BRAINPOWER: GROUNDBREAKING THINKERS IN WISCONSIN

Decoding calls of the wild

Marquette's 'Dr. Dolittle' uses computers to unlock the meaning behind snorts, rumbles and cheeps

By MARK JOHNSON
markjohnson@journalsentinel.com

Posted: Oct. 20, 2007

In childhood, Dr. Dolittle never had a pet of his own. The family kept fish, but he did not name or talk to them, feed them or clean their tanks. His enduring memory is that once, when he was 4 or 5, he banged the aquarium with a wooden block until the glass broke, and a catfish spilled out and flopped about on the floor.

By his own admission, Dr. Dolittle wasn't "a big animal person." In some respects, he still isn't.

He's more of a computer person, one who talks to technology the way others talk to pets, with an occasional flash of tough love -"Better not freeze up on me, or I'll get mad."

His real name is Michael Johnson, and he's a 40-year-old Marquette University engineering professor, founder of the ambitious but little-known Dr. Dolittle Project. In a small lab at the Olin Engineering Center, Johnson puts recordings of whales, birds and elephants through sophisticated computer analysis, leading to important advances in the understanding of animals.

His work is changing the way we listen to our fellow creatures and might just help us discover a language in their songs and rumbles. If such a claim sounds outrageous, consider an animal much on Johnson's mind of late: the prairie dog, spurned by ranchers and farmers across the West.

A little more than a year ago, Johnson opened a large business envelope from Arizona, and out slid papers from a researcher who has been studying prairie dog communications for 20 years. That's a long time, especially when you consider that these rodents from the squirrel family appear to have a limited repertoire, all of which sounds like *cheep*!

But through years of experiments and observation, Con Slobodchikoff, a biology professor at Northern Arizona University, has discovered that prairie dogs make different calls when they see a human, or a coyote, or a red-tailed hawk. Show a prairie dog pictures of an oval, circle and triangle, and it will make distinctive calls for each.

In fact, a single prairie dog *cheep* lasting one-tenth of a second might convey the following information: There is a human wearing a green shirt who is tall and walking slowly.

"So far, I feel we've found the most sophisticated animal language that's been described," Slobodchikoff says. "The problem that I have, what I want to know now is: Where in the prairie dog call is the word *green* encoded?"

That question led the prairie dog expert to a husky man with a thick mustache and a habit of exclaiming "Coolness!"

Dr. Dolittle.

****

In the five years since Johnson launched the Dr. Dolittle Project, he has helped researchers at Disney's Animal Kingdom discover that elephants, like humans, have unique voices, and that female elephants use a particular rumble, a kind of *come hither* voice, to signal males when they're ready to mate.

His work enabled scientists at University of Connecticut to show that beluga whales engage in a human response to noise known as the Lombard effect. Like friends trying to talk over the din at a party, whales raise their voices to be heard over the drone of ships in the St. Lawrence River estuary.

When another researcher in Connecticut sent recordings of 200 chickens clucking in a single room, Johnson was able to determine that some were stressed. This is important because a stressed chicken produces fewer eggs.

By taking techniques used to examine human speech and tailoring them to the study of animals, Johnson "made a major leap," says Michael Darre, a professor of animal and poultry science at the University of Connecticut. Darre, who examined the connections between chicken calls and stress, is now expanding this work to hogs, horses and dairy cattle.

"A lot of it," he says, "is because Mike Johnson has spurred us on."

"I think it's great work. Insightful," says John R. Buck, who teaches in the department of electrical and computer engineering at the University of Massachusetts Dartmouth. Buck compares Johnson's innovations to "building a better set of binoculars" for animal researchers.

The Dolittle work has broad applications, from keeping animals happy in captivity to developing a precise census of endangered species from recordings in the wild.

But the implications of Johnson's project go well beyond such matters to address our long-established views of the other inhabitants on Earth.

"Essentially we're saying there's a gulf between us and the rest of the animals, and this gulf is based on language," Slobodchikoff says. "Because we have language, we can think about the world. They can't think about the world because they don't have language."

If they do have language, however, and if it shows sophistication, "that starts to blur the distinction between us and other animals," he says.

Either way, the Dolittle research will be followed by people with different agendas - animal rights groups, their opponents, even some scientists who have lost the ability to view animals objectively.

