Science & Technology

Hanging from the Language Tree

In a famous experiment over 30 years ago, psychology professor Herb Terrace hoped to prove that chimpanzees could acquire speech. Today, as director of the Primate Cognition Laboratory at Columbia, he’s searching for the missing link to cognition.

By
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Ebbinghaus taking a metacognition test in Terrace's monkey lab. Photo courtesy of Herb Terrace.

On a nippy day in December 1973, a doctoral student named Stephanie LaFarge climbed the steps to her five-bedroom Upper West Side brownstone carrying a newborn sucking on a pacifier. The baby was not hers, or even of her species. The hairy, saucer-eyed infant was a male chimpanzee. LaFarge ’85GSAS, ’87TC planned to raise him as her own, under the guidance of her former professor Herbert S. Terrace, as part of an elaborate experiment to see if chimps could acquire language.

Terrace, a young Columbia psychologist who already had established himself as an expert in animal cognition, believed apes could learn to communicate, even think aloud, through sign language. All they needed, he thought, was a nurturing human-family environment.

At the time, the ape language wars were raging in academia. In one corner were the Chomskians, those who agreed with MIT linguist Noam Chomsky that only humans have innate syntactical ability. In the other were Skinnerians like Terrace who sided with Harvard psychologist B. F. Skinner, who believed that language is learned, and therefore could be taught to nonhuman primates.

Terrace based his beliefs on his groundbreaking Harvard dissertation, in which he proved he could teach pigeons in less than an hour how to distinguish red from green and horizontal from vertical lines. Skinner later told *New York* magazine, “Herb was one of the best graduate students I ever had, if not the best.”

When he joined the faculty at Columbia University in 1961, Terrace already had a national reputation for his work with birds. Having heard of the successes of researchers who communicated with chimpanzees, Terrace was convinced he’d get better results by immersing the chimp in a humanlike environment.

With bravado, he named the baby Nim Chimpsky. For the next four years, Nim, dressed in clothes made for toddlers, lived a life of privilege and fame. His face was splashed on magazine covers; he appeared on the *David Susskind Show*, *60 Minutes*, and *Sesame Street*. Novelist Kurt Vonnegut visited him. Tutors worked with him for hours, teaching him to sign. He seemed to be catching on, stringing together signed words to make such declarations as “banana me eat banana.”

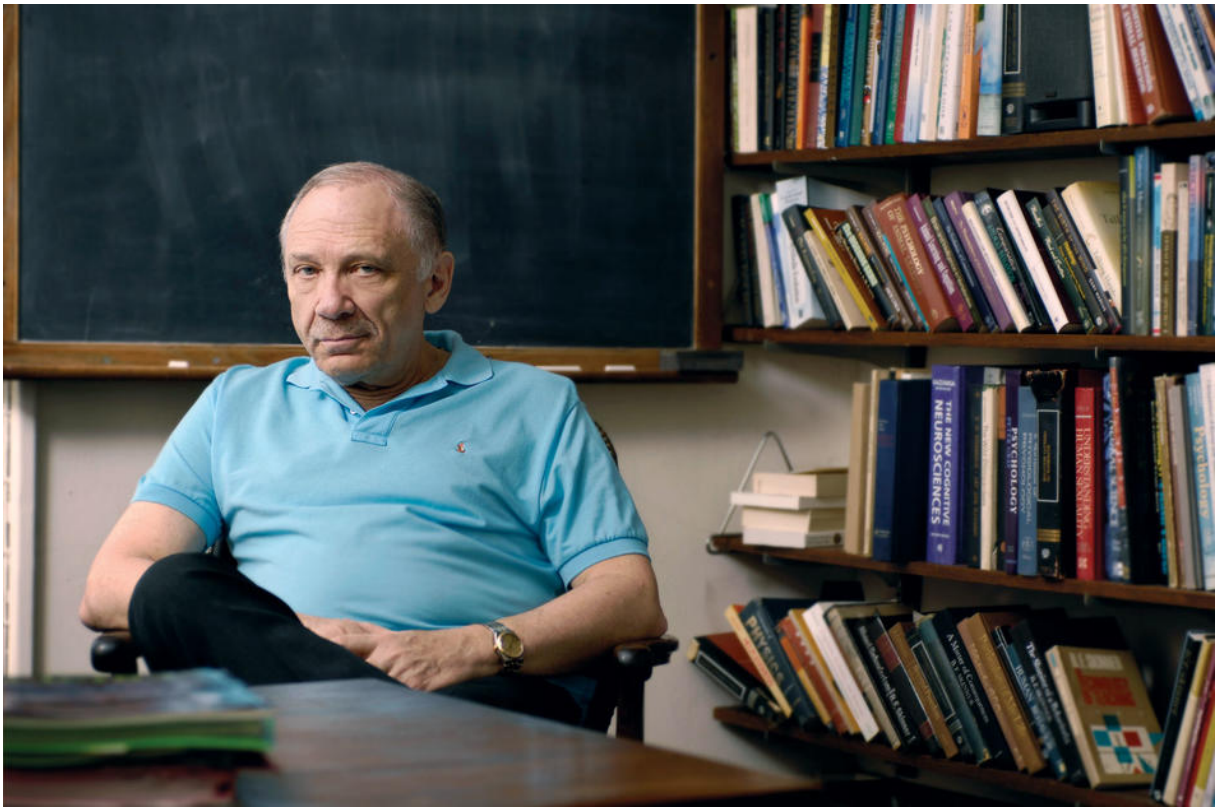
After three years of tutoring, Nim had learned 125 signs, an impressive number. But the chimp wasn’t forming sentences. Unlike children, who string words together to create sentences that become more complex as they get older, Nim’s language

