Animal's Minds:

Minds of Their Own Animals are smarter than you think.

By Virginia Morell

Photograph by Vincent J. Musi

In 1977 Irene Pepperberg, a recent graduate of Harvard University, did something very bold. At a time when animals still were considered automatons, she set out to find what was on another creature's mind by talking to it. She brought a one-year-old African gray parrot she named Alex into her lab to teach him to reproduce the sounds of the English language. "I thought if he learned to communicate, I could ask him questions about how he sees the world."

When Pepperberg began her dialogue with Alex, who died last September at the age of 31, many scientists believed animals were incapable of any thought. They were simply machines, robots programmed to react to stimuli but lacking the ability to think or feel. Any pet owner would disagree. We see the love in our dogs' eyes and know that, of course, Spot has thoughts and emotions. But such claims remain highly controversial. Gut instinct is not science, and it is all too easy to project human thoughts and feelings onto another creature. How, then, does a scientist prove that an animal is capable of thinking—that it is able to acquire information about the world and act on it?

"That's why I started my studies with Alex," Pepperberg said. They were seated—she at her desk, he on top of his cage—in her lab, a windowless room about the size of a boxcar, at Brandeis University. Newspapers lined the floor; baskets of bright toys were stacked on the shelves. They were clearly a team—and because of their work, the notion that animals can think is no longer so fanciful.

Certain skills are considered key signs of higher mental abilities: good memory, a grasp of grammar and symbols, self-awareness, understanding others' motives, imitating others, and being creative. Bit by bit, in ingenious experiments, researchers have documented these talents in other species, gradually chipping away at what we thought made human beings distinctive while offering a glimpse of where our own abilities came from. Scrub jays know that other jays are thieves and that stashed food can spoil; sheep can recognize faces; chimpanzees use a variety of tools to probe termite mounds and even use weapons to hunt small mammals; dolphins can imitate human postures; the archerfish, which stuns insects with a sudden blast of water, can learn how to aim its squirt simply by watching an experienced fish perform the task. And Alex the parrot turned out to be a surprisingly good talker.

Thirty years after the Alex studies began, Pepperberg and a changing collection of assistants were still giving him English lessons. The humans, along with two younger parrots, also served as Alex's flock, providing the social input all parrots crave. Like any flock, this one—as small as it was—had its share of drama. Alex dominated his fellow parrots, acted huffy at times around Pepperberg, tolerated the other female humans, and fell to pieces over a male assistant who dropped by for a visit. ("If you were a man," Pepperberg said, after noting Alex's aloofness toward me, "he'd be on your shoulder in a second, barfing cashews in your ear.")

Pepperberg bought Alex in a Chicago pet store. She let the store's assistant pick him out because she didn't want other scientists saying later that she'd deliberately chosen an especially smart bird for her work. Given that Alex's brain was the size of a shelled walnut, most researchers thought Pepperberg's interspecies communication study would be futile.

"Some people actually called me crazy for trying this," she said. "Scientists thought that chimpanzees were better subjects, although, of course, chimps can't speak."

Chimpanzees, bonobos, and gorillas have been taught to use sign language and symbols to communicate with us, often with impressive results. The bonobo Kanzi, for instance, carries his symbol-communication board with him so he can "talk" to his human researchers, and he has invented combinations of symbols to express his thoughts. Nevertheless, this is not the same thing as having an animal look up at you, open his mouth, and speak.

Pepperberg walked to the back of the room, where Alex sat on top of his cage preening his pearl gray feathers. He stopped at her approach and opened his beak.

"Want grape," Alex said.

"He hasn't had his breakfast yet," Pepperberg explained, "so he's a little put out."

Alex returned to preening, while an assistant prepared a bowl of grapes, green beans, apple and banana slices, and corn on the cob.

Under Pepperberg's patient tutelage, Alex learned how to use his vocal tract to imitate almost one hundred English words, including the sounds for all of these foods, although he calls an apple a "banerry."

"Apples taste a little bit like bananas to him, and they look a little bit like cherries, so Alex made up that word for them," Pepperberg said.

