Young chimpanzees watch and mimic an adult as she digs for termites, showing that the ability to learn by observing others is not unique to humans.

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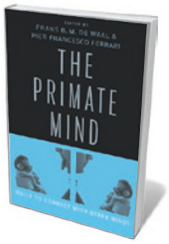
PRIMATE COGNITION

Copy that

The past decade has seen a revolution in our perception of primates' social brains, says **Christian Keysers**.

Every time my 18-month-old daughter sees me using a tool, she tries to copy me. She steals my pen to write, and excitedly brushes the few teeth she has when I brush mine. Such a capacity for connecting with and learning from other minds also manifests itself in the empathy we feel with other people's emotions, and in our ability to understand others' goals and help them. Through that ability, we can create and manage the complex social world that is arguably the key to our species' dominance.

Ten years ago, human minds were thought to be unique in their ability to connect. But as *The Primate Mind* shows, there has been a revolution in our understanding. This collection of essays, the result of a 2009 conference organized by primatologist Frans de Waal and ethologist Pier Francesco Ferrari, presents an authoritative, surprising and enriching picture of our monkey and ape cousins. We now know that they have remarkably sophisticated social minds, and that their poor performance in social tasks set by humans was more a result of researchers asking the wrong questions than deficiencies in their experimental subjects.



The Primate Mind: Built to Connect With Other Minds
EDITED BY FRANS B. M. DE WAAL AND PIER FRANCESCO FERRARI
Harvard University Press: 2012. 416 pp. $49.95, £36.95

For example, a chapter by psychologists April Ruiz and Laurie Santos explores whether non-human primates can monitor where others are looking and use that information in their own decision-making — a test of whether the animal understands what another perceives. Primatologists first tested this by seeing whether monkeys followed an experimenter's gaze to find a box containing food. The animals performed unexpectedly poorly. But changing the task from cooperation to competition unleashed the primates' true potential: macaques readily stole food from humans who looked away, but refrained from doing so when watched. Placing the task in a setting more relevant to macaque social life, which is less cooperative than our own, emphasized the continuity between our social mind and that of our primate ancestors.

The study of imitation has followed a similar path. In the early 2000s, when I began comparing how the macaque and human brains respond to the sight and sound of others' actions, I was struck by the similarities between the two species' frontal and parietal mirror systems. This system maps the actions of others onto the observer's own actions. In humans, it is thought to allow imitation, and we suspected that the same should go for monkeys. But to my surprise, primatologists at the time believed that monkeys and apes could not imitate.

The Primate Mind shows how this discrepancy between neural similarities and behavioural dissimilarities has been resolved. There is more than one way to copy others: one can either mimic every detail, or achieve the same goal by different means. Recent studies, reviewed in chapters by cognitive biologist Ludwig Huber and by primatologist Andrew Whiten and his colleagues, reveal that apes will rationally shift between these alternatives.

If apes see a man pressing a button with his head because his hands are occupied holding a blanket, they will press the button with their hands. Apes thus demonstrate something smarter than simple imitation — the ability to infer why a person is doing something in a particular way. But

if the man's hands are not occupied, giving the ape no clue as to why the person would push a button with his head, chimpanzees tend also to use their heads. It is one of many illustrations of how easy it is to misinterpret experimental results: the apes' ability to copy the details of an action only when it makes sense was misinterpreted as an inability to imitate fine details.

The essay by Whiten and his colleagues shows us that primate imitation is sometimes best studied with ape demonstrators. Chimps in a sanctuary in Uganda have been seen moving their hands up and down in synchrony with a chimp cracking a nut with a stone, and so acquiring the same skill. Many similar examples give uncontestable evidence that apes and monkeys, and even dogs and birds, can learn how to perform an action by observing others in natural environments. The disagreement between the neurological and behavioural evidence has dissolved.

Instead, we now understand that mirror neurons map the sight of observed actions onto motor programmes that allow an animal to achieve the observed goal through a variety of different actions. By bringing neuroscience and behaviour together, these findings pave the way to a deep biological understanding of how we learn by observing others. One day, this knowledge might inspire the design of robots that watch your skilled actions, and then do as you did.

