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INSIDE JEB

Porpoises adjust echolocation clicks to distinguish objects from clutter

Freja wearing eye covers approaching the aluminium sphere by echolocation. Photo credit: Solvin Zankl.

Hollywood representations of Cold War sonar depict torpedoes blinking unhindered across green screens. Yet, the reality of navigating by echolocation is far more demanding for the animals that depend on it. Porpoises and bats must differentiate between the echoes generated by background objects and the juicy morsels they are intent upon catching. And the difficulties of interpreting the environment are even more challenging for aquatic creatures; sound travels in water at 4.5 times the speed in air, leaving porpoises and dolphins with even less time to distinguish between echoes returning from objects that are close together. Chloe Malinka from the University of Aarhus, Denmark, explains that porpoises were thought to be unable to differentiate sounds that appear within 264 µs of each other, placing a natural limit – around 20 cm – on the separation between objects that they should be able to distinguish by echolocation, making her wonder how echolocating porpoises differentiate objects that are close to each other.

Malinka travelled to the Fjord & Bælt Centre, Denmark, home to harbour porpoises Freja and Sif who have been collaborators of Peter T. Madsen's for almost 20 years. 'It's always a pleasure to work with Freja and Sif – two of the world's most studied echolocators', says Malinka, who set the animals the task of distinguishing between a 5 cm diameter aluminium sphere, which they had been trained to recognise, and a 5 cm wide steel sphere placed 13.5, 27, 54 or 108 cm away. 'We gently attached opaque cups over the eyes of the porpoises to act as a blindfold, so that they could only use echolocation to solve the task', says Malinka. She also attached an underwater microphone behind the animals' blow holes to record the clicks that they produced while approaching the objects and the echoes they heard. 'The porpoises were given fish as a reward for correctly selecting the aluminium target', says Malinka, who also filmed the animals as they approached the spheres.

Impressively, both porpoises successfully selected the aluminium sphere more than 93% of the time, even when the spheres were only 13.5 cm apart – closer than the scientists thought the animals could distinguish. 'Peter, Laia [Rojan-Doñate] and I were surprised to find that Freja and Sif were able to do this, even with small differences in the timings of the returning echoes from each of the targets', says Malinka. But how were the porpoises pulling off the feat?

The secret was in the rapid cascade of clicks – known as buzzes – produced by the animals as they closed in on their target. 'We observed that when the targets were closely spaced and the discrimination task was more difficult the porpoises buzzed for longer and started buzzing from farther away', says Malinka. In addition, the porpoises clicked faster as they approached the closest pairs of spheres and more softly in the final moments of the approach. As the porpoises closed in, they also moved their heads from side to side more, directing their acoustic focus toward one sphere and then then other, before making their decision.

'We think that the porpoises were benefiting from their highly directional biosonar beam', says Malinka, explaining that objects directly in line with the powerful beam of sound will return stronger reflections than objects off to the side, allowing the porpoise to home in precisely on the aluminium target. So, porpoises are not hampered by being unable to distinguish echoes that arrive within 264 µs of each other. They adapt their echolocation clicks while closing in to gather more information during their approach, allowing them to directly pursue a target despite being bombarded by distracting echoes from surrounding clutter.

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