Alex could count to six and was learning the sounds for seven and eight.

“I’m sure he already knows both numbers,” Pepperberg said. “He’ll probably be able to count to ten, but he’s still learning to say the words. It takes far more time to teach him certain sounds than I ever imagined.”

After breakfast, Alex preened again, keeping an eye on the flock. Every so often, he leaned forward and opened his beak: “Ssse... won.”

“That’s good, Alex,” Pepperberg said. “Seven. The number is seven.”

“Ssse... won! Se... won!”

“He’s practicing,” she explained. “That’s how he learns. He’s thinking about how to say that word, how to use his vocal tract to make the correct sound.”

It sounded a bit mad, the idea of a bird having lessons to practice, and willingly doing it. But after listening to and watching Alex, it was difficult to argue with Pepperberg’s explanation for his behaviors. She wasn’t handing him treats for the repetitious work or rapping him on the claws to make him say the sounds.

“He has to hear the words over and over before he can correctly imitate them,” Pepperberg said, after pronouncing “seven” for Alex a good dozen times in a row. “I’m not trying to see if Alex can learn a human language,” she added. “That’s never been the point. My plan always was to use his imitative skills to get a better understanding of avian cognition.”

In other words, because Alex was able to produce a close approximation of the sounds of some English words, Pepperberg could ask him questions about a bird’s basic understanding of the world. She couldn’t ask him what he was thinking about, but she could ask him about his knowledge of numbers, shapes, and colors. To demonstrate, Pepperberg carried Alex on her arm to a tall wooden perch in the middle of the room. She then retrieved a green key and a small green cup from a basket on a shelf. She held up the two items to Alex’s eye.

“What’s same?” she asked.

Without hesitation, Alex's beak opened: "Co-lor."

"What's different?" Pepperberg asked.

"Shape," Alex said. His voice had the digitized sound of a cartoon character. Since parrots lack lips (another reason it was difficult for Alex to pronounce some sounds, such as *ba*), the words seemed to come from the air around him, as if a ventriloquist were speaking. But the words—and what can only be called the thoughts—were entirely his.

For the next 20 minutes, Alex ran through his tests, distinguishing colors, shapes, sizes, and materials (wool versus wood versus metal). He did some simple arithmetic, such as counting the yellow toy blocks among a pile of mixed hues.

And, then, as if to offer final proof of the mind inside his bird's brain, Alex spoke up. "Talk clearly!" he commanded, when one of the younger birds Pepperberg was also teaching mispronounced the word green. "Talk clearly!"

"Don't be a smart aleck," Pepperberg said, shaking her head at him. "He knows all this, and he gets bored, so he interrupts the others, or he gives the wrong answer just to be obstinate. At this stage, he's like a teenage son; he's moody, and I'm never sure what he'll do."

"Wanna go tree," Alex said in a tiny voice.

Alex had lived his entire life in captivity, but he knew that beyond the lab's door, there was a hallway and a tall window framing a leafy elm tree. He liked to see the tree, so Pepperberg put her hand out for him to climb aboard. She walked him down the hall into the tree's green light.

"Good boy! Good birdie," Alex said, bobbing on her hand.

"Yes, you're a good boy. You're a good birdie." And she kissed his feathered head.

He was a good birdie until the end, and Pepperberg was happy to report that when he died he had finally mastered "seven."

Many of Alex's cognitive skills, such as his ability to understand the concepts of same and different, are generally ascribed only to higher mammals, particularly primates. But parrots, like great apes (and humans), live a long time in complex societies. And like primates, these birds must keep track of the dynamics of changing relationships and environments.

"They need to be able to distinguish colors to know when a fruit is ripe or unripe," Pepperberg noted. "They need to categorize things—what's edible, what isn't—and to know the shapes of predators. And it helps to have a concept of numbers if you need to keep track of your flock, and to know who's single and who's paired up. For a long-lived bird, you can't do all of this with instinct; cognition must be involved."

