

Mars-bound astronauts face chronic dementia risk from galactic cosmic ray exposure

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'The space environment poses unique hazards to astronauts,' says study leader Charles Limoli, UCI professor of radiation oncology. 'Exposure to these [highly energetic charged] particles can lead to a range of potential central nervous system complications that can occur during and persist long after actual space travel.' Credit: Steve Zylius / UCI

Will astronauts traveling to Mars remember much of it? That's the question concerning University of California, Irvine scientists probing a phenomenon called "space brain."

UCI's Charles Limoli and colleagues found that exposure to highly energetic charged particles - much like those found in the [galactic cosmic rays](#) that will bombard astronauts during extended spaceflights - causes significant long-term brain damage in test rodents, resulting in cognitive impairments and dementia.

Their study appears today in Nature's *Scientific Reports*. It follows one last year showing somewhat shorter-term brain effects of galactic cosmic rays. The current findings, Limoli said, raise much greater alarm.

"This is not positive news for astronauts deployed on a two-to-three-year round trip to Mars," said the professor of radiation oncology in UCI's School of Medicine. "The space environment poses unique hazards to astronauts. Exposure to these particles can lead to a range of potential central nervous system complications that can occur during and persist long after actual space travel - such as various performance decrements, memory deficits, anxiety, depression and impaired decision-making. Many of these adverse consequences to cognition may continue and progress throughout life."

For the study, rodents were subjected to charged particle irradiation (fully ionized oxygen and titanium) at the NASA Space Radiation Laboratory at New York's Brookhaven National Laboratory and then sent to Limoli's UCI lab.

Six months after exposure, the researchers still found significant levels of brain inflammation and damage to neurons. Imaging revealed that the brain's neural network was impaired through the reduction of dendrites and spines on these neurons, which disrupts the transmission of signals

among brain cells. These deficiencies were parallel to poor performance on behavioral tasks designed to test learning and memory.

In addition, the Limoli team discovered that the radiation affected "fear extinction," an active process in which the brain suppresses prior unpleasant and stressful associations, as when someone who nearly drowned learns to enjoy water again.

"Deficits in [fear extinction](#) could make you prone to anxiety," Limoli said, "which could become problematic over the course of a three-year trip to and from Mars."

Most notably, he said, these six-month results mirror the six-week post-irradiation findings of a 2015 study he conducted that appeared in the May issue of *Science Advances*.

Similar types of more severe cognitive dysfunction are common in brain cancer patients who have received high-dose, photon-based radiation treatments. In other research, Limoli examines the impact of chemotherapy and cranial irradiation on cognition.

While dementia-like deficits in astronauts would take months to manifest, he said, the time required for a mission to Mars is sufficient for such impairments to develop. People working for extended periods on the International Space Station, however, do not face the same level of bombardment with galactic cosmic rays because they are still within the Earth's protective magnetosphere.

Limoli's work is part of NASA's Human Research Program. Investigating how space radiation affects [astronauts](#) and learning ways to mitigate those effects are critical to further human exploration of space, and NASA needs to consider these risks as it plans for missions to Mars and beyond.

Partial solutions are being explored, Limoli noted. Spacecraft could be designed to include areas of increased shielding, such as those used for rest and sleep. However, these highly energetic charged particles will traverse the ship nonetheless, he added, "and there is really no escaping them."

Preventive treatments offer some hope. Limoli's group is working on pharmacological strategies involving compounds that scavenge free radicals and protect neurotransmission.

More information: *Scientific Reports*, [DOI: 10.1038/srep34774](https://doi.org/10.1038/srep34774)

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