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ESSAY

Can evolution explain how minds work?

Biologists have tended to assume that closely related species will have similar cognitive abilities. Johan J. Bolhuis and Clive D. L. Wynne put this evolutionarily inspired idea through its paces.

Darwin's theory of evolution by natural selection is broadly accepted among biologists, but its implications for the study of cognition are far from clear. Few within the scientific pale would argue against the proposition that life on Earth has evolved and that this general principle can be extended to the process of thought. But in taking an evolutionary approach, biologists have tended to assume that species with shared ancestry will have similar cognitive abilities, and that the evolutionary history of traits can be used to reveal how we and other animals perform certain mental tasks. A closer analysis suggests things aren't so simple.

In *The Descent of Man,* Darwin proposed that there is "no fundamental difference between man and the higher mammals in their mental faculties" on the basis of his belief that all living species were descended from a common ancestor. He also suggested that "there is a much wider interval in mental power between one of the lowest fishes … and one of the higher apes, than between an ape and man". To support his argument, he outlined cases in which forerunners of human intelligence could be found in "higher mammals", including "similar passions, affections, and emotions, … [such as] … jealousy, suspicion, emulation, gratitude, and magnanimity".

Darwin's reports of "a sense of humour … wonder and curiosity" or "the association of ideas, and reason" in animals may seem far-fetched, but many contemporary researchers do not shy away from using similar anthropomorphic language in their interpretation of animal behaviour. Over the past two decades, researchers have reported that chimpanzees can empathize with other members of their species, and that they reconcile and even console each other after conflicts. Monkeys and apes have been credited with a sense of fairness and aversion to inequity and, in the case of apes, an awareness of the mental states of others — in other words, a theory of mind.

A closer look at many of these studies reveals, however, that appropriate control conditions have often been lacking, and simpler explanations overlooked in a flurry of anthropomorphic overinterpretation. For instance, capuchin monkeys were thought to have a sense of fairness because they reject a slice of cucumber if they see another monkey in an adjacent cage, performing the same task, rewarded with a more-sought-after grape. Researchers interpreted a monkey's refusal to eat the cucumber as evidence of 'inequity aversion' prompted by seeing another monkey being more generously rewarded. Yet, closer analysis[1] has revealed that a monkey will still refuse cucumber when a grape is placed in a nearby empty cage. This suggests that the monkeys simply reject lesser rewards when better ones are available.

Such findings have cast doubt on the straightforward application of Darwinism to cognition. Some have even called Darwin's idea of continuity of mind a mistake[2].

One solution fits many

Laboratory studies of a number of species performing a wide range of tasks indicate that different species may have arrived at similar solutions to cognitive problems because they have experienced similar selection pressures, not because they are closely related. In other words, evolutionary convergence may be more important than common descent in accounting for similar cognitive outcomes in different animal groups.

For example, we now know that birds are capable of feats that match or even exceed those reported in monkeys and apes. Rooks, for example, rub their bills together after one of them has been involved in a confrontation with another bird. Equivalent stroking and embracing in chimpanzees would be labelled 'consolation'. The self-directed pecking that magpies show when they are put in front of a mirror after a mark has been placed on their body is similar to the reactions seen in apes given the same treatment. In magpies, this behaviour has been interpreted as evidence for some degree of self-recognition. But in apes, the same behaviour has been thought to indicate a deeper level of self-consciousness. Caledonian crows outperform monkeys in their ability to retrieve food from a trap tube — from which food can be accessed only at one end. The crows can also work out how to use one tool to obtain a second with which they can retrieve food, a skill that monkeys and apes struggle to master.

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Researchers have tried for decades to teach apes some form of language, be it by using visual symbols or gestures. But linguists generally agree that the resulting efforts made by chimps and bonobos don't qualify as language[3]. One of the prerequisites for language is being able to imitate sounds that are created by someone else. Our primate cousins show no inclination to do this. Yet many parrots and songbirds are striking vocal mimics. Furthermore, the way that they learn to sing is not unlike how human infants learn to speak. Both children and the chicks of parrots and songbirds learn many of their vocalizations during a sensitive period early in life. They also undergo a transitional period during which their attempts to speak or sing increasingly come to resemble those of adults. Recent studies even suggest that starlings can identify certain syntactic features of sound patterns that non-human primates miss.