Being able mentally to divide the world into simple abstract categories would seem a valuable skill for many organisms. Is that ability, then, part of the evolutionary drive that led to human intelligence?

Charles Darwin, who attempted to explain how human intelligence developed, extended his theory of evolution to the human brain: Like the rest of our physiology, intelligence must have evolved from simpler organisms, since all animals face the same general challenges of life. They need to find mates, food, and a path through the woods, sea, or sky—tasks that Darwin argued require problem-solving and categorizing abilities. Indeed, Darwin went so far as to suggest that earthworms are cognitive beings because, based on his close observations, they have to make judgments about the kinds of leafy matter they use to block their tunnels. He hadn't expected to find thinking invertebrates and remarked that the hint of earthworm intelligence "has surprised me more than anything else in regard to worms."

To Darwin, the earthworm discovery demonstrated that degrees of intelligence could be found throughout the animal kingdom. But the Darwinian approach to animal intelligence was cast aside in the early 20th century, when researchers decided that field observations were simply "anecdotes," usually tainted by anthropomorphism. In an effort to be more rigorous, many embraced behaviorism, which regarded animals as little more than machines, and focused their studies on the laboratory white rat—since one "machine" would behave like any other.

But if animals are simply machines, how can the appearance of human intelligence be explained? Without Darwin's evolutionary perspective, the greater cognitive skills of people did not make sense biologically. Slowly the pendulum has swung away from the animal-as-machine model and back toward Darwin. A whole range of animal studies now suggest that the roots of cognition are deep, widespread, and highly malleable.

Just how easily new mental skills can evolve is perhaps best illustrated by dogs. Most owners talk to their dogs and expect them to understand. But this canine talent wasn't fully appreciated until a border collie named Rico appeared on a German TV game show in 2001. Rico knew the names of some 200 toys and acquired the names of new ones with ease.

Researchers at the Max Planck Institute for Evolutionary Anthropology in Leipzig heard about Rico and arranged a meeting with him and his owners. That led to a scientific report revealing Rico's uncanny language ability: He could learn and remember words as quickly as a toddler. Other scientists had shown that two-year-old children—who acquire around ten new words a day—have an innate set of principles that guides this task. The ability is seen as one of the key building blocks in language acquisition. The Max Planck scientists suspect that the same principles guide Rico's word learning, and that the technique he uses for learning words is identical to that of humans.

To find more examples, the scientists read all the letters from hundreds of people claiming that their dogs had Rico's talent. In fact, only two—both border collies—had comparable skills. One of them—the researchers call her Betsy—has a vocabulary of more than 300 words.

"Even our closest relatives, the great apes, can't do what Betsy can do—hear a word only once or twice and know that the acoustic pattern stands for something," said Juliane Kaminski, a cognitive psychologist who worked with Rico and is now studying Betsy. She and her colleague Sebastian Tempelmann had come to Betsy's home in Vienna to give her a fresh battery of tests. Kaminski petted Betsy, while Tempelmann set up a video camera.

"Dogs' understanding of human forms of communication is something new that has evolved," Kaminski said, "something that's developed in them because of their long association with humans." Although Kaminski has not yet tested wolves, she doubts they have this language skill. "Maybe these collies are especially good at it because they're working dogs and highly motivated, and in their traditional herding jobs, they must listen very closely to their owners."

Scientists think that dogs were domesticated about 15,000 years ago, a relatively short time in which to evolve language skills. But how similar are these skills to those of humans? For abstract thinking, we employ symbols, letting one thing stand for another. Kaminski and Tempelmann were testing whether dogs can do this too.

Betsy's owner—whose pseudonym is Schaefer—summoned Betsy, who obediently stretched out at Schaefer's feet, eyes fixed on her face. Whenever Schaefer spoke, Betsy attentively cocked her head from side to side.

Kaminski handed Schaefer a stack of color photographs and asked her to choose one. Each image depicted a dog's toy against a white background—toys Betsy had never seen before. They weren't actual toys; they were only images of toys. Could Betsy connect a two-dimensional picture to a three-dimensional object?