That is why Johnson avoids giving animals human characteristics - the kind of funny voices and personalities millions of people invent for their pets.

"I don't want to put words in the animals' mouths," Johnson says. "I have run into people who have basically decided a priori that animals have feelings, that animals do talk, and that becomes a fundamental driving force and it messes up their research. . . . If it turned out that a species has absolutely no language structure, and they make a bunch of random noises - say I found that out - that needs to be OK."

****

Over the years, Johnson's view of animals has evolved into the kind of complex picture other people develop of religion, science, progress or morality.

In adulthood, he has shared his home with one pet, Lady, a shepherd mix. He wrestled and played fetch with Lady, but when she died several years ago at the age of 10, he did not put up a monument or bury her ashes. For many months, though, he felt an emptiness each time he entered the house and realized she would not be bounding up to greet him.

Scientific objectivity has not precluded Johnson from marveling at animals in zoos. On the contrary, he and his wife, Patricia, have "collected zoos" since they began seeing each other 18 years ago as undergraduates at LeTourneau University, a private Christian school in Longview, Texas. They have continued the tradition with their daughter, Evy, 3, a frequent visitor to the Milwaukee County Zoo.

Maps of the United States and the world hang in their Brookfield basement with pins stuck into every city where they've visited a zoo: six on the world map, including Belize, Paris and Beijing; 38 on the U.S. map, including Tyler, Texas, the zoo the Johnsons strolled through on one of their first dates.

As they've added pins, Patricia Johnson has watched her husband take greater interest in zoo conditions. He dislikes seeing social animals such as elephants penned in by themselves. In fact, he'd be quite content to see conservationists cite the Dolittle work to support their cause.

For Johnson, animals occupy the crossroads where his views as a scientist intersect with his views as a Christian, one who takes seriously the notion that humans must be stewards of the Earth.

The scientist is fascinated by the complexity of animal behavior. The way 30 dolphins form a circle in the ocean around smaller fish, then close the circle and take turns swimming inside to feed. The way birds make two vocal sounds at once - something beyond the ability of humans. The way one elephant signals another from its social group, even though the two are miles apart.

The Christian finds something spiritual in the science.

"There's a design to what you see, and it inspires you with a sense of beauty and awe," Johnson says. "And if you're a Christian, it inspires you with a sense of a creator who made these things in such a phenomenal way. The more you study it, the more you realize how intricate the design is."

Still, after years of study, Johnson remains more engineer than animal expert. On one occasion, he speaks of a "tribe of elephants" for several moments before correcting himself. "They're not really tribes. They're herds."

****

Johnson was born in Chicago into a home intentionally bereft of pets. Elmer Johnson, his father, had strong feelings about the treatment of animals.

"Elmer grew up on a dairy farm in northern Wisconsin," says Darlene Johnson, Michael's mother. "He just really believed that animals should not be cooped up in a house in the city."

Michael's early detachment toward animals had one notable exception: elephants. Once, when he was 7 or 8, he got lost at the circus, lingering in front of an exhibit after his Sunday school class had moved on. His eyes fixed on the elephants. with their long trunks and fanlike ears, the embodiment of what it means to be different.

The oldest of four children, Michael was bright, a little chunky and sure of himself. He excelled in math and science and read "The Wizard of Oz" and "Lord of the Rings."

But it was another children's series that earned an enduring place in his heart: the Doctor Dolittle books, written between 1920 and 1952 by the British author Hugh Lofting. Like an earlier generation of children, Johnson found himself drawn to the magical notion of communicating with animals.

At the same time, he could be quite skeptical and independent.

"He was probably in middle school when he told us at the dinner table that he wasn't sure about this God thing," Darlene Johnson recalls. "He was going to figure it out on his own."

Soon after the family moved to Marion, Ohio, his gifts became evident. In ninth grade, he won a citywide science fair with a project on nuclear energy. His project included an actual World War II bombshell and a paper diagram illustrating the inside of a nuclear fission bomb.

In his senior year, Johnson took calculus at a satellite campus of Ohio State University. He'd also discovered computers and was writing his own programs for games of the Space Invaders variety.

Despite his intelligence and independence, he never quite abandoned childhood. As a boy, he had walked through the house, singing the Peter Pan anthem, "I Won't Grow Up."