abilities remained, in Terrace's words, "flat." So in 1977, four years after he picked up the infant chimp, Terrace ended the project and returned Nim to the Institute for Primate Studies in Norman, Oklahoma.

Around the same time, Terrace began working on a book about Project Nim. His research required him to review hours of videotaped sessions with the chimp. One day, while watching in slow motion, Terrace's eyes widened. He leaned forward, amazed at what he realized for the first time: Nim wasn't communicating; he was mimicking his teachers.

Terrace hit rewind, and reviewed one tape after another, astonished to find that Nim had never spontaneously signed. He was parroting his instructors, following prompts, to get a food reward.

"It was there all the time, but I didn't see it," Terrace says. "We were so busy focusing on the chimp that we weren't paying attention to the teacher. Once it was clear, it was clear. I knew I had to tell the world."



Herb Terrace (Tanit Sakakini)

Terrace wondered whether it was just Nim or if other famous apes had fooled their researchers. He began analyzing videos of other investigators: Allen and Beatrice Gardner and their chimp Washoe; and Francine Patterson and her gorilla Koko. Examining freeze-frames, Terrace could see that the apes were being inadvertently prompted. The evidence was damning: apes, he concluded, can't learn language.

Terrace, along with a Columbia psycholinguist and two graduate students, published their findings in a 1979 article in *Science*. He also acknowledged publicly that Chomsky was right.

"For the moment, our detailed investigation suggests that an ape's language learning is severely restricted," Terrace wrote. "Apes can learn many isolated symbols (as can dogs, horses, and other nonhuman species), but they show no unequivocal evidence of mastering the conversational, semantic, or syntactic organization of language."

He was not prepared for the response. The article angered many primate cognition researchers, who feared it would impede their work. And they were right; funding for ape language-acquisition studies fell.

Thirty years later, sitting in his Schermerhorn Hall office, Terrace, 72, still feels reverberations: "I have a reputation for being a killjoy." But that wasn't his intention. "I had this fantasy that I was going to be Dr. Doolittle," Terrace says. "Everybody wanted the chimps to have language, as did I originally. What would be better? It would have been the first time we communicated with another species."

Terrace's work with Nim allowed him to witness the remarkable adaptive behavior and intelligence of chimps. Nim easily learned how to wash dishes, use a toilet, and fish (with his hands). He was also cunning: the chimp could trick people into giving him things he craved — pizza, ice cream, beer.

"It was clear that the chimp was very smart and was thinking, but, contrary to Descartes, he was thinking without language," Terrace says.

(Several other researchers insist that their apes do understand language and can communicate using signs and vocalizations. Terrace's response: knowing the words for objects is not the same as using words in different combinations to form new thoughts, which is the hallmark of language acquisition.)

Terrace has a theory of how language developed in humans, and it has much to do with early intimate socialization. Those who don't get it — as was the case for thousands of Eastern European children orphaned during World War II — struggle to speak. The longer children are deprived of human interaction, the harder it is for them to talk. Terrace asks the question: if a baby were left on a deserted island with food and shelter, would it eventually on its own utter a word? The evidence suggests he wouldn't.

This is the same problem autistic children face. Infants acquire language by watching their parents mouth sounds. Babies begin uttering monosyllabic words by the time they are about a year old. By 18 months, a child can point to an object, and name it — something he learns by following the eyes of his parent. Humans have a white sclera surrounding a dark iris, unlike all other animals, making it easy for babies to see where adults are looking. One of the early symptoms of autism is the inability of a baby to see where someone is pointing; instead, they often look at the gesturing hand.

