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Review Article

Others Section

Neuroscience of Cognitive Adaptations in Space: A Review Article

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ABSTRACT

The brain can continuously adapt to changing circumstances and environmental needs. Astronauts must adjust to a brand-new, weightless environment in space. Numerous space mission-specific environmental factors may impact neurocognitive function. Previous research has found that multiple psychomotor functions, such as postural control, accuracy of movement patterns, internal synchronisation, spatial orientation, and the neurological management of ongoing work, have deteriorated during space flight. Apart from disease and injury, toxic radiation, decompression mishaps, pharmaceutical side-effects, and excessive radiation exposure may all impact neurocognitive performance in space. Computerised exams and exercise equipment are just a couple of the instruments developed to evaluate and address these deficiencies and issues. How the brain will adjust to extended space travel is still a mystery. This review article thoroughly analyses state-of-the-art and upcoming challenges in cognitive neuroscience in space, from analog missions and computer simulations to orbit around the Earth and beyond. Thus; the aim of this review is to provide a better understanding of the various phases that our brain undergoes while exposed to entirely different environments.

Keywords: Astronauts, Brain, Injury, Radiation, Weightless environment

INTRODUCTION

Understanding the environment and forming scientific theories are essential for exploring, monitoring, and preserving the atmosphere of the world. However, there are many difficulties with how the human nervous system reacts in space. More extended space missions require extensive research and understanding of how microgravity, radiation, and prolonged isolation affect human physiology and psychology. Techniques like noninvasive brain stimulation (NiBS) including transcranial magnetic stimulation (TMS) and transcranial electrical stimulation (tES), need to be explored to improve in-flight performance, assist astronauts with pre-flight Earth-based training, and find biomarkers of post-flight brain functions for the best use of rehabilitative measures [1]. NASA's human research program has been researching the changes that could happen in the human body in space for more than 50 years. Both neuroscientists and psychologists are intensely interested in comprehending these factors impacting space travel. Future deep space missions will significantly benefit from understanding how the body adjusts to living in the spaceflight environment for extended periods [2].

Under zero or microgravity, balance, mobility, and other brain processes are impacted. Cognitive neuroscience in space aims to figure out how the mind and brain acknowledge the unique circumstances of the environment in space. Unfortunately, because of the price and payload limitations of space missions, conventional imaging methods of the brain, such as magnetic resonance imaging (MRI), cannot be used in space. To permit extremely in-depth examinations of brain activity and cognitive performance, new imaging techniques like non-invasive brain stimulation, TMS, neuropsychological assessment tools, and several other measures have been developed on Earth. Understanding space flight's underlying neurobehavioral and neuropsychological aspects is crucial for neuroscientists and psychologists [3].

It has been demonstrated that the space environment affects practically all human physiological systems [4]. The significant health risks associated with space travel include high exposure to harmful radiation, various gravity fields, hypoxic environments, lack of a day and night cycle, vibration, extended confinement, and isolation, as well as anxiety resulting from living in a small, hostile space [4]. These concerns are associated with unique physiological and performance risks, including alterations in the immune system, metabolism, and cardiovascular functions; muscular diseases; and motion sickness see [Table/Fig-1] [5].

S. No.	Brain area	Function	Symptoms
1.	Somatosensory cortex	• proprioception • somatic sensations	• somatosensory problems
2.	Primary and association visual cortex (Brodmann area 17,18)	• Visual perception	• colour perception problems • loss of acuity
3.	Auditory association cortex (Brodmann area 22)	• Hearing and auditory perception	• sound localisation in hearing
4.	Prefrontal and premotor cortex (Brodmann area 11,47,6)	• problem solving • memory • management • planning • executive functions	• decision making errors • attention problems • inability to concentrate
5.	Primary motor cortex (Brodmann area 4)	• Voluntary movement initiation especially in distal muscles	• difficulty reaching targets in voluntary movements
6.	Frontal eye field	• non tracking voluntary eye movements	• visual attention problems
7.	Cerebellum	• body posture • equilibrium • skilled motor movements	• motor coordination • movement timings problems
8.	Vestibular system	• Gravity sensing • sensory orientation • 3D positioning in space	• Space motion Sickness • headache • vomiting • malaise • dizziness
9.	Limbic system	• emotional behaviour • motivation • olfaction • learning • decision making	• Diminished social behaviour • irritability • lack of motivation • depression • anxiety • mood problems
10.	Brainstem	• sleep cycle and arousal	• Disturbed sleep pattern

[Table/Fig-1]: Summary of different areas of the brain and symptoms associated with microgravity in space [5].

