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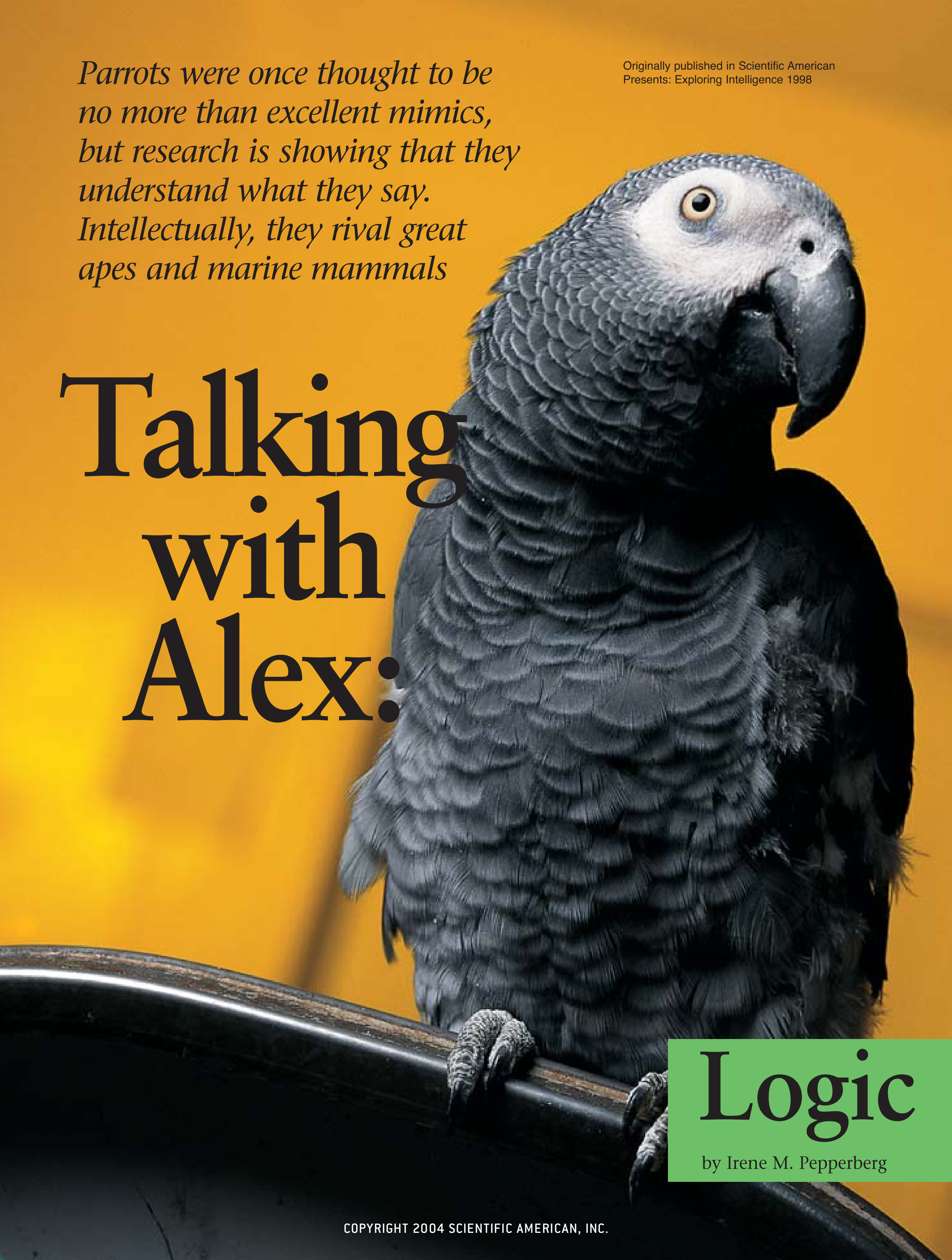
Parrots were once thought to be no more than excellent mimics, but research is showing that they understand what they say. Intellectually, they rival great apes and marine mammals

Talking with Alex: Logic

by Irene M. Pepperberg



Bye. I'm gonna go eat dinner. I'll see you tomorrow," I hear Alex say as I leave the laboratory each night. What makes these comments remarkable is that Alex is not a graduate student but a 22-year-old Grey parrot.

