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April 3, 2007

## Time in the Animal Mind

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Correction Appended

Humans are born time travelers. We may not be able to send our bodies into the past or the future, at least not yet, but we can send our minds. We can relive events that happened long ago or envision ourselves in the future.

New studies suggest that the two directions of temporal travel are intimately entwined in the human brain. A number of psychologists argue that re-experiencing the past evolved in our ancestors as a way to plan for the future and that the rise of mental time travel was crucial to our species' success. But some experts on animal behavior do not think we are unique in this respect. They point to several recent experiments suggesting that animals can visit the past and future as well.

The first clues about the twists and turns of mental time travel came from people with certain brain injuries that caused them to forget autobiographical details without forgetting the information they had picked up along the way. A man known in the scientific literature as K.C., for instance, could play chess with no memory of having ever played it. K.C. could remember sentences psychologists taught him without any memory of the lessons.

K.C. had lost what psychologists now call episodic memory. Endel Tulving, a Canadian psychologist, defined episodic memory as the ability to recall the details of personal experiences: what happened, where it happened, when it happened and so on.

Dr. Tulving argued that episodic memory was distinct from other kinds of memory that did not involve personal experience. People can remember how to get to a subway stop, for example, without recalling the first time they were there.

Episodic memory was also unique to our species, Dr. Tulving maintained. For one thing, he argued that episodic memory required self-awareness. You can't remember yourself if you don't know you exist. He also argued that there was no evidence animals could recollect experiences, even if those experiences left an impression on them.

Many animal behavior experts agreed with Dr. Tulving, even though they had not actually run experiments testing the idea. But when Nicola Clayton, a comparative psychologist, first heard about the claim, she had a different reaction. "I could feel my feathers ruffling," said Dr. Clayton, who is now at the University of Cambridge. "I thought, hang on, that doesn't make sense."

Dr. Clayton began to test western scrub jays to see if they met any of the criteria for episodic memory. The jays can hide several thousand pieces of food each year and remember the location of each one. Dr. Clayton wondered if scrub jays simply remembered locations, or if they remembered the experience of hiding the food.

She ran an experiment using two kinds of food: moth larvae and peanuts. Scrub jays prefer larvae to peanuts

while the larvae are still fresh. When the larvae are dead for a few hours, the jays prefer peanuts. Dr. Clayton gave the birds a chance to hide both kinds of food and then put them in another cage. She later returned the birds to their caches, in some cases after four hours and in other cases after five days.

The time the scrub jays spent away from their caches had a big effect on the type of food they looked for. The birds that waited four hours tended to dig up larvae, and the birds that had to wait for five days passed the larvae by and dug up peanuts instead. (To make sure they were not just picking up the smell of rotten larvae and avoiding those spots, Dr. Clayton dumped out the caches as soon as the birds had made them, and filled all of them with fresh sand.)

In 1998, Dr. Clayton and her colleagues published the results of their experiment, declaring that scrub jays met the standards for “episodic-like” memory. Ever since, Dr. Clayton has been investigating the memories of scrub jays more deeply. Last year, for example, her team discovered that scrub jays not only remember when and where they hide food, but also whether they are being watched at the time. If one scrub jay notices another one watching it hide food, it tends to dig up the cache later and hide it somewhere else. Other scientists have followed Dr. Clayton’s lead and have searched for signs of episodic-like memory in other animals. When rats are exploring a maze, for example, they seem to be able to recall which kinds of food they encountered along the way. Hummingbirds seem to remember where and when they visited individual flowers for nectar. Rhesus monkeys can remember where they put food, but not how long ago they put it there.

Some researchers have not been persuaded by these studies, however.

“Animals seem to be living very much in the present,” said Thomas Suddendorf, a comparative psychologist at the University of Queensland in Australia.

Dr. Suddendorf argues that a scrub jay could remember type of food along with the location of a cache without having a sense or memory of self. “Information is not really what characterizes mental time travel,” Dr. Suddendorf said. “I know that in 1967 in Sweden my mom gave birth to me, but that doesn’t mean I can travel back to that time and experience that event.”

Episodic memory also depends on many other faculties that have only been clearly documented in the human mind, Dr. Suddendorf argues. He said he believes it evolved after our ancestors branched off from other apes. The advantage lay not in knowing the past, however, but in providing “an advantage for predicting the future,” he said.

Recent brain scanning studies support Dr. Suddendorf’s link between the past and future. Daniel Schacter, a psychologist, and his colleagues at [Harvard University](#) recently studied how brains function as people think about past experiences and imagine future ones. Constructing an episodic memory causes a distinctive network of brain regions to become active. As a person then adds details to the memory, the network changes, as some regions quiet down and others fire up.

The researchers then had their subjects think about themselves in the future. Many parts of the episodic memory network became active again.

Dr. Suddendorf argues that these overlapping networks for mental time travel evolved at least 1.6 million years ago. He points to stone tools hominids made at that time. Paleoanthropologists have determined that the tools were moved many miles from where they were made.

“If you’ve just eaten, the only reason you’re going to take a tool with you is if you anticipate using it in the future,” he said.

Dr. Suddendorf has roused comparative psychologists to action — “like a red rag to a bull,” as one comparative psychologist, Sara Shettleworth of the University of Toronto, put it. They have been looking for evidence that animals can also plan for the future.

Some studies suggest not. Cebus monkeys, for example, will eat until they are stuffed and throw the rest of the food out of their cage, despite the fact that they will not have food the next morning.

But in other studies, animals show more promise. “We tested squirrel monkeys to see if they could anticipate the future, and to our surprise it looks like they could,” said Dr. William Roberts, a comparative psychologist at the University of Western Ontario. He and his colleagues ran a test in which they offered squirrel monkeys a choice between one piece of date or four. Not surprisingly, the monkeys took four.

But the scientists then began to take away water from the monkeys before they offered the choice. If the monkeys took four pieces, the scientists kept the water away for three hours. If the monkeys took one, the scientists returned the water in half an hour. The monkeys learned to choose one date. Even though they were not thirsty at the time, they anticipated becoming thirsty in the future. (If the scientists stopped withholding water, the monkeys went back to picking four pieces of dates instead of one.)

Dr. Clayton recently tested her scrub jays for foresight. She and her colleagues put the birds in three adjoining compartments for six days. Each morning the birds were shut for two hours in one of two rooms. In one room they got nothing to eat. In the other room, they got powdered pine nuts (the scrub jays can eat the powder, but they cannot cache it). For the rest of the day, each bird could move around all three rooms and enjoy more powdered nuts.

On the seventh day, the scientists switched the powdered pine nuts with real ones. If the birds were so inclined, they could cache the pine nuts in ice cube trays the scientists put in the two morning rooms. “If I’m a bird, what I could do is take some of the provisions and hide it in there so that if I do wake up there in the morning, I can get my own breakfast,” Dr. Clayton said.

Dr. Clayton found that the birds put over three times more pine nuts in the no-breakfast room than in the breakfast room. She argues that the results mean that birds can take action for their future needs, knowing what they’ll need and where they’ll need it.

Other experts on animal behavior say that the study is compelling. Even Dr. Suddendorf, who has been so critical of previous studies, is intrigued by Dr. Clayton’s results. He said he wonders how long the birds can plan ahead: “Can they do this for an event next week or next month like humans can? Is it limited to caching, to just food?”

“It’s good to see people waking up to this,” Dr. Suddendorf said. “In five years the picture is going to look a lot clearer. The future looks bright for research on the future.”

Correction: April 5, 2007

Pictures with an article in Science Times on Tuesday about how animals experience time were published in error. The photographs were of the Florida scrub jay — not the western scrub jay, which was used in the research described in the article.

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