WHO ARE YOU CALLING BIRD BRAIN?

BY CHARLES WOHLFORTH

ILLUSTRATIONS BY JONATHON ROSEN

The amazing smarts of crows, jays, and other corvids are forcing scientists to rethink when and why intelligence evolved.

Nicky Clayton is no better at sitting still than are the birds she studies. Back in the 1990s, her colleagues at the University of California at Davis would stay at their computers at lunchtime, but she would wander outside and watch as western scrub-jays stole bits of students' meals and secretively cached the food. During these informal field studies, Clayton, an experimental psychologist, noticed that the birds returned frequently to their stashes and changed their hiding places.

"I thought, 'This is odd,'" she says. "I assumed birds would cache for a long time—days or months. But this was for minutes." She theorized that the birds were moving their caches to avoid pilfering. When food was plentiful, they grabbed as much as possible and hid it, then hid it again when they could do so without being observed by potential thieves. That behavior implied that the scrub-jays might be thinking about other birds' potential actions, a type of flexible thinking that was supposedly beyond the capabilities of a scrub-jay's little brain.

Clayton realized that if she could capture this caching behavior in the laboratory, she might be able to decode the social cognition of birds—the way they think about one another. She might learn whether they are capable of deception, if they respond differently to individual competitors, how well they evaluate their degree of privacy, and other aspects of their mental processes.

"I had a lucky break with caching," Clayton says. "I saw this as a niche, an area that other people weren't busy with that might be quite interesting. Little did I know where it would lead."

Scientists had already established the amazing memories of corvids, the family of birds that includes jays, crows, ravens, and nutcrackers. The Clark's nutcracker can hide thousands of seeds at a time and has passed tests of recall up to 285 days later. Clayton sought to find out how deep those skills run. Many animals have impressive mental capabilities for certain narrow tasks, but such aptitudes seem to reflect hardwired or conditioned adaptations to specific challenges. That is distinctly different from a human's ability to create and manipulate a flexible mental model of the world.

Within a few years of her lunchtime insight, Clayton was conducting the first experimental demonstrations of a nonhuman animal engaged in mental time travel. Her experiments demonstrated that scrub-jays plan for the future, recall incidents from the past, and mentally model the thinking of their peers. Since then her work has expanded even further. She has found other mental capacities in birds that rival or surpass those of any other nonhuman species and come uncannily close to abilities we thought were ours alone.

When she left her native England in 1995 for her position at U.C. Davis, Clayton already believed there was much more to corvid cognition than people thought, having studied their memory development during her graduate studies at Oxford University. The scrub-jays in the park were not the only thing that lit a fire under her. She also drew inspiration from another English expatriate, a neuroscientist doing related work from a different perspective, studying social cognition in rhesus macaques. That researcher, Nathan Emery, would later become her husband. Like many romances, theirs faced some early tests. Soon after they met, Clayton recalls critiquing a draft paper of Emery's on primate eye-gazing. The paper included a chart listing mental capabilities that were the sole province of primates. "I kept writing in the margin, 'Oh, no it's not,'" she says, "which I'm sure he found very irritating."

After Clayton's groundbreaking work at U.C. Davis, she returned to England in 2000 and rapidly rose to become a full professor at Cambridge University and director of natural sciences at the university's Clare College. Emery made the move as well, becoming a Royal Society University Research Fellow at Cambridge. They married in 2001 and together have pursued the study of animal social cognition, with Clayton drawing her husband's attention more to the avian side of things.

As she waded into the study of complex cognition, Clayton found herself in a field that was full of intriguing but poorly documented research. Scientists had striven for decades to demonstrate that nonhuman primates have mental abilities similar to ours. Experiments teaching chimps—like the famous Washoe—to communicate using sign language received enormous publicity but rarely withstood critical analysis. Other projects aimed to show that animals have a theory of mind, the ability to model the thinking of others (as when we judge whether a poker player is bluffing or if a potential mate is truly in love). But here, too, the studies seemed to glimpse such abilities in animals without ever delivering definitive proof.

