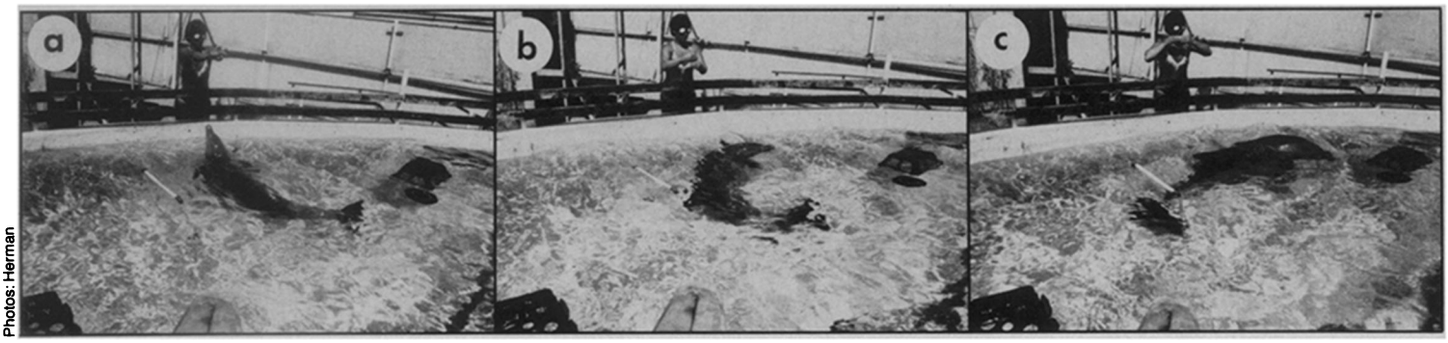


Photos: Herman

Grammar-Schooled Dolphins

By BRUCE BOWER

Phoenix, a female bottlenosed dolphin, swims deliberately through the waters of a 50-foot-wide tank at the Kewalo Basin Marine Mammal Laboratory in Honolulu, guided by a series of underwater whistlelike noises produced by computer-controlled waveform generators. Each distinctive whistle represents a word chosen by human investigators — in this case, a string of five whistles translates to SURFACE HOOP FETCH BOTTOM BASKET. Without missing a beat, Phoenix swims to a hoop on the surface and pushes it toward the tank bottom with her beak. She passes another hoop attached to the floor of the tank and a basket floating on the surface and then touches her mobile hoop to a basket on the tank bottom. The assignment is successfully completed.

Akeakamai, another bottlenosed dolphin and Phoenix's tankmate, understands and obeys similar commands that are transmitted through the hand gestures of numerous trainers.

According to investigators Louis M. Herman, Douglas G. Richards and James P. Wolz, experiments with these two aquatic creatures illustrate the ability of the dolphin to understand basic types of sentences. Phoenix and Akeakamai, the scientists say, have learned that a whistle or gesture stands for an object, action or modifier, understand the grammatical rules that allow these "words" to be combined in many ways to form sentences, respond correctly to sentences with novel word combinations and comprehend references to objects they cannot see. This is an improvement over controversial attempts to demonstrate language and sentence processing skills in apes (SN: 5/10/80, p. 298) because the focus is on comprehension, not language production, say the researchers in the March 1984 issue of COGNITION.

Some scientists are skeptical of animal language studies, including those with dolphins, while others cite the dolphin work as pioneering. Herman and his colleagues do not claim that dolphins use language in their natural world. "We used an important subset of language — imperative sentences — and showed that dolphins could understand it," says Richards, now a research associate at the Smithsonian Institution and a communications consultant at Booz, Allen & Hamilton in Bethesda, Md.

Attempts by John Lilly in the 1960s to prove that dolphins have a natural language and to teach them English gained unfortunate notoriety, he adds. Lilly's work was "poorly documented, of questionable validity and is not useful scientifically."

There are preliminary indications that Akeakamai has a limited language-producing ability. She can mimic computer-generated sounds and use them to label reliably five types of objects — a ball, Frisbee, hoop, pipe and person. But dolphin language production "is still at a very basic level," says Richards.

What researchers know about natural dolphin communication is also basic. Do ocean-dwelling animals use distinctive whistles or clicks to tell others that food is nearby or the youngsters are wandering off? No one knows for sure.

"Dolphins use vision in the wild," notes Richards, "but they're acoustically oriented. Their whole perception of the world may be different from that of humans. They're not cute little people in wet suits."

The two Hawaii-based dolphins, however, "are sensitive to grammatical structure and semantic information," says Herman, a psychologist and director of the Kewalo Basin facility. "Those are key ingredients of sentences."

