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Effects of Exposure to Space Radiation on Brain and Behavior

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On exploratory class missions, such as a mission to Mars, astronauts will be exposed to types and doses of radiation (cosmic rays) that are not experienced in low earth orbit where the space shuttle and International Space Station operate. Cosmic rays are composed of alpha particles, protons and particles of high energy and charge (HZE particles), such as 56Fe and 16O. Exposure to HZE particles and protons produces oxidative stress and inflammatory responses in the central nervous system leading to a disruption of neuronal function and, in turn, to a disruption of behavioral performance. The changes in neuronal function include loss of hippocampal neurogenesis, changes in signaling molecules and dopaminergic neurotransmission in the striatum, and disruption of autophagy, the process by which damaged proteins are sequestered and removed from the cell. Changes in cognitive/behavioral performance include changes in baseline anxiety (emotion), measured using the elevated plus-maze; in spatial and non-spatial learning and memory, measured using the Morris water maze and novel object recognition task; and in the responsiveness of the organism to changes in environmental contingencies, measured using operant responding on an ascending fixed-ratio schedule. While exposure to non-lethal levels of all types of HZE particles and protons can produce changes in neural and behavioral endpoints, there are differences in the effectiveness with which different HZE particles disrupt neuronal function and cognitive performance. The factors influencing the effectiveness of HZE particles in disrupting neuronal function and cognitive performance include the characteristics of the specific particle (its energy and linear energy transfer) and the characteristics of the individual (age and gender). The interaction between the characteristics of the HZE particles to which astronauts will be exposed and the characteristics of the individual astronaut will affect the probability that exposure to space radiation will disrupt neuronal function and, consequently, the probability that there will be deficits in cognitive performance which have the potential to affect the ability of astronauts to successfully meet mission requirements.

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