differences in curiosity-driven behaviors emerge within the first year of life in human infants (Muentener et al., 2018).

By the second year of life, infants are aware of what they do and do not know—and when they reach gaps in their knowledge (e.g., when their expectations are violated) they actively work to fill those gaps, either by exploring their environment or seeking out information from a knowledgeable social partner (Bazhydai et al., 2020; Goupil et al., 2016; Kovács et al., 2014; Lucca & Wilbourn, 2019; Stahl & Feigenson, 2015), which is not dissimilar from dogs, as noted above (Belger & Bräuer, 2018; Piotti et al., 2017; Völter & Huber, 2021).

Emerging evidence also suggests that curiosity is stable across infancy and childhood, and strongly predicts later learning outcomes (Muentener et al., 2018). When individuals experience heightened states of curiosity, they have increased activity in brain regions associated with reward and memory, learn that information better, and retain that information longer than individuals who are less curious (Kang et al., 2009). This effect starts early in development: toddlers are better equipped to retain information they specifically requested, than information they did not (Lucca & Wilbourn, 2016), and young children who are highly curious achieve better academic outcomes than less curious children (Shah et al., 2018).

Longitudinal studies in both humans and dogs suggest the degree to which individuals exhibit neophilia, innovation, and information seeking, among other, similar behaviors, early in development shapes their world experience over their life history (Bray, Gruen, et al., 2021; Raine et al., 2002). More curious individuals tend to fare better in many aspects of life across the lifespan: curiosity predicts career success (Kashdan et al., 2020), positive social relationships (Kashdan et al., 2011), improved mental health outcomes (Kashdan et al., 2018), and healthy aging (Sakaki et al., 2018). Given the fundamental importance of early curiosity on later life outcomes, it is critical to consider the ways in which curiosity might impact a range of other aspects of canine behavior, such as success in working capacities and in the context of re-homing, response to trauma, and adaptive aging.

The Curious Case of Dogs and Humans…

Though a common ancestor was long gone by the time Paleolithic humans and incipient dogs encountered one another, our two species nevertheless began an anomalous journey of convergent social evolution (Germonpré et al., 2012; Range & Virányi, 2014; Shipman, 2017). In addition to promoting physical changes from the wildtype common to many domestics (i.e., reduced body mass, shortening of the face and tooth-size reduction, reduced sexual dimorphism, reduced cranial capacity), the domestication of dogs over the last ~25,000 years has also resulted in important behavioral signatures relevant to a capacity for curiosity— including, and especially, reduced aggression and reactivity, increased proclivity for exploration, and an extended juvenile period (Belyaev et al., 1985; Darwin, 1875; Kaminski & Marshall-Pescini, 2014; Trut, 1999; Trut et al., 2009; but see Lord et al., 2020).

Domestication is likewise implicated in neuroanatomical adaptations that may influence the phenotypic expression of curiosity-related behaviors. Selection on social behavior has altered the anatomy of distributed gray matter networks in several regions of the brain (Hecht et al., 2021), and, in contrast to historic assumptions about brain size in domesticates, may actually lead to increased total gray matter volume (Garamszegi et al., 2023; Hecht et al., 2021). Domestication has, most notably, prepared dogs to view humans as social companions, which in turn opens many doors to cognitive expansion (Hare et al., 2002; but see Udell et al., 2010), and could be a driver in these neuroanatomical changes.

Presently, dogs and humans continue to impact each other's socio-cultural traits and biology, and our species' shared social evolution and niche have resulted in a canine companion with a remarkable inclination to solicit information from us (Fugazza et al., 2018; Ostojić & Clayton, 2014; Salomons et al., 2021).

Soliciting information from an individual with whom one has no shared language or culture demands innovation, a hallmark of curiosity. In seeking a desired response from humans, dogs readily modify engagement strategies (Bhattacharjee et al., 2018; Merola et al., 2012) such as switching from vocalization to gestural signaling, and other attention-seeking behaviors that can be shaped through experience (Gaunet, 2022; Persson et al., 2015). Emerging research shows that dogs also have implicit expectations about objects, contact, and causality (Völter and Huber, 2021; Belger and Bräuer, 2018); and when responses violate expectations instilled through training, dogs attempt new and different behaviors (Marshall-Pescini et al., 2009; Nickerson, 2019).

… and Dogs Without Humans

Much of what is currently known about dog curiosity comes from dogs' interactions with humans. This raises the question of what canine curiosity might look like in the absence of humans (though not in a deprivation state). Some have made suppositions about dogs in a hypothetical post-human world (Pierce & Bekoff, 2021), with a main takeaway being that dogs' inherent sociality would prepare them well for evolutionary success with or without humans, as others argue it did for humans early in our own history without dogs (Benítez-Burraco et al., 2020; Wrangham, 2019). Dogs' social skills, such authors posit, would facilitate introgression with wolves, coyotes, and other canids, and dogs would, in some ways, revert to an ancestral (e.g. "wolf-like") state. But the animals these authors describe as ultimately emerging would no longer be dogs, simply because dogs, for the entirety of their species existence, have operated within the constraints of a human world. Modern dogs' responses to new environmental and social pressures would always be informed by this relationship in the presence of humans.

