THE SCIENCE BEHIND THE "INSANE IN THE CHROMATOPHORES" VIDEO: MISSION BLUE TALKS TO THE BRAINS BEHIND THE VIRAL SQUID VIDEO

August 27, 2012

By Mera McGrew

With nearly a million views in less than a week, a video of a long fin inshore squid (Loligo pealei) changing color to the beat of the 1993 Cypress Hill hit "Insane in the Brain" has gone viral. The video titled "Insane in the Chromatophores," highlights the ability of squid to neurally control the color of their skin.

"Insane in the Chromatophores" provides an up-close view of a long fin inshore squid's dorsal side fin as researchers tested the effects of music on the squid's pigmented cells, which are scientifically known as chromatophores. Using the cockroach leg protocol, researchers essentially hijacked the neural system that controls coloration in the squid's skin by stimulating the chromatophore motoneurons with an electrical signal produced by a song. The result, as seen in the video, is an impressive and beautiful display of the squid's chromatophores expanding and collapsing to the beats of the song "Insane in the Brain."

Mission Blue connected with Greg Gage and Paloma T. Gonzalez-Bellido who were two of the brains behind this insane video. Greg is an electrical engineer and co-founder of Backyard Brains, a group dedicated to making neuroscience accessible, which produced and released the "Insane in the Chromatophores" video. Paloma is a neruoscience postdoctoral associate in Roger Hanlon's Lab in the Marine Resource Center of the Marine Biological Labs. She conducts research on the electrophysiological properties of chromatophores and helped with the preparation of the video.

Why did you create this video?

Greg: We are always looking for ways to explain neuroscience in new and interesting ways. One of our main goals is to expand the teaching of neuroscience in High School classrooms. Having compelling demonstrations helps both the teachers and students.

What's going on in the video?

Paloma: Chromatophores are the pigmentary elements found in the skin of cephalopods. In the case of the long fin squid, there are three types of chromatophores: Yellow, Red and Brown. The expansion of each chromatophore is controlled neurally. We can hijack the neural system that controls coloration in the skin of a squid by stimulating the chromatophore motoneurons with the electrical signal produced by a song. The chromatophores expand according to the music's frequencies.

Without ears, how does the long-fin squid respond to the beat of the song?

Paloma: The chromatophore's [the pigmented cells] responses are not caused by an auditory stimulus. It looks like it because the chromatophore activity is correlated to the song. The correlation results because chromatophore expansion follows neural excitation in a graded manner (i.e. more excitation equals more expansion) and because we have used the waveform of the music as the neural stimulus to excite the neurons.

Nonetheless, Squids do detect sounds and research by Dr. Aran Mooney (WHOI) is shedding light into the mechanism that allows squid to hear.

For more details on neural excitement:

Specifically, what is causing the color-change in the squid's skin?

Paloma: Each chromatophore has a pigment cell, which contains a pigment sac. Each pigment cell has 15 to 25 muscles, named radial muscles, that attach to it. Whenever all the radial muscles contract at the same

time, the pigment sac in the middle of each chromatophore is stretched out evenly, changing the shape of the sac from a small round ball to a flat enlarged pancake.

For more information on how a cephalopod chromatophore works see an excellent review by Messenger (2001).

Is the cockroach leg stimulus protocol used within ongoing research?

Greg: Yes. We are currently collaborating with a computer scientist to use digital vision combined with the stimulus protocol to make the cockroach leg do much more than just dance to the beat of the music. Early results indicate that we may be able to obtain complete one-dimensional control.

Does the video highlight recent significant findings and or advances in oceanic research?

Paloma: This preparation is being used to learn more about neural skin control in cephalopods. The insane chromatophore video quickly demonstrates to non-scientists that neurons control the pigmented coloration in cephalopod skin. In addition, the video highlights that chromatophore of different colors respond differently to the same stimulus. Thus, we can see that yellow and brown chromatophores have different electrophysiological properties. At the moment, we are investigating those properties, so that we can better understand how the neural control of body coloration works in these animals.

It is important to clarify that the animal did not suffer. We stimulated the neurons in a similar manner to how the brain would do it, there is no pain sensing involved in this excitation. Before preparing the squid tissue for neural stimulation, the squid was anesthetized and euthanized.

Did the squid react the same way to all songs and or audio stimuli?

Greg: Definitely not. The song needs to have bass frequencies for the chromatophores to expand. The reason has to do not with the squid's song preferences, but rather the underlying biophysics of how neurons fire action potentials. If you play classical music, for example, you would not see as strong of an effect. The low frequencies allow the cells membranes to charge long enough to reach the threshold where actions potentials are generated.

Are there other animals, besides squids, that have dynamic control of their skin color?

Paloma: Yes, octopus and cuttlefish also have the ability to change color in this dramatic manner. Fish also have neural control of their coloration, but their chromatophores are built differently, and so they take much longer to change shape. In addition, most people are familiar with the color change of chameleons, but that signal change is slow because it is hormonal, not neural.

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