Schaefer held up a picture of a fuzzy, rainbow-colored Frisbee and urged Betsy to find it. Betsy studied the photograph and Schaefer's face, then ran into the kitchen, where the Frisbee was placed among three other toys and photographs of each toy. Betsy brought either the Frisbee or the photograph of the Frisbee to Schaefer every time.

"It wouldn't have been wrong if she'd just brought the photograph," Kaminski said. "But I think Betsy can use a picture, without a name, to find an object. Still, it will take many more tests to prove this."

Even then, Kaminski is unsure that other scientists will ever accept her discovery because Betsy's abstract skill, as minor as it may seem to us, may tread all too closely to human thinking.

Still, we remain the inventive species. No other animal has built skyscrapers, written sonnets, or made a computer. Yet animal researchers say that creativity, like other forms of intelligence, did not simply spring from nothingness. It, too, has evolved.

"People were surprised to discover that chimpanzees make tools," said Alex Kacelnik, a behavioral ecologist at Oxford University, referring to the straws and sticks chimpanzees shape to pull termites from their nests. "But people also thought, 'Well, they share our ancestry—of course they're smart.' Now we're finding these kinds of exceptional behaviors in some species of birds. But we don't have a recently shared ancestry with birds. Their evolutionary history is very different; our last common ancestor with all birds was a reptile that lived over 300 million years ago.

"This is not trivial," Kacelnik continued. "It means that evolution can invent similar forms of advanced intelligence more than once—that it's not something reserved only for primates or mammals."

Kacelnik and his colleagues are studying one of these smart species, the New Caledonian crow, which lives in the forests of that Pacific island. New Caledonian crows are among the most skilled of tool-making and tool-using birds, forming probes and hooks from sticks and leaf stems to poke into the crowns of the palm trees, where fat grubs hide. Since these birds, like chimpanzees, make and use tools, researchers can look for similarities in the evolutionary processes that shaped their brains. Something about the environments of both species favored the evolution of tool-making neural powers.

But is their use of tools rigid and limited, or can they be inventive? Do they have what researchers call mental flexibility? Chimpanzees certainly do. In the wild, a chimpanzee may use four sticks of different sizes to extract the honey from a bee's nest. And in captivity, they can figure out how to position several boxes so they can retrieve a banana hanging from a rope.

Answering that question for New Caledonian crows—extremely shy birds—wasn't easy. Even after years of observing them in the wild, researchers couldn't determine if the birds' ability was innate, or if they learned to make and use their tools by watching one another. If it was a genetically inherited skill, could they, like the chimps, use their talent in different, creative ways?

To find out, Kacelnik and his students brought 23 crows of varying ages (all but one caught in the wild) to the aviary in his Oxford lab and let them mate. Four hatchlings were raised in captivity, and all were carefully kept away from the adults, so they had no opportunity to be taught about tools. Yet soon after they fledged, all picked up sticks to probe busily into cracks and shaped different materials into tools. "So we know that at least the bases of tool use are inherited," Kacelnik said. "And now the question is, what else can they do with tools?"

Plenty. In his office, Kacelnik played a video of a test he'd done with one of the wild-caught crows, Betty, who had died recently from an infection. In the film, Betty flies into a room. She's a glossy-black bird with a crow's bright, inquisitive eyes, and she immediately spies the test before her: a glass tube with a tiny basket lodged in its center. The basket holds a bit of meat. The scientists had placed two pieces of wire in the room. One was bent into a hook, the other was straight. They figured Betty would choose the hook to lift the basket by its handle.

But experiments don't always go according to plan. Another crow had stolen the hook before Betty could find it. Betty is undeterred. She looks at the meat in the basket, then spots the straight piece of wire. She picks it up with her beak, pushes one end into a crack in the floor, and uses her beak to bend the other end into a hook. Thus armed, she lifts the basket out of the tube.

"This was the first time Betty had ever seen a piece of wire like this," Kacelnik said. "But she knew she could use it to make a hook and exactly where she needed to bend it to make the size she needed."