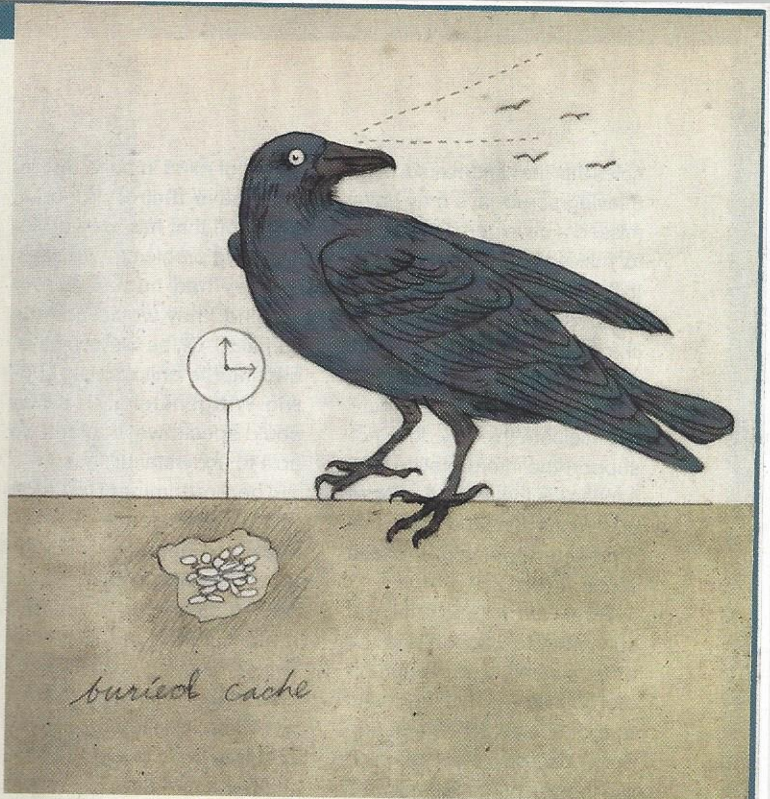
Experimental psychologist Sara Shettleworth of the University of Toronto summed up the shaky history of these studies in a 1998 textbook in which she reported a history of ambiguous and mistaken findings in the field, concluding that little had been accomplished in a century of work on social cognition in animals. Clayton has taken a different tack from the earlier research. "It wasn't ecologically inspired," she says. "It was psychologically inspired. We were asking, 'How can we understand a chimpanzee mind?' while the mind we really understand is the human's." From the start, Clayton saw the problem differently. "If theory of mind means thinking about how others are thinking, then how you think as a human might differ from how you think as a scrub-jay or an ape," she says. Instead of trying to train animals to do human tasks, she studied mental adaptations that corvids might need in their own setting. And instead of surmising the animals' thinking from field observations or working with a single trained subject, she conducted repeatable laboratory experiments, carefully designed to rule out alternative interpretations, with multiple birds whose history was uncorrupted by previous work. "You can look at these birds' behavior in the wild, but that doesn't tell you it's cognitive," she says. "It tells you that you should go and do an experiment."

At first Clayton's captive scrub-jays refused to engage in the caching behavior she had seen on the Davis campus. She released the birds into a room with food and plenty of places to hide it, but when she returned the birds to their cages, nothing had been left behind. In the wild, she realized, scrub-jays cache mostly in their home territory. So Clayton allowed the birds to cache in the enclosures where they lived day to day; then they quickly began storing the worms and nuts she provided just as they had the booty stolen from students' lunches.

Collaborating with Tony Dickinson, a comparative psychologist at Cambridge, Clayton showed in 1998 that the remarkable cognitive capacities of scrub-jays extend beyond the social realm to include the ability to negotiate the passage of time. She found that the birds would return to caches when the food they had hidden was about to spoil. The jays also adjusted their retrieval pattern when presented with new information about how quickly a certain food goes bad, abandoning those caches whose contents had passed their expiration date.