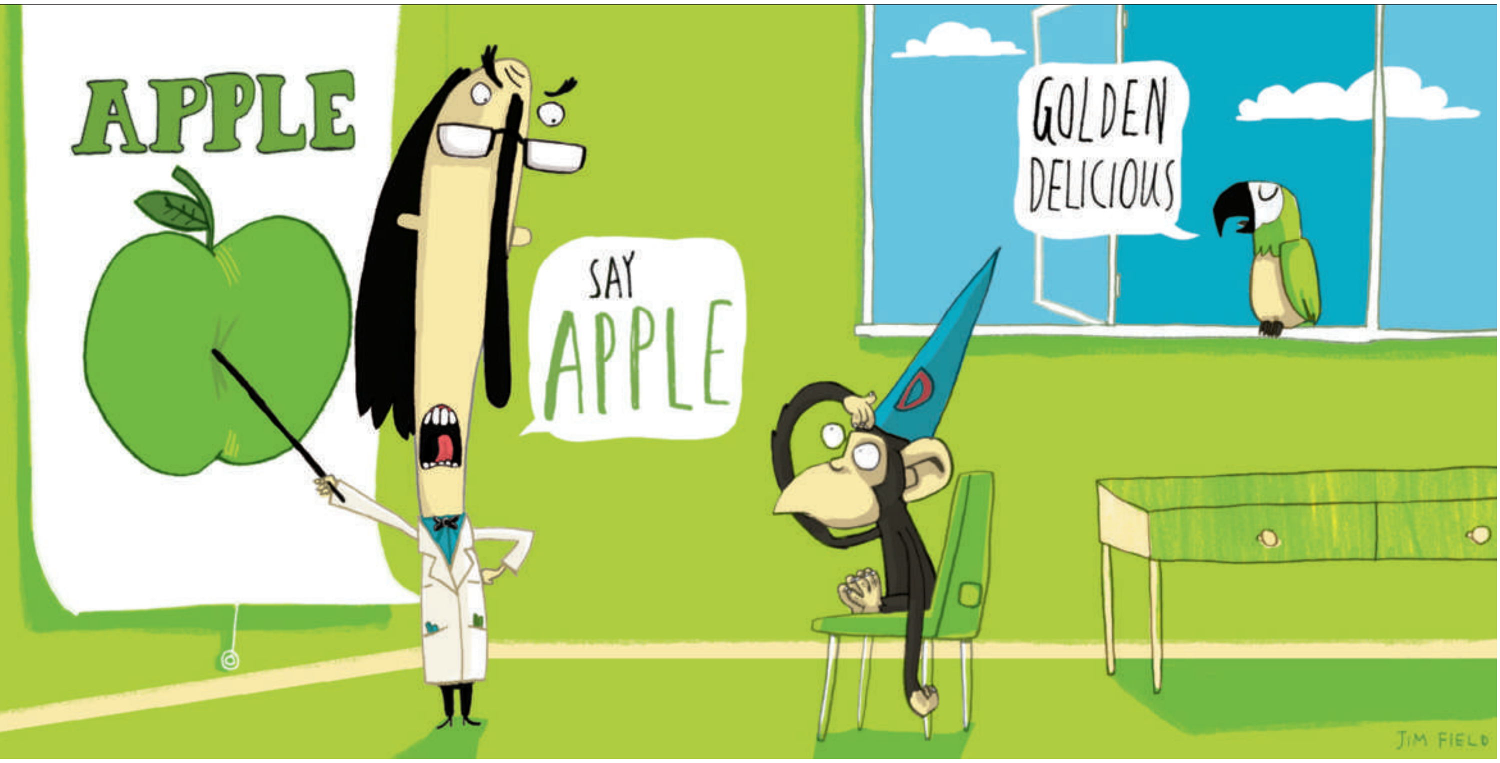
The appearance of similar abilities in distantly related species, but not necessarily in closely related ones, illustrates that cognitive traits cannot be neatly arranged on an evolutionary scale of relatedness.

