

whispers

Vivienne Baillie Gerritsen

We all depend on cues. Without them, the notion of community would not exist. Cues are the cement of society, and their nature can be very diverse. Birds whistle. Hogs grunt. Plants give off scents. Fish use bioluminescence. Slugs release pheromones. Humans talk. Many species have more than one way of flinging cues to one another: while capable of emitting sounds, they can also discharge smells, touch each other and make gestures. Humans, for example, have brought signalling to a peak by adding clothes, tattoos, piercing, makeup, jewellery and all forms of bodily transformations to their repertoire to add refinement – and perhaps a touch of egocentricity – to their means of exchange. But though it may seem that individualism is, paradoxically, what drives communication these days, every signal is a manifestation of the belonging to a part – however small – of society. Many other animals have also evolved intricate means of communication. Ants, in particular. Over time, these insects have acquired an advanced form of social behaviour driven by these mysterious invisible cues called pheromones whose effects depend highly on a protein known as odorant receptor co-receptor, or Orco.



Synaesthetics, by Margaret Mannion Kallen

Courtesy of the artist

Ants and their intricate social behaviour have been under scientific scrutiny since the second half of the 19th century. The Swiss psychiatrist Auguste Forel (1848-1931) was one of the first scholars to consider them. In 1874, an initial account of his observations was made in a long treatise that was applauded by Charles Darwin, followed 50 years later by a five-volume opus on the social habits of ants: *Le monde social des fourmis*. Though the parallels he made between ant behaviour and

human social and political behaviour remained controversial, Forel's contribution to the field was fundamental. So much so that, in 1979, Switzerland issued a 1,000 franc bank note bearing his portrait on one side, and drawings of ants on the other. At about the same period as Forel, the American entomologist William Morton Wheeler (1867-1937) was also studying ant behaviour, and saw each ant colony as an organism *per se*, thus founding the notion of superorganism. Towards the middle of the 20th century, the social behaviour of ants could be studied in the light of genetics. This gave birth to the field of sociobiology, pioneered by the American biologist and theorist E.O. Wilson.

If you have spent time watching ants, you will have noticed that they tend to follow each other along the same paths, which either lead them away from or towards their home: the ant hill. These are the older ants that are sent out to find materials for nest building or food for their kin. The younger ants stay inside, looking after the even younger ants, while yet other ants are building nests, nursing, foraging or taking care of the queen. Each ant knows what it has to do. And it does it without words and books of regulations. So what is it that guides them? What is sending out the orders? Pheromones. Pheromones are molecules that no one can see or smell – a sort of biological whisper that has the disturbing power of acting upon an organism's behaviour. In the

world of ants, pheromones are capable of giving shape to a whole society. The queen releases pheromones that prevent her progeny from being reproductive, while other pheromones keep ants on the same trail, stimulate them to socialize, groom eggs, nurse, forage, elicit alarm responses, build nests...

Pheromones influence behaviour by triggering off a reaction sensed by the ants' antennae, and which is relayed to the brain. They do this by binding to specific receptors – odorant receptors, or ORs – that are lodged in the membranes of antennal odorant receptor neurons in the antennae and whose axons plunge into the antennal lobe, itself composed of a dense network of globule-shaped nerve fibres, or glomeruli. When a pheromone activates an OR, a series of transduction pathways are set in motion, from the antennae down to the lobes and then to the ant's central nervous system. None of this is new; humans taste food and smell scents in much the same way for instance. What is surprising in ants is the co-receptor Orco: this protein is involved not only in binding ORs but in a number of other events too.

Orco is a highly conserved transmembrane olfactory co-receptor that forms a heterodimer with all insect ORs. Upon pheromone-binding, the Orco/OR heterodimer acts as a ligand-gated ion channel thus activating the odorant receptor neurons and transmitting the message down to the antennal lobe. When Orco is deficient in ants, some are found wandering on their own or unable to forage successfully, while others are seen to twitch their antennae abnormally or lay only few eggs and not tend to them. Such abnormal behaviour would be expected if the pheromone transduction pathway is tampered with. What scientists also discovered,

however, is that not only does Orco show signs of being far more strongly involved in the olfactory pathway than it is in that of other insects but it also seems to have a direct role in 1) locating and maintaining ORs in the neuronal membranes as well as in 2) regulating the number of glomeruli in the antennal lobes – which would imply that it has a role in the ant's neural development. With respect to other insects, the ant olfactory system is particularly intricate. As an order of magnitude – and perhaps complexity – the repertoire of OR genes in *Drosophila* is encoded by 60 genes, whereas it is encoded by over 300 genes in the ant genome! As for the *Drosophila* antennal lobes, they contain about 42 glomeruli while the ant lobes have over 400...

Though Orco seems to have many skills, no one knows how the co-receptor fulfils them on the molecular level. The ant olfactory system probably still depends on an ancestral olfactory mechanism since, even when Orco is deficient, some ants are able to carry out typical social behaviours such as eliciting alarm responses or grooming eggs. Orco certainly seems to have an important role in the development of the ant's olfactory system, and it is crucial in the study of social behaviour that depends on chemicals. Though the brains of humans and ants cannot be compared, the wandering and antennae-twitching anti-social ants echo certain psychiatric traits in humans, which we know can be rectified with chemistry. The ant olfactory system is also a source of inspiration for network engineers. How do ants avoid congestion? How do they optimize their movements? It is very intriguing ground, and leaves us with that slightly troubled feeling that we are perhaps not the complete masters of our actions.

Cross-references to UniProt

Odorant receptor co-receptor, *Harpegnathos saltator* (Jerdon's jumping ant): E2BJ30
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