Akeakamai and Phoenix's linguistic journey began in June 1978, when they were caught in shallow waters off the coast of Mississippi. Once in Honolulu, they went through a seven-month pretraining regimen during which food rewards were used to develop associations between sounds or hand gestures and objects or actions that would later turn up in the language study. Later in training, it was usually possible to teach a new word immediately by presenting a new symbol together with a new object. After a vocabulary of about 20 words was established, the dolphins were introduced to two-, three-, four- and five-word sentences.

The basic rules are that object words precede action words, and modifiers come before objects. Thus the two-word instruction WINDOW TAIL-TOUCH means "Go to any underwater window in the tank and touch it with your tail flukes." Longer sentences contain the action words FETCH or IN that refer to relations between objects. The structure of these sentences in visual language is radically different from that in acoustic language. For Phoenix, the acoustic sentence SURFBOARD FETCH SPEAKER means "Go to the surfboard [di-

Can these playful creatures learn to understand 'humanlike' sentences? In one word, yes, according to some researchers.

rect object] and take it to the speaker [indirect object]." In Akeakamai's gestural language, the grammar is reversed: The indirect object comes first, then the direct object and finally the action. The sentence SPEAKER SURFBOARD FETCH tells her to take the surfboard to the speaker. Object modifiers referring to the surface and bottom of the tank and to the dolphins' left and right can make instructions even more complex.

Dolphins who perform tricks at an oceanarium learn specific behaviors through reinforcement. Phoenix and Akeakamai, however, have learned to respond to "words" that can be combined into hundreds of different commands. They have proven adept at understanding novel sentences in which a word that has just been learned or a new combination of words is inserted into a familiar sentence form. During a set of tests conducted in late 1982, Phoenix responded correctly to 85 percent of 368 familiar and novel sentences, and Akeakamai responded correctly to 83 percent of 308 familiar and novel sentences. Most of the dolphins' errors concerned indirect objects or their modifiers. Even when errors occurred, the main thrust of a sentence was almost always understood.

The researchers went to great lengths to ensure that the dolphins did not receive nonverbal prompting from human trainers or cues from the way in which sentences were presented, although "it's darn close to impossible to eliminate all human cues," says Richards. The objects in a dolphin's vocabulary drifted randomly about the tank when a sentence was given; numerous trainers — some with minimal experience using gestures — delivered hand signals while wearing opaque goggles to mask their eye movements from the dolphins; responses were judged by an observer who did not know what instruction had been given, and all responses were videotaped to confirm the results.

Herman says these precautions lend support to his contention that the dolphins can understand grammar. When human cues were largely eliminated, he says, the animals successfully handled sentences they had never before been exposed to and made sense of sentences using different grammatical rules.

Furthermore, when longer sentences were introduced with more complex grammatical structures, the dolphins responded correctly on the first presentation of the instructions. Phoenix, for example, responded correctly to the instruction FRISBEE FETCH BOTTOM HOOP ("Take the Frisbee to the hoop on the bottom of the tank") although it was her first sentence with a modified indirect object. Modifiers were rarely attached to the wrong object by either animal.

Akeakamai was also taught a gesture for the word IN, which she then immediately incorporated into her grammatical system. On the first occasion an IN sentence was given — BASKET HOOP IN — she swam to the hoop, carried it to the basket and correctly placed it inside.

The dolphins similarly generalized about words themselves. HOOP, for instance, came to signify all types of hoops the experimenters might throw into the tank, not just the hoop originally used to train the dolphins.

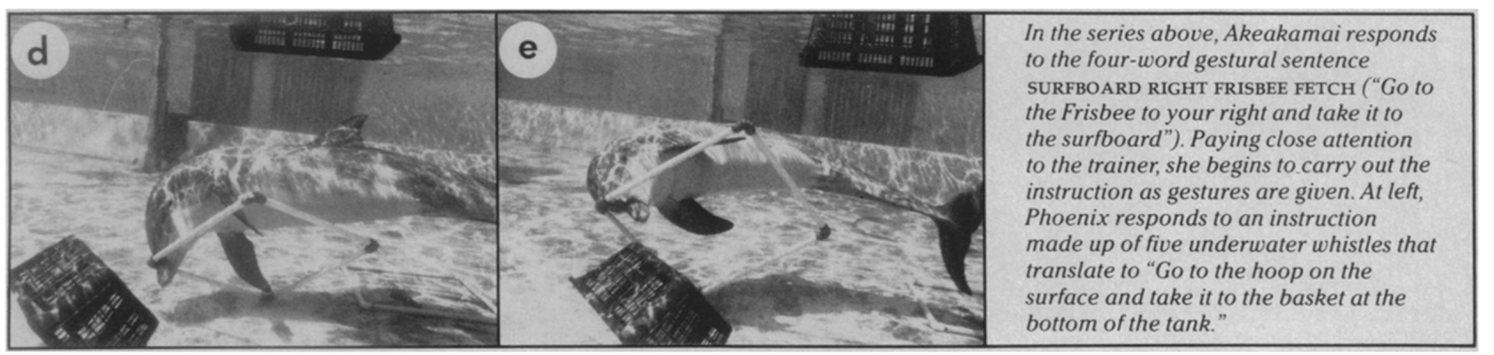
"From necessity, both dolphins over time had to develop an ability to understand sentences and search for objects in terms of object attributes rather than object locations," says Herman.

