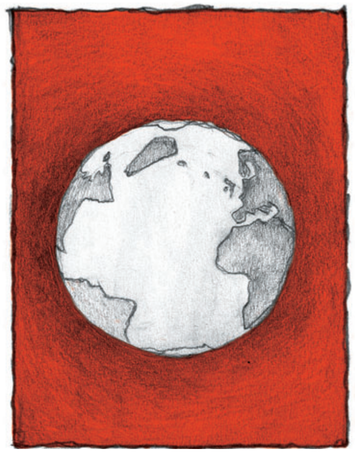
Keeping track of the literature isn't easy, so Outside JEB is a monthly feature that reports the most exciting developments in experimental biology. Short articles that have been selected and written by a team of active research scientists highlight the papers that JEB readers can't afford to miss.

Outside JEB

PESTICIDES



DRUGGED BEES GO MISSING

The quiet drone of busy bees in our garden flower patch is as much a fixture of summer as the barbecue and beach. With their fabled industry, bees move between flowers, collecting pollen that nourishes the young in their hive and pollinates each new flower. Most of our cultivated crops are pollinated in this way, as are a large fraction of the wildflowers that decorate the landscape. Unfortunately, this crucial ecosystem service that we take for granted is in peril. Bees are in precipitous decline across the world, suffering from the mysterious blight called colony collapse disorder (CCD). Two controversial papers published recently in the journal *Science* provide compelling evidence that pesticides are to blame.

Neonicotinoids are neurotoxic pesticides that can paralyse and kill insect herbivores by acting as neurotransmitter receptor agonists and are used to protect more than 100 crop species worldwide. Because they spread to all parts of the plant, including pollen and nectar, bees are exposed to low pesticide doses while foraging. Until now, the effects of such sublethal exposure on bees have been unclear.

Using a miniaturized electronic tagging system to barcode more than 600 bees, Mickael Henry and colleagues from the INRA in France examined the consequences of neonicotinoid exposure on honey bee foraging behaviour (Henry et al., 2012). The team individually monitored bees as they left or entered the experimental hive. The bees in this experimental set-up had two fates: they either returned to the hive or died trying. The researchers found that risk of death in pesticide-exposed bees increased roughly twofold when compared with control bees. This increased risk was evident if the bees were naive or experienced foragers, and with hives that were far away or nearby. Essentially, the pesticide-exposed bees got lost on their way home.

In a second study, Penelope Whitehorn and colleagues from the University of Stirling, UK, found equally striking effects of pesticides on bumblebees. The researchers fed bees a diet of pesticide similar to what they would experience in the field and then monitored colony growth rates (Whitehorn et al., 2012). Compared with unexposed controls, the treated bee colonies were nearly 10% smaller. This may seem a small difference, but the consequences of this reduction were dramatic. The treated colonies only produced one or two queens, compared with nearly 15 for the untreated bee colonies. Without queens, a colony of bees will leave no descendants.

Neonicotinoid pesticides may not kill the two examined bee species immediately, but their demise comes all the same through more subtle and difficult to detect means. Does this mean that neonicotinoid pesticides are the cause of CCD? Although the evidence of these studies is damning, it is perhaps too early to say. In addition to pesticides, other studies have implicated mites, viruses, general habitat loss or some complex interaction between these as causes of CCD. However, given the irreplaceable role of bees in crop pollination and honey production – not to mention their staggering economic value – it would seem most prudent to ban neonicotinoid pesticides while the jury is out. As of June 2012, France has taken this cautious step, much to the displeasure of pesticide manufacturers. UK authorities, however, are inexplicably yet to do so.

10.1242/jeb.064303

Henry, M., Beguin, M., Requier, F., Rollin, O., Odoux, J.-F., Aupinel, P., Aptel, J., Tchamitchian, S. and Decourtye, A. (2012). A common pesticide decreases foraging success and survival in honey bees. *Science* **336**, 348-350.
Whitehorn, P. R., O'Connor, S., Wackers, F. L. and Goulson, D. (2012). Neonicotinoid pesticide reduces bumble bee colony growth and queen production. *Science* **336**, 351-352.