They gave Betty other tests, each requiring a slightly different solution, such as making a hook out of a flat piece of aluminum rather than a wire. Each time, Betty invented a new tool and solved the problem. “It means she had a mental representation of what it was she wanted to make. Now that,” Kacelnik said, “is a major kind of cognitive sophistication.”

This is the larger lesson of animal cognition research: It humbles us. We are not alone in our ability to invent or plan or to contemplate ourselves—or even to plot and lie.

Deceptive acts require a complicated form of thinking, since you must be able to attribute intentions to the other person and predict that person’s behavior. One school of thought argues that human intelligence evolved partly because of the pressure of living in a complex society of calculating beings. Chimpanzees, orangutans, gorillas, and bonobos share this capacity with us. In the wild, primatologists have seen apes hide food from the alpha male or have sex behind his back.

Birds, too, can cheat. Laboratory studies show that western scrub jays can know another bird’s intentions and act on that knowledge. A jay that has stolen food itself, for example, knows that if another jay watches it hide a nut, there’s a chance the nut will be stolen. So the first jay will return to move the nut when the other jay is gone.

“It’s some of the best evidence so far of experience projection in another species,” said Nicky Clayton in her aviary lab at Cambridge University. “I would describe it as, ‘I know that you know where I have hidden my stash of food, and if I were in your shoes I’d steal it, so I’m going to move my stash to a place you don’t know about.’”

This study, by Clayton and her colleague Nathan Emery, is the first to show the kind of ecological pressures, such as the need to hide food for winter use, that would lead to the evolution of such mental abilities. Most provocatively, her research demonstrates that some birds possess what is often considered another uniquely human skill: the ability to recall a specific past event. Scrub jays, for example, seem to know how long ago they cached a particular kind of food, and they manage to retrieve it before it spoils.

Human cognitive psychologists call this kind of memory “episodic memory” and argue that it can exist only in a species that can mentally travel back in time. Despite Clayton’s studies, some refuse to concede this ability to the jays. “Animals are stuck in time,” explained Sara Shettleworth, a comparative psychologist at the University of Toronto in Canada, meaning that they don’t distinguish among past, present, and future the way humans do. Since animals lack language, she said, they probably also lack “the extra layer of imagination and explanation” that provides the running mental narrative accompanying our actions.

Such skepticism is a challenge for Clayton. “We have good evidence that the jays remember the what, where, and when of specific caching events, which is the original definition of episodic memory. But now the goalposts have moved.” It’s a common complaint among animal researchers. Whenever they find a mental skill in a species that is reminiscent of a special human ability, the human cognition scientists change the definition. But the animal researchers may underestimate their power—it is their discoveries that compel the human side to shore up the divide.

“Sometimes the human cognitive psychologists can be so fixed on their definitions that they forget how fabulous these animal discoveries are,” said Clive Wynne of the University of Florida, who has studied cognition in pigeons and marsupials. “We’re glimpsing intelligence throughout the animal kingdom, which is what we should expect. It’s a bush, not a single-trunk tree with a line leading only to us.”

Some of the branches on that bush have led to such degrees of intelligence that we should blush for ever having thought any animal a mere machine.

In the late 1960s a cognitive psychologist named Louis Herman began investigating the cognitive abilities of bottlenose dolphins. Like humans, dolphins are highly social and cosmopolitan, living in subpolar to tropical environments worldwide; they’re highly vocal; and they have special sensory skills, such as echolocation. By the 1980s Herman’s cognitive studies were focused on a group of four young dolphins—Akeakamai, Phoenix, Elele, and Hiapo—at the Kewalo Basin Marine Mammal Laboratory in Hawaii. The dolphins were curious and playful, and they transferred their sociability to Herman and his students.

“In our work with the dolphins, we had a guiding philosophy,” Herman says, “that we could bring out the full flower of their intellect, just as educators try to bring out the full potential of a human child. Dolphins have these big, highly complex brains. My thought was, ‘OK, so you have this pretty brain. Let’s see what you can do with it.’”

