Locust research shows how the company you keep shapes what you learn

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A solitary male desert locust (left) facing a gregarious male (right) of the same species. Credit: Tom Fayle, University of Cambridge

(Phys.org) —A team of scientists has shown how the environment shapes learning and memory by training locusts like Pavlov's dog to associate different smells with reward or punishment.

Desert locusts are notorious for their devastating swarms. However, they do not always live in swarms—they switch between a lone living 'solitary phase' and a swarming 'gregarious' phase. The two phases differ profoundly in looks, behaviour and in their life style.

The new research from the Universities of Sussex, Leicester and Cambridge, published today (21 November 2013) in the journal *Current Biology*, examines how locusts associate odours with nutritious or toxic food.

Solitary locusts rely on camouflage to evade predators, and they avoid eating toxic plants; but gregarious locusts eat these plants to 'impregnate' themselves with toxins to deter predators. The transformation to gregarious behaviour, which happens when solitary locusts are forced together into a crowd, is complete within a few hours.

Locusts should consider toxic food 'bad' while they live alone but 'good' when they are in a swarm, which made the researchers ask how do swarming locusts learn that 'bad is the new good'?

Such research is important because it provides new insights into how animals can quickly switch between very different life styles that are adapted to different environments.

Dr Jeremy Niven, who heads the Laboratory of Evolutionary Computational Neuroscience in the School of Life Sciences at the University of Sussex, says: "Our research shows how animals that undergo a profound transformation in their lifestyle also adapt their learning and memory capabilities to cope with the new environment in which they find themselves."

For the study, when solitary locusts were presented with an unfamiliar odour together with toxic food, they assigned it an aversive ('bad') value. But if the locust is in a crowd and starting to change to the gregarious state, it assigns an appetitive ('good') value to the same odour. Ecologically, this makes sense because, being a gregarious locust, it should find and eat toxic plants to defend itself against predators.

But if a solitary locust has already learned about an odour and then it finds itself in a crowd, what would happen to its memories? Can it switch the value that it has assigned to the odour, or more precisely, does crowding change the value of a previous memory from aversive to appetitive? Solitary locusts, the researchers found, cannot do this: they are stuck with the value of their already acquired memories. Also, locusts in the transitional period cannot form any new aversive memories, but can still form new appetitive memories.

The researchers then simulated the context in which the switch to swarming behaviour takes place in the field and found that the gregarious locusts blocked aversion learning, enabling those locusts to effectively re-train themselves to learn that the same odour that indicated 'bad' now indicates 'good'.

Co-author Dr Swidbert Ott from the University of Leicester explains: "Desert locusts aggregate into swarms when they run out of food—the crowding is driven by hunger and competition for the last few plants in the desert. They are pretty desperate when they transform into the gregarious phase, so they will give the toxic plants another try. And because they can no longer form aversive memories, any food is now rewarding and they form the new 'correct' appetitive memory with the odour. This is how they re-train themselves to eat the toxic plants."

Dr Niven adds: "Because newly crowded locusts don't form memories about toxins they ingest, all they remember is the pleasant side of what they ate, and they ignore the toxin. In this way, a smell previously associated with a toxin can become associated with a pleasant experience.

"The changes in learning and memory we're proposing don't require the locusts to understand what's happening to them—they just have to feed and form associations."

The study recalls the work of Russian physiologist Ivan Pavlov who famously studied dogs salivating in anticipation of food. Pavlov rang a bell every time he presented the dog with food. After a few 'training sessions' ringing the bell alone was sufficient to make the dog salivate, as it had come to associate the sound of the bell with getting food.

The scientists trained the locusts in similar fashion, except that the unfamiliar smell replaced the bell in Pavlov's experiments: they gently blew either vanilla or lemon odour at a restrained locust, while they spoon-fed it with artificial food.

After training, the researchers walked the locust on a rod split into two arms: one arm scented with lemon, the other with vanilla. Without training, locusts preferred vanilla over lemon. But if nutritious food was paired with the lemon odour during the training, the locusts chose the lemon-scented pathway. Solitary locusts trained to associate toxic food with vanilla also chose to walk along the lemon-scented route."

The new results show how brains do not solve problems 'in a vacuum' but in interaction with the environment.

Dr Niven says: "Simply crowding a locust won't change its mind about the odour being 'bad'. We first thought, this is pretty daft, the locust should now like the odour. But even we humans struggle to forget food poisoning although we know the next meal is fine. The locusts do not operate in a vacuum, they live in the desert. When they need to re-evaluate the 'meaning' of an odour, it takes only a simple modification of the rules by which they learn: turn off learning 'bad' but keep learning 'good', and the locust can retrain itself.

"So a little brain that learns simple rules can be successful if able to interact with the environment."

More information: The paper 'Phenotypic Transformation Affects Associative Learning in the Desert Locust' is published in the journal *Current Biology* and will be available online on 21 November.

Provided by University of Sussex

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