Terrace's work with monkeys helps us have a better understanding of how we process information in the absence of language, which is the foundation that we built upon when we learned to speak.

As Terrace moves forward, people continue to resurrect the past. Just last year the book *Nim Chimpsky: The Chimp Who Would Be Human* came out. James Marsh, the director of the Oscar-winning documentary Man on Wire, is currently working on a piece about Project Nim for the BBC.

While the public knows him for his experiment with Nim, Terrace is revered by his peers for his body of work that spans five decades. Robert Hampton, a primate cognition specialist at Emory University, calls him a "leader in the cognitive revolution." This March, the Comparative Cognition Society, a nonprofit organization of scientists, honored Terrace with a lifetime achievement award for his "Outstanding Contributions to the Study of Cognitive Processes in Animals."

For the past 30 years, Terrace has been investigating primate intelligence. He's concerned with these questions: In the absence of language, how do monkeys process information? What is their mental framework? How do they form thoughts? What do they think about?

“I decided to study thinking without language,” Terrace says, “and in particular, how monkeys create sequences in the absence of language.”

Entering the Minds of Monkeys

The hall is long, wide, devoid of color or natural light. White cinder block walls. White ceilings. The cement floors are painted a drab, high-gloss grey. In this sterile environment, in a building on the health science campus, Terrace’s monkeys are helping him make sense of how our minds work.

He works exclusively with rhesus macaques, monkeys that have hairless beige faces that resemble rubber masks. The rest of their bodies, with the exception of their rear ends, are covered with hair. Most of them are brown and tan. Oberon is an exception; his hair is shock white, even though he’s no older than the others. They have long tails, which lie flat when they’re sitting.

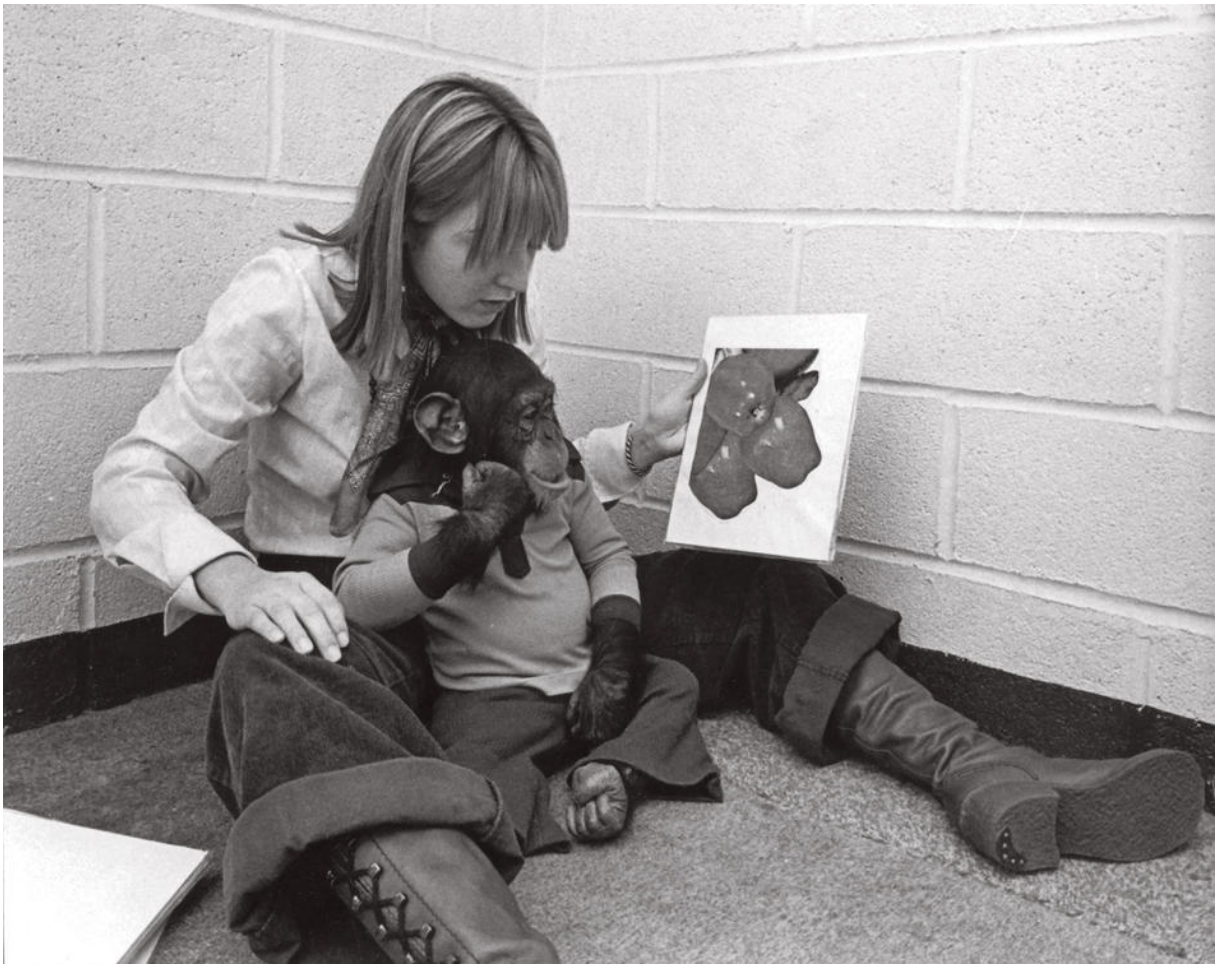
Most of them — Macduff, Oberon, Prospero, Horatio, Augustus, Benedict — are named for Shakespearean characters. Terrace also named a couple as homage to two of his favorite composers, Mozart and Coltrane, and two others for pioneering psychologists, Lashley and Ebbinghaus.