To communicate with the dolphins, Herman and his team invented a hand- and arm-signal language, complete with a simple grammar. For instance, a pumping motion of the closed fists meant “hoop,” and both arms extended overhead (as in jumping jacks) meant “ball.” A “come here” gesture with a single arm told them to “fetch.” Responding to the request “hoop, ball, fetch,” Akeakamai would push the ball to the hoop. But if the word order was changed to “ball, hoop, fetch,” she would carry the hoop to the ball. Over time she could interpret more grammatically complex requests, such as “right, basket, left, Frisbee, in,” asking that she put the Frisbee on her left in the basket on her right. Reversing “left” and “right” in the instruction would reverse Akeakamai’s actions. Akeakamai could complete such requests the first time they were made, showing a deep understanding of the grammar of the language.

“They’re a very vocal species,” Herman adds. “Our studies showed that they could imitate arbitrary sounds that we broadcast into their tank, an ability that may be tied to their own need to communicate. I’m not saying they have a dolphin language. But they are capable of understanding the novel instructions that we convey to them in a tutored language; their brains have that ability.

“There are many things they could do that people have always doubted about animals. For example, they correctly interpreted, on the very first occasion, gestured instructions given by a person displayed on a TV screen behind an underwater window. They recognized that television images were representations of the real world that could be acted on in the same way as in the real world.”

They readily imitated motor behaviors of their instructors too. If a trainer bent backward and lifted a leg, dolphin would turn on its back and lift its tail in the air. Although imitation was once regarded as a simpleminded skill, in recent years cognitive scientists have revealed that it’s extremely difficult, requiring the imitator to form a mental image of the other person’s body and pose, then adjust his own body parts into the same position—actions that imply an awareness of one’s self.

“Here’s Elele,” Herman says, showing a film of her following a trainer’s directions. “Surfboard, dorsal fin, touch.” Instantly Elele swam to the board and, leaning to one side, gently laid her dorsal fin on it, an untrained behavior. The trainer stretched her arms straight up, signaling “Hooray!” and Elele leaped into the air, squeaking and clicking with delight.

“Elele just loved to be right,” Herman said. “And she loved inventing things. We made up a sign for ‘create,’ which asked a dolphin to create its own behavior.”

Dolphins often synchronize their movements in the wild, such as leaping and diving side by side, but scientists don’t know what signal they use to stay so tightly coordinated. Herman thought he might be able to tease out the technique with his pupils. In the film, Akeakamai and Phoenix are asked to create a trick and do it together. The two dolphins swim away from the side of the pool, circle together underwater for about ten seconds, then leap out of the water, spinning clockwise on their long axis and squirting water from their mouths, every maneuver done at the same instant. “None of this was trained,” Herman says, “and it looks to us absolutely mysterious. We don’t know how they do it—or did it.”

He never will. Akeakamai and Phoenix and the two others died accidentally four years ago. Through these dolphins, he made some of the most extraordinary breakthroughs ever in understanding another species' mind—a species that even Herman describes as "alien," given its aquatic life and the fact that dolphins and primates diverged millions of years ago. "That kind of cognitive convergence suggests there must be some similar pressures selecting for intellect," Herman said. "We don't share their biology or ecology. That leaves social similarities—the need to establish relationships and alliances superimposed on a lengthy period of maternal care and longevity—as the likely common driving force."

"I loved our dolphins," Herman says, "as I'm sure you love your pets. But it was more than that, more than the love you have for a pet. The dolphins were our colleagues. That's the only word that fits. They were our partners in this research, guiding us into all the capabilities of their minds. When they died, it was like losing our children."

Herman pulled a photograph from his file. In it, he is in the pool with Phoenix, who rests her head on his shoulder. He is smiling and reaching back to embrace her. She is sleek and silvery with appealingly large eyes, and she looks to be smiling too, as dolphins always do. It's an image of love between two beings. In that pool, at least for that moment, there was clearly a meeting of the minds.

Source: http://ngm.nationalgeographic.com/2008/03/animal-minds/virginia-morell-text