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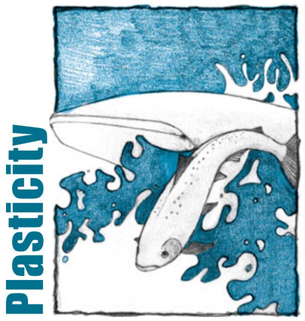
OUTSIDE JEB

Exercise gives fish a boost of boldness



Some animals spend their lives in constant motion – dashing, jumping, flitting, swimming, running, swinging and soaring about – while others are veritable couch potatoes. Differences in daily physical activity can occur because of ecological disparities, such as relative predation risk or proximity to resources; or internal factors, such as individual needs, motivations and physical limitations. There is also another reason why individuals vary in the amount of time they spend moving – personality. Animal personalities are generally thought to vary in terms of how willing they are to explore, their boldness, aggressiveness and sociability. Regular exercise has been shown to elicit increased motivation to continue exercising (i.e. it changes behavior). Elektra Sinclair, of the University of Sydney, and her international team of collaborators asked the question: if exercise can change some behaviors, can it also affect personality? Could the personalities of the mosquitofish she studied be altered by changing the amount of time they were required to exercise each day, i.e. would shy, sedentary fish be molded into lean, mean, venturous machines?

Sinclair and her colleagues caught wild mosquitofish and housed some of them in tanks where water flowed continuously (exercise groups), and some in tanks where the water was still (control groups). After 28 days, they tested the maximum swimming speed and strength of the fish in each group, and how quickly each fish left a novel refuge, as well as the distance the fish explored throughout the tank. Lastly, the authors placed similarly sized pairs of males within each treatment group together and recorded the behavior of the males when they came in contact with each other, to determine which group of males was more aggressive towards other males. Sinclair and her team found that not only were the fish that had been undergoing fitness training for a month significantly better swimmers, relative to the sedentary group, but also they were bolder, explored more and were more aggressive with other males.

To test whether it was the increased locomotor performance that influenced the behavior of the fish (that is, enhanced performance gave them a boost that encouraged boldness), the authors repeated the treatments (with exercise and without) with new sets of fish, but before the behavioral tests, they administered a calcium channel blocker (nifedipine) to the exercised fish to reduce swimming performance. As expected, the nifedipine-treated fit fish did not out-swim the sedentary fish. And, following the treatment, the fit fish were no more eager to explore or aggressive than the control fish. Surprisingly, however, the nifedipine had no effect on boldness. The nifedipine-treated fit fish fearlessly continued to leave their refuges sooner than the control fish.

By forcing the fish to swim regularly, the authors improved the fish's overall locomotor performance via increased cardiovascular, muscular and metabolic function, releasing them from the physiological constraint imposed by inactivity. The interplay between ecology, physiology and behavior demonstrated in this study has far-reaching implications. Not only are differences in personality at the population level potentially mediated by the specific physical demands of the local habitat but also animal personalities are labile and reversible. In addition, the training effects on personality should not be ignored in studies of performance. This study also suggests that the best way to get, and stay, motivated is to start moving. So start moving.

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Sinclair, E. L. E., de Souza, C. R. N., Ward, A. J. W. and Seebacher, F. (2014). Exercise changes behaviour. *Funct. Ecol.* **28**, 652-659.

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Octopuses don't get theirs arms in a twist

It can be complicated enough co-ordinating four limbs, but imagine how bewildering life would become trying to control eight. This is the predicament octopuses contend with on a daily basis. They avoid this potential confusion to some extent by not having proprioception – they are not always aware of where their arms are. Also, each arm can move independently without any input from the brain, courtesy of thousands of neurons taking control on a local level. With each arm being covered in suckers, whose reflex is to stick to everything, it begs the question – how do octopus arms not get tangled up? A recent study by Nir Nesher and his team at the Hebrew University of Jerusalem, Israel, published in *Current Biology*, reveals how a self-recognition mechanism prevents octopuses from getting in a twist.

The team's first exciting observation was that the suckers on freshly amputated octopus arms never attached to octopus skin. The suckers did attach to any parts of an octopus arm where bare flesh was exposed, and also to inanimate objects such as Petri dishes. Nesher explains, 'It was unlikely to be vision playing a role here, as amputated arms which display

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such behaviour don't have eyes'. This led the team to start looking at chemical signals. Sure enough, when the team produced a chemical extract from octopus skin and applied it to the Petri dishes, it reduced the suckers' reflex to attach firmly to the object. Interestingly, when they used chemical extracts from fish skin instead, the octopus suckers attached to the Petri dish with great enthusiasm.

A chemical-sensing mechanism is a method by which octopuses can stop getting their arms in a tangle, with minimal involvement of the brain. However, there will be occasions when being able to attach your suckers to another octopus – they're not opposed to a spot of cannibalism – would be a useful skill to have. To do this, though, octopuses would need to override this 'default' option in their suckers of not sticking to octopus skin. It appears that attached octopus arms can do just that; using their brains to override the non-stick reflex, octopuses can choose to attach to octopus skin. Furthermore, it appears that octopuses can even tell whether an amputated arm offered as food is one of their own or comes from another individual; they don't like to hold on to their own amputated arms.

So octopus arms will always default to not grasp octopus skin, but higher circuitry within the nervous system can override this reflex. A self-avoidance mechanism of this sort could have major implications for the design of robots and for use in artificial intelligence. In particular, creating a bio-inspired robot whose limbs can react to changes in terrain, for example, without needing instructions from central processors can have implications for advancing technologies in search and rescue operations. For now, though, octopuses can continue enjoying a non-tangled existence, while keeping their options open should a tasty octopus-related snack present itself.

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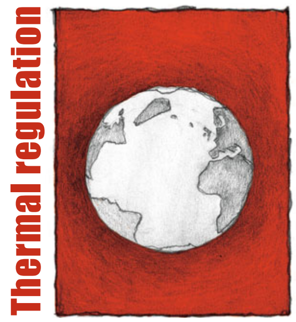
Hot koalas seek trees to keep their cool



During the hot Australian summers, mammals run the very serious risk of overheating. One important avenue for heat loss for mammals and birds is the cooling through evaporation that occurs during sweating, panting or fur licking. The problem is that evaporative cooling is costly; large amounts of water are lost and when water is a limited resource, animals must use other heat-loss mechanisms in order to avoid overheating and dehydration. Many Australian mammals face this conundrum during the very dry and hot summers. Koalas, in particular, obtain most of their water from the eucalyptus leaves they eat and may not even have access to water during dry periods. This means that in order to conserve water, they must use other physiological or behavioural mechanisms to cool down. Natalie Briscoe and her colleagues from the University of Melbourne, La Trobe University, James Cook University and the University of Wisconsin, were intrigued by this possibility and decided to study koalas in their natural environments to determine whether these cuddly marsupials would change their behaviour during the hot months in order to keep their cool.

Briscoe and her team radio-tracked koalas during the winter and summer months and recorded behaviours such as posture, activity, and height and location in the tree, as well as microclimate and habitat data. They also recorded the temperature of different parts of trees using a thermal imaging camera. Finally, they used a biophysical model of heat exchange to predict what the koalas' heat-loss requirements are under different environmental conditions and the potential for conductive heat loss when koalas are in direct contact with cooler tree trunks and branches.

Their biophysical model predicted that during hot days, hugging trees would allow koalas to lose enough heat such that the need for evaporative cooling could be substantially reduced or even entirely abolished. Indeed, Briscoe's observations indicate that koalas choose thicker tree trunks and branches (larger surface area for conductive heat loss) during hot weather and they were more often observed on the main tree trunks rather than on branches at these times. Koalas also used non-food trees more often during hot weather than during mild conditions. Interestingly, these species of trees were also cooler than food trees, sometimes up to 8.9°C lower than the environmental temperature, providing a large temperature gradient to aid in heat loss.

When we think of koalas, we usually form the mental image of a cuddly bear-like marsupial holding on to a eucalyptus tree. Rarely do we think, however, that 'tree hugging' is much more than a way of passing time for koalas or of being close to their lunch, and that, in fact, it might be a crucial behaviour for their survival during hot weather. With increasingly hotter and dryer seasons predicted as climate changes, and during the already recurring heat waves of the Australian summers, tree trunks could be important heat refuges for many arboreal species, including koalas.

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A giant fibre bypass for the fly

The nervous system is no slacker: each constituent synapse only takes a few milliseconds to transfer its information from one cell to the next. This allows an animal to rapidly sift through the sensory world in order to determine the best behavioural response. However, sometimes even this process takes too much time, as can be the case when an animal has to respond to a fast-approaching predator. A recent study by researchers at the Janelia Farm Research

Campus, USA, has elucidated a neural mechanism that allows an animal to speed up its behavioural response for these occasions.

The team noticed that the fruit fly *Drosophila melanogaster* responds to looming threats with one of two escape behaviours: a slow, stable response, in which the fly raises its wings before it jumps off and flies away, and a faster, far less stable response, in which the fly does not elevate its wings before it jumps off, shaving 8 ms off the response time. How does a fly choose between these two responses? A well-known cell that is involved in the initiation of escape responses in many species of animal is the giant fibre (GF) interneuron, though its precise function is unclear. The authors therefore decided to genetically activate or inhibit this neuron and see what the behavioural response would be.

They noticed that activation of this neuron led to the initiation of the fast, unstable escape behaviour, while inactivation rendered the flies incapable of performing this fast response. This suggests that the GF is both necessary and sufficient for this behaviour, and raises the possibility that the choice between the fast and slow modes is simply a matter of turning this cell on or off. To test this possibility, the researchers decided to record the activity of this neuron in flies performing these behaviours.

To their surprise, the GF was active not just when the fly performed the fast escape response; it also fired during some of the slower responses, raising doubt about how it is involved in the choice between fast and slow escape responses. In order to figure this out, the authors performed a detailed analysis of the correlation between the activity of the GF neuron, the properties of the visual stimulus and the exact behavioural action selected at any given time.

The researchers found that the timing of the activity of the GF neuron relative to the stimulus was crucial: the approach of a predator initiates an escape response in the fly that, by default, is the slower one; only if the predator approaches with sufficient speed is the GF activated, which then overrides the slower response to produce a faster escape. However, only if the GF is activated during a particular time window during the behavioural sequence is it capable of overriding the slower response, which explains why the GF can be active even during some of the slower responses.

Flies in which the GF was genetically inhibited were not able to escape from damselflies, one of their natural predators, when they approached the flies at their fastest attack speeds. This shows that the seemingly insignificant 8 ms difference that the faster response makes can actually save the life of a fruit fly.

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