Causes of Neurological Issues

According to Kanas and Manzey, there are four primary causes of neurocognitive and neurobehavioral issues in space: 1) physical aspects, such as acceleration, lack of gravity, radiation exposure, and light and dark cycles; 2) human habitation factors, such as noise, temperature, vibration, light, and air quality; 3) psychological components, such as loneliness, peril, and workloads; and 4) psychosocial or interpersonal factors, such as crew size, gender effects, cultural effects, and personality conflicts [4].

Space Analogs

Research on Earth may also contribute to the growing consensus on how the brain functions in space. Unique settings called space simulations or "space analog settings" are used to accomplish this.

Space analogs serve as practical terrestrial stand-ins, or analogues, for teams working in interplanetary and microgravity situations. They also serve as a foundation for scholarly investigation and technical advancement [6]. The objective is to uncover potential changes in the emotional responses, social dynamics, dispersion, and command of crew members throughout a prolonged period of isolation since they are restricted in an isolating environment. "Space analogs" are typically found in harsh, distant locations (deserts, polar regions). The "bed-rest trials," in which people execute various tasks while lying supine on a bed for extended periods with their heads slightly cocked downward, are another approach to comprehending these changes. A study conducted while on bed rest mirrors some features of weightlessness, enabling researchers to examine the body's response to weightlessness and find out strategies for keeping succeeding astronauts healthy and active [7].

Effect of Microgravity or Weightlessness

Space radiation

The types of radiation encountered on Earth differ from those in space [8]. The prime sources for space radiation are cosmic rays from the galaxy, solar energy particles, and particles from the Earth's magnetic field. These ionising radiations rip through the substance, leaving behind severe damage, like an atomic-scale cannonball. Exhaust emissions set in motion by the initial radiation particle might also cause more damage [8].

The difficulty of shielding against space radiation particles, particularly cosmic rays of the galaxy, is a significant obstacle to lowering the hazards of radiation. Depending on the amount and time of radiation cosmonauts are exposed to, overall, increased radiation exposure may have both short and long-term health effects. People have a greater threat of cancerous and degenerative conditions like heart disease and cataracts on increased exposure to radiation [9]. The long-lasting effects of radiation exposure on astronauts' health pose significant health dangers. The short-term concerns of radiation exposure include functional alterations, such as altered cognition, mood and aberrant motor coordination, that may impair astronauts' productivity during the trip [9]. Ionising radiation can harm the Central Nervous System (CNS), altering cognitive function, bringing on weariness, and lowering performance.

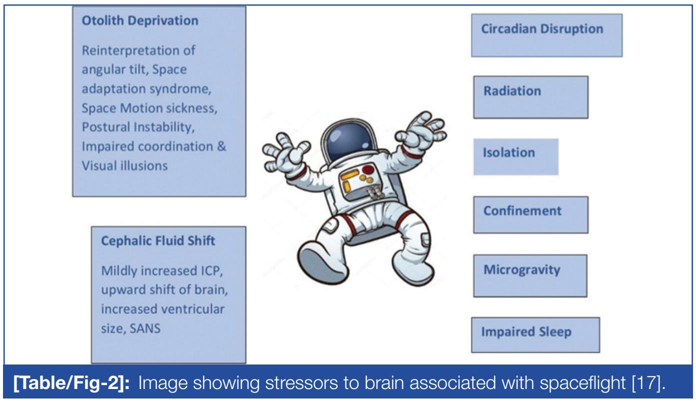
Given the degree of mispairing in DNA repair in brain cells, such damages may have a variety of noticeable repercussions, including myelin degradation, a decrease in local metabolism, and changes to synapse density and microcirculation [10-12].

It is anticipated that cosmic radiation will severely threaten deleterious neurobehavioral impacts when in space. Recent studies have found that cosmic radiation causes significant damage to the brain, more prominently affecting the frontal cortex and hippocampus [13,14]. This destruction has been linked to a wide spectrum of harmful conditions, such as taste aversion, difficulties with reversal learning, disruptions in reinforcement behaviour, context-specific fear conditioning, and problems with learning and memory establishment in space [14]. According to recent studies, space missions lead the grey matter in the brain to degrade far more quickly than it would otherwise. Fatigue and memory loss are two progressive signs of grey matter disorder [14]. A study has revealed that equal doses cause various cortical regions, including the anterior cingulate, posterior cingulate, and basal forebrain, to lose functionality [15].

