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PRESERVING COGNITION IN SPACE USING ULTRASOUND BRAIN STIMULATION

Abstract

As space agencies prepare to send astronauts on voyages to Mars, there is growing concern over the effects of long-term space travel on brain health. Both cosmic radiation and micro-gravity have been shown to exert cellular changes in neurons, with evidence showing long-term damage to neural networks and cognitive dysfunction in mice exposed to conditions astronauts would face in deep space. The maintenance of astronauts' emotional and cognitive health is pertinent to the success of these missions, and thus strategies must be to developed to protect astronauts' brains on extended space voyages. We propose utilizing a new brain stimulation paradigm, transcranial ultrasound (TUS), towards this end. TUS sends ultrasonic waves into the brain that can modulate neural activity, and thereby emotional and cognitive function. TUS has been found to improve mood and cognitive functioning in humans, as well as prevent memory loss in an Alzheimer's model of mice. Mechanisms include activating or suppressing the activity of neurons, opening of the blood-brain barrier, and triggering release of neural growth factors. TUS within certain parameters causes negligible tissue heating and no observable tissue damage, indicating its potential as a long-term therapy. Ultrasound is already being used diagnostically on the International Space Station, and is being investigated towards preventing bone atrophy in microgravity. This demonstrates the feasibility of using ultrasound in space, while revealing convenience in the many uses of ultrasound technologies. We would like to conduct a pilot study in which mice are exposed to cosmic radiation in the International Space Station to maximally model the environment astronauts would face on a journey to Mars. Treatment parameters will be tested to find optimal usage towards prevention of brain damage and preservation of mental health in space, by analyzing histological changes in brain samples as well as monitoring emotional and cognitive function. Clinical trials are already underway towards the application of TUS in Alzheimer's, and thus following our studies in mice we can quickly proceed to testing TUS on astronauts. With manned missions to Mars only decades away, medical developments such as TUS must match the pace of advancements in space technology so that astronauts can reach Mars healthy and able to fulfill their duties as pioneers of humanity.