The wrong question

The difficulty of not knowing whether shared ancestry or convergence accounts for similar cognitive outcomes in different species is not the only problem with applying an evolutionary approach to cognition. Another major stumbling block is that it is extremely difficult, if not impossible, to identify the factors that originally drove the emergence of contemporary animal and human traits.

According to Leda Cosmides and John Tooby[4], protagonists of evolutionary psychology, "Our modern skulls house a Stone Age mind". Indeed, this assumption — that the human mind evolved as a result of selection pressures faced by our Stone Age ancestors — underpins the field. Thus, the tendency of modern humans to spontaneously fear spiders rather than cars, which are far more dangerous, is thought to stem from the prevalence of poisonous arachnids, rather than dangerous driving, during the Pleistocene.

This approach overlooks the importance of culture in shaping the human mind. It also assumes that all traits evolve as a result of natural selection, whereas they may be inconsequential, or by-products of selection acting on some other trait. However, the most serious problem with this perspective is that cognitive traits of past generations leave little trace in the fossil record. Without being able to reconstruct the mind of our hunter-gatherer predecessors, we can only



J. FIELD

guess at the selection pressures they faced[5].

Last but not least, evolutionary analyses have been used to tackle questions for which they are ill suited. Nobel laureate Niko Tinbergen famously considered evolution to be one of the four great problems in behavioural biology. He pointed out that questions concerning the development, function and mechanistic causes of behaviour deserve equal weight[6]. Many of the questions about cognition asked by psychologists and behavioural biologists concern the underlying causal mechanisms. How does the dog open the gate? How does the parrot imitate human vocal sounds? Evolutionary analyses, however, because they are analyses of history, cannot uncover how an animal achieves a particular feat.

Take, for example, food storing in closely related bird species. The marsh tit stores seeds in tree bark or in the ground, and is able to retrieve them several days later. Its close relative the great tit, on the other hand, doesn't store at all. Such differences between species in their reliance on food stores have led researchers to suggest that the ability to remember the location of buried food involves an adaptively specialized spatial memory and brain structure, the hippocampus. To verify this idea, researchers have attempted to show that spatial memory and the size of the hippocampus vary between species depending on the degree to which they store food.

This is an interesting evolutionary hypothesis. But the suggestion that a specialized memory and hippocampus are needed specifically for storing food is not supported by the evidence[6]. Comparative studies of storing and non-storing bird species have failed to reveal a consistent relationship between the size of the hippocampus and food-storing capability. Moreover, food-storing species in general do not perform any better in spatial-memory laboratory tasks than non-storers[6].

Had it been discovered, a relationship between hippocampus volume and food storing would have hinted that a larger hippocampus underpins a superior spatial memory. Even then, a causal analysis would be needed to test this hypothesis. It could be, for example, that the hippocampus affects another trait that differs between storers and non-storers. Questions about the causal underpinnings of behavioural differences can be elucidated only with a causal analysis, not through reconstructing evolutionary history.

Theory and practice

Clearly, functional and evolutionary questions are intertwined, as are questions of causation and development. It is unclear, however, what an analysis of the evolutionary history of cognitive behaviours could add to our understanding of how they work, even if such an analysis were possible. At most, an evolutionary interpretation could provide clues to the underlying mechanisms responsible — but such clues would have to be verified using controlled experiments.

We are not suggesting an abandonment of Darwin's insights. Rather, we call for care in their application. When reconstructing the evolutionary history of cognitive traits, there is no a priori reason to assume that convergence will be more important than common descent or vice versa. In addition, evolutionary theory may suggest hypotheses about the mechanisms of cognition, but it cannot be used to actually study these mechanisms.

As long as researchers focus on identifying human-like behaviour in other animals, the job of classifying the cognition of different species will be forever tied up in thickets of arbitrary nomenclature that will not advance our understanding of the mechanisms of cognition. For comparative psychology to progress, we must study animal and human minds empirically, without naive evolutionary presuppositions. ■

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