Vestibular and Sensorimotor System

The vestibular organ in the labyrinth of the ear comprises semicircular canals, the chief sensors for angular motion in humans. Three interconnected tori that make up its architecture are filled with endolymph. A pliable gelatinous structure called the cupula is deflected by the angular movements of the head, which results in the endolymph flowing and sending nerve messages. Finally, an interpretation of angular motion is produced by these signals [16].

NASA's Human Research Program recognised decreased mobility brought on by vestibular and sensorimotor changes related to space flight as a significant concern for human space missions [Table/Fig-2] [17]. The risk is highest during and after transitions between various gravity environments, when locomotion and spatial orientation reductions may have a significant operational impact [16].



[Table/Fig-2]: Image showing stressors to brain associated with spaceflight [17].

Respiratory rate, blood pressure, and heart rate may all be affected by vestibular dysfunction. Dysautonomia's behavioural impacts can lead to anxiety disorders, panic attacks, and agoraphobia. Orthostatic intolerance may be a pathophysiological consequence of decreased baroreceptor function. Naturally, nausea, vomiting, hypovolemia, and exhaustion are possible side symptoms of impaired stipulation's disequilibrium [18,19].

Post-flight, astronauts have shown postural deficiencies and declines in sensorimotor ability. According to research findings, postural stability decreased, and postural recovery time rose due to flight duration [20].

Disruption of the Sleep Cycle

The week before launch or just before spaceflight is when a decline in cognitive function is most likely to happen [21]. During the transitional phases of missions, performance declines were frequently seen, indicating a potential impact of stress [21]. Circadian and Rapid Eye Movement sleep abnormalities were linked to even more reduction in flight and slower recovery after a flight, as well as to shorter response time, an increase in error, and impaired working memory and perception. Good emergency response and continued high-level cognitive performance are required from astronauts. And if they don't get enough sleep, they won't be able to. To prevent their internal biological clocks, or circadian rhythm, from being affected by factors like varied dark and light cycles, a confined and noisy environment, and the stress of extended isolation and confinement, astronauts must receive good sleep. Given that there may be periods when there will be a lot of work to be done and a changing schedule, it is crucial to prepare for the exhaustion astronauts may encounter during spaceflight [21]. Negative sleep and circadian disturbances are linked to spaceflight. Hippocampal atrophy and poor sleep are linked to neurodegenerative and neuropsychiatric disorders [21].

Wearable headbands are being created to enhance sleep quality. They promote cognitive performance under sleep deprivation, and reduce the severity and extent of "sleep inertia" after rapid waking [21,22].

Space Motion Sickness

Switching from one gravitational field to another is more complicated than it sounds. It can harm balance, movement, head eye coordination, hand-eye coordination, and spatial orientation. Some members even experience space motion sickness. It is acknowledged that sensory conflict is the main culprit behind space motion sickness. The mismatch between the vestibular system's anticipated and observed sensory signals is the root cause of sensory conflict, especially when combined with contradictory signals from the visual, tactile, and proprioceptive senses. Disorientation and, if chronic, the emergence of motion sickness is caused by this mismatch, which results in a loss of ecological "calibration." Head movements may be the commanding provocative stimuli for inducing space motion sickness, as they cause discordant cues to be transmitted to the CNS regions responsible for central integration of semicircular canal and otolith information necessary for maintaining spatial orientation and stabilising eye and body movements [23]. Pallor, elevated body temperature, cold sweating, malaise, appetite loss, nausea, exhaustion, vomiting, and anorexia are the most common symptoms of space motion sickness. These symptoms are comparable to those of other types of motion sickness [24].

For a range of activities, including properly controlling a robotic arm, fixing delicate machinery, successfully landing a spacecraft on a planet's surface, and delivering medical care, fine motor abilities are essential [24]. Functional task testing is in place to identify and enhance balance control after touching down gravity. Fine motor skill tests like pointing, dragging, pinch-rotating, and tracing are conducted to determine changes in astronauts' capacity to operate computer-operated equipment [24].

Psychosocial Concerns in Protracted Space Travel

The good outcomes of adjusting to settings, seasonal disorders associated with changes in the physical surroundings, and alterations in emotions and cognitive performance are a few examples of individual difficulties. The processes of crew cohesion, stress, conflict, social relationships, social support, the effects of group diversity and leadership styles on small group dynamics, and interactions between the crew and mission control are all examples of interpersonal difficulties. Units on extended space missions may suffer from interpersonal issues, which are caused by animosity between crew members, that is transferred to the outside monitoring staff, and by crew cohesion breakdowns and ambiguous leadership responsibilities. The impact of corporate cultures and mission duration on team performance, crew liberty, and organisational needs for extended missions are a few examples of administrative difficulties. Crewmember conflict, cohesiveness, and leadership are significant difficulties impacting people working in solitary surroundings, and they need to be investigated more in space, according to the surveys administered [25].