For his 17th birthday, Johnson went to Chuck E. Cheese. The restaurant's entertainers, in their furry animal suits, seemed uncertain how to perform for a birthday boy old enough to drive.

****

Even in college, he saw the world the way a computer might.

He shot pool and saw geometry in motion. He played poker and thought in probabilities - as good a reason as any for teaching the game to a professor's daughter years later at Purdue.

When Johnson typed commands into a primitive Tandy computer, what he saw was "a little black box that's doing something that sort of seems like thinking." That little box freed him to think creatively, unrestrained by the size or complexity of a problem.

At LeTourneau, the computer man blossomed in other ways, singing in a barbershop quartet, serving as newspaper editor and student vice president, and seldom lacking for dates on Saturday night. After graduating in 1990, he married and set out on a conventional engineering career path - at least in the beginning.

Johnson worked for a couple of consulting companies in Dallas, moved to San Antonio to work for a technology firm called Datapoint and began pursuing a master's degree at night. In January 1993, after a year and a half at Datapoint, Johnson was laid off. Four months of unemployment left a temporary crack in his confidence but allowed him to finish his master's degree.

Later that year, the Johnsons moved north to be closer to their families, and Michael took a job developing communications systems for a company in Oshkosh. Although he enjoyed the work, he grew restless.

One evening in 1996, he was describing his career frustrations to his wife. Well, she asked, what do you want to do?

As he spoke, she scribbled a list. Teaching. Research. Cool engineering projects. Don't these require a doctorate? she asked. And there was the answer: He would return to school.

Johnson went to Purdue University to study communications and signal processing, knowing little about the work, only that it seemed interesting.

While his wife earned a master's in industrial technology, Johnson learned the science of sound. How a shout or whisper compresses molecules as it travels through the air in waves. How those waves look when sounds are loud (tall) or soft (short), when they are high frequency (close together) or low frequency (far apart). How scientists break the pattern of waves into chunks of 15 to 30 milliseconds to view the sound fragments of a word as simple as *sun*.

Johnson found himself well-suited to this science with its reliance on mathematical tools such as Fourier transforms and hidden Markov models, devices that help scientists sort and group sounds. Moreover, as an engineer, it was his nature to attack a problem by breaking it into smaller pieces, the fundamental method of analyzing speech.

Speech almost always meant human speech, and, at Purdue, that was all Johnson studied. A professor assigned him to a research project on stuttering, for which he wrote some of the computer programs.

"I didn't teach him. He taught me," says Anne Smith, the professor who picked Johnson for the stuttering project. "Really what he's brilliant at - he's one of the few electrical engineering types I've ever met who can just explain things to you without sitting down and writing formulas."

Johnson arrived at Marquette University in August 2000. Hired to teach electrical and computer engineering, he set out to find a research project of his own.

He expected to study human speech.

****

In December 2000, Michael and Patricia Johnson celebrated their 10th wedding anniversary by visiting Disney's Animal Kingdom in Orlando, Fla. - another pin for their zoo map.

They ran across an exhibit where visitors could peer through glass into research labs, or as Michael put it: "Look, Ma, see the scientists." A video explained that the scientists had outfitted elephants with microphone collars to record their snorts and rumbles.

"We should talk to someone," Patricia Johnson said.

Michael balked. They were on vacation.

But Patricia hated to see him miss an opportunity. She approached an employee dressed in full safari gear and asked for contacts on the elephant research. The worker ducked inside the building and returned with names and e-mail addresses.

Later that day, it dawned on Michael Johnson: This might be the project he'd been seeking. Soon after returning to Milwaukee, he e-mailed the Disney researchers, and in August 2001, they sent elephant recordings.

The 140 elephant calls - a data set 1,000 times smaller than the norm for speech processing - drove home one of the great challenges of animal research. Those who study human speech can tape their subjects for hours in a studio. Animal researchers capture hours of silence and background noise while waiting for their subjects to sing, snort or chirp.

Researchers had labeled the 8- to 10-second rumbles based on what the elephants appeared to be doing, either saying "Hi" (a contact rumble) or telling others to follow (a kind of "Let's go!" rumble). Johnson and Marquette doctoral student Patrick Clemins wondered if their computer could tell one rumble from the other. This process of grouping animal sounds was a crucial first step toward uncovering their meaning.