The monkeys play and sleep in individual cages so they won’t hurt each other. Vet technicians check on them regularly, feed them Purina Monkey Chow, and give them apples and oranges throughout the day. They place the monkeys in an exercise pen for hours at a time, where they swing and dangle from ropes and branches. But each weekday morning, for about an hour, the monkeys take part in elaborate tests.

Terrace and a team of lab assistants and graduate students are currently conducting four studies with the monkeys. One tests their ability to memorize and recall information. Another shows the monkey’s ability to demonstrate logic and reasoning. Another records their understanding of thematic concepts. A fourth tests metacognition — their ability to think about their thinking.

The trials are conducted in four-foot-square testing chambers, about twice the height of the monkeys, where monkeys tap on touch-screen monitors to record their choices. If they answer correctly, banana pellets pop out of a dispenser. A miniature camera records their actions, which are displayed on a video screen for technicians

to observe. The computers also record how fast they answer, when they pause, and for how long.



Nim learns the sign for apple from one of his favorite instructors, Laura-Ann Petitto. Photo courtesy of Herb Terrace.

Since there are five chambers, only five monkeys can work at any given time. They seem eager to step inside, to get their crack at winning a snack. It is Lashley's turn. The green-eyed monkey scurries into the testing chamber. Before him, a series of photographs appears on the screen: a person, a fish, a bird, and flowers. In this test, Lashley must remember these concepts in that order. The screen is cleared and then displays new photos. One after the next, Lashley gets it right. Natalie Portman, a goldfish, a cardinal, daisies. Then, Halle Berry, a school of fish, a raven, a yellow tulip. And so on.

Following each correct sequence, a token appears on the edge of the screen, signaling to Lashley that he was correct. After several consecutive correct trials, tokens accumulate to the top of his bank, letting Lashley know that he is about to

win. He sticks his hand under the dispenser, and out pops a banana pellet.

Lashley is named for Karl Spencer Lashley, an American psychologist known for his pioneering work in the area of memory. One of Terrace's star monkeys, he's been the subject of three papers published in *Psychological Science*.

So far, it seems the rhesus macaques involved in this test — Augustus, Coltrane, Mozart, and Lashley — are able to distinguish the four groups, which, Terrace says, is remarkable, considering they have never seen birds or fish. Even more surprising is the monkeys' ability to respond to these categories in a specific order — humans, fish, birds, flowers — even though they are seeing new photographs each time.

The lab's computers have more than 2000 photographs of each category and include a wide variety of angled shots so the monkeys don't latch onto one feature, such as beaks, to figure out which one is a bird. The monkeys can pick out a bird even based on a close-up shot of a wing.

While other labs have tested chimps' understanding of single categories, or concepts, Terrace's lab is the first to show that monkeys can distinguish among four categories and order them into arbitrarily defined sequences. Their performance has revealed a higher level of cognition than was previously thought possible. Even children can't do this well until the age of four or five.

Monkeys not only understand concepts, they also can memorize long lists of items and recall them — even months later. "Clearly this is thinking without language," Terrace says. "This kind of machinery was there as long as 50 million years before humans even appeared in evolution. So when humans developed language, it had this and other nonverbal skills to build upon."

