NASA Studies Nanomechanics of Inner Ear

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(PhysOrg.com) -- Learning how to walk again after long-duration space flights is a problem astronauts face as they readjust to Earth's gravity. To learn how microgravity affects human space travelers, NASA scientists studied the nanomechanics of hair cells in the inner ear.

Using the the toadfish (*Opsanus tau*) as their model, scientists tested whether hair cells amplify stimuli from very small head movements, and if so, can the brain regulate this enhanced sensitivity and shift this function on or off? Test results showed that an organism’s ability to maintain equilibrium is regulated by hair cell sensory organs, including hearing organs.

"These hair cells are specialized mechanical sensors that are used to understand sound in the environment, and countermove the head for balance and coordination," said Richard Boyle, a space bioscientist at NASA’s Ames Research Center, Moffett Field, Calif. "Understanding the fundamental physiology of the hair cell in the inner ear is critical to identifying the impact of spaceflight on an organism." Boyle is an author of "Mechanical amplification by hair cells in the semicircular canals" scheduled for publication in the *Proceedings of the National Academy of Science,* on Feb. 2, 2010.

The inner ear organs are designed and precisely attuned to changes in the environment: for the hearing organ, a change in the sound pressure, such as caused by a car horn, can deform the ear drum and rapidly lead to the recognition and location of the sound. For the balance organ, movement of the head, such as unexpectedly stepping off the curb, is sensed and rapidly leads to motor reflexes to maintain equilibrium. The more sensitive our ability is to detect these changes, the more acute our sensation. This remarkable tuning and amplification to detect the slightest stimuli, allows us to adjust our posture.

For large movements this amplification is not evident. It is over the very small head movements that the amplification process benefits our ability to sense movement. But this places the hair cell systems at the blink of instability.

Fortunately, the amplification process is not all-or-nothing, but actually controlled by the organism. According to the organism's intended behavior, this instability can be turned off through a pathway from the brain back to the inner ear organs. For example, during a large, self-generated movement of the head, as one rapidly turns to view the location of the car horn, the amplification process can be turned off.

Fossil evidence, dating from at least the Devonian Period 400 million years ago, shows that the elaborate sensory structures used to sense the organism's movement are remarkably conserved among vertebrata. The results demonstrate an active process in the hair cells of an ancient bony fish, thus suggesting that the mechanism is ancestral, and may underlie the broad appearance of active hair cell processes in amphibians, reptiles, birds, and mammals, including humans.

During orbital missions, organisms on board the spacecraft are exposed to microgravity. Microgravity exposure causes severe disorientation or "space adaptation syndrome" for many human travelers, a condition similar to what we on Earth experience as motion sickness. The possible cause is a miscommunication of information provided by various sensory systems.

"A change in gravity has a profound effect on how organisms maintain coordination and balance," said Boyle. "This information is essential to understanding the human condition on Earth, and may contribute to the science that will eventually lead to improved diagnostics and treatment of disorders, such as dizziness and motion sickness," he added.

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