Laryngeally echolocating bats

Arising from: N. Veselka *et al.* *Nature* 463, 939–942 (2010)

Echolocation of bats is a fascinating topic with an ongoing controversy regarding the signal processing that bats perform on the echo. Veselka *et al.*[1] found that bats that use the larynx for producing the echolocating ultrasound have a stylohyal bone that connects the larynx to the auditory bulla. I propose that the stylohyal bone is used for heterodyne detection of Doppler-shifted echoes. This would allow very precise frequency resolution and phase-sensitive analysis of the returning echoes for determining the velocity of echolocated objects like insects.

The stylohyal bone connects the larynx, the area where the ultrasound is generated, to the auditory bulla that is in turn connected to the cochlea. Veselka *et al.*[1] found by micro-computed tomography that this connection is present in all of the 26 species of laryngeally echolocating bats that they analysed. The function of this bone is not yet entirely clear. Veselka *et al.*[1] list three possible functions: the stylohyal bone could transmit the outgoing signal in order to ensure its accurate registration by the brain, the bone could provide a mechanical reafference, or it could dampen vibrations of the middle ear in order to prevent self-deafening.

I would like to suggest another purpose. The stylohyal bone could transmit the outgoing signal to both ears in order to provide what is called a 'local oscillator' in electronic signal processing. In heterodyne detection schemes the reference signal from the local oscillator is mixed with the signal to be detected. The result is a beat note at the difference frequency of both signals. The beat note arises from alternating constructive and destructive interference between the signal and the local oscillator. This technique is widely used, for example in commercial frequency-modulated (FM) radio receivers. It allows for very precise and phase-sensitive frequency measurements. Such precise and separate measurements of the Doppler-shifted return signals at both ears of the bat could yield two components of the velocity vector of the object that scatters the bat's ultrasound signal, for example an insect. This would enable the bat to predict the location of moving objects with much higher accuracy. If the stylohyal bones or the auditory bulla resonate at the frequency of the outgoing signal with very little damping, they could preserve the outgoing signal to bridge the time lag between the end of the outgoing signal and the beginning of the return signal.

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Received 18 February; accepted 14 April 2010.

1. Veselka, N. *et al.* A bony connection signals laryngeal echolocation in bats. *Nature* **463**, 939–942 (2010).

Competing interest: declared none.

doi:10.1038/nature09156