Developmental Research in Space: Predicting Adult Neurobehavioral Phenotypes via Metabolomic Imaging

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As human habitation and eventual colonization of space becomes an inevitable reality, there is a necessity to understand how organisms develop over the life span in the space environment. Microgravity, altered CO_2, radiation and psychological stress are some of the key factors that could affect mammalian reproduction and development in space, however there is a paucity of information on this topic. Here we combine early (neonatal) in vivo spectroscopic imaging with an adult emotionality assay following a common obstetric complication (prenatal asphyxia) likely to occur during gestation in space. The neural metabolome is sensitive to alteration by degenerative changes and developmental disorders, thus we hypothesized that that early neonatal neurometabolite profiles can predict adult response to novelty. Late gestation fetal rats were exposed to moderate asphyxia by occluding the blood supply feeding one of the rats' pair uterine horns for 15min. Blood supply to the opposite horn was not occluded (within-litter cesarean control). Further comparisons were made with vaginal (natural) birth controls. In one-week old neonates, we measured neurometabolites in three brain areas (i.e., striatum, prefrontal cortex, and hippocampus). Adult perinatally-asphyxiated offspring exhibited greater anxiety-like behavioral phenotypes (as measured the composite neurobehavioral assay involving open field activity, responses to novel object, quantification of fecal droppings, and resident-intruder tests of social behavior). Further, early neurometabolite profiles predicted adult responses. Non-invasive MRS screening of mammalian offspring is likely to advance ground-based space analogue studies informing mammalian reproduction in space, and achieving high-priority multigenerational research that will enable studies of the first truly 'space-developed' mammals.