The key to maximising environment adaption and minimising declines during and after long-length missions is enhanced screening and selection, leadership, surviving, and interpersonal skills training, and organisational reform [26].

Psychiatric Disorders in Space

Several psychiatric issues have been documented while in space. The majority of cases include adjustment reactions, which typically include depressive or anxious symptoms.

Asthenisation is a form of adjustment reaction connected to the idea of neurasthenia, according to Russian psychologists and flight surgeons. Some symptoms include irritability, fatigue, emotional lability, trouble focusing, restlessness, enhanced sensitivity, palpitations, unstable blood pressure, and issues with sleep and food [27].

Reduced motivation and energy levels, as well as passiveness, are signs of low resilience.

For cosmonauts, excessive noise exposure, primarily from equipment and crew operations, may increase their stress levels. Sleep quality and wakefulness may both be affected [28].

Effects on the Limbic System

By projecting vestibular neurons via several synaptic inputs to the hippocampus, vestibular neurons may be able to influence the limbic system. The glucocorticoid receptors on hippocampal neurons send negative feedback to the blood corticosterone, the primary hormone in stress reactions. The change in gravity also affects the limbic system [29].

Stress hormones target the hippocampus because it is a remarkably malleable and delicate part of the brain [30]. Chronic stress inhibits the proliferation of dentate gyrus granule neurons in the hippocampus, and repeated stress causes dendrites in the CA3 area to atrophy [30].

The human hippocampus, which experiences atrophy in several illnesses and is accompanied by deficiencies in declaratory, episodic, spatial, and situational memory performance, is pertinent to studying hippocampal structural plasticity [30,31].

Exercise, video gaming, a healthy diet, nutritional supplements, good sleep habits, and self-adapted visuospatial learning processes are some countermeasures that will help preserve hippocampal plasticity and spatial awareness [31].

Visual Impairment Intracranial Pressure Syndrome (VIIP Syndrome)

Due to hypoxia exposure, microgravity, and low atmospheric pressure, the VIIP-Syndrome (visual impairment intracranial pressure syndrome) poses a significant risk for human-crewed flight. This worsens the effects of hypoxia, causing increased intracranial pressure, edema of the optic nerve papilla, and vision impairment. The brain, as well as other neuronal tissues like the retina and more large nerves like the optic nerve, are affected by disruption of the blood-brain barrier, upward repositioning of the optic nerves, and globe flattening [32].

Space Flight Associated Neuro-Ocular Syndrome (SANS)

During space travel, the microgravity environment creates several health issues. One issue is damaging the visual system, resulting in a condition called "Spaceflight-Associated Neuro-Ocular Syndrome," an illness (SANS) [33,34].

Long-term exposure to microgravity causes the brain to grow and the cerebrospinal fluid that covers the brain and spinal cord to become more prominent. Globe flattening was found using MRI [34]. Astronauts with disc edema were given lumbar punctures, demonstrating slightly increased pressures. According to scientists, increased "intracranial tension," or stress in the skull during spaceflight, is thought to be the root of these eye problems [35].

NASA has concentrated on lowering the likelihood of any mental health issues occurring while in space. The selection process for astronauts includes hours of psychological testing. The agency employs mental health professionals, including psychiatrists and psychologists, to help astronauts during space missions. The organisation conducts not only mental health screenings but also uses psychosocial services to improve wellbeing. The Family support office offers educational programs and informative updates as a resource for astronaut families. Care gifts, hobbies, and internet access can help crew members feel more at home. More techniques like NiBS, including TMS and tES, need to be explored in order to improve in-flight performance, assist astronauts with pre-flight Earth-based training, and find biomarkers of postflight brain functions for the best use of rehabilitative measures [10].

CONCLUSION(S)

Space exploration is a fascinating human goal that, however, entails a series of hazards with detrimental physical and psychological consequences. While our understanding of these effects on the physical body is improving, there is still considerable work to be done in the areas of neurocognitive and psychological phenomena, particularly in the context of lengthy missions. Major obstacles lie ahead, and more study is required to fully comprehend how the biology and mind of humans would be affected by the entirely new space environment and the planetary systems in our solar system. Understanding all aspects present in human space flight, including those relating to cognition, psychiatry, and neuroscience, requires an understanding of how our brain works to adapt to the space environment. To ensure a safe and dependable trip to space, mitigation strategies to possibly prevent risks related to space exploration and to safeguard the astronauts from space radiations during and after their missions need to be explored further.

