Insects can teach us about the origins of consciousness

19 April 2016, by Colin Klein And Andrew Barron

Are compound eyes the window to the soul? Credit: Gilles San Martin/Flickr, CC BY-SA

Do bees like the taste of nectar? Does the ant foraging for your crumbs feel better when she finds one?

Are insects merely tiny robots? Or, in the phrase popularised by the philosopher Thomas Nagel, is there something it is like to be a bee?

Until recently, most scientists and philosophers would have laughed at the question. But now, research is challenging that dismissive attitude towards invertebrate consciousness.

It is worth clarifying what we mean when we talk about insect consciousness, since the term consciousness carries a lot of baggage. Everyone agrees that bees can take in environmental information and perform impressive computations on it.

We want to know something more: whether insects can feel and sense the environment from a first-person perspective. In philosophical jargon, this is sometimes called "phenomenal consciousness".

Rocks, plants and robots don't have this. Metaphorically speaking, they are dark inside.

Conversely, most of us think that a dog running for its dinner isn't just a little guided missile. It smells its food, wants to eat and sees the world around it as it runs.

Each of these *feel* a certain way to us, and they feel like something for the dog too. If that is right, then dogs are conscious, at least in the minimal sense.

Does this ant look angry to you? Credit: r reeve/Flickr, CC BY-NC-ND

Consciousness is sometimes used to refer to a much more complicated capacity: the ability to *self-reflect*. That is a rare achievement. Humans may well be the only animals that can become aware that they are aware. Even then, we are mostly just conscious in the more minimal sense, rarely pausing for true self-reflection.

The structure of consciousness

The consciousness of others is a thorny philosophical problem. Our typical handle on consciousness is through observing behaviour. We think babies and dogs feel hungry, in part because they act like we do when we feel hungry.

Behavioural analogies become harder when we consider animals such as insects, which don't look

or act much like us. We might say that a bee is angry when we disturb its hive. But an angry bee doesn't act much like an angry toddler, so it's easy to remain sceptical. Behaviour alone certainly doesn't prove that any animal is conscious.

An emerging approach to animal consciousness offers a way forward. Rather than moving from behaviour back to experience, this new approach moves directly to the neural underpinnings of consciousness.

Even if insect behaviour is very unlike our own, there might be important similarities between their brains and ours. On this new approach, we can thus ask whether the insect brain has the structures that could support a basic capacity for any form of consciousness.

Neuroscientist Björn Merker has argued that the capacity for awareness in humans depends on structures in the midbrain alone.

The midbrain is the evolutionarily ancient neural core that our enormous neocortex surrounds like a thick rind. Self-awareness requires our evolutionarily young neocortex, but awareness is supported by the simpler and evolutionarily much older midbrain.

Why is the midbrain so important? Once animals started moving around in their environment, they had to decide where to go next. Deciding efficiently requires combining many different sources of information into a single neural model with a single perspective on the world.

Tying together knowledge, desire and perception in this integration is the start of a first-person perspective on the world, and thus the origin of conscious experience.

What it's like

While insect brains are minute – the largest are far smaller than a grain of rice – new research has shown that they perform the same ancient functions as the human midbrain.

The insect central complex ties together memory, homeostatic needs and perception in the same integrated way. This integration has the same function as well: to enable effective action selection.

In the bee, this detailed representation of the animal in space is what allows it to perform remarkable feats of navigation. Thus, while insect brains and human brains could not look more different, they have structures that do the same thing, for the same reason and so support the same kind of first-person perspective.

That is strong reason to think that insects and other invertebrates are conscious. Their experience of the world is not as rich or as detailed as our experience – our big neocortex adds something to life! But it still feels like something to be a bee.

If this argument is correct, studying insects is a powerful way to study basic forms of consciousness. The honeybee brain has less than a million neurons, which is roughly five orders of magnitude fewer than a human. That is a lot easier to study.

Completely mapping the insect nervous system is within the realm of current technology. Several labs are already working on it.

Once we map the insect nervous system, we can emulate it to test theories of computational function. Initiatives such as The Green Brain Project have already used existing knowledge to begin building a biologically-inspired drone that behaves like a honeybee in complex environments.

Studying invertebrate experience also opens the possibility of studying how and why conscious experience evolved. Our research suggests the tantalising possibility that consciousness has evolved – and been lost – multiple times across evolutionary history.

One important driver of this process is mobility in the environment. Parasitic worms that have lost their ability to freely navigate have also lost the brain structures responsible for the first-person perspective.

This suggests a close relationship between consciousness and the demands of moving around the world. By clarifying the environmental demands that press animals to evolve the capacity for consciousness, we might thus shed light on the relationship between subjectivity and the external world.

Invertebrates have long been overlooked in the study of consciousness. The time has come to take them seriously as a scientific and philosophical model for the evolution of subjective experience.

More information: Andrew B. Barron et al. What insects can tell us about the origins of consciousness, *Proceedings of the National Academy of Sciences* (2016). DOI: 10.1073/pnas.1520084113

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