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Inside JEB

BEES RECOGNISE FACES USING FEATURE CONFIGURATION

Geoffrey Portelli

Going about their day-to-day business, bees have no need to be able to recognise human faces. Yet when Adrian Dyer trained the fascinating insects to associate pictures of human faces with tasty sugar snacks, they seemed to be able to do just that. But Martin Giurfa from the Université de Toulouse, France, suspected that that the bees weren't learning to recognise people. 'Because the insects were rewarded with a drop of sugar when they chose human photographs, what they really saw were strange flowers. The real question is what strategy do they use to discriminate between faces,' explains Giurfa. Wondering whether the insects might be learning the relative arrangement (configuration) of features on a face, Giurfa contacted Dyer and suggested that they go about systematically testing which features a bee learned to recognise to keep them returning to Dyer's face photos (p. 593).

Teaming up with Aurore Avarguès-Weber, they first tested whether the bees could learn to distinguish between simple face-like images. Using faces that were made up of two dots for eyes, a short vertical dash for a nose and a longer horizontal line for a mouth, Avarguès-Weber trained individual bees to distinguish between a face where the features were cramped together and another where the features were set apart. Having trained the bee to visit one of the two faces by rewarding it with a weak sugar solution, she tested whether it recognised the pattern by taking away the sugar reward and waiting to see if the bee returned to the correct face. It did.

So the bees could learn to distinguish patterns that were organised like faces, but could they learn to 'categorise' faces? Could the insects be trained to classify patterns as face-like *versus* non-face like, and could they decide that an image that they had not seen before belonged to one class or the other? To answer these questions, Avarguès-Weber trained the bees by showing them five pairs of different images, where one image was always a face and the other a pattern of dots and dashes. Bees were always rewarded with sugar when they visited the face while nothing was offered by the non-face pattern. Having trained the bees that 'face-like' images gave them a reward, she showed the bees a completely fresh pair of images that they had not seen before to see if the bees could pick out the face-like picture. Remarkably they did. The bees were able to learn the face images, not because they know what a face is but because they had learned the relative arrangement and order of the features.

But how robust was the bees' ability to process the 'face's' visual information? How would the bees cope with more complex faces? This time the team embedded the stick and dot faces in face-shaped photographs. Would the bees be able to learn the arrangements of the features against the backgrounds yet recognise the same stick and dot face when the face photo was removed? Amazingly the insects did, and when the team tried scrambling real faces by moving the relative positions of the eyes, nose and mouth, the bees no longer recognised the images as faces and treated them like unknown patterns.

So bees do seem to be able to recognise face-like patterns, but this does not mean that they can learn to recognise individual humans. They learn the relative arrangements of features that happen to make up a face-like pattern and they may use this strategy to learn about and recognize different objects in their environment.

What is really amazing is that an insect with a microdot-sized brain can handle this type of image analysis when we have entire regions of brain dedicated to the problem. Giurfa explains that if we want to design automatic facial recognition systems, we could learn a lot by using the bees' approach to face recognition.

10.1242/jeb.042366

Avarguès-Weber, A., Portelli, G., Benard, J., Dyer, A. and Giurfa, M. (2010). Configural processing enables discrimination and categorization of face-like stimuli in honeybees. *J. Exp. Biol.* **213**, 593-601.

INSECTS WIPE FEET CLEAN TO GET A GRIP

Have you ever noticed that insects' feet just never seem to get dirty? No matter that they've been standing on, they still stick to the next surface. The same can't be said for man-made adhesives: sticky tape soon becomes contaminated and fails to bond. And many insects maintain the same adhesive structures throughout the whole of their adult lives, so they have to keep them clean somehow. James Bullock from the University of Cambridge explains that many creatures groom their bodies to maintain them in tip-top condition, but running insects can't groom their feet after every step, so he and his colleagues, Christofer Clemente, Andrew Beale and Walter Federle, wondered whether the insect's attachment surfaces are self-cleaning (p. 635). Could the insects be cleaning their feet simply by taking the next step?

'Broadly speaking insects use two adhesive systems: smooth and hairy,' explains Bullock. Some insects' feet are smooth and covered in a thin fluid film that helps them to hold on tight, while other insects' feet are coated with fluid covered microscopic hairs that mould to surfaces as they attach. Knowing that stick insects have smooth feet while dock beetles have hairy feet, the team decided to find out whether both species could clean their dirty feet by walking across a smooth surface.

Coating a beetle's hairy foot with simulated dirt (microscopic polystyrene spheres ranging in size from 1 to 45 μm diameter), the team gently touched the insect's foot against a series of microscope slides and either pulled them off directly or slid the foot slightly before detaching it. Measuring the force that it took to pull the insect's feet free, the team found that during the first foot contact, the attachment forces plummeted by as much as 90%. However, after each additional contact the attachment forces improved, especially when they slid the foot before detaching. And when the team scrutinised the beetle's footprints, they could clearly see microscopic beads left behind in the adhesive fluid.