Parrots are famous for their uncanny ability to mimic human speech. Every schoolchild knows "Polly wanna cracker," but the general belief is that such vocalizations lack meaning. Alex's evening good-byes are probably simple mimicry. Still, I wondered whether parrots were capable of more than mindless repetition. By working with Alex over the past two decades, I have discovered that parrots can be taught to use and understand human speech. And if communication skills provide a glimpse into an animal's intelligence, Alex has proved that parrots are about as smart as apes and dolphins.

When I began my research in 1977, the cognitive capacity of these birds was unknown. No parrot had gone beyond the level of simple mimicry in terms of language acquisition. At the time, researchers were training chimps to communicate with humans using sign language, computers and special boards decorated with magnet-backed plastic chips that represent words. I decided to take advantage of parrots' ability to produce human speech to probe avian intelligence.

My rationale was based on some similarities between parrots and primates. While he was at the University of Cambridge, Nicholas Humphrey proposed that primates had acquired advanced communication and cognitive skills because they live and interact in complex social groups. I thought the same might be true of Grey parrots (*Psittacus erithacus*). Greys inhabit dense forests and forest clearings across equatorial Africa, where vocal communication plays an important role. The birds use whistles and calls that they most likely learn by listening to adult members of the flock.

Further, in the laboratory parrots demonstrate an ability to learn symbolic and conceptual tasks often associated with complex cognitive and communication skills. During the 1940s and 1950s, European researchers such as Otto D. W. Koehler and Paul Lögler of the Zoological Institute of the University of Freiburg had found that when parrots are exposed to an array of stimuli, such as eight flashes of light, some of them could subsequently select a set containing the same number of a different type of object, such as eight blobs of clay. Because the birds could match light flashes with clay blobs on the basis of number alone means that they understood a representation of quantity—a demonstration of intelligence.

But other researchers, including Orval H. Mowrer, found that they were unable to teach these birds to engage in referential communication—that is, attaching a word "tag" to a particular object. In Mowrer's studies at the University of Illinois, a parrot might learn to say "hello" to receive a food reward when its trainer appeared. But the same bird would also say "hello" at inappropriate times in an attempt to receive another treat. Because the parrot was not rewarded for using the word incorrectly, eventually it would stop saying "hello" altogether. Some of Mowrer's parrots picked up a few mimicked phrases, but most learned nothing at all.

Because parrots communicate effectively in the wild, it occurred to me that the failure to teach birds referential speech might stem from inappropriate training techniques rather than from an inherent lack of ability in the psittacine subjects. For whatever reason, parrots were not responding vocally to the standard conditioning techniques used to train other species to perform nonverbal tasks. Interestingly, many of the chimpanzees that were being taught to communicate with humans were not being trained with the standard paradigms; perhaps parrots would also respond to nontraditional training. To test this premise, I designed a new method for teaching parrots to communicate.

Go Ask Alex

The technique we use most frequently involves two humans who teach each other about the objects at hand while the bird watches. This so-called model/rival (M/R) protocol is based, in part, on work done by Albert Bandura of Stanford University. In the early 1970s Bandura showed that children learned difficult tasks best when they were allowed to observe and then practice the relevant behavior. At about the same time, Dietmar Todt, then at the University of Freiburg, independently devised a similar technique for teaching parrots to replicate human speech.

In a typical training session, Alex watches the trainer pick up an object and ask the human student a question about it:

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for example, "What color?" If the student answers correctly, he or she receives praise and is allowed to play with the object as a reward. If the student answers incorrectly, however, the trainer scolds him or her and temporarily removes the object from sight. The second human thus acts as a model for Alex and a rival for the trainer's attention. The humans' interactions also demonstrate the consequences of an error: the model is told to try again or to talk more clearly.

