We've been looking at ant intelligence the wrong way

4 September 2013, by Antoine Wystrach

A lot cleverer than he looks. Credit: vpickering

How intelligent are animals? Despite centuries of effort by philosophers, psychologists and biologists, the question remains unanswered. We are inclined to tackle this question using a top-down approach. It seems intuitive to start with our own assumptions about human intelligence, and design experiments that ask whether animals possess similar anthropomorphic abilities.

Do animals have a language, or a personality? Do they feel empathy or achieve abstract reasoning? This approach does suit the study of animals closely related to us, like apes. But is it relevant when studying animals such as insects?

Insects certainly display complex and apparently intelligent behaviour. They navigate over long distances, find food, avoid predators, communicate, display courtship, care for their young, and so on. The complexity of their behavioural repertoire is comparable to any mammal.

However, they have a tiny brain, and probably because of assumptions about the limitations of tiny brains, researchers generally avoid seeking human abilities in insects. In his 1969 book, The Sciences of the Artificial, Herbert Simon contemplates an ant wandering on the beach:

Viewed as a geometric figure, the ant's path is irregular, complex, and hard to describe. But its complexity is really a complexity in the surface of the beach, not the complexity in the ant.

Simon explains that the complexity observed in the behaviour is not necessarily in the ant, but in the interaction between the ant and the surrounding complex environment. This idea has allowed scientists to avoid any idea of an anthropomorphic intelligence, by looking instead for the simplest solutions to explain complex behaviour.

Assume an animal is the simplest it can be, whilst looking for proof of a higher level of intelligence. With such an approach, research in insect intelligence is working bottom-up, with simple (and boring) initial explanations being steadily replaced by increasingly complex (and exciting) explanations.

Decades of bottom-up research have passed since Simon looked at his ant on the beach, and Simon himself would be surprised at how complex, and intelligent, insects are. The change of perspective that allowed him to profess the ant's simplicity has, in fact, revealed an alien complexity, one not driven by anthropomorphic considerations.

We now know that the path produced by a navigating ant is based on sophisticated mechanisms.

Ants use a variety of cues to navigate, such as sun position, polarised light patterns, visual panoramas, gradient of odours, wind direction, slope, ground texture, step-counting … and more. Indeed, the list of cues ants can utilise for navigation is probably greater than for humans.

Counter-intuitively, years of bottom-up research has revealed that ants do not integrate all this information into a unified representation of the world, a so-called cognitive map. Instead they possess different and distinct modules dedicated to different navigational tasks. These combine to allow navigation.

One module keeps track of distance and direction travelled, and continually updates an estimate of the best "bee-line" home. A second module, dedicated to the learning of visual scenery, allows ants to recognise and navigate rapidly along important routes as defined by familiar visual cues. Finally, ants possess an emergency plan for when both of these systems fail to indicate what to do: in other words, when the ant is lost. In this case, they display a systematic search pattern.

In our recent work, published in *Proceedings of the Royal Society B*, we have discovered a fourth strategy: backtracking. We showed that ants keep track of the direction they have just been travelling, allowing them to backtrack if they unexpectedly move from familiar to unfamiliar surroundings.

From a human perspective, this seems sensible, and is probably what we would do if unexpectedly encountered an unfamiliar street while walking through town. What is most interesting, with regard to the cognitive sophistication or intelligence of the ant, is that ants display this backtracking behaviour only if they had seen their nest's surroundings immediately prior to getting lost. This ensures that backtracking happens only when the ant is likely to be beyond the nest, rather than short of it.

Thus we have evidence that ants can also take into account what they have recently experienced in order to modulate their behaviour. What's more, we have shown that the ant's navigational modules are not purely isolated. In the case of backtracking for instance, the experience of familiar visual scenery modulates the use of sky compass information.

Evolution has equipped ants with a distributed system of specialised modules interacting together. These results demonstrate that the navigational intelligence of ants is not in an ability to build a unified representation of the world, but in the way different strategies cleverly interact to produce robust navigation.

We need to keep in mind that this is only our current level of understanding. Even insect brains are far too complex to be fully understood in the near future. Perhaps we will have misjudged the intelligence of ants just as much as we think Simon did. However, we know that continued bottom-up research is the principled way to pull back the veil on insect intelligence, without the spectre of anthropomorphism.

More information: rspb.royalsocietypublishing.or … /1769/20131677.short

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