genetic variation in traits subject to strong directional or stabilizing natural selection (*12*) is an obvious, but as yet unsupported, alternative (*2*). However, if the explanation were to lie in population processes—such as inbreeding and genetic drift—then tropical species should also exhibit lowered genetic variance in other traits (such as body size) and in neutral marker genes. Neither expectation was met in this study (see the figure, panel C) (*2*).

Whatever the reason(s) for differing levels of genetic variation in key tolerance traits in narrowly and widely distributed *Drosophila* species, the message from the Kellermann *et al*. study is loud and clear: Genetic constraints on adaptive evolution in response to climate warming may be more widespread than previously thought (*1*, *13*). The challenge for future studies in evolutionary physiology (*14*) is to reveal how general these findings are, and uncover the mechanisms behind the observed patterns.

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10.1126/science.1179326

BEHAVIOR

Like Infant, Like Dog

Michael Tomasello and Juliane Kaminski

The domestic dog possesses social-cognitive skills that parallel those of human children.

Over the past decade, behavioral scientists have uncovered a surprising set of social-cognitive abilities in the otherwise humble domestic dog. These abilities are not possessed by dogs' closest canine relatives, wolves, nor by other highly intelligent mammals such as great apes. Rather, these skills parallel some of the social-cognitive skills of human children. On page 1269 of this issue, Topál *et al*. extend our understanding of these specialized abilities, showing that in some situations, they may lead man's best friend, just as they do young children, into curious errors. (*1*).

The original experimental task suggesting unusual social-cognitive skills in dogs was a communication task (*2*, *3*). If a piece of food is hidden in one of several opaque cups, and then a human points to the cup containing the food, a dog can infer the location of the hidden food quite readily. To comprehend the pointing gesture in this context, a dog must infer something about why the human is directing its attention to a boring cup—why the human's communicative gesture is relevant to their search for the food. Dogs' skills in this task are surprising because, as simple as it seems for humans [human infants solve it at around the first birthday (*4*)], even our nearest primate relatives, the great apes, fail at it miserably (*5*), as do wolves (*5*, *6*). Dogs have not shown special cognitive skills relative to other mammals in nonsocial cognitive tasks, such as understanding space or physical causality (*7*), whereas they show special social-cognitive skills even as young puppies, before they've had much experience with humans (*5*, *8*). The so-called domestication hypothesis is thus that dogs' specialized skills arose as adaptations for interacting and communicating in the human social environment in which they have lived for more than 10,000 years (*5*, *6*, *9*).

Eager to please. Dogs, like human infants, are specially adapted for following instructions from humans.

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The task that Topál *et al*. used is called the object permanence task. For human infants, the result is rather strange. Suppose you hide an object in location A several times, and an infant finds it there each time. If you then hide the object in location B, right in front of its eyes, the infant continues to search for it at location A. Some theorists believe this error indicates that infants have a profoundly different conception of the world than adults (*10*). In a previous study, Topál and colleagues (*11*) proposed a very different explanation—that infants are attending not just to the object but also to the adult performing the hiding operations. Because the adult is calling the infant's attention and showing the manipulations, the infant sees the original hiding act (in location A) as pedagogy from the adult about where this object normally goes. By the time the adult hides it in location B, the infant already has learned a general principle about this object's normal location. In an experiment, infants made the location error much more often if the adult performed the original hiding of the location A object with pedagogical social cues (such as eye contact and calling the child's name). The infants apparently believed adult instruction more than they believed their own eyes,

In the current study, Topál *et al*. report that pedagogical social cues affect domestic dogs in much the same way. Dogs also follow human instruction accompanied by such cues over their own visual experience. It should be noted, however, that the human also gave some pedagogical cues to the dog when hiding the object in location B. Why dogs nevertheless gave precedence to the information from the initial location A trials is still an open question.

Topál *et al*. also report that the manipulation of pedagogical cues does not affect human-raised wolves at all—they go with what they see in all cases. This finding provides strong support for the domestication hypothesis, by again showing striking dog-

Max Planck Institute for Evolutionary Anthropology, Deutscher Platz 6, D-04103 Leipzig, Germany. E-mail: tomas@eva.mpg.de

wolf differences, and striking dog-human convergences—in this case, in a task with which most dogs have no previous experience.

But there is an interesting difference between dogs and human infants. Topál *et al*. observed that dogs did not make the location error if the person hiding the object in location B was not the same person who hid it in location A. Children made the error whether the person was the same or not. The authors interpret this as showing that human children are sensitive to true pedagogy—they, in essence, take instruction from all adults equally, considering it as general cultural information, whereas dogs are sensitive only to communication from humans about the immediate situation. It is possible that neither dogs nor any other nonhuman species communicate generalized (normative) information in this way.