One experiment showed that jays can even prepare for the future. Given the opportunity in the evening to place a cache in either of two cages—one in which they had previously been hungry at breakfast time and one in which they had previously been fed—the birds made the correct choice, without practice, provisioning

"We thought these abilities were uniquely human. The fact that jays have them says no."



the cage where breakfast had not been provided in the past. Neurologists believe that episodic memory (the recall of a moment rather than a skill or a fact) uses the same structures in the human brain's hippocampus as does imagination. Both functions demonstrate our capacity for mental time travel, the ability to recall past events or envision new ones. Clayton's experiments raise for the first time the possibility that scrub-jays can mentally time travel too.

"We thought these abilities were uniquely human," she says. "The fact that jays have them says no."

In Clayton's experiments, the scrub-jays' social thinking repeatedly proved more complex than anyone had predicted. The birds remembered if they were being watched by other birds when they cached, and by which ones. They would wait until a potential thief was distracted before hiding their food, or would choose a spot that was dark or otherwise difficult for the competing bird to see. If another bird could potentially hear the process of hiding the food, they chose quieter material in which to dig—sand rather than pebbles. If they had no choice but to cache in plain sight, the scrub-jays would return soon after, when conditions permitted privacy.

Clayton recognized that the birds' behaviors could be conditioned, merely reflecting innate skills, or the learned association linking a cue to an action. To address these possibilities, she, Emery, and colleagues added an additional experiment. They hand-raised scrub-jays without giving them the opportunity to steal from other birds' caches. Those "naive" jays did not take precautions to avoid being victims of theft. Apparently, the ability to avoid theft by others depended on projecting a bird's own experience. It took a thief to know a thief.

"The fact that it was only experienced thieves that did it—that really blew my mind," Clayton says. It was at that point that she and Emery began to invoke cognition to explain the birds' maneuverings. She became convinced that they really do have complex cognitive abilities.

Other researchers have also narrowed the mental differences between people and birds. Bernd Heinrich, a behavioral ecologist at the University of Vermont, has documented ravens' extraordinary social organization, secretive storing of food, elaborate communication, and extensive play, both in the field and in an aviary; he has described these results in books such as *Mind of the Raven.*

Recently, in collaboration with Thomas Bugnyar, an Austrian biologist, Heinrich measured ravens' caching and problem solving in the lab, with results broadly similar to Clayton's. He concludes, even more unequivocally than she, that ravens attribute to their competitors "the capacity of knowing." Other researchers studied the cleverness of New Caledonian crows, which can spontaneously invent novel tools.

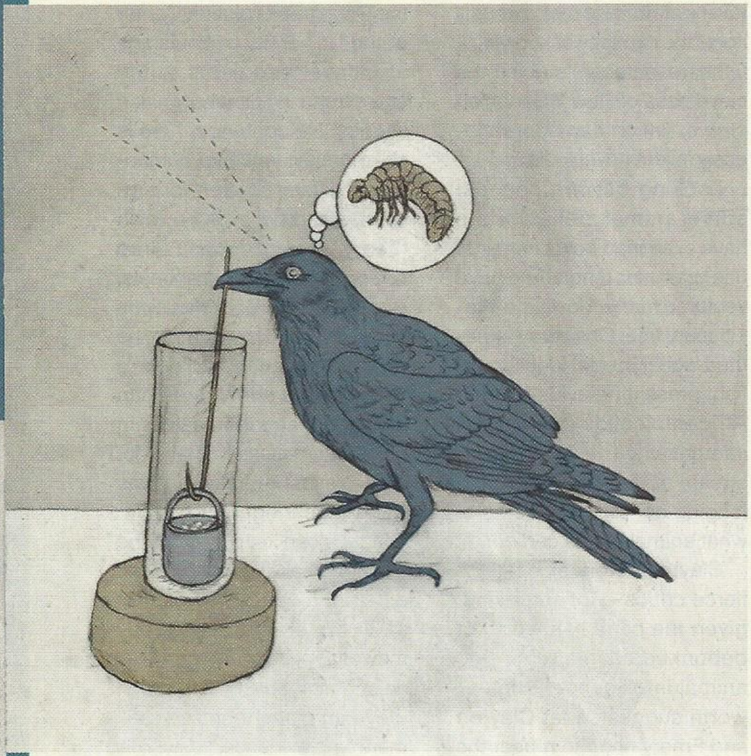
Looking beyond corvids, some animal behaviorists have examined how songbirds use grammar. And some have ventured farther down the evolutionary tree. One study attributed higher mental functions to fish, presenting evidence that African cichlids can reason inferentially. The accelerating stream of discoveries is challenging our understanding of what animal minds can do.