For example, while wolves are more prone to explore the physical environment with greater persistence when faced with an unsolvable task, dogs, including free-ranging dogs, are more apt to "give up" sooner, instead seeking assistance from a specific social partner, e.g. a human (Marshall-Pescini et al., 2017). Rather than "lacking" intrinsic motivation, this behavior in dogs could be interpreted as social exploration and exploitation, which may reflect a fundamental cognitive difference between wolves and dogs that dogs cannot go "backwards" from.

Forss and Willems (2022) posit that our curiosity has been selected for along with increased sociality. Modern humans are able to be curious, and indeed thrive especially during environmental exploration because we are free from the hazards of navigating an environment with natural predators (other than disease). Dogs, too, have undergone a similar selection during domestication with humans, which may result in either 1) reduced curiosity in the absence of social cues; or 2) increased curiosity writ large.

And so, in the interest of being curious, the influence of human presence on canines' curiosity about and engagement with their immediate environment presents a worthwhile thought experiment: How might domesticated dogs, including free-ranging dogs, explore their environments differently without humans? How would they choose to modify their environment if given the opportunity? Or, in another sense, have dogs acquired from humans epistemic curiosity, if it indeed exists?

A Cursory Understanding of Canine Curiosity

The questions posed above are not currently easy to answer, and we propose potential routes to future discovery.

First, however, applied sciences do offer us some information about curiosity in dogs. Environmental or "habitat" enrichment, a strategy well-known to captive animal caregivers and in laboratory animal medicine, has more recently been the driving force behind canine training and welfare campaigns (Epstein et al., 2021; Gunter et al., 2021; Gunter & Feuerbacher, 2022; Lindig et al., 2020). Puzzle toys, nose games, "smell walks," joint exercise, and activity variation are all encouraged by veterinarians to avoid the progression of canine cognitive dysfunction (Benzal & Rodríguez, 2016; Milgram et al., 2006) and by professional trainers as a mechanism for averting undesirable behaviors in household dogs, which are often signs of boredom (Fernandez, 2022).

Lack of exposure to novel stimuli diverts cognitive power and can incite unhealthy activities such as 1) over-eating/unreasonable attention to food, which can lead to both obesity and reduced quality of life among other behavioral issues, and 2) scratching, chewing, and other destructive behaviors (Cline et al., 2021; Turner, 1997). In the context of working dogs, introducing varied, rather than routine, activities for puppies starting at an early age can be a crucial tool for researchers and trainers in helping dogs meet success in a given "career" (e.g., detection, search and rescue, medical assistance (Bray, Otto, et al., 2021; Bray et al., 2019). Job placement can be more optimally matched by monitoring the experiences individual dogs seek out, attend to, and learn best from.

Perhaps more than from enrichment studies, much of what we know about dogs' curiosity is connected to what causes them to be especially "un-curious." Fear is an unfortunately accessible study in shelter animal medicine, and has critical implications for successful rehoming of dogs. We thus have a wealth of knowledge about how previous experiences of trauma influence a dog's response in a given situation or to various stimuli. Evaluating fear responses shows, to no surprise, that traumatized individuals are often the opposite of curious— displaying fear of, resistance to, or aggression in the face of novel stimuli/situations; and exhibiting "shutdown" behavior and/or antisocial or social avoidance tendencies (Collins et al., 2022; Hennessy et al., 2020; Rooney et al., 2016; Willen et al., 2019).

While the results from such studies are significant in developing and garnering support for welfare-oriented behavioral modification curricula, they demonstrate what we already know— environment and ontogeny both affect the emergence and sustainment of canine curiosity, just as for other cognitive processes (Fishbein et al., 2019; Kramer et al., 2004; Lampe et al., 2017; Pellegrini & Pellegrini, 2013). What these studies typically do not highlight is that defining and documenting curiosity in domesticated dogs is inextricably linked to their evolutionary relationship with human companions.

Could Human Infants Teach Us More About Curiosity in Dogs?

Presuming then that it is reasonable to compare these phenomena in developing humans and dogs given similarities in methodological approaches (e.g., accounting for a lack of language) and cognitive abilities (MacLean et al., 2017), we might use what we know about curiosity in human infants to develop methods for also better understanding curiosity in dogs. For example, a few studies regarding dogs' attachment styles help us to uncover some of the psychological mechanisms behind dogs being curious and bold when exploring their environments.