The strongest evidence that the dolphins can form mental representations of objects described in sentences comes from "displacement" tests. On these tests, the dolphin might be asked with signs or sounds to carry out some action on an object not present in the tank. Then, after a delay of 30 seconds or more, the object is introduced into the tank simultaneously with several other "distractor" objects at randomly determined locations. Almost invariably, the object indicated is responded to correctly.

The animals might also be asked BALL QUESTION ("Is there a ball in the tank?"). If there is, the dolphin presses a YES paddle; if not, she presses a NO paddle. Again, she is almost always correct.

These results indicate that dolphins may be capable of understanding more than just imperative sentences, but such linguistic abilities have yet to be explored fully, says Herman. Natural communication by animals may be more complex than is usually assumed, he adds.

On the human side, researchers of animal language should concentrate first on comprehension, which is easier to control and measure than language production or "talking," notes Richards. "Some of the ape researchers wanted to talk with animals," he says. "This may have been too ambitious."



In the series above, Akeakamai responds to the four-word gestural sentence SURFBOARD RIGHT FRISBEE FETCH *("Go to the Frisbee to your right and take it to the surfboard"). Paying close attention to the trainer, she begins to carry out the instruction as gestures are given. At left, Phoenix responds to an instruction made up of five underwater whistles that translate to "Go to the hoop on the surface and take it to the basket at the bottom of the tank."*

Ron Schusterman, a psychologist at California State University at Hayward, agrees. For the past three years, he and co-worker Kathy Krieger have tested two California sea lions for comprehension of simple imperative sentences. A third sea lion is now being trained.

"We've been able to duplicate [Herman's] dolphin results quite well up to a point," says Schusterman. Training procedures similar to those followed with the dolphins were used to teach hand gesture "words" to the sea lions. Acoustic training was omitted, although sea lions hear well. The animals built up a vocabulary of about 20 words and, he says, now understand over 500 two-, three- and four-word sentences.

When sea lions are given instructions concerning an object that is not in their tank, they have difficulty responding correctly if they have not seen it in the past 10 to 12 seconds, says Schusterman. Their performance on these "displacement" tests falls short of what the dolphins have done.

"Sea lions can't hold on to information as long as dolphins can," he notes. "Dolphins process more information and have better short-term memories." But both species, he maintains, have clearly shown that they can understand instructions contained in imperative sentences.

"Language may not be as complicated as animal psychologists tend to think of it," says Schusterman."The crucial difference between animals and humans, though, is that most animals are controlled by what's in front of them."

Some researchers are beginning to look at the degree to which apes can understand and use symbols to represent objects that may not be in front of them. Duane M. Rumbaugh and E. Sue Savage-Rumbaugh, who originally trained two chimpanzees to use geometric symbols to communicate with one another, are now conducting comprehension experiments with pygmy chimps who they say are more "humanlike" than other chimps. The Rumbaughs, of Georgia State University and the Yerkes Regional Primate Research Center in Atlanta, plan to publish their first results next year.

"The dolphin work is excellent," says Duane Rumbaugh. "At first we assumed an animal understands the use of a symbol if it reliably produces the symbol. That was wrong. Comprehension skills have to be cultivated apart from production skills."

Although animal language research is controversial, "the data base is irrefutably strong," holds Rumbaugh, and it demonstrates that nonhuman organisms are capable of some types of language comprehension and production.

Other investigators are not convinced that the dolphin work and its comprehension approach are an improvement over past efforts. "The heart of the matter is that the items the dolphins respond to all refer to [concrete objects]," says psychologist David Premack of the University of Pennsylvania in Philadelphia. "It's misleading and wrong to conclude that they understand the properties of language and sentences in the human sense."