A popular theory among psychologists who work with nonhuman primates is that apes and monkeys form thoughts by conjuring images in their minds without the need to attach words to concepts. Using this thought process, Terrace says, monkeys can think in abstract terms, and can even understand the limitations of their knowledge and strategize ways to improve what they know, what psychologists call metacognition.

Metacognition studies on animals are still in their infancy. The first paper on the topic was published in 1997 by J. David Smith, a psychologist at the State University

of New York at Buffalo. The test subjects were dolphins.

“Twenty years ago a lot of people would have said it was impossible to answer the question, ‘Can monkeys think about their thinking?’ ” says Hampton, who also does cognitive research on rhesus macaques. “But now we’re fairly confident that monkeys regulate their own thinking and can comment on it.”

High-Stakes Testing, Monkey-Style

These days, Terrace is in the midst of perfecting a metacognition test he believes will provide further evidence that monkeys can use the highest level of problem-solving skills, regulating their thinking in a manner that suggests to some psychologists that they have a reflective conscious.

In this test, monkeys are shown five to nine photographs, which they have to memorize. Then, several photographs appear on a screen, with some distracter photographs. The monkey has to decide which photographs were shown in the original bunch by tapping on a “yes” or “no” icon. Next comes the tricky part: they have to decide how well they think they did and place bets on their own performance. It forces them to think: did I do poorly or ace it?

They can bet “high,” which will give them more banana pellets if they are right, but if they’re wrong, they will see the tokens on the screen disappear. If they bet “low,” they don’t lose much, but all they stand to win is a single banana pellet. So they need to think smart and be discerning if they want to win a jackpot of banana pellets.

If the monkeys seem to be getting bored of the tests, Terrace ups the ante by replacing the banana pellets with M&M’s. “It’s as if now you’re playing poker for fifty dollars instead of ten dollars,” he says.

Monkeys hate to lose, especially when their reward is a snack. On occasions when they lose any chance of getting a banana pellet, they act eerily like someone at a casino who has lost a huge amount of money. They stare at the computer monitor and shriek in disbelief as they watch the tokens disappear from the screen. They frown. They fall backward. They cover their faces with their arms. The losses seem to make them strive to do better next time, says Terrace.

Ebbinghaus, named for the German psychologist Hermann Ebbinghaus, is the new star of the bunch. On a new test given recently, he was able to assess whether he did poorly, OK, or very well. He chose high risk and was accurate 77 percent of the time.

The results have huge significance. “This shows us that he’s choosing discriminatively,” says Gin Morgan, one of Terrace’s graduate students who helped devise and run the test. “It means that he not only understands the task but, more important, that he can reflect on his performance and decide whether or not it was correct.”

Bones Are of No Use

Through the study of primate cognition, we get clues about how the minds of humans evolved. “If you want to study cognition, this is where you go,” Terrace says. “The monkeys are a tool that allows us to go into the past of our own ancestry so we can have an understanding of how cognition evolved. This stuff doesn’t fossilize. Bones aren’t going to help you.”

Present-day monkeys, in other words, have minds that are similar to our common ancestors, a species that split from the line that led to humans millions of years ago. By studying their minds, researchers are able to understand the foundation of mental processes that evolved into the more complex mind of humans.

“By understanding the way a monkey’s mind works, we have a glimpse of the possibility of how a baby’s mind develops,” says Lisa Son, an assistant professor of psychology at Barnard College who studied under Terrace and continues to collaborate with him. Son runs a child cognition lab at Barnard and says there are limitations on what you can glean from testing kids. “There are so many questions I want to answer about humans that you can get only from studying nonhumans,” Son says. “I know that sounds odd, that it sounds counterintuitive, but it’s true.”

“It’s a basic principle of science,” says Terrace. “If you want to understand something complex, start with the simplest preparation and see how it got there.”

Metacognition research also is helping educators who have struggled to find ways to teach autistic children. Three years ago, Terrace adapted one of his video skills tests for autistic children in a New Jersey school, and it proved more effective in teaching children math than having an instructor work directly with them. Because most autistic children have difficulty socializing, they learn more easily from machines than from people.

It is with a determined zeal that Terrace is hunting for answers about how humans gained the ability to speak, based on a theory he has developed. He plans to lay out his findings in a book he hopes to publish next year. In it, he'll explain how the foundation of thought processes in monkeys became a foundation for humans, who developed a more sophisticated way of communicating. He wouldn't have learned that without Ebbinghaus or Lashley, and certainly not without Nim Chimpsky.

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