"Our primate cousins share empathy and the inclination to cooperate."

One by one, claims to human uniqueness have fallen. Other essays by de Waal and anthropologists Brian Hare and Jingzhi Tan show that our primate cousins share empathy and the inclination to cooperate. Apes console other apes after conflict. Chimps overcome their fear of water to save a drowning chimp. Monkeys can favour actions that benefit other monkeys. Apes even recruit other apes to collaborate with them, and will negotiate a fair distribution of pay-offs.

Clearly, we are different from other primates. I have never seen macaques display anything like a toddler's eagerness to imitate. *The Primate Mind* suggests that it may not be the capacity to imitate, but the motivation to do so that sets us apart from other animals. Like all good suggestions, this opens the door to more questions about the mechanisms and evolution of such motivation — and, ultimately, about how our own social minds evolved from the deeply interconnected minds of our primate cousins. ■

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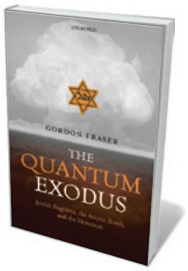
Books in brief



The Quantum Exodus: Jewish Fugitives, the Atomic Bomb, and the Holocaust
Gordon Fraser OXFORD UNIVERSITY PRESS *267 pp. £25 (2012)*
It is no accident that the Holocaust and the Manhattan Project occurred at the same time, says science writer Gordon Fraser. Adolf Hitler's policies created a diaspora of exceptional Jewish physicists, who realized both the potential of atomic weaponry and the ambitions of the Nazi regime. Fear of the regime drove them to develop the weapons, convinced that they were locked in a race, Fraser says. However, as he notes, the Nazis' focus on the Final Solution actually distracted them from pursuing the bomb.

Waking the Giant: How a Changing Climate Triggers Earthquakes, Tsunamis, and Volcanoes
Bill McGuire OXFORD UNIVERSITY PRESS *320 pp. £18.99 (2012)*
Volcanologist Bill McGuire uses the relationship between atmosphere and geosphere as his springboard for a wide discussion of how climate change could affect what happens on and below Earth's surface. Arguing that sea-level rise, melting ice and other factors could trip already unstable geological systems such as active fault lines, he trawls deep history and new research to examine the evidence. He makes the case for a subterranean dimension to the unfolding drama of climate change.

Bird Sense: What it's Like to Be a Bird
Tim Birkhead BLOOMSBURY *266 pp. £16.99 (2012)*
Anyone who has watched a soaring gull must have wondered how it feels to be up there, alone and aloft. Animal-behaviour expert Tim Birkhead seeks to tell us, one sense at a time. Even familiar capabilities have alien elements in birds — many species can see ultraviolet light, for example. Sight also has a crucial role in birds' ability to navigate using Earth's magnetic field: a robin with a blurry contact lens on its right eye, for example, loses its sense of direction. Finally, Birkhead speculates about birds' emotions. Is a goose that seems to stand vigil over its dead partner truly grieving?

How Economics Shapes Science
Paula Stephan HARVARD UNIVERSITY PRESS *367 pp. $45 (2012)*
A big biomedical lab spends 18 cents a day to keep one lab mouse, amounting to hundreds of thousands of dollars for animals each year. Economist Paula Stephan takes an exhaustive look at how publicly funded science pays such bills, and how this affects research, researchers and the economy. She argues that expanding universities and stagnant budgets have made funders and scientists more risk-averse, and stunted the development of young investigators. She recommends decoupling research and training to reduce the over-production of PhDs, and forcing universities to bear more salary costs.

What did the Romans Know? An Inquiry into Science and Worldmaking
Daryn Lehoux UNIVERSITY OF CHICAGO PRESS *288 pp. $45 (2012)*
If you rub a magnet with garlic, wrote the Roman philosopher Plutarch, it loses its power to attract. The tale inspired classicist Daryn Lehoux to investigate how these educated people came to believe silly things, and why we now realize they're risible. He defends Roman knowledge, arguing that figures such as Galen, Ptolemy and Cicero forged a distinctive investigative approach shaped by their religious, cultural and political environment.