Clayton's work also has its fierce critics—not surprising, given the century's worth of debunked claims regarding animal intelligence. Shettleworth suggests that Clayton and Emery need to repeat the thieving experiment in a different way, with a large number of fresh birds divided into groups according to whether or not they have experience as thieves. "I think the work is provocative but not proven," Shettleworth says, "because those birds have a history."

Daniel Povinelli, director of the Cognitive Evolution Center at the University of Louisiana at Lafayette, objects to the entire trend in animal cognition studies. He contends there is still more evidence for human-animal differences than for similarities and believes our own theory of mind fools us into seeing our abilities in animals, even when simpler explanations would suffice. For example, he does not agree that Clayton's experiments show birds can mentally place themselves in different times, as humans do. "They're just representing, as Nicky has elegantly shown, that they can keep track of the relative breakdown of foods in different locations," Povinelli says. "To step back and say they can reason about time as an unobservable line on which they can place themselves—there's no evidence."

As for theory of mind, Povinelli argues that Clayton's experimental design was inadequate to show it because the birds could have responded to their competitors not by imagining the content of their thinking but just by using rules. He also notes that the hand-reared, non-thieving scrub-jays may have missed a developmental stage for making the rules. "Nicky and those guys want to say the birds are thinking, 'I know what it was like when the birds stole from me,'" Povinelli says. But he believes the naive birds' failure to anticipate thievery does not support the interpretation. "All it means is that birds that have undergone certain experiences represent those experiences across time."

Povinelli's fundamental challenge to Clayton and the other scientists studying animal cognition is that they need to produce evidence that animals possess a theory of mind like the one humans have, with the ability to mentally model counterfactual ideas, such as thinking about what another person would do in a hypothetical situation.



Emery counters that there is a limit to what we can expect to learn from animal minds. "We will never be able to find human theory of mind in nonhumans. They have their own social cognition that has evolved for their own problems," he says. "If they had human theory of mind, they would be little humans." Or, as Clayton says, quoting the philosopher Ludwig Wittgenstein, "If a lion could speak, we wouldn't be able to understand him."

The predominant attitude of Western science, Clayton says, has been that animals are unthinking automatons until proved otherwise, in line with a biblical view of the animal kingdom having been given by God for our use. But she cites a Hindu colleague who took the opposite point of view, putting the burden of proof on scientists to show that animals are not mentally complex. "Why should you start out with the idea that animals don't have a theory of mind?" Clayton asks. "Why not start out with the idea that they do?"

The risk, she recognizes, is lapsing into folk psychology and interpreting animal behavior using the mental machinery with which we negotiate our human relationships. A dog owner comes home to find a mess but shows mercy because the dog seems remorseful. But does the dog really feel regret as we would? Or is the show of regret a conditioned response associated with receiving a less severe punishment? Or could the animal be manifesting an instinctive program, treating the owner as a dominant member of the pack? Perhaps all three processes are at work.

Clayton has built her career trying to avoid these uncertainties. She believes that only experiments in the laboratory can escape the thicket of alternative interpretations that confound field observations. (That is why her team continues to endure the painstaking and time-consuming task of acquiring and working with lab-bound corvids.) Nevertheless, wildlife biologists keep reporting tales of bird intelligence outside of the lab as well.

