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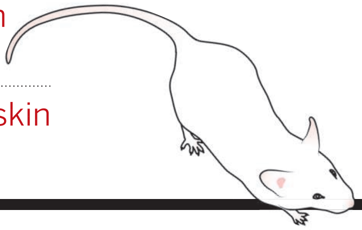

PERSPECTIVES

Look into my eyes. Changes in oxytocin concentration in a dog might elicit similar changes in a human and vice versa.

EVOLUTION

Dogs hijack the human bonding pathway

Oxytocin facilitates social connections between humans and dogs

By **Evan L. MacLean**[1,2] *and* **Brian Hare**[1,2,3]

Tens of thousands of years ago, a wolf-like predator gave rise to a more docile lineage, which soon became our trusted fireside companions (*1*). How did dogs become so embedded in human societies? Why do we feel genuine friendship, love, and social attachment in our relationships with dogs? On page 333 in this issue, Nagasawa *et al.* (*2*) reveal a powerful mechanism through which dogs win our hearts—and we win theirs in return.

Until recently, most research on human social and cognitive evolution concentrated on our closest primate relatives. Meanwhile, sitting at our feet was a remarkable case of evolutionary convergence. Inspired by developmental psychologists studying human infants, comparative psychologists began studying family dogs. It quickly became apparent that dogs have much more to tell us about cognition, and ourselves, than many might have imagined (*3*). This is particularly true when it comes to how dogs understand the social world. Even as puppies, dogs spontaneously respond to cooperative human gestures, such as pointing cues, to find hidden food or toy rewards. By contrast, great apes must have extensive experience with people to show similar skills (*4*). This use of social cues extends to a wide range of social gestures, including gaze direction and even the use of arbitrary communicative markers. Such

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abilities provide humans with a social foundation for word learning, another area in which dogs have been surprisingly adept (*5*). Incredibly, dogs' attention to social information leads not only to skillful problem solving, but also to the same socially mediated errors that young children make. For example, both dogs and children are likely to interpret eye contact as communicative, even in contexts when it is not (*6*). Thus, dogs exhibit many of the same cognitive flexibilities and biases that characterize our own species.

The domestication hypothesis suggests that humanlike tendencies in dogs are the result of selection for easygoing temperaments, which allowed dogs to interact with humans much like conspecific partners (*7*). Direct comparisons with wolves show that like great apes, but unlike dog puppies, wolves are only skilled with human gestures when heavily socialized. Unlike dogs, wolves—who do not expect humans to be cooperative social partners—do not look to humans for help when faced with an unsolvable problem (*8*). Wolves also ignore the ostensive social cues that lead human infants and dogs to make predictable errors in certain cognitive tasks (*6*). Therefore, the evidence to date suggests that the set of unusual traits found in dogs is not simply inherited from wolves.

If dog psychology was shaped by domestication, what biological mechanisms were affected? How do these mechanisms make possible an interspecies relationship that is surprisingly successful from an evolutionary perspective? The neuropeptide oxytocin has long been known for its role in affiliative social behavior, and the formation of bonds between members of a species. But can oxytocin facilitate social relationships between species? Comparisons of humans and dogs before and after they interact with each other have revealed notable increases in circulating oxytocin, as well as endorphins, dopamine, and prolactin, in both species (*9*). In addition, exogenous administration of oxytocin causes dogs to initiate more social contact with other dogs and humans (*10*), and allows dogs to tune into human social cues even more faithfully (*11*). These findings suggest not only an interspecies effect of oxytocin, but also the exciting possibility of a feedback loop—that is, shifts in oxytocin concentration in a dog might elicit similar changes in a human and vice versa—just as is seen when a mother bonds with her infant.

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Nagasawa *et al.* report the strongest test yet of the idea that humans and dogs are locked in an oxytocin feedback loop that is mediated in part through mutual gaze—sustained eye contact between human and dog (see the figure). The authors observed 30 dog owners (24 female, 6 male) interacting with their dogs (15 females and 15 males of varying breeds and ages) and measured changes in both the dogs' and owners' urinary oxytocin concentrations before and after the two interacted. In previous work, the authors found that owners who report the highest relationship satisfaction with their dogs also have dogs who maintain mutual gaze with them the most (*12*). Nagasawa *et al.* demonstrated that dog owners whose dogs gazed at them the most had the largest change in urinary oxytocin after interacting with their canine companions (*2*, *12*). Their dogs, in return, experienced a similar oxytocin increase, the magnitude of which correlated with that of the owner. When they carried out a similar experiment with wolves, there was no evidence of this type of relationship, even though the wolves were tested with the people who had raised them as pups.

> ***"Why do we feel genuine friendship, love, and social attachment…with dogs?"***

But is there a causal relationship between mutual gazing and oxytocin release? Nagasawa *et al.* administered oxytocin to a new group of dogs before they interacted with their owners. Not only did the authors see an increase in the extent of mutual gaze between owners and dogs, but they also detected an increase in oxytocin in the dog owners as a result. Oxytocin administered to dogs increased oxytocin concentration in their owners through increased mutual gaze—however, this effect occurred only with female dogs. Collectively these findings mirror studies demonstrating that oxytocin administration to human parents can have parallel effects in their infants, as a result of increased affiliative parental behavior (*13*).

Evolution is notoriously thrifty, often recycling old mechanisms for new purposes. Nagasawa *et al.*'s findings suggest that dogs have taken advantage of our parental sensitivities—using behaviors such as staring into our eyes—to generate feelings of social reward and caretaking behavior. Because these processes are bidirectional, dogs themselves likely experience similar rewards, ensuring that the feedback loop is propagated. From an evolutionary perspective, the challenge for dogs may simply have been to express a behavioral (and morphological) repertoire that mimicked the cues that elicit caregiving toward our own young. Indeed, these juvenile characteristics of dogs are known to carry a selective advantage with respect to human preferences (*14*). Once dogs were capable of eliciting such responses in humans, interspecific bonds could be maintained through the feedback loop, which originally evolved to promote bonding between mother and child. Recent brain imaging studies have also demonstrated that when human mothers view images of their child or their dog, a common network of brain areas related to emotion, reward, and affiliation is activated (*15*). Thus, diverse aspects of our biology appear to be tuned into dogs and children in remarkably similar ways.

If they stand the test of time, the implications of these findings are far-reaching. In addition to providing clues about how dogs became a part of human history, the results also help to elucidate the proximate mechanisms through which our relationships with dogs may be salubrious. For example, the benefits of assistance dogs for individuals with autism or posttraumatic stress disorder—conditions for which oxytocin is currently being used as an experimental treatment—may arise partly through these social pathways. Thus, an important future challenge will be to probe the extent to which these findings generalize to diverse populations. In the meantime, Nagasawa *et al.* have provided more evidence that when your dog is staring at you, she may not just be after your sandwich. ■

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