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A Phenomenon Discovered While Imaging Dolphin Echolocation Sounds

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Abstract

Our ultimate goal is to investigate if dolphins use language or possibly graphic information in their intricate whistles and clicks. In images obtained from digital recordings of dolphins echolocating on submerged objects, we have uncovered a surprising occurrence. Hydrophone recordings of dolphin echolocation noises were fed into a CymaScope, an analogue device in which a voice coil motor directly linked to a water-filled fusedquartz cell is acoustically activated in the vertical axis. The resulting wave patterns were recorded with a digital video camera. We observed the formation of transient wave patterns in some of the digital video frames that clearly matched the shapes of the objects on which the dolphin echolocated, including a closed cell foam cube, a PVC cross, a plastic flowerpot, and a human subject. As further confirmation of this phenomenon the images were then converted into 3-dimensional computer models. The thickness of the computer models was related to the brightness of a contrast-enhanced image at any given position, with brighter portions thicker and darker ones thinner. A high-definition 3D printer was used to manufacture these 3-dimensional virtual models in photopolymers.

Keywords: Dolphin echolocation; Hydrophone recordings; Cyma Scope; Faraday waves; standing waves; 3D printing

INTRODUCTION

We show that dolphin echolocation sound fields contain embedded shape information that can be retrieved and imaged by a CymaScope sensor when reflected off objects. Object pictures can be exhibited in two ways: as 2-D images or as 3-D printed objects. To echolocate, bottlenose dolphins (Tursiops truncatus) employ directional, high-frequency broadband clicks, either individually or in bursts known as "click trains." Each click lasts anywhere from 50 to 128 microseconds. Our team detected the highest frequencies at around 300 kHz, although other studies have recorded frequencies as high as 500 kHz generated by Amazon river dolphins . By processing the returning echoes, dolphins may navigate, locate, and classify things using clicks. Other Cetacea, most bats, and some humans use echolocation, also known as bio-sonar (Sound Navigation and Ranging). Dolphins echolocate on objects, humans, and other life forms both above and below water. Although the specific biological mechanisms by which dolphins "see" with sound are still unknown, the fact that they do so is well documented. Pack and Herman discovered, for example, that "a bottlenosed dolphin... was capable of rapidly detecting a range of complexly structured objects both inside the senses of vision and echolocation, as well as across these two senses." Shape information registers directly in the dolphin's perception of objects, whether by vision or echolocation, and these precepts are easily shared or integrated across the senses, as seen by the immediacy of accuracy of intercessory recognition was nearly errorless regardless of whether the sample objects were presented to the echolocation sense … the visual sense (E-V matching) or the reverse… Overall, the results suggested that what a dolphin “sees” through echolocation is functionally similar to what it sees through vision “cognition.

Herman and Pack also demonstrated that “...cross-modal recognition of... complexly formed objects utilising the senses of echolocation and vision... Under both visual to echoic (V-E) and echoic to visual (E-V) matching, 24 of the 25 pairs were errorless or nearly so (E-V). For 20 V-E pairings and 24 E=V pairings, the first trial recognition happened... The findings point to the possibility of direct echoic awareness of object shape... and show that prior object exposure isn't necessary for spontaneous cross-modal recognition’s.

Winthrop Kellog was the first to study dolphin echolocation in depth and found their sonic abilities remarkable. He discovered that dolphins are able to track objects as small as a single “BB” pellet (approximately 0.177 inch) at a range of 80 feet and negotiate a maze of vertical metal rods in total darkness. A recent study showed that a bottlenose dolphin can echolocate a 3-inch water -filled ball at a range of 584 feet, analogous to detecting a tennis ball almost two football fields away.

Click trains and whistles have a frequency range of 0.2 to 300 kHz, and they appear to come from at least two pairs of phonators or phonic lips near the blowhole. Pumping air between air sacs above and below the phonators excites the phonic lips. Attached muscles can quickly change the posture of the phonators.