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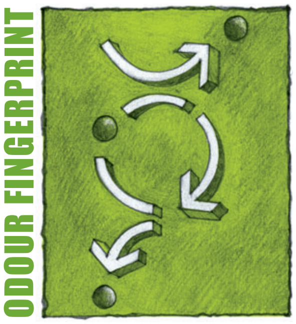
OUTSIDE JEB

Seals scent their relatives



Many people go to great lengths to make sure they smell good. Aftershaves and perfumes may smell great, but they don't tell you too much about the individual's health, hometown or how friendly they are likely to be. In the animal kingdom, however, things are slightly different. Their world abounds with smells and olfactory communication is one of the commonest forms of interaction. These natural fragrances, such as pheromones and strong-smelling urine, might not always smell as good as our eau de toilette, but they do contain information about the physiological state of the individual. They can be used for communication between members of the same family, territorial rivals and potential mates, and the intricate details contained within such chemical fingerprints have now been revealed in a recent study published by Martin Stoffel and colleagues from Bielefeld University, Germany. By studying colonially breeding Antarctic fur seals (*Arctocephalus gazella*), the team discovered that the chemical cues between a mother and her offspring contain a multitude of information about relatedness, genetic quality and colony membership.

The study, published in *PNAS*, took place on an isolated island in the Southern Atlantic Ocean. Over 65,000 fur seals breed there each year, packed into dense colonies. One of the key questions that inspired the researchers was just how do mothers locate their pups amongst thousands of other individuals when returning from foraging trips at sea? Does olfaction play a role? Communication by smell is an incredibly tricky matter to study, because of the huge mixture of chemicals on an animal's skin. Moreover, the chemical composition of the skin can be affected by external factors such as microbial flora and internal determinants like hormones and body condition. The team gathered data on the chemical compositions of the odours of 44 mother–offspring pairs by rubbing a cotton wool swab under the eye and behind the snout, in addition to taking minute skin samples. Through the use of mass spectrometry, the team investigated the compounds in the scent samples and calculated the genetic relatedness of the animals using total genomic DNA extraction.

When the analysis was complete, it was evident that the chemical footprints of the pups were significantly more similar to their mothers than could be expected by chance. A follow-up experiment demonstrated that this similarity wasn't just a function of spatial proximity, and that this unique scent profile allows mothers to recognise their pups. It is also likely that other close relatives could use the same mechanism for recognition because the chemicals present in the skin are genetically encoded, which could be highly significant when it comes to choosing a mate, as it would enable you to avoid breeding with relatives. As genetic diversity is frequently linked to survival, this scent-identification mechanism could help preserve genetic diversity through the avoidance of inbreeding.

The study shows just how much vital information can be contained within a chemical signal and how detailed these fingerprints are. From an evolutionary perspective, this makes perfect sense – the ability to smell is the first sense to develop and, for the parent, the ability to recognise offspring by olfaction is paramount, as mistaken identity can result in wasted energy and loss of offspring. It is also highly likely that this ability to recognise relatives by olfaction is not unique to fur seals and is prevalent throughout the animal kingdom. So next time you cover yourself in your fragrance of choice, think carefully about the chemical signal you are sending to those around you.

10.1242/jeb.112714

Stoffel, M. A., Caspers, B. A., Forcada, J., Giannakara, A., Baier, M., Eberhart-Phillips, L., Müller, C. and Hoffman, J. I. (2015). Chemical fingerprints encode mother-offspring similarity, colony membership, relatedness, and genetic quality in fur seals. *Proc. Acad. Nat. Sci. USA.* **112**, E5005-E5012.

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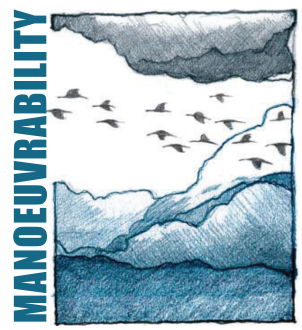
For hummingbirds, nature is not a wind tunnel



Hummingbirds are aeronautical wonders. They hover, zoom, dive and halt with arresting speed and accuracy. Most of what we know of their flight capabilities comes from studies in the lab – wind tunnel experiments that test maximum flight speeds and force. However, Katherine Sholtis, of the University of North Carolina at Chapel Hill, USA, and her collaborators wanted to understand how the birds' fantastic maneuverability in the lab related to what they were doing in more real-world circumstances. That is, how the patterns that were recorded in the lab match what we see out of our windows or in the wild.

The authors used multiple high-speed camera videography to film wild male and female Ruby-throated hummingbirds (*Archilochus colubris*) as the birds fed at a hummingbird feeder adjacent to a wooded area. They recorded the flying behavior of hummingbirds as they fed alone and as they interacted with another competing bird at the feeder. They also recorded differences between when the birds were approaching the feeder from a nearby perch and when they were flying in from elsewhere. The team was interested in how flying speed,

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acceleration, force and energy use varied under these different circumstances.

They found that, not surprisingly, birds that were being chased flew faster than birds that were alone. But interestingly, birds that were chased away from the feeder and the unrestricted birds both used about the same amount of energy when they left the feeders. The birds that were chased sped away faster, but because they chose a less energetically expensive route, forward or down, compared with the unrestricted birds' choice to fly upward, the energy use of both birds balanced out in the end. So, while being chased away might be inopportune, it was not more energetically expensive.

The authors also found that the birds that were flying in to defend the feeders from perches flew in at greater speeds and velocities than birds flying in from elsewhere. They found that defending birds turned with the greatest force and that, based on calculations from other studies, the birds in this study appeared to use most of their available maximum flight force when departing from the feeder. While these results provide many real-world insights into hummingbird flight maneuvers, because most of the defending and unrestricted birds were male and most of the birds being chased were female, these differences could also reflect sex-specific differences in performance or behavior.

Previous lab studies with these birds have measured maximum level flying speeds as a standard of performance. But Sholtis and her colleagues found that the birds they were studying never reached those maximum level flying speeds. Birds defending the feeder flew the fastest, but their speed was still below the maximum recorded in wind tunnels in the lab, and the wild birds flew downward rather than along a level trajectory.

The authors argue that because only maximum flight force and power – not maximum level flying speed – were observed under natural conditions, these are the performance measures that should be studied in hummingbirds. The authors also caution that these natural competitive interactions in Ruby-throated hummingbirds may not be the best model if the goal is to quantify maximum forward flight performance. And although this study shows why their natural exertions may not be as straightforward to study as those of animals in the lab, the interactions are still fun to watch.

10.1242/jeb.112706

Sholtis, K. M., Shelton, R. M. and Hedrick, T. L. (2015). Field flight dynamics of hummingbirds during territory encroachment and defense. *PLoS ONE*, **10**, e0125659.

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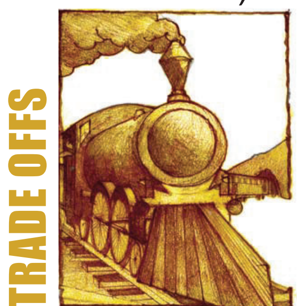
The fast and the furious(ly manoeuvrable)



When face to face with a predator, would you rather have blistering speed to out-run or fancy footwork to out-manoeuvre your foe? If you opted for speed, you're not alone. We intuitively think quicker means better when it comes to eluding capture. Our fascination with fast is so pervasive that most research on predation and prey evasion focuses solely on maximal speeds when evaluating performance. But, are we missing an important part of the predator–prey story? Christofer Clemente and Robbie Wilson from the University of Queensland, Australia think so. In fact, they suggest that when it comes to gauging success in escaping from predators, our thinking needs a change in direction.

Clemente and Wilson wanted to explore the role of traits other than speed in determining whether a victim escapes from a predator unscathed. They decided to focus on manoeuvrability; the capacity to turn rapidly within a confined space (i.e. with a small turning radius). Unfortunately, studying animal twists and turns has taken a backseat to speed in most research to date for one very practical reason: manoeuvrability is a hard thing to quantify and measure, especially in free-living animals. To overcome these logistic challenges, the team had to think outside the box. They designed a tablet-based game to simulate encounters between on-screen 'prey' dots and the ultimate food- (and technology-) motivated predators: university students. The team manipulated the behaviour of a single prey dot moving left to right across the screen by programming differences in prey speed, size and directional changes (manoeuvres) into discreet trials. To capture the prey and end the trial, the human predator had to tap on the moving dot within a certain radius of accuracy. After thousands of trials on dozens of volunteers, the researchers were able to evaluate what combinations of prey size, speed and manoeuvrability fared best when facing the touch of death.

If you initially opted for speed over foot-work in the thought experiment above, don't fret: Clemente and Wilson confirmed the importance of being fast when it comes to escape success. However, their results also suggest that for slow prey, manoeuvrability can be the difference between escaping or ending up as dinner. The interaction between speed and manoeuvrability is even more complex when considering body size. Larger prey were hugely disadvantaged when travelling at intermediate speeds compared with smaller prey. Yet, body size did not seem to interact with manoeuvrability to determine escape success: more manoeuvrable means more likely to escape across all prey sizes. The researchers note that smaller animals such as mice and lizards, which have relatively slow absolute speeds, also tend to be highly manoeuvrable.

Clemente and Wilson's research stresses the need to move beyond the current focus on speed when it comes to predicting the outcomes of predator–prey interactions. Understanding the role of traits like manoeuvrability, as well as acceleration and predictability, may provide a more complete picture of how some individuals thwart the hunt. Despite all this complexity surrounding escape success and performance, one clear pattern emerges: slow and steady definitely does not win the race!

10.1242/jeb.112698

Clemente, C.J. and Wilson, R. S. (2015). Speed and manoeuvrability jointly determine escape success: exploring the functional bases of escape performance using simulated games. *Behav. Ecol.* doi:10.1093/beheco/arv080.

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Peptides help flies find food faster

Even in an unchanging world we might not experience the same sensations twice. The smell of freshly baked bread can make us ravenous when we're hungry, but nauseous when full; the sight of beer might make us thirsty at the end of a long day, but rather less so the morning after. This flexibility in behaviour enhances animals' chances of survival by tuning their actions to what produces the most beneficial outcome at any given time. *Drosophila melanogaster* provides an interesting example of this phenomenon: starved flies are more sensitive to attractive odours, such as low levels of vinegar, allowing them to detect food sources more efficiently. At the same time, they are less sensitive to repulsive odours, such as CO_2, allowing them to ignore potentially toxic compounds. How could this seemingly paradoxical response be implemented?

A team of researchers at the University of California, San Diego, has addressed this question in a study recently published in *eLife*. The authors had two prime candidate peptides for the opposing responses: sNPF and tachykinin, two molecules that are implicated in behavioural responses to nutrition. In the first experiment, they tested whether removing the receptor for these molecules in olfactory neurons affected the reaction of starved flies to attractive and repulsive odours.

They found that removing these receptors had almost opposite effects: without the sNPF receptor starved flies were attracted less to an attractive odour, but without the tachykinin receptor they were repulsed less by a repellent odour. This suggests that each of these signals is responsible for one of the opposite changes in behaviour that starvation induces; so how do these signals affect the processing of olfactory information? The simplest mechanism would be to have each peptide specifically affect the connections between those olfactory neurons that sense attractive or repulsive odours with their respective partner neurons. In order to find out whether this theory was correct the team removed the receptor for sNPF in olfactory neurons that sense the attractive odour and removed the tachykinin receptor from those that sense the repulsive odour.

The sensitivity changes followed the predictions from the simplest mechanism: attraction was attenuated in flies in which the sNPF receptor was removed from attractant-sensing neurons and repulsion was enhanced in flies in which the tachykinin receptor was removed from repellent-sensing neurons. These results suggest that sNPF specifically sensitizes attraction, whereas tachykinin specifically dampens aversion.

So, how does starvation recruit these peptides to modulate olfaction? In previous studies, *Drosophila* insulin was found to be a sensor of the nutritional state of the animal. When the team inhibited insulin signalling in the repellent olfactory neurons, they noticed that fully fed animals displayed starved-like behaviour – an effect that could be blocked by inhibition of the receptor for tachykinin. This suggests that, in starved animals, lower levels of insulin signalling directly potentiate the tachykinin receptor within a subset of olfactory neurons and thereby repress aversion.

This study shows how the nutritional state can affect the processing of sensory information and can lead to the fine-tuning of behaviour. The peptides described in this study have homologues in mammals, making a case as clear as ever that what is found in the fly, could be found in man.

10.1242/jeb.112680

Ko, K. I., Root, C. M., Lindsay, S. A., Zaninovich, O. A., Shepherd, A. K., Wasserman, S. A., Kim, S. M., Wang, J. W. (2015). Starvation promotes concerted modulation of appetitive olfactory behavior via parallel neuromodulatory circuits. *eLife* doi:10.7554/eLife.08298.

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