We then repeat the training session with the roles of trainer and model reversed. As a result, Alex sees that communication is a two-way street and that each vocalization is not specific to an individual. In Todt's studies, birds were exposed only to pairs of individuals who maintained their respective roles. As a result, his birds did not respond to anyone other than the human who initially posed the questions. In contrast, Alex will respond to, interact with and learn from just about anyone. The fact that Alex works well with different trainers suggests that his responses are not being cued by any individual—one of the criticisms often raised about our studies. How could a naive trainer possibly cue Alex to call an almond a "cork nut"—his idiosyncratic label for that treat?

In addition to the basic M/R system, we also use supplemental procedures to enhance Alex's learning. For example, once Alex begins to produce a word describing a novel item, we talk to him about the object in full sentences: "Here's the paper" or "You're chewing paper." Framing "paper" within a sentence allows us to repeat the new word frequently and with consistent emphasis, without presenting it as a single, repetitive utterance. Parents and teachers often use such vocal repetition and physical presentation of objects when teaching young children new words. We find that this technique has two benefits. First, Alex hears the new word in the way that it is used in normal speech. Second, he learns to produce the term without associating verbatim imitation of his trainers with a reward.

We also use another technique, called referential mapping, to assign meaning to vocalizations that Alex produces spontaneously. For example, after learning the word "gray," Alex came up with the terms "grape," "grate," "grain," "chain" and "cane." Although he probably did not produce these specific new words intentionally, trainers took advantage of his wordplay to teach him about these new items using the modeling and sentence-framing procedures described earlier.

Finally, all our protocols differ from those used by Mowrer and Todt in that we reward correct responses with intrinsic reinforcers—the objects to which the targeted questions refer. So if Alex correctly identifies a piece of wood, he receives a piece of wood to chew. Such a system ensures that at every interaction, the subject associates the word or concept to be learned with the object or task to which it refers. In contrast, Mowrer's programs relied on extrinsic reinforcers. Every correct answer would be rewarded with a preferred food item—a nut, for example. We think that such extrinsic rewards may delay learning by causing the animal to confuse the food item with the concept being learned.

Of course, not every item is equally appealing to a parrot. To keep Alex from refusing to answer any question that doesn't involve a nut, we allow him to trade rewards once he has correctly answered a question. If Alex correctly identifies a key, he can receive a nut—a more desirable item—by asking for it directly, with a simple "I wanna nut." Such a protocol provides some flexibility but maintains referentiality of the reward.

What's Different, What's the Same

I began working with Alex when he was 13 months old—a baby in a species in which individuals live up to 60 years in captivity. Through his years of training Alex has mastered tasks once thought to be beyond the capacity of all but humans and certain nonhuman primates. Not only can he produce and understand labels describing 50 different objects and foods but he also can categorize objects by color (rose, blue, green, yellow, orange, gray or purple), material (wood, wool, paper, cork, chalk, hide or rock) and shape (objects having from two to six corners, where a two-cornered object is shaped like a football). Combining labels for attributes such as color, material and shape, Alex can identify, request and describe more than 100 different objects with about 80 percent accuracy.

In addition to understanding that colors and shapes represent different types of categories and that items can be categorized accordingly, Alex also seems to realize that a single object can possess properties of more than one category—a green triangle, for example, is both green and three-cornered. When presented with such an object Alex can correctly characterize either attribute in response to the vocal queries "What color?" or "What shape?" Because the same object is the subject of both questions, Alex must change his basis for classification to answer each query appropriately. To researchers such as Keith J. Hayes and Catherine H. Nissen, who did related work with a chimpanzee at the Yerkes Regional Primate Research Center at Emory University, the ability to reclassify items indicates "abstract aptitude." On such tests, Alex's accuracy averages about 80 percent.

Alex has also learned the abstract concepts of "same" and "different." When shown two identical objects or two items that vary in color, material or shape, Alex can name which attributes are the same and which are different. If nothing about the objects is the same or different, he replies, "None." He responds accurately even if he has not previously encountered the objects, colors, materials or shapes.

Alex is indeed responding to specific questions and not just randomly chattering about the physical attributes of the objects. When presented with a green, wooden triangle and a blue, wooden triangle, his accuracy was above chance on questions such as "What's same?" If Alex were ignoring the question and responding based on his prior training, he might have responded with the label for the one anomalous attribute—"color"—rather than either of the correct answers—"matter" or "shape."

