pointing cues, cats were less likely than dogs to look towards a human when facing an insoluble problem situation [5]. This result with cats is even more interesting if one considers that the social structure of their ancestors was most probably more similar to that of foxes than dogs.

In support of their hypothesis, Hare and Tomasello have suggested that there might be a relationship between 'emotional reactivity' and social skills at the individual level. It is well known that 'taming' or 'socializing' animals can decrease 'emotional reactivity'. Interestingly however, some recent studies suggest a dissociation: although socialized wolves seem to approach the performance level of dogs in the cueing task after extensive human contact, they are not facilitated in cases requiring *initiation* of communication with humans [6]. Further, some of our large-scale observations (N=160) on dogs of different breeds suggest that there is no relationship between aggressiveness and performance in the 'cueing-test'; dogs that are aggressive towards a threatening human are just as successful as friendly ones (J. Vas, unpublished data).

Taken together these data suggests that the reduction of 'emotional reactivity' alone (either by genetic selection or by experience and learning) is not enough to explain dog behavior. Therefore it seems inescapable that we must look for behavioral changes that might have emerged as a result of selection in social domains other than aggression and fear. At the moment we have three candidates.

First, recent observations have shown that 4-month-old dogs but not wolves fulfil the criterion of attachment to humans even if members of both species have been socialized to similar levels [7]. Second, there is evidence that over the course of domestication, dogs' vocalization has changed fundamentally in comparison to that of wolves: dogs 'invented' barking in fearful situations and, unlike wolves, they seem to be able to modify the frequency and pulsing of barking [8,9]. Third, we suggest that by having more flexible looking (gazing) behavior dogs can also use it for communication of affiliative intent [6]. Interestingly, as looking behavior is mainly associated with agonistic behaviors in wolves, selection for animals with extended looking/gazing behavior without displaying aggression or fear [10] could also have resulted as a 'byproduct' of the reduction of aggressive and fearful behavior.

Finally, there might be a methodological point to be considered that makes the fox-experiment difficult to interpret. It is very likely that foxes have 'inadvertently' been selected for basically the same behavior as they actually showed in the cueing test (i.e. approach human or hands providing food). Namely, when the experimenter extended his arm to the bowl containing the hidden food in the cueing test, performance of tamed foxes can be attributed to their selected preference for approaching humans or parts of the human body. As such cueing was also relatively easy for socialized wolves to rely on, without further control experiments the relevance of the fox study on the origin of social skills in dogs is disputable.

Acknowledgements

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Letters Response

The emotional reactivity hypothesis and cognitive evolution

Reply to Miklósi and Topál

Brian Hare and Michael Tomasello

Max Planck Institute for Evolutionary Anthropology, Deutscher Platz 6, Leipzig, Germany

In our review of dog social problem-solving abilities we proposed the 'emotional reactivity hypothesis', which suggests that selection on social-emotional systems could have provided an initial catalyst for wider social cognitive evolution in dogs, other non-human species and perhaps even in human evolution [1].

Corresponding author: Hare, B. (hare@eva.mpg.de).

Specifically, it might be that novel social problem-solving skills have commonly evolved as incidental by-products of selection on social-emotional systems (e.g. selection on systems mediating fear and aggression). In this way animals with altered temperaments became motivated to apply inherited cognitive abilities to solve new social problems (i.e. previously they were too afraid, aggressive or disinterested even to participate in such interactions). Once this initial evolution occurred, placing the organism in a new 'adaptive space' in which old cognitive systems become useful in novel settings, selection can then act on any existing variance in these newly expressed abilities – potentially leading to further increases in flexibility and cognitive adaptation [1–3].

Miklosi and Topal [4] have correctly noted that our enthusiasm for this hypothesis' should be tempered by the dearth of relevant cross-species comparisons. For example, there is still little direct evidence from dogs that their unusual social skills are due to changes in their levels of emotional reactivity relative to wolves [1]. In fact, evidence in favour of such a hypothesis largely comes from the finding that fox kits from a population of foxes selected experimentally for their tendency to approach a human fearlessly and non-aggressively were as skilled at using human gestures as dog puppies, and more skilled than age-matched control foxes (not selected on the basis of their approach behavior) [3]. In addition, there is currently no strong evidence from work with canids or any other species that such temperament evolution might facilitate direct selection on cognitive abilities expressed in a new adaptive space, which then leads to new cognitive adaptation (it might be the case that selection on temperament alone is enough to produce most observed changes in problem-solving behavior; for example, in the foxes).

Clearly, more comparative tests are necessary (essential will be thorough comparisons between various domesticates and their ancestral wild types). However, the emotional reactivity hypothesis provides an incipient theoretical framework to aid in the design and interpretation of future comparative experiments. Ultimately such comparisons will be crucial in identifying evolutionary processes that led to changes in social problem-solving abilities in non-humans as well as in humans.

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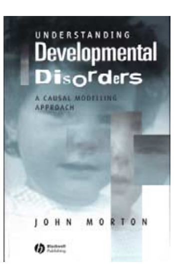
Book Review

Plotting the causes of developmental disorders

Understanding Developmental Disorders: A Causal Modelling Approach by John Morton, 2004, Blackwell. (300 pp.) £55.00 ISBN 0 631 18757 X (hbk)/£19.99 ISBN 0 631 18758 8 (pbk)

Michael S.C. Thomas

School of Psychology, Birkbeck College, University of London, Malet Street, London, WC1E 7HX, UK



What causes autism? Is it a genetic problem? Is it due to a brain abnormality, or is it a result of a viral infection? Could it be a consequence of low intelligence? Or is autism a more specific difficulty, perhaps with developing normal executive functions, or with forming coherent high-level conceptual representations, or with reasoning about mental states? Is it a difficulty with the false-belief task? How might these various 'explanations' be related? In fact, could all of them be right?

John Morton's recent book, *Understanding Developmental Disorders*, presents a diagramming technique to pull apart competing causal models of developmental disorders. It is the crystallization of many years' experience of research in this area. Morton illustrates the technique using several topical disorders, including autism, dyslexia, attention deficit–hyperactivity disorder and conduct disorder. He goes on to demonstrate the implications of such causal theories for issues such as diagnosis and individual variability.

Here's a simplified overview of how Morton's technique works. Take a piece of paper. Split it into three horizontal bands. Label them 'Biology', 'Cognition', and 'Behaviour'. Draw a vertical line down the left-hand side, and to the left of the three bands, write 'Environment'. Now, add boxes with the various facts you know about the disorder, placing them in the appropriate bands. For example, for autism, brain abnormalities would be placed in a box in

Corresponding author: Thomas, M.S.C. (m.thomas@bbk.ac.uk).
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