Memory in honeybees: What the right and left antenna tell the left and right brain

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It is widely known that the right and left hemispheres of the brain perform different tasks. Lesions to the left hemisphere typically bring impairments in language production and comprehension, while lesions to the right hemisphere give rise to deficits in the visual-spatial perception, such as the inability to recognize familiar faces.

In the last few years, we have become used to the idea that functional asymmetry between the left and right sides of the nervous system is not unique to humans: fishes, amphibians, birds and mammals have functional and anatomical asymmetries.

So, the idea that all vertebrate species, even non-human ones without any linguistic skills, have an asymmetric brain seems to be finally accepted. Now, this process of extension among species is going on and brain lateralization has been extended beyond the class Vertebrata. Insects, with their nervous system so different from that of vertebrates, are also "lateralized", as shown in a paper published in PLoS ONE by Lesley J. Rogers of the Centre for Neuroscience and Animal Behaviour, University of New England (Australia), and Giorgio Vallortigara, of the Centre for Mind/Brain Sciences, University of Trento (Italy).

The authors studied memory in bees using a widely tested procedure, known as proboscis extension reflex (PER). When presented with a droplet of sugar solution, the honeybee extends its proboscis to get it. If an odour stimulus, such as lemon scent, is present shortly before the droplet, after very short training, animals learn to extend their proboscis

when the odour alone is presented.

The honeybee can learn to discriminate between different odours, extending its proboscis to lemon and not to vanilla, keeping memory of the correct scent for a long period. The odour is perceived by the two antennae that honeybees have on their heads. After the bees had been trained using both antennae, Rogers and Vallortigara tested their recall ability, by coating either the left or right antenna with a harmless latex-based substance and thus rendering one antenna incapable of detecting odour.

The authors observed that, one hour after training, honeybees recognized the correct odour when the right antenna was in use and didn't when using the left antenna. However, 24 hours after training, the pattern reversed: correct responses were significantly higher when the left antenna was in use.

The "lateralization" appears to be linked to memory consolidation. Testing animals using lateral presentation (the odour was presented to the left or right side of the bee) and no coating of the antennae (both antennae in use), the authors found that bees showed better recall of the task when they were tested at one hour after training using the right antenna, an effect that disappeared three hours after training. However, by 6 hours after training, a lateral shift had occurred and the memory could be recalled mainly when the left antenna was in use. The left antenna took over on the long period (after 6 hours and remained so at 24 hours).

It would seem that the right antenna and the associated neural structures form the basis for a short term and relatively temporary memory, and left antenna supports long term learning, taking place from about 3 hours after training on.

It is not clear at present whether learning via the right antenna is sufficient to trigger shorter-term encoding on the right side of the brain and longer-term encoding on the left side of the brain. An alternative hypothesis would be that the memory encoding is the same on both sides of the brain but only the right antenna has access for shorter-term recall and only the left antenna has access for longer-term recall.

What could the ecological reason for that be? Perhaps the shift from one antenna to the other allows use of the right antenna to learn about new odours without interference from odour memories in long-term stores. It is known that bees visit different flowers at different times of the day, as nectar becomes available, and this would require the formation of different odour associations during the course of the day, a process that might be aided if recall of earlier odour memories is avoided on the learning side of the brain.

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