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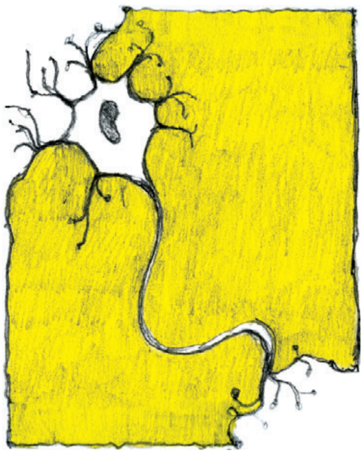
MOTOR SKILLS



PRACTICE MAKES PERFECT, EVEN IF IT DOESN'T LOOK LIKE IT

Learning new skills can be hard: it takes time and, above all, practice. Only through a gradual process of trial and error do we acquire the ability to walk, speak, or play the trumpet. This process, called motor skill learning, involves two structures within the brain: an 'actor', which adjusts the behaviour of the animal, and a 'critic', which monitors the effect of the adjustments and compares it with the desired outcome. The interaction between these two regions results in a reinforcement of the adjustments made by the actor that the critic thinks will take the behaviour closer toward the desired outcome, until practice has indeed made perfect.

A central yet untested assumption in the current model of motor skill learning is that the gradual changes implemented by the actor are an important part of this learning, and that the critic monitors progress by feedback received from the movements that are generated as a result of these changes. A groundbreaking study recently published by Jonathan Charlesworth, Timothy Warren and Michael Brainard in *Nature* disputes this assumption.

Bengalese finches can be trained to modify the pitch of their song, a gradual process of motor skill learning requiring the anterior forebrain pathway (AFP) as the actor, and dopaminergic neurons within the basal ganglia as the critic. The authors of the study decided to test whether the adjustments implemented by the AFP actor were required in the training process by blocking the output of the AFP to the motor system with a drug.

As expected from previous studies, the finches did not gradually change their song in response to the training regime when the drug was applied. However, much to their surprise, when the authors removed the drug, the birds immediately produced a perfectly modified pitch. The finches therefore skipped all the steps that they normally take during the training process, and instantly went from novices to experts. These findings suggest that the step-by-step improvements normally seen during training are not required for learning.

However, when the team disrupted neuronal activity within the AFP during training, they found that not only was there no gradual improvement but also the birds did not modify their song after the drug was removed. Inactivating the AFP actor therefore interferes with learning, suggesting that activity within the circuit is required during training.

These findings show that Bengalese finches can modify their song even without gradual improvements, suggesting that the critic does not monitor the consequences of the actor's adjustments. So how does the critic know whether to tell the actor it is improving? The authors speculate that it is not the animal's movements that the critic looks at but the underlying brain activity instead. The critic probably receives a representation of the activity of the motor system, a so-called 'efference copy', which it uses to identify successful adjustments.

This study takes a huge leap towards identifying the neural mechanisms underlying motor skill learning, and will direct many future experiments in the field. Just don't think it will help you to become the next Miles Davis: you'll still have to practice.

10.1242/jeb.064311

Charlesworth, J. D., Warren, T. L. and Brainard, M. S. (2012). Covert skill learning in a cortical-basal ganglia circuit. *Nature* **109,** 2049-2053.

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COMMUNICATION

FOR CRAYFISH CLAWS, SIZE ISN'T EVERYTHING

In a crayfish fight to the death, the combatant with the larger claws usually has better odds. In fact, many crayfish fights don't even make it to the death. After sizing up each other's claws, called chelae, the crayfish with the smaller chelae will often surrender before the fight even begins. This is a sound strategy: it keeps both parties from getting unnecessarily injured, and the stronger crayfish wins. Unless large chelae are not as strong as they appear. When size-based signals are used to determine the outcome of competition, deception can run rampant. Crayfish may gain an advantage merely by investing more in the size of a chela than in the muscle used to power it. Michael Angilletta Jr of Arizona State University, USA, and Robbie Wilson of the University of Queensland, Australia, set out to find whether chela size was an honest indicator of strength in male crayfish.

The researchers collected wild male crayfish and measured the force produced as each chela clamped down on a sensor composed of metal plates. To be sure that they were measuring actual maximum force production, the researchers measured force production at different temperatures and multiple times for each crayfish.

While the authors found that in general strength increased with chela size, larger chelae exhibited much greater variation in force production. This pattern held across temperatures, so differences in strength among chela are likely to be a product of real physiological differences, instead of the crayfish's motivation at that time.

As a result of this variation in strength, the larger the chela, the more unreliable the chela size as a signal of potential force production. In some cases, larger chelae were weaker than slightly smaller counterparts. These asymmetries of size and strength suggest that deceptive signaling in crayfish is common. Angilletta and Wilson propose two explanations for this phenomenon: either the crayfish benefit tremendously from having deceptive chelae or, alternatively, crayfish pay tremendous costs for attempting to identify their opponents' deceptive chelae.

Cryptic asymmetry between size and performance adds another dimension of uncertainty to the competitive interactions of crayfish. A crayfish may not be able to accurately account for the strength of his competitor, or even know which chela is most dangerous. Further study may elucidate some of the complexities of dominance and the evolution of deceptive signaling in crayfish, to find out why bigger isn't always better.

10.1242/jeb.064337

Angilletta, M. J. and Wilson, R. S. (2012). Cryptic asymmetry: unreliable signals mask asymmetric performance of crayfish weapons. *Biol. Lett.* **8**, 551-553.

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CAMERA-LADEN LEATHERBACKS DOCUMENT FEEDING

There are obvious barriers for marine scientists interested in characterizing the foraging success of endangered marine predators. Issues ranging from decreasing animal numbers, to vast migratory patterns and sheer oceanographic scale must be considered. Prior to technological advances, researchers seeking to discern behavioral and nutritional aspects of the food chain – in the very deepest reaches of the marine ecosystem – had to rely on analyses of data collected over sporadic observations. However, in a recent Canadian collaborative study published in *PLoS ONE*, Susan Heaslip, Sara Iverson, Don Bowen and Michael James, from Dalhousie University and the Bedford Institute of Oceanography, describe how they managed to surmount each of these obstacles to precisely quantify the foraging behavior of a threatened species: the leatherback turtle.

Before this study, direct and sustained observation of the leatherbacks' foraging strategy had not been documented because of the turtles' immense east–west migration pattern – up to 18,000 km round trip from tropical nesting beaches to foraging grounds – and the enormous depths that they plumb. In order to understand the immediate survival challenges faced by the turtles, the team set out to document the animals' foraging behavior and to observe how they capture and handle prey, using recent technological advances. The authors tracked the turtles' progress with GPS while recording their foraging behavior with 19 turtle-borne cameras.

Using continuous video, the authors documented 601 prey captures. They found that the turtles' diet was very restricted – the lion's mane jellyfish was the turtles' most common victim – and they showed that the jellyfish were attacked and consumed completely in each hunt. The researchers were able to estimate the approximate size of each jellyfish prior to ingestion, which they found ranged from 3.1 to 22.7 cm in diameter – although the authors add that these prey-size calculations are likely to underestimate the actual size, as measurements were made based on images taken prior to capture, when jellyfish were positioned at a greater distance from the camera. Also, when calculating the rates at which the turtles encountered prey, the team noted foraging hotspots – patchily dispersed zones with high numbers of jellyfish – that reflect crucial foraging areas for leatherback turtles.

In order to better understand the turtles' daily energy intake in relation to their energy output, the researchers measured their capture success rates and migratory patterns, as well as the size of the captured prey. Based on their observations, the authors calculated that turtles consume an average of 73% of their body mass, approximately 261 lion's mane jellyfish per day, equating to an average energy intake of 3–7 times their daily metabolic requirements.

This study intimately documents the highly efficient (albeit highly selective) feeding behavior of the leatherback turtle. The researchers provide insight into how the animal sustains an extended migration and their data support the importance of conservation strategies that consider the entire food chain in the context of the animal's ecosystem.

10.1242/jeb.064329

Heaslip, S. G., Iverson, S. J., Bowen, W. D. and James, M. C. (2012). Jellyfish support high energy intake of leatherback sea turtles (*Dermochelys coriacea*): video evidence from animal-borne cameras. *PLoS ONE* **7**, e33259.

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