In one compelling example, wildlife researcher Stacia Backensto, a graduate student at the University of Alaska at Fairbanks, was stymied by bird cognition when she began studying how ravens used ambient heat from buildings to adapt to life on the dark, frigid oil fields of the Arctic coast. "It's interesting to be studying something so smart. You're constantly dueling with this bird that you're trying to capture," she says. "You're constantly playing these games to outsmart it."

Backensto discovered she could get closer to the ravens if she wore an oil field worker's uniform. Still, she found it almost impossible to catch the birds in the second year of her study. They had learned all her tricks—even ravens she had not seen before, in areas she had not previously visited. Finally she had to don a complete disguise: a uniform stuffed with pillows plus a shaggy wig, fake beard, glasses, and a mustache. It worked, although the university's business office wanted to know why Backensto was spending research funds at a place called the Party Palace.

Beyond the anecdotes and individual case studies, there is a common thread among the birds that show the strongest signs of intelligence—the ravens, jays, and other corvids, along with parrots. Each of these species possesses an avian neocortex of exceptional size relative to its body, rears its young for an extended period, and lives in a complex social environment—not merely in a large population of cooperating creatures, such as bees or ants, but in a dynamic setting of alliances and competition. The same is true of the most clearly intelligent mammals: toothed whales, dolphins, and primates.

"It's not just living in big groups, it's the complexity of social life," Clayton says. This social hypothesis gives the animals a reason for evolving intelligence, which their physical environment alone might not demand. Clayton suggests that a cognitive arms race among their own kind drove corvids to evolve, as the spy-versus-spy game of caching, stealing, hiding, and deceiving escalated the need for an ever-sharper mind.

Once the ability to think flexibly emerges in an evolutionary line, descendants can apply it to face varying challenges. For example, ravens and killer whales, both highly social, also both alter the ways they gather food and use their habitat so they can live near the equator as well as in the high Arctic.

Last year Emery investigated the latent intelligence of corvids by testing rooks, which do not use tools in the wild,

NICKY CLAYTON'S BIRD'S-EYE VIEW

Nicky Clayton's fascination with birds does not end when she leaves her Cambridge University office. Over the years, the avian world has infiltrated her personal life as well, informing her off-hours interests in dance and social connection. And conversely, she has developed ideas related to her research by looking at bird behavior through the prism of her own experience.

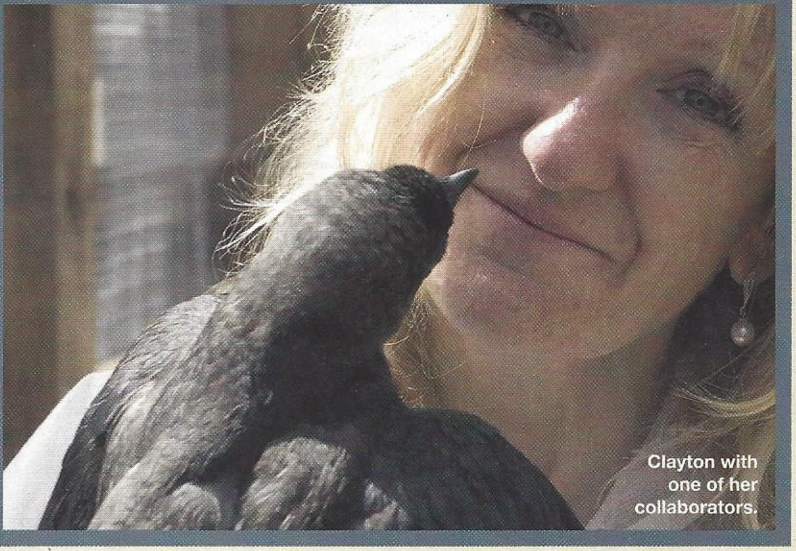
With a slight frame and sharp mind, Clayton likes being compared to a bird. As busy as the corvids she studies, she dances six days a week, even during university terms. And to push her metaphor further, you might say that she pays close attention to her plumage: Her dresses come from Milan, and she perches on stiletto heels day and night, whether relaxing at home, practicing salsa, or striding across the medieval flagstones of Cambridge at a breakneck speed.

