# Mind Maps

## What representation of the world underlies animal brainwork?

By JULIE ANN MILLER

Picture yourself in your bedroom in the house where you lived as a child. Point in the direction of the kitchen. You have just used a cognitive, or thought, map (SN: 3/19/83, p. 188).

Scientists are asking whether an animal, as it makes its way through the natural environment, employs similar internal representations of the outside world. Or does it memorize, landmark by landmark, its way from nest, hive or cave out to food sources and back again?

One straightforward way of asking about maps is to determine whether any animals can read man-made maps. Guy Woodruff and David Premack of the University of Pennsylvania have had limited success trying to teach chimpanzees to use a map of a room.

The chimp was successful in finding food with a full-size, three-dimensional map. That is, if the chimp observed the experimenter putting food in one of two containers, in an identical room it would go directly to that container. The chimp could also obtain information about the location of food from a canvas on the floor of the the first room, and then from smaller and smaller versions of this "map" marked with miniature furniture. But when the map was rotated, or when a new map and new room were used, the chimp's performance was no better than one would expect from chance.

Limited success with man-made maps, of course, does not rule out the possibility that the chimp uses a mental map of its own design. From observations of chimps finding hidden food in a field, Emil W. Menzel Jr. of State University of New York at Stony Brook says, "The concept of cognitive mapping is by no means the only possible explanation of the data, but I can think of none that seems any more succinct and able to encompass all the details of performance."

To examine how animals organize information, an experimenter carried a chimpanzee around a field while hiding 18 pieces of food in clumps of grass and other natural cover. Then this chimp and five companions were let loose in the field.

The first chimp, called the informed animal, found almost all the food. It took an efficient route that bore no detectable relationship to the path along which it had been carried. The probability of randomly getting so short a route was less than 1 in 1,000, Menzel reports.

There were some general rules underlying the chimp food-finding. Several hiding places close together were approached before a single hiding place in the opposite direction but less distant. If another chimp had removed the food from a hiding place, the informed animal often re-searched the spot. But it seldom returned to a place it had emptied itself. The informed animal seldom searched any location more than one meter from an actual hiding place. "Their most common 'error' here was searching a hiding place that looked to us almost precisely like a 'correct' one, and was within a few meters of it," Menzel says.

"Judging especially from our own difficulty in re-finding the piles of food that we ourselves had hidden, even when we had a map that showed these locations to the nearest 9 square meters, the animals' memory of exact location seemed at least as good as our own," Menzel says.

What about rats in a maze? Do they solve the problem by mapping their previous behavior and then referring to this map to make later behavioral choices? This sort of mental activity may be the best explanation in some cases, but in other experiments simpler explanations suffice.

At the recent meeting in Berlin of the Dahlem Conference on the Biology of Learning, Allan Wagner of Yale University gave as an example a classical experiment in which a rat on a small wagon is pulled through a complex maze to a food goal. (The wagon ensures that the rat is not learning a motor pattern.) The rat, when put on its own four paws, was shown to have benefitted from its experience as a passenger. But careful analysis demonstrated that the animal was using as a cue a light in the room outside the maze. The rat's behavior could be explained by the simple rule: At each junction turn toward this light. There was no need for the animal to have memorized a map.

Another alternative to a cognitive map

Paul Fusco

*Chimpanzees can use a simple map, a canvas with miniature furniture, to learn where food is hidden—as long as the map is in the proper orientation in the room it represents.*

is a well-ordered "snapshot album." The behavior of ants has been explained by them remembering the image of the complex pattern the forest canopy — the tree trunks and branches — makes against the sky (SN: 10/11/80, p. 230).

Honeybees navigate in their home range as if they had an internal map, or at least an extensive album of snapshots. They may fly to a landmark, then to food, but return to the hive by a direct route. If a bee is forced to make a detour on its way to a food source and on its way back, it will still, in its dance, communicate the location of the food as if it had used a direct path.

James L. Gould of Princeton University reports two preliminary approaches to exploring whether bees use maps. Experienced bees carried in the dark to a new feeding site circle once and then fly back to the hive. Inexperienced bees just circle the feeding site. Gould suggests the experienced bees may be using a photo from some previous flight path or may be using a map.

In another experiment, Gould gives bees food in a boat in the middle of a lake. The scout reports this find to the hive, but it gets no recruits. However, if the food is on the far shore of the lake, recruits do reach it (SN: 4/23/83, p. 271). These findings may indicate that the bee has a map that includes the location of the lake and the knowledge that water is an unlikely place for a bee to find food.

If a bee has a map, it uses it more flexibly in some situations than others, says Martin Lindauer of Wurzburg University in West Germany. When a bee is foraging, it can easily find a feeding station that has been moved 10 meters since the bee's last visit. But when the bee returns to its hive, it will be lost if the hive has been moved half a meter.

Investigators at the conference argued about how conservatively a "map" must be defined and the value of the concept. "When the animal has a detailed description of the environment, we can be fooled to think its conceptions are more complex than they are. In some cases there is just a description of environment and general rules of operation. Do we call this a map?" Wagner says.

The idea of mapping is a shorthand way of stating that animals take into account the nature and relative positions of objects, including themselves, and that they can deduce new relationships and achieve new performances beyond their direct training, Menzel says. But he has some doubts about the concept's value.

Menzel says, "... once one invokes cognitive mapping there is no reason in principle not to also talk about cognitive clocks, compasses, thermometers, lie detectors and all manner of other gadgets, which makes me [think] there must be a much simpler and more direct and monolithic way of getting around in the world." □

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**Annual Review of Physical Chemistry,** Vol. 34—B. Seymour Rabinovitch, Ed. A dedication to Henry Eyring and a chapter by Joseph O. Hirschfelder telling of his adventures in theoretical chemistry introduce this volume. Annual Review, 1983, 669 p., illus., $28.

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