"It's the equivalent of setting down the alphabet of an unknown language," says Volker Deecke, who works for the marine mammal research unit at the University of British Columbia.

A few decades ago, animal researchers went about this work without high-powered computer analysis, studying diagrams of sound, labeling them, building a database over the course of weeks and months. The methods Johnson developed could do the work in minutes, and with greater precision, finding distinctions between animal calls that once seemed identical.

The computer at Marquette correctly grouped eight of the first nine rumbles, but those were the cleanest recordings, and the number was too small to draw conclusions. When Clemins added more rumbles, accuracy dropped to 65% - not enough to say the computer was doing better than guessing. Worse yet, an early attempt to identify voices of individual elephants was only 32% accurate.

Recognizing that negative results are a fact of research, Johnson and Clemins pressed on. In the summer of 2002, they switched to hidden Markov models, seldom used for animals but state of the art in the analysis of human speech.

Some speech systems require separation between each part of a phrase (for example: Come. . . here. . . now). However, hidden Markov models account for the fluid nature of speech, by breaking each word or call into parts - the transition into a sound, the sound itself and the transition to the next sound.

Clemins further modified a system tailored to human speech by making sure the computer emphasized a much lower frequency common to elephants.

Accuracy improved. The computer hit 90% when identifying the voices of individual elephants.

By 2002, a year into the work, the project still lacked a name and grant money. Johnson sent a proposal seeking funding to the National Science Foundation, an agency that promotes advances in health and science. Months later, the grant was denied.

Still, reviewers were enthusiastic about the idea, enough so to convince Johnson it would be worth trying again.

For the second application, he and Clemins expanded the project's vision, continuing the elephant research but adding experts from other institutions who would examine the speech of beluga whales, chickens, dolphins and other species.

The work would draw on expertise from the fields of psychology, biology, linguistics, machine learning and signal processing. Johnson hoped to develop a tool kit eventually that could be used to study any species. In time, communication across the animal kingdom might begin to shed some of its mystery.

Johnson gave the research a name both ambitious and playful: The Dr. Dolittle Project.

On the morning of June 17, 2003, an e-mail from the science foundation arrived. The first words Johnson read were: "Michael: I am pleased to inform you. . . "

Although they had requested a larger sum, Johnson and Clemins were overjoyed with the five-year, $1.2 million grant. The money would pay for graduate students at Marquette and the University of Connecticut, computers and travel to conferences.

Dolittle was no longer just a fanciful children's book. It was science.

****

Leah Jamieson, the Purdue professor whose daughter Johnson had instructed in poker, calls his Dolittle work "groundbreaking."

"Applying the techniques from speech and signal processing to the world of animal vocalizations," says Jamieson, now dean of Purdue's college of engineering, "that was very different."

And, she adds, "fun."

So far, Johnson and his collaborators have published at least a half-dozen journal papers based on their work. The Dolittle project has also attracted new animal experts, including Tomasz Osiejuk, head of the behavioral ecology department at Poland's Adam Mickiewicz University. Osiejuk has been recording ortolan buntings, a small songbird in Europe and western Asia, hoping to understand the evolution, structure and meaning of their chirps.

And then, of course, there is Slobodchikoff and his prairie dogs.

Those lightning *cheeps,* so seemingly rich in information, now pose a unique challenge for Johnson and raise questions about animal speech and intelligence.

We don't know if animals have conversations in the way humans do, Johnson explains. We don't know if they ask each other questions, or remark on the warmth of the sun or chill of the ocean. Perhaps they express only basic responses to the world: hunger, fear, the drive to procreate.

If humans can isolate the part of the prairie dog *cheep* that means "green," it will be a step toward answering the larger questions.

"I don't know that we can," Johnson says, leaning back and pausing to break the question into pieces. "But if we can show experimentally that there are differences, if we can prove, therefore, that differences exist, and they exist in the signal, we have all of the information that we need. . . . The prairie dogs can tell the difference. We're smart, too. We should be able to tell the difference."

Before the child in him can be swept away by the "coolness" of the idea, the scientist has the last word.

"It may require thinking in a different way," he says. "We don't think like prairie dogs."