Suckers for learning: why octopuses are so intelligent

July 7 2021, by Lisa Poncet

Credit: Morten Brekkevold, CC BY-NC-SA

Our last common ancestor with the octopus existed more than 500 million years ago. So why is it that they seem to show such peculiar similarities with humans, while at the same time appearing so alien? Perhaps because despite their tentacles covered with suckers and their lack of bones, their eyes, brains and even their curiosity remind us our own thirst for knowledge.

In ethology, the study of behaviour, we explore this intelligence, which we classify as individual "cognitive abilities". These are the mechanisms through which information from the environment is perceived, processed, transformed, remembered and used to take decisions and act.

From a behavioural point of view, the flexibility with which an animal can adapt itself and adjust its behaviour to novel situations is a good indicator of its cognitive abilities. Numerous studies indicate the octopuses possess great flexibility in their behaviours, whether they express them in their natural environment or inside a tank in a laboratory.

Armed and dangerous

So what makes octopuses so smart?

Let's focus first on their defence mechanisms. Faced with multiple predators—including fish, birds and whales—octopuses are masters of camouflage. They can imitate their environment by modifying the colour and even the texture of their skin.

Without a shell, octopuses are vulnerable, and always try to remain hidden in a shelter such as a cavity or the space beneath a rock. Some species maintain their shelter by removing sand and adding pebbles and shells. Some prefer to wrap themselves in shells and pebbles, while others transport their shelter in their arms. This is the case for the coconut octopus, which, true to its name, has been observed carrying coconut shells around to hide within in case of danger.

Octopuses are also formidable predators themselves, and their attack mechanisms are suited to the wide variety of prey they consume, including seashells, crustaceans, fish and even other cephalopods. They can use their vision and camouflage skills to hunt, and their arms to

explore, touch and taste their environment to seize every bit of food within reach.

The octopus is a thoughtful hunter. It can cooperate with other species such as groupers to hunt hidden prey. It can learn to avoid crabs bearing poisonous anemones or find a way to cautiously attack them while avoiding being stung.

Octopuses use different techniques to consume seashells and molluscs, either pulling apart the shell by force and placing a small stone inside to keep it open, or drilling into the shell to inject a paralysing toxin which will make the prey open up. This toxin is injected into a very precise muscle under the shell, and octopuses learn and remember the drilling site of each seashell they consume.

Boneless, not brainless

We can test the cognitive abilities of octopuses in the lab. In our EthoS laboratory, we are currently working on the memory and future planning abilities of the common octopus. They are complex animals to study, because of their astonishing abilities.

Their incredible strength allows them to easily destroy our lab tools: be careful with underwater cameras, they can open the waterproof box to drown them! And because octopuses are boneless, they can easily escape their tanks through the smallest of openings. They are also extremely curious and will spend their time catching hands, nets or any other object introduced to their tank. From there, it is up to them to decide when to release their catch.

The opening of jars, while impressive and often used to illustrate octopus intelligence, is not their most remarkable ability. This is mostly a matter of dexterity and gripping, and octopuses are quite slow when

executing this task: even when over-trained, an octopus always takes more than a minute to open a jar. A better example of their impressive intelligence is their ability to manipulate an L-shaped object so it can pass through a small square opening in a wall.

Credit: AI-generated image (disclaimer)

Octopuses also excel in discriminative learning: confronted with two objects, they learn to attack one of them in exchange for a reward, basing their choice on characteristics such as colour, shape, texture or taste, and they can retain this information for several months. They can also generalise, a complex thought process in which they need to spontaneously apply a previously learned rule to new objects. For example, octopuses who have previously learnt to attack a real ball can go on to attack a virtual ball on a screen.

Octopuses can also use conditional discrimination, that is, they can modify their choice depending on the context. For example, they can learn to attack an object only in the presence of bubbles. They can also use spatial learning, and find an hidden shelter by remembering its position, or use visual cues to know how to orient their arm inside an opaque T-shaped apparatus.

Last but not least, octopuses can learn by watching other octopuses carry out tasks, such as choosing one specific object over another. This is surprising, because they are mainly solitary creatures.

Grade: sea minus

Octopuses meet every criteria for the definition of intelligence: they show a great flexibility in obtaining information (using several senses and learning socially), in processing it (through discriminative and conditional learning), in storing it (through long-term memory) and in applying it toward both predators and prey.

Despite their obvious abilities, octopuses are oddly erratic in their responses, especially in visual discrimination tasks, in which they carry out the correct response around 80% of the time, while other animals succeed almost perfectly.

And do not be mistaken: octopuses may be clever, but in the classroom of cephalopods they would be the bright but unruly pupil, and the cuttlefish would be top of the class.

The humble cuttlefish is less familiar, but is the subject of numerous research projects worldwide. Less disruptive than octopuses, they possess exceptional learning abilities, can pick up complex rules in no time and apply them perfectly.

Provided by The Conversation