Last year Clayton had a rare opportunity to bring her two sides together when Mark Baldwin, the artistic director of the London-based Rambert Dance Company, asked her to help create a contemporary dance commemorating the 150th anniversary of Charles Darwin's *On the Origin of Species*. She agreed and then spent weeks sorting out how to express evolution in dance. "I was thinking I could just give them a straight science talk, but that's a bit boring," she says. "Given that I love to dance, it made sense for me to merge the two."

Clayton borrowed elements from tango and then added some moves based on avian sexual selection; as reference, she showed the Rambert dancers video of the mating ritual of birds of paradise. "I referred to it as bird ballet," she says of the ritual. "The maestro comes on the scene—I call him the principal dancer—and he's seen to do this amazing series of jetés across his little stage. And you see all these females gathering and critically looking, and then you see him benefit from his successful performance by mating with them all."

In the resulting work, titled "The Comedy of Change," Baldwin included a solo that evoked the bird of paradise video. Reviewers found the piece beautiful but, as with the behavior of the birds Clayton studies, a bit mysterious. One writer who attended a performance in Northampton that was primarily for schoolchildren appreciated it more—thanks no doubt to a talk Clayton gave in advance.

Clayton still glows about this experience. As a young girl she loved birds, dance, and clothes. Now she has all three, adding dance company science adviser to her list of titles and honors. All of that curiosity and optimism spills right back into her academic work, as she attempts to decode the minds of her scrub-jays. "I just like watching them behave," she says, "and using that to generate ideas." C. W.



Clayton with one of her collaborators.

HOWARD GUEST

with complex tasks requiring tools. With each step in his laboratory experiments, the challenges got harder and more complicated, but because of the rooks' understanding of cause and effect, they produced solutions without resorting to trial and error. They chose rocks and sticks to drop down a tube in order to open a door to get food. In an experiment inspired by Aesop's fables, Emery presented the rooks with a worm floating out of reach in a tube of water. The birds put rocks in the tube to raise the water level to capture the worm. They even manufactured tools, bending a wire to make a hook to pull a bucket holding food out of a tube. The tool worked only with a bend of a precise curvature, around 100 degrees. "We wouldn't have expected that at all," Emery says. "That's why we said in the paper that it is an example of insight. It's coming up with a novel solution, to innovate."

Birds and mammals are distant on the tree of life. Their last common ancestor lived 280 million years ago and their brains are quite different in size and structure; birds notably lack the mammalian six-layer cortex. So Clayton and Emery argue that intelligence had to evolve separately in corvids and primates, starting at distant points but converging to solve the same problems of managing social interaction.

Intelligence might turn up anywhere it aids survival—in the use of protective coloring or the ability to molt, for instance. It may be rare only because it is not needed very often. "We think intelligence is this great thing because it's the thing that has made us special," Clayton says. "Yet when you compare us with insects, such as species of mosquitoes, there are a number of measures where we are not the best."

We cannot say for certain how important thinking is for action, whether in animals or in human beings. Shettleworth concedes that Clayton's scrub-jays met the behavioral criteria for future planning when they cached their breakfast in the right cage before bedtime. "Does that mean they are thinking about breakfast when doing it?" she asks. "We don't know."

Shettleworth notes that the unconscious connections of associative learning can, even among people, produce complex behaviors, such as unconsciously eating a bowl of cereal. "Conscious cognition may be very much overrated in our conduct of daily life," she says.

In the end, we cannot be sure of another person's conscious thinking, much less the thinking of another species. A computer can be programmed to seem conscious. Scrub-jays might be built to seem conscious too. Presumably even a person could be conditioned to claim consciousness falsely. As Emery says: "I could be lying to you. I could be completely unconscious but telling you I am conscious." ◼