Dogs' special social-cognitive skills are not "normal" in that they do not gesture for or teach humans reciprocally, and they do not use their comprehension abilities with other dogs. They have evolved specialized skills for dealing with their unique situation in which they benefit by taking orders from humans. Indeed, a recent study has found more sophisticated communicative skills in dogs that have been directly selected by humans for specific tasks such as hunting and herding (*12*). Domestic dogs thus illustrate one way in which specialized cognitive skills may evolve to meet special ecological circumstances.

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10.1126/science.1179670

NEUROSCIENCE

Erasing Fear Memories

Tommaso Pizzorusso[1,2]

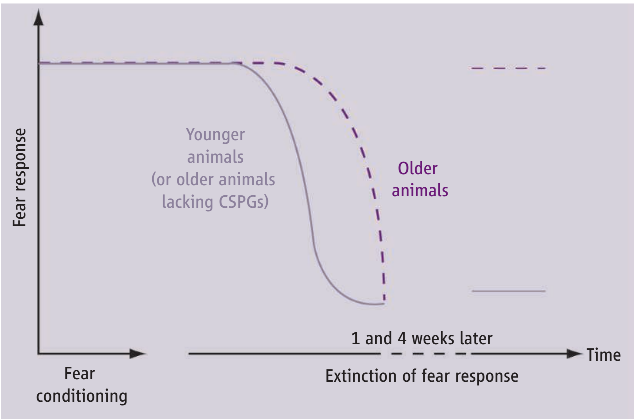
Why are memories of traumatic events nearly impossible to eliminate?

Events that are associated with trauma and fear often leave memories that reoccur spontaneously, leading to excessive fear, anxiety, and, in some cases, posttraumatic stress disorder. Such relapses of fear memories constitute a major clinical problem, and their elimination is a major cornerstone of psychological therapy. Many neurobiological studies are therefore focused on understanding how fear memories are controlled (*1*). On page 1258 of this issue, Gogolla *et al*. (*2*) take an important step in the field by determining that the extracellular environment in a particular region of the brain—the amygdala—is responsible for making fear memories erasure-resistant.

"Extinction" is a popular behavioral technique to block recurring traumatic memories. This form of learning is characterized by a decrease in a fear response when the contingent relationship—between a conditioned stimulus (e.g., a sound) and an unconditioned stimulus (e.g., an electric shock)—is compromised. This situation is most commonly implemented when the conditioned stimulus is repeatedly presented in the absence of the shock (*3*). It is now well accepted that extinction represents new learning and does not erase the preexisting memory (*4*). Indeed, the original memory can spontaneously recover, or it can be renewed, when the conditioned stimulus is presented in contexts different from that in which the extinction protocol was administered. The resilience of traumatic memories to extinction represents a serious obstacle for treating disorders characterized by abnormal fear and anxiety.

Gogolla *et al*. were inspired by previous work originating from fields as diverse as development of fear conditioning (when fear is associated with a neutral stimulus) and plasticity of the visual cerebral cortex. These studies demonstrated that in contrast to the inability of an extinction protocol to erase the fear memory in adult rats, extinction of acquired fear in young rats (17 days after birth) deletes the fear memory (*5*). Further studies showed that sensitivity to erasure of fear memories is already lost at 23 days after birth. At all ages, extinction of fear conditioning in rats implicated neuronal circuits in the amygdala, a brain region necessary for fear memory acquisition and extinction. What changes occur during amygdala development that are responsible for switching off the susceptibility of fear memory to the process of elimination?

Developmental windows during which neural plasticity is different from that of adult animals have been extensively studied in the mammalian visual cortex. Visual



Resisting erasure. Young mice as well as adults lacking chondroitin sulfate proteoglycans (CSPGs) in their amygdalae showed a faster extinction of the fear response (solid line) (which was acquired during prior fear conditioning), compared to adult mice treated with placebo (dashed line). When fear memory was retested 1 and 4 weeks after the extinction protocol, only the young mice and adults lacking CSPGs had completely eliminated the fear memory, whereas fear response had reoccurred in the placebo group.

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[1]Istituto Neuroscienze CNR, via Moruzzi, 1 56100 Pisa, Italy. [2]Dip. Psicologia, Via S. Salvi, 12–Pad. 26 Università di Firenze, 50135 Firenze, Italy. E-mail: tommaso.pizzorusso@in.cnr.it