IAF/IAA SPACE LIFE SCIENCES SYMPOSIUM (A1)
Interactive Presentations - IAF/IAA SPACE LIFE SCIENCES SYMPOSIUM (IP)

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LONGITUDINAL BRAIN CONNECTIVITY CHANGES AFTER LONG-DURATION SPACEFLIGHT

Abstract

With the aim to unravel adaptive mechanisms in the brains of space crew by means of MRI, structural and anatomical data arising from T1-weighted data appears to be not well-suited because of the widespread structural shape changes overshadowing any indication for neuroplasticity [1]. As such, functional MRI can address this limitation by providing information on functional connectivity (FC) across the brain.

In this work, we acquired resting-state functional MRI data in 15 cosmonauts before and shortly after a six-month mission to the ISS. We acquired follow-up data in 11 of these cosmonauts eight months after return to Earth. After applying various correction and denoising steps, we estimated the a global FC measure in each MRI voxel [2]. This measure represents the degree to which one voxel shows correlating activity fluctuations with each other voxel in the brain. Hence, high ICC values indicate that a region is highly connected within the brain. We first compared pre- and post-flight data through a paired t-test (n=15), followed by two customized comparisons that test for changes between pre- and post-flight, which either remain changed at follow-up (sustained) or which reverse back to pre-flight levels (normalized). Results are considered significant at a voxel-level threshold of p¡0.005 and a cluster-level threshold of p¡0.05 corrected for family-wise error (FWE).

We found that the posterior cingulate cortex (PCC) shows decreased ICC after spaceflight compared to before (T=6.04, df=14). Again the PCC, and also the thalamus, showed decreased ICC that sustained in the longer term (T=6.62, T=8.92 resp. df=10). The right angular gyrus showed increased ICC post-flight which sustained in the longer term (T=7.13, df=10). Lastly, the bilateral anterior insular cortex showed decreased ICC post-flight which normalized back to pre-flight levels (T=7.26, df=10).

Our results overall indicate that multimodal hubs of the brain are affected by spaceflight, rather than primary sensory and motor areas. Particular highlights are the effects seen in the right angular gyrus, which is involved in verticality perception [3], and the anterior insula, which is involved in processing vestibular information [4]. Sustained effects may indicate long-term learning mechanisms in space crew, while normalizing effects indicate a transient response to altered gravity levels. This first study on resting-state connectivity in space crew demonstrates FC changes indicative of neuroplasticity in multimodal brain hubs after spaceflight, with the potential to sustain or normalize in the long run.

[1] doi: 10.1038/s41526-021-00133-z [2] doi: 10.1016/j.neuroimage.2011.06.075 [3] doi: 10.1093/cercor/bht267 [4] doi: 10.3389/fnbeh.2015.00334