Adaptation to Altered Vestibular Inputs with Spaceflight

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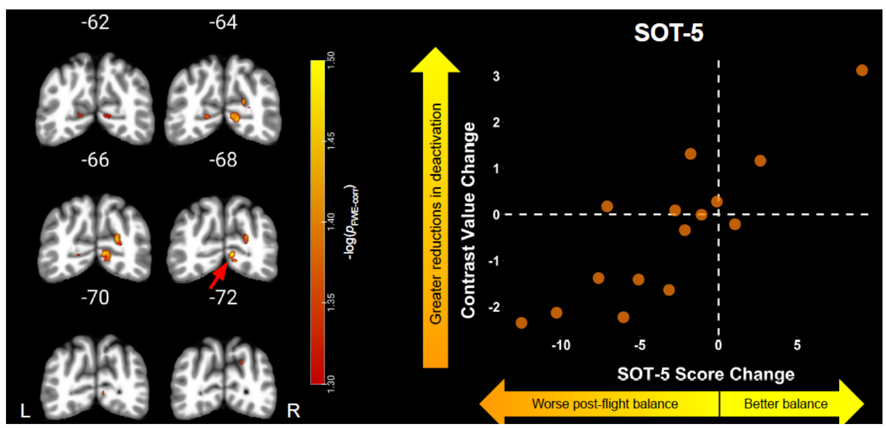
Studying adaptation to the microgravity environment provides insight into how the central nervous system responds to an environment for which it has not evolved. Microgravity alters vestibular signalling, due to the otoliths' functional dependence on gravity. Adaptive modifications are reflected in post-spaceflight aftereffects, including declines in vestibularly-mediated behaviors, until re-adaptation to Earth's 1G environment occurs. Here we examine how spaceflight affects neural processing of applied vestibular stimulation. We used fMRI to measure brain activity in response to vestibular stimulation in 15 astronauts pre- and post-spaceflight. We also measured balance and functional mobility. Data were collected twice pre-flight and four times post-flight (out to six months). As expected, vestibular stimulation at the pre-flight sessions elicited activation of the parietal opercular area (i.e., "vestibular cortex") and deactivation of somatosensory and visual cortices. Pre- to post-flight, we found widespread reductions in this somatosensory and visual cortical deactivation, supporting sensory compensation and reweighting with spaceflight. Further, these pre- to post-flight changes in brain activity correlated with changes in standing balance; greater pre- to post-flight reductions in deactivation of visual cortices associated with less post-flight balance decline (see Figure). The observed brain changes recovered towards baseline values by six months post-flight. Together, these findings provide evidence for sensory reweighting and adaptive cortical neuroplasticity with spaceflight. These results have implications for better understanding compensation and adaptation to vestibular functional disruption and provide insight into how humans learn to move in the microgravity environment.



Within multiple visual cortical regions (left images), brain activity changes from pre- to post-flight correlated with balance performance changes on Sensory Organization Test (SOT) condition 5.

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