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ADVANCED CONCEPTS IN LIFE-SCIENCES CLOSED-LOOP MONITORING FOR THE FUTURE ASTRONAUT – BRAIN COMPUTER INTERFACES AND INTEGRATED BIO-MEMS

Abstract

Current monitoring of astronaut health in space utilizes standard approaches that capture physiology data at scheduled mission intervals. Some of this data is downloaded locally at specified time-points; other data is streamed at more regular intervals to ground-based monitoring teams. In both instances, data is rarely immediately actionable for stabilizing or improving physiological markers, especially in emergencies or high-performance situations. Further, monitoring of specific medical indicators may require a break in a routine schedule, followed by delayed diagnosis, mitigation or care.

We present several rapidly evolving technologies for real-time monitoring and intervention, to optimize astronaut health and/or performance, and stabilize medical crises. Some of these technologies are based in current state-of-art neuroscience and genetic toolboxes. One such technology that will be discussed is the future of optogenetic brain-computer interfaces (BCI).1 BCIs in combination with miniaturized biosensors and body-embedded biomedical microelectromechanical systems (bio-MEMs) may provide a self-contained system for first-order astronaut health maintenance and monitoring – including sleep deprivation, homeostatic disruption, and radiation damage – with automated cellular level stimulation and repair. The ultimate goal is to create a Brain-Body Network, consisting of closed-loop sensor and actuator technology developed using evolving optical, genetic and nanomedical tools, to provide the long-duration astronaut with ongoing health-optimization and medical crisis mitigation.

Giving astronauts control over these systems and the data will be imperative, both for real-time closed-loop intervention and for protection of privacy. Ethical issues regarding human enhancement will arise, but the pay-off will be significant in terms of ameliorating human disease and improving terrestrial health. This paper explores the state-of-the-art in founding technologies that support this vision, and provides a call toward development of other technologies that will rapidly augment astronaut health.

1 Pashaie R, Anikeeva P, Lee JH, Prakash R, Yizhar O, Prigge M, Chander D, Richner T, Williams J. Optogenetic Brain Interfaces. IEEE Rev Biomed Eng. In press, 2014. doi 10.1109/RBME.2013.2294796