Historically, Bowlby (1958) theorized that survival in both human and many non-human animal infants is dependent upon forming attachment bonds with caregivers, usually the mother, and Ainsworth (1989) further argued that using this attachment figure as a so-called "secure base" from which to explore the external environment is most crucial to development. More recently, the secure-base concept has been applied to dogs in an effort to understand what encourages bold/exploratory behavior, as their bonds with humans appear to mimic attachment beyond other forms of affection (Nagasawa et al., 2015). Horn, Huber, and Range (2013) found similarity between the secure-base effect in dog-owner and infant-caregiver relationships, wherein dogs were more likely to spend time manipulating a novel task in the presence of their owner, and suggest this effect extends to other areas of canine behavior and cognition. Others have likewise supported use of the secure base test as an effective approach to considering some of the cognitive hallmarks of curiosity in dogs, especially as it appears to last beyond early development (Udell et al., 2021).

In an experiment using a preferential looking paradigm, Lucca and Wilbourn (2018) demonstrated that when infants are curious (i.e., when they explicitly request information), they not only learn more efficiently about the things they are curious about, they also demonstrate enhanced learning of unrelated information (i.e., information they did not specifically request). Because dogs have likewise learned to request information from humans (Belger and Bräuer, 2018) it is possible that even in the absence of humans, they, like infants, may ultimately be better prepared in general to uptake new and unrelated information when they are curious. Comparison of shelter and lab-reared dogs, free-ranging dogs, and household pets would be especially useful in these studies, given varied degrees of interaction with humans (Duranton and Gaunet, 2016).

At least one recent study used human infant testing paradigms to investigate dogs' expectations about generic information (Johnston et al., 2021), specifically in relation to communication, though these findings suggest communicative cues do not have the same effect as on human infants (e.g., do not shape the way dogs encode objects). Violation-of-expectancy procedures have likewise been borrowed from the human developmental literature to investigate dogs' understanding of object permanence (Zentall & Pattison, 2016) and influence on target object exploration (Völter et al., 2023), which provide ecologically relevant insights in canine cognition.

In addition to aiding in experimental design, looking to developmental work could guide us toward an understanding of what curiosity looks like in the dog brain, beyond what we know about domestication-related changes. The neural mechanisms of curiosity-driven learning in humans have been identified through fMRI experiments demonstrating that curiosity is associated with increased activation in brain regions associated with reward and memory (Kang et al., 2009). Curiosity modulates learning by triggering an increase in dopamine production, a key ingredient in hippocampal functioning (Gruber et al., 2014). The effect of curiosity on brain structure and performance endures over time: individual differences in curiosity predict hippocampus size (Bromberg-Martin & Hikosaka, 2009; Gruber & Ranganath, 2019). The tools for investigating potential similarities in dogs are already at our disposal: advances in canine fMRI availability and reliability coupled with large datasets from longitudinal, multi-lab studies of canine cognition such as the Dog Aging Project (Kaeberlein et al., 2016) open doors for future exploration.

In particular, neural mechanisms of olfaction in dogs are well understood (Jia et al., 2014; Prichard et al., 2020), though not necessarily in the context of curiosity— yet olfaction may be the most direct-access route to "seeing" curiosity manifest behaviorally in dogs. Scent mapping is a critical tool for canines when it comes to acquisition of information (Andrews et al., 2022; Kokocińska-Kusiak et al., 2021) and perhaps one of the easiest avenues to explore potential epistemic curiosity in dogs. There is typically no direct reward to olfactory exploration outside of working contexts, and for many pet dogs prolonged sniffing is often discouraged (e.g., on walks that are dedicated to "doing business" (Aspling et al., 2015). Emerging research in the realm of olfaction capitalizes on the dog-human connection and indicates that violation-of-expectation paradigms could again be informative (Bräuer & Blasi, 2021)— even more so if expanded upon in combination with fMRI.

Mapping the Future of Canine Curiosity

There is a fundamental difference between dogs and other canids who did not evolve alongside humans, primarily that their social skills have developed specifically for enhancing human-dog interactions. Even free ranging dogs, which make up the majority of the world's domesticated dogs (Hughes and Macdonald, 2013), prefer human contact to food, when offered, and camp intentionally close to human settlements (Bhattacharjee et al., 2017; Sen Majumder et al., 2016). And, New Guinea Singing Dogs, those "re-wilded" canids, display attachment to humans (Sumridge et al., 2021). Thus, a common canine characteristic (gregariousness toward humans) presents an opportunity to investigate how dogs respond in the face of unexpected, uncertain, and/or novel cues, specifically when presented by familiar humans (Udell et al., 2021).

With this in mind, we should make an attempt to understand what factors would influence dogs not reverting, but rather "upping their cognitive game" (and in what direction) to capitalize on what the human-dog relationship has to this point instilled in them. Even in the absence of provisioned puzzle boxes and treat games, it is possible that our celebration of curiosity and our insistence on exploration has transferred to our canine companions in significant enough ways to see them into a future where encouragement to explore the external environment even also translates to further developing and then exploring their own internal states.

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