The beetle's hairy feet were self-cleaning. However, the insects seemed to run into a problem with the 10 μm beads: they could never get their feet entirely clean. And when the team took a closer look at the hairs on the beetle's feet, they could see why. The beetle's hairy feet were clogged with the beads, which fitted perfectly between adjacent hairs.

Having tested the beetles' hairy feet, the team turned their attention to the smooth footed stick insects. Repeating the same tests that they had tried on the beetles, the team could see that the stick insects' attachment forces returned to normal when they slid the insects' feet before detaching. So insects with smooth feet are also capable of cleaning their feet when they include a brief slide. However, when the team measured how the attachment forces changed over successive footfalls when they simply pulled the feet free without sliding them, the insects were never able to get their feet entirely clean. 'Smooth footed insects need some sort of slide to shake off the spheres,' says Bullock.

So sticky insect feet are self-cleaning, and Bullock and his colleagues are keen to find out exactly how the insects sticky feet dislodge dirt when they get contaminated.

10.1242/jeb.042408

Clemente, C. J., Bullock, J. M. R., Beale, A. and Federle, W. (2010). Evidence for self-cleaning in fluid-based smooth and hairy adhesive systems of insects. *J. Exp. Biol.* **213**, 635-642.

BEES USE ACHROMATIC CONTRAST TO SEE RED

Most bees don't bother visiting red flowers; red flowers are usually reserved for other pollinators such as hummingbirds. But no one explained this to *Bombus dahlbomii* bumblebees in Chile. According to Jaime Martínez-Harms from the Universidad de Chile, they are perfectly happy visiting red blooms so long as they have good quality nectar. But how do the insects locate the vivid blooms? Martínez-Harms explains that bees only have three visual receptors, tuned to ultra violet, blue and green wavelengths. They cannot see red, or at least not in the way that we see it. Curious to find out how the cunning insects have adapted to see flowers that they should be colour-blind to, Martínez-Harms and his colleague Natalia Márquez headed south to collect both the blooms and their bees to find out how bees see red (p. 564).

Carefully transporting the delicate flowers back to Santiago in coolers, Martínez-Harms and Mary Arroyo measured the wavelengths of light reflected by the flowers to see if any of them reflected colours that could be detected by the bees. But many of the flowers only reflected red wavelengths, so the bees couldn't recognise the red blooms by their colour with the standard set of bumblebee photoreceptors. They must be using another strategy.

Next, Martínez-Harms and Natalia Márquez decided to test the insects' colour vision. They travelled further south to the Chilean temperate forest to collect a nest of *B. dahlbomii* bees. 'It was not easy to find a nest. The insects are rare because their numbers have been reduced by agriculture,' says Martínez-Harms. However, after three fieldtrips, the duo eventually located a nest and drove it back to the laboratory in Santiago.

Teaming up with neurobiologists Jorge Mpodozis and Adrian Palacios, Martínez-Harms measured the sensitivity of the bees' eyes to find out if they had developed a specialised receptor to see red, but the insects had not.

Having confirmed that the bees could not detect red wavelengths, Martínez-Harms wondered whether the insects were using other non-colour cues, such as intensity differences (achromatic contrast), to find the flowers.

Simulating a red flower nestled amongst foliage with a red disc on a green background, Martínez-Harms trained bees to visit the red disc by rewarding them with a tempting sugar solution. Once the bees had learned to visit the fake flower, Martínez-Harms offered them the choice between the red 'flower' and a blue 'flower' (blue disc on a green background), to see if the bees could distinguish between the two. Sure enough, the bees ignored the blue flower and continued returning to the red flower. They could differentiate between the red and blue 'flowers'.