REFERENCES

[1] Rinaldi A. Research in space: In search of meaning. EMBO Rep. 2016 Aug [cited 2022 Jul 25];17(8):1098-102 [Internet]. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4967952/.

[2] Mars K. What happens to the human body in space? [Internet]. 2021 [cited 2022 Jul 25]. Available from: http://www.nasa.gov/hrp/bodyinspace.

[3] De la Torre GG. Cognitive Neuroscience in Space. Life (Basel) [Internet]. 2014 Jul 3 [cited 2022 Jul 22];4(3):281-94. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4206847/.

[4] Shirah B, Ibrahim BM, Aladdin Y, Sen J. Space neuroscience: Current understanding and future research. Neurol Sci. 2022;43(8):4649-54.

[5] Van Ombergen A, Demertzi A, Tomilovskaya E, Jeurissen B, Sijbers J, Kozlovskaya IB, et al. The effect of spaceflight and microgravity on the human brain. J Neurol [Internet]. 2017 [cited 2023 Jan 7];264(Suppl 1):18-22. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5610662/.

[6] Fluid Dynamics in the Inner Ear [Internet]. [cited 2022 Jul 22]. Available from: https://ifd.ethz.ch/research/group-kleiser/inner-ear.html.

[7] Space Psychology and Psychiatry [Internet]. [cited 2022 Jul 27]. Available from: https://link.springer.com/book/10.1007/978-1-4020-6770-9.

[8] Perez J. Why space radiation matters [Internet]. 2017 [cited 2022 Jul 26]. Available from: http://www.nasa.gov/analogs/nsrl/why-space-radiation-matters.

[9] Onorato G, Di Schiavi E, Di Cunto F. Understanding the effects of deep space radiation on nervous system: the role of genetically tractable experimental models. Frontiers in Physics [Internet]. 2020 [cited 2022 Jul 26];8. Available from: https://www.frontiersin.org/articles/10.3389/fphy.2020.00 2.

[10] Arone A, Ivaldi T, Loganovsky K, Palermo S, Parra E, Flamini W, et al. The burden of space exploration on the mental health of astronauts: A narrative review. Clin Neuropsychiatry [Internet]. [cited 2022 Jul 25];18(5):237-46. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8696290/.

[11] Published KT. Space radiation threat to astronauts explained (Infographic) [Internet]. 2013 [cited 2022 Jul 26]. Available from: https://www.space.com/21353-space-radiation-mars-mission-threat.html.

[12] Published RR. NASA wants to change the way it protects astronauts from radiation [Internet]. 2021 [cited 2022 Jul 26]. Available from: https://www.space.com/nasa-changing-astronaut-radiation-exposure-limit.

[13] Fu Y, Talavage TM, Cheng JX. New imaging techniques in the diagnosis of multiple sclerosis. Expert Opin Med Diagn [Internet]. 2008 Sep 1 [cited 2023 Feb 4];2(9):1055-65. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2662586/.

[14] Mercadante AA, Tadi P. Neuroanatomy, Gray Matter. In Treasure Island (FL): StatPearls Publishing; 2022 [cited 2023 Feb 4]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK553239/.

[15] Stahn AC, Kühn S. Brains in space: The importance of understanding the impact of long-duration spaceflight on spatial cognition and its neural circuitry. Cogn Process [Internet]. 2021 Sep 1 [cited 2022 Jul 25];22(1):105-14. Available from: https://doi.org/10.1007/s10339-021-01050-5.

[16] About ADS [Internet]. [cited 2022 Jul 27]. Available from: https://ui.adsabs.harvard.edu/about/.

[17] May S. Sleeping in Space [Internet]. 2015 [cited 2022 Jul 26]. Available from: http://www.nasa.gov/audience/foreducators/stem-on-station/ditl_sleeping.

[18] Jandial R, Hoshide R, Waters JD, Limoli CL. Space–brain: The negative effects of space exposure on the central nervous system. Surg Neurol Int [Internet]. 2018 Jan 16 [cited 2022 Jul 26];9:9. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5791508/.

[19] Özelbaykal B, Öğretmenoğlu G, Gedik Ş . The effects of space radiation and microgravity on ocular structures. Turk J Ophthalmol [Internