Chocolate makes snails smarter

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Chocolate isn't usually on the diet for snails, but when Lee Fruson and Ken Lukowiak from the University of Calgary, became curious about the effects of diet on memory, they decided to try a flavonoid from chocolate, epicatechin (epi) on the pond snail Lymnaea stagnalis to see if it improved the animals' memories. After a dose of epi, the pond snails were able to remember a training protocol for longer and the memories were stronger.

Type the word 'superfood,' into a web browser and you'll be overwhelmed: some websites even maintain that dark chocolate can have beneficial effects. But take a closer look at the science underpinning these claims, and you'll discover just how sparse it is. So, when University of Calgary undergraduate Lee Fruson became curious about

how dietary factors might affect memory, Ken Lukowiak was sceptical. "I didn't think any of this stuff would work," Lukowiak recalls. Despite his misgivings, Lukowiak and Fruson decided to concentrate on a group of compounds – the flavonoids – found in a wide range of 'superfoods' including chocolate and green tea, focusing on one particular flavonoid, epicatechin (epi). However, figuring out how a single component of chocolate might improve human memory is almost impossible – too many external factors influence memory formation – so Lukowiak turned to his favourite animal, the pond snail *Lymnaea stagnalis*, to find out whether the dark chocolate flavonoid could improve their memories. They publish their discovery that epi improves the length and strength of snail memories in *The* Journal of Experimental Biology.

According to Lukowiak, the molluscs can be trained to remember a simple activity: to keep their breathing tubes (pneumostomes) closed when immersed in deoxygenated water. He explains that pond snails usually breathe through their skins, but when oxygen levels fall, they extend the breathing tube above the surface to supplement the oxygen supply. However, the snails can be trained to remember to keep the breathing tube closed in deoxygenated water by gently tapping it when they try to open it, and the strength of the memory depends on the training regime.

First, Fruson identified an epi concentration – 15 mg m^3 pond water – that didn't affect the snails' behaviour; 'We have to be sure that we're not looking at wired animals', chuckles Lukowiak. Then, the duo tested the molluscs' memories. Explaining that a half-hour training session in deoxygenated water allows the snails to form intermediate-term memories (lasting less than 3 h) but not long-term memories (lasting 24 h or more), Fruson and Lukowiak wondered whether epi would improve the snail's memories, allowing them to form long-term memories after shorter memory training. Amazingly, when Fruson plunged the molluscs into deoxygenated water to tested their memories a day later, they

remembered to keep their breathing tubes closed. And when the duo provided the snails with two training sessions, the animals were able to remember to keep their breathing tubes shut more than 3 days later. Epi had boosted the molluscs' memories and extended the duration, but how strong were the epi-memories?

Lukowiak explains that memories can be overwritten by another memory in a process called extinction. However, the original memory is not forgotten and if the additional memory is stored weakly, it can be lost and the original memory restored. So, Fruson and Lukowiak decided to find out how strong the epi-boosted memory was by trying to extinguish it. Having trained the snails, the duo then tried to replace it with a memory where the snails could open their breathing tubes. However, instead of learning the new memory, the epi-trained snails stubbornly kept their breathing tubes shut. The epi-memory was too strong to be extinguished.

The duo also found that instead of requiring a sensory organ to consolidate the snails' memories – like their memories of predators triggered by smell – epi directly affects the neurons that store the memory. So, Lukowiak is keen to look directly at the effect that epi has on memory neurons and adds that the cognitive effects of half a bar of dark chocolate could even help your grades: good news for chocoholics the world over.

More information: Fruson, L., Dalesman, S. and Lukowiak, K. (2012) A flavonol present in cocoa [(–)epicatechin] enhances snail memory. *J. Exp. Biol.* 215, 3566-3576.
jeb.biologists.org/content/215/20/3566.abstract

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