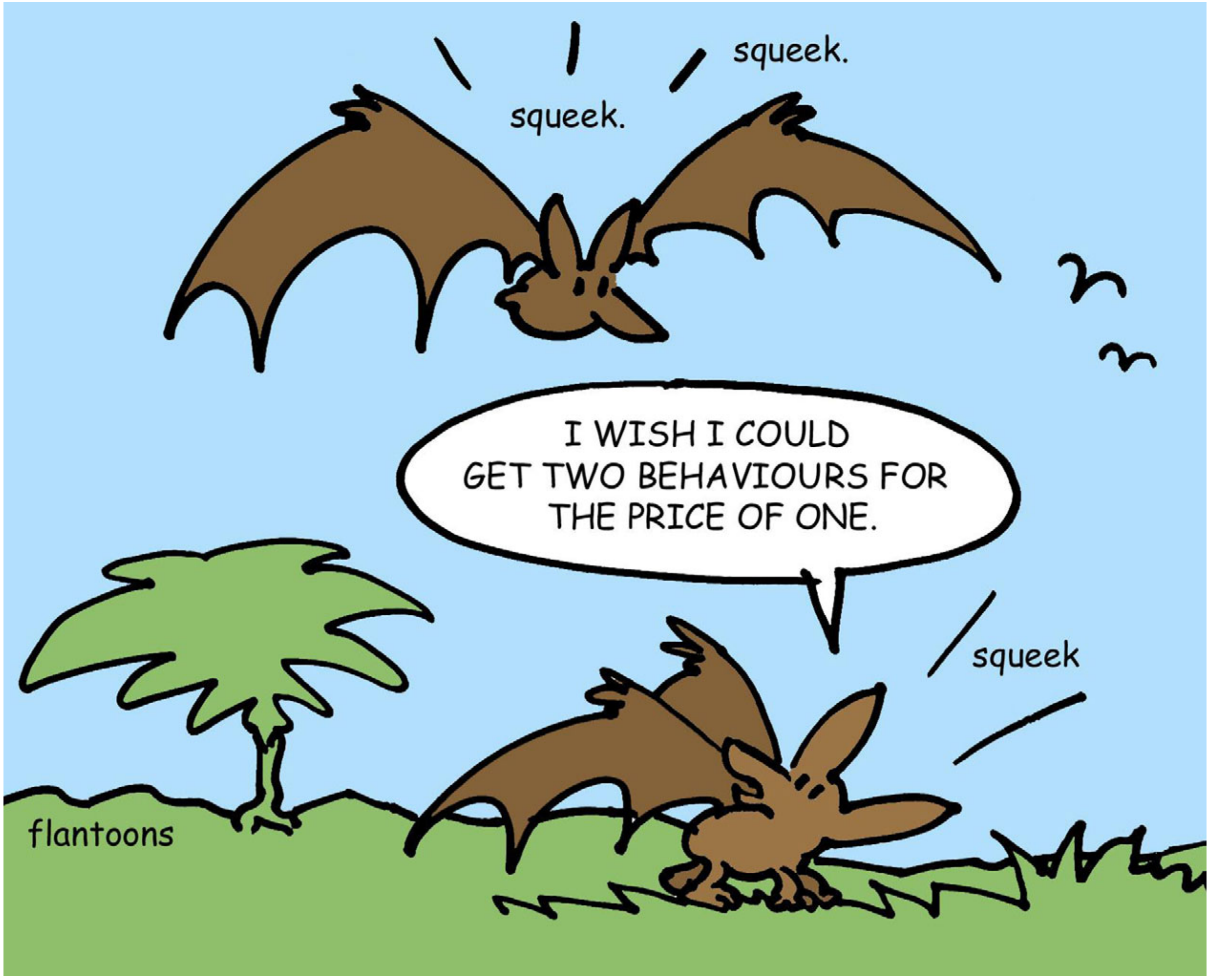
Then Martínez-Harms made the bees' choice more difficult. If the insects were locating red flowers by the intensity contrast between the 'flower' and its surroundings, Martínez-Harms reasoned that a dark green disc on a green background would look identical to the red flower on its green background. Amazingly, when he showed the insects red and dark green discs against a green background, the insects could not distinguish between them and visited them equally. The bees use the intensity contrast between red flowers and the green background to locate them, as the blooms look like dark patches against the surrounding foliage.

So, *B. dahlbomii* can see red, but not the way that we do.

10.1242/jeb.042390

Martínez-Harms, J., Palacios, A. G., Márquez, N., Estay, P., Arroyo, M. T. K. and Mpodozis, J. (2010). Can red flowers be conspicuous to bees? *Bombus dahlbomii* and South American temperate forest flowers as a case in point. *J. Exp. Biol.* **213**, 564-571.

WALKING BATS DO NOT COORDINATE CALLS TO CUT COSTS



Echolocation is an energetically expensive way to sense the surrounding environment, but bats have got around this by synchronising their breathing pattern with their wing beat cycle. By doing this flying bats have reduced the cost of echolocation to almost nothing. But what about terrestrial bats that crawl on all fours, have they also reduced their echolocation costs by synchronising their breathing and footfall patterns? Curious to find out how terrestrial bats deal with the prohibitive costs of echolocation, Stuart Parsons, Daniel Riskin and John Hermanson filmed *Mystacina tuberculata* as the animals walked and flew while recording their echolocation calls (p. 551).

Analysing the movies, it was clear that the bats did synchronise their calls with their wing beats during flight, but instead of producing one call at the start of each downstroke, *M. tuberculata* called twice, once at the end of the downstroke and early in the upstroke, suggesting that it uses alternative mechanisms from other flying bats to save energy when generating calls. Also, *M. tuberculata* did not coordinate its calls with its footfall pattern while walking and its calls were weaker and more frequent. So *M. tuberculata* do not cut their echolocation costs while walking. The team is unsure why the animals produce echolocation calls, when other senses would do better when crawling through acoustically cluttered leaf litter on the ground.

10.1242/jeb.042358

Parsons, S., Riskin, D. K. and Hermanson, J. W. (2010). Echolocation call production during aerial and terrestrial locomotion by New Zealand's enigmatic lesser short-tailed bat, *Mystacina tuberculata. J. Exp. Biol.* **213**, 551-557.

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