In the early 1970s, Premack taught a chimpanzee named Sarah a "language" using colored plastic tokens arranged in patterns resembling strings of words. Questions such as "What is the color of ----?" were answered correctly when familiar objects were replaced by their plastic symbols, even when the colors were not those of the objects represented. But he concludes in *The Mind of an Ape* (1983, W. W. Norton & Co., New York) that while the chimpanzee can make distinctions in the meaning of words, there is no evidence that chimps can make grammatical distinctions necessary to use sentences.

"The dolphin research is well controlled," says Premack, "but a serious problem is the researchers' free use of the notion of a 'sentence.' Human language consists of abstract items and rules, not just objects, properties and actions."

In addition, language production and comprehension are a single system in adult humans, contends Premack. Dolphins' inability, at least so far, to produce language and understand abstract concepts demonstrates the limited nature of their language skills, he says.

This argument does not hold water with Herman. "He's upping the ante," responds the dolphin researcher, "with the traditional argument that if animals can do it, then it can't be language." But dolphins, unlike apes, have demonstrated an ability to understand grammar, he says. Furthermore, Herman notes, animal language skills may be more like those of young children; in both cases, it is not clear that production and comprehension are one system.

"Even if dolphins can't produce language, it doesn't mean they can't understand it," he adds. "I'd be surprised if they didn't show severe limitations in their understanding, but language is not an all-or-none proposition. There are degrees of sentence competency, and we have shown that symbols can take the place of objects for dolphins."

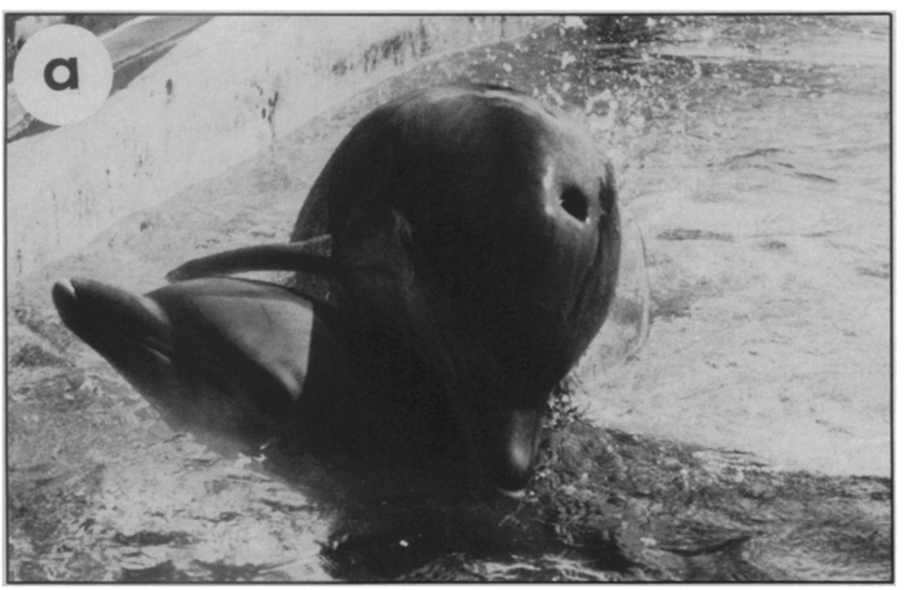
But unintentional cues from the experimenters may play a larger role than grammatical comprehension in the dolphins' performance, says linguist Thomas A. Sebeok of the University of Indiana in Bloomington. Sebeok and Herbert Terrace of Columbia University in New York have criticized ape language researchers for ignoring these effects, which might include a trainer's nodding or eye movements.

They also stress that apes are clever at learning to do what gets them praise, food or other rewards, while their language skills have been played up by wishful scientists.

The same may be true of dolphins and dolphin researchers, says Sebeok, who cautions that he would need to examine personally the experimental setup in Hawaii to be sure.

In the meantime, Herman — who is confident his experimental controls would pass a Sebeok inspection—plans to obtain two additional dolphins. They will be trained in the same language, possibly one based on simple sounds that can be combined to form words. The dolphins' ability to communicate with one another using a common language can then be studied.

Is there any hope that animal language researchers will communicate more constructively with each other in a field marked by controversy? "When any new scientific field comes on the scene, it takes a while to sort out the bickering among researchers," says Rumbaugh. "But in the last few years, many investigators have begun to share their results and work cooperatively." □



Phoenix (top) responds to the instruction AKEAKAMAI OVER.