Alex's comprehension matches that of chimpanzees and dolphins. He can examine a tray holding seven different objects and respond accurately to questions such as "What color is object-X?" or "What object is color-Y and shape-Z?" A correct response indicates that Alex understood all parts of the question and used this understanding to guide his search for the one object in the collection that would provide the requested information. His accuracy on such tests exceeds 80 percent.

We also used a similar test to examine Alex's numerical skills. He currently uses the terms "two," "three," "four," "five" and "sih" (the final "x" in "six" is a difficult sound for a parrot to make) to describe quantities of objects, including groupings of novel or heterogeneous items. When we show Alex a "confounded number set"—a collection of blue and red keys and toy cars, for example—he can correctly answer questions about the number of items of a particular color and form, such as "How many blue key?" His accuracy in this test, 83.3 percent,

DIALOGUE 1

Alex is shown two plant stakes and three keys on a tray.

Trainer: **How many key?**

Alex: **Wood**

Irene (*with back to tray, to trainer*): **Are there any wood?**

Trainer (*to Irene*): **Yes.**

Irene: **Try that.**

Trainer: **Okay, tell me, how many wood?**

Alex: **Two.**

Irene: **Two?**

Trainer: **Yes.**

Alex is given one stake, which he chews apart. It is replaced, and the tray is presented again.

Trainer: **Now, how many key?**

Alex: **Key.**

Trainer: **That's right, keys. How many?**

Alex: **Two wood.**

Trainer: **There are two wood, but you tell me, how many key?**

Alex: **Five.**

Trainer: **Okay, Alex, that's the number of toys; you tell me, how many key?**

Alex: **Three.**

Irene: **Three?**

Trainer: **Good boy! Here's a key.**

DIALOGUE 2

Irene: **Okay, Alex, here's your tray. Will you tell me how many blue block?**

Alex: **Block.**

Irene: **That's right, block…how many blue block?**

Alex: **Four.**

Irene: **That's right. Do you want the block?**

Alex: **Wanna nut.**

Irene: **Okay, here's a nut.** (*Waits while Alex eats the nut.*) **Now, can you tell me how many green wool?**

Alex: **Sisss…**

Irene: **Good boy!**

TRANSCRIPTS OF DIALOGUES indicate that Alex can count objects on a tray. Dialogue 1, recorded in 1986, shows that Alex can distinguish five objects of two different types—in this case, plant stakes and keys. Dialogue 2, from 1997, reveals that Alex has become more sophisticated in his ability: presented with a more complex set of objects), Alex can count the number of blue blocks and green wool balls without being distracted by the other items on the tray.

equals that of adult humans who are given a very short time to quantify similarly a subset of items on a tray, according to work done by Lana Trick and Zenon Pylyshyn of the University of Western Ontario.

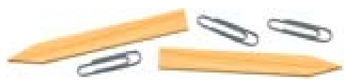
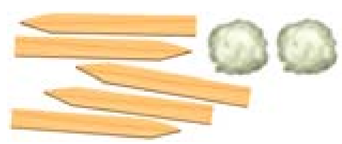
Alex also comprehends at least one relative concept: size. He responds accurately to questions asking which of two objects is the bigger or smaller by stating the color or material of the correct item. If the objects are of equal size, he responds, "None." Next, we will try to get Alex to tackle relative spatial relations, such as over and under. Such a proposition presents an added challenge because an object's position relative to a second object can change: what is "over" now could be "under" later.

One last bit of evidence reinforces our belief that Alex knows what he is talking about. If a trainer responds incorrectly to the parrot's requests—by substituting an unrequested item, for example—Alex generally responds like any dissatisfied child: he says, "Nuh" (his word for "no"), and repeats his initial request. Taken together, these results strongly suggest that Alex is not merely mimicking his trainers but has acquired an impressive understanding of some aspects of human speech.

Tricks of the Training

What is it about our technique that allows Alex to master these skills? To address that question, we enlisted a few years ago the help of Alo, Kyaaro and Griffin—three other juvenile Grey parrots. Of the many different variations on our technique we tried with these parrots, none worked as well as the two-trainer interactive system. We attempted to train Alo and Kyaaro using audiotape recordings of Alex's training sessions. The birds also watched video versions of Alex's sessions while they were in isolation (with an automated system providing rewards) or in the presence of trainers who were slightly interactive. Griffin viewed the same videos in the presence of a highly interactive human trainer who rephrased material on the video and questioned the bird directly. Although all three parrots occasionally mimicked the targeted labels presented in the interactive video sessions, they failed to learn referential speech in any of these situations.

When we then trained these birds using the standard M/R protocol, their test scores improved dramatically. In the past two years Griffin, for example, has acquired labels for seven objects and is beginning to learn his colors. The parrots' failure to learn from the alternative techniques suggests that modeling and social interactions are important for maintain-

Object set	Target items	Alex's response	Correct
	Keys	Wood	
	Wood	2	✓
	Rocks	2	✓
	Keys	3	✓
	Wood	2	✓
	Jacks	4	✓
	Yellow wool	4	✓
	Corks	2	✓
	Rocks	Rock	
	Wood	Wool	

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ALEX'S ACCURACY in identifying the number of targeted items in 1986 was 70 percent (seven out of 10 questions); now Alex is correct more than 80 percent of the time.

ing the birds' attention during training and for highlighting which components of the environment should be noted, how new terms refer to novel objects and what happens when questions are answered correctly or incorrectly. All these concepts are critical in training birds to acquire some level of human-based communication.

The M/R technique and some variants have also proved valuable in teaching other species referential communication. Diane Sherman of New Found Therapies in Monterey, Calif., uses the M/R technique for teaching language skills to developmentally delayed children. Even Kanzi, the bonobo (pygmy chimpanzee) trained by Sue Savage-Rumbaugh and her colleagues at Georgia State University, initially learned to communicate with humans via computer by watching his mother being trained—a variant of our modeling technique. Kanzi's abilities are probably the most impressive of all primates' trained to date. Chimpanzees have been taught human-based codes through a variety of techniques; however, apes that were trained using protocols similar to those developed by Mowrer demonstrated communication skills that were far less flexible and less "languagelike" than those of apes trained using systems that had more in common with our techniques.

Bird Brains

Alex continues to perform as well as apes and dolphins in tests of intellectual acuity, even though the structure of the parrot brain differs considerably from that of terrestrial and aquatic mammals. Unlike primates, parrots have little gray matter and thus not much of a cerebral cortex, the brain region associated with cognitive processing in higher mammals. Other parts of Alex's brain must power his cognitive function.

The parrot brain also differs somewhat from that of songbirds, which are known for their vocal versatility. Yet Alex has surpassed songbirds in terms of the relative size of their "vocabularies." In addition, he has learned to communicate with members of a different species: humans. With each new utterance, Alex and his feathered friends strengthen the evidence indicating that parrots are capable of performing complex cognitive tasks. Their skills reflect the innate abilities of parrots and suggest that we should remain open to discovering advanced forms of intelligence in other animals. SA

About the Author

IRENE M. PEPPERBERG's work is for the birds—or so the funding agencies first thought. "My early grants came back with pink sheets basically asking what I was smoking," she jokes. Pepperberg actually trained as a theoretical chemist: as a Ph.D. student at Harvard University, she generated mathematical models to describe boron compounds. But an episode of *Nova* featuring "signing" chimps, singing whales and squeaking dolphins drew her to her current work. "I was fascinated to see that people could study animal behavior as a career," she says. Now Pepperberg is an associate professor at the University of Arizona at Tucson, a city that brings tears to her eyes—literally. "I'm allergic to everything that grows in Tucson," Pepperberg says of the trees, grasses, molds and weeds. In 1997 she used the funds from a John Simon Guggenheim Memorial Foundation fellowship to write a book on parrot cognition and communication, *In Search of King Solomon's Ring: Studies on the Communicative and Cognitive Abilities of Grey Parrots* (currently in press).

Alex also has a life in publishing—he is the title character in *Alex and Friends,* a children's book about the animals that have learned to communicate with humans. Through the Internet, you can order a special copy—one that Pepperberg has signed and Alex has chewed. It is available at www.azstarnet.com/nonprofit/alexfoundation/ on the World Wide Web.