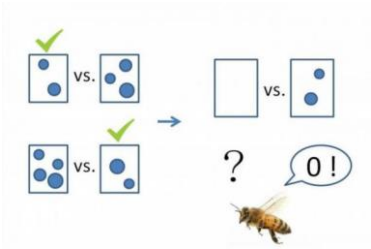
ScienceWatch – The Insect That Knows Nothing

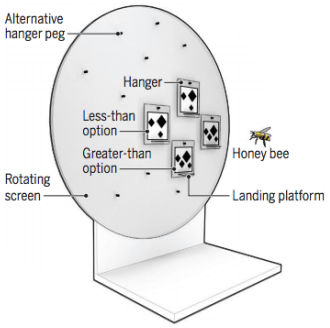


"Zero is a difficult concept to understand and a mathematical skill that doesn't come easily-it takes children a few years to learn." – A. Dyer

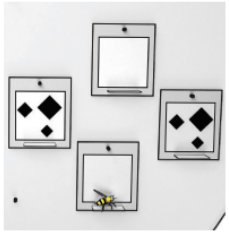
The concept of zero is relatively new to human understanding. Its usage first appeared in 5th century C.E. India. Children don't grasp the concept until the age of four or five, and for a long time humans thought they were in an exclusive club. But within the past decade researchers have found that some monkeys and a famous African grey parrot, named Alex, can comprehend "nothing" on a numerical continuum. Now a report in the June 8, 2018 issue of *Science* demonstrates that the tiny honey bee (*Apis mellifera*) can do it too.

Honey bees are smart. They have good short-term memories, understand sameness and difference and can learn from other bees. They also can count and discriminate up to four objects. So a team led by Scarlett Howard and Adrian Dyer, RMIT University, Melbourne, Australia, decided to find out if bees trained to count could also understand zero.

They trained bees to comprehend the concepts of "greater than" and "less than" using what they called "appetitive-aversive differential conditioning." Bees were shown two pairs of white panels with different numbers of elements (black squares, or circles) and were rewarded with sugar water when they landed on the correct panel or punished with bitter-tasting quinine water when they landed on the wrong panel. The shapes were of different sizes and the panels were randomly rotated to prevent the bees from gaining any spatial clues. Alcohol washes between each test also removed any possible olfactory cues.



Trained bees quickly learned to make the right choice over 80% of the time. They learned either "less than" or "more than" and could rank panels containing up to four objects. For example, bees that learned "less than" mostly landed on the panels displaying fewer objects.



Next the trained bees were challenged to compare an empty white panel with one containing unfamiliar shapes (diamonds) and patterns. Bees trained to "less than" chose the empty panels most of the time, while bees trained to "more than" chose panels containing shapes. The bees found it harder to judge—they took longer to decide and were wrong more often— when the empty set was compared to panels with one or two objects as compared to five or six. This finding, which is seen when children are similarly tested, strongly suggests that the bees were looking at the numerical distance between panels when making their choice; *i.e.*, bees and humans conceive zero in analogous ways.

Bees and humans are separated by hundreds of millions of years of evolution. Furthermore, a bee brain is the size of a sesame seed and contains only about 800,000 neurons compared to a human brain with over 80 billion so it's hard to know how a bee brain represents zero.

"The discovery that bees can show such elaborated understanding of numbers was really surprising given their tiny brain size. Large brains are thus not necessary to play with numbers. This capacity is therefore probably shared by many animals," said research team member Dr. Aurore Avarguès-Weber

Dr. Dyer believes a better understanding of the neural processes that allow a bee brain to comprehend zero would help in developing artificial intelligence. If bees can perceive zero with a brain of less than a million neurons, it suggests there are simple ways to teach artificial intelligence new tricks, he said.

These experiments suggest that bee's comprehension of zero is similar to that of some humans and primates, said Dr. Howard. "We still have some things to figure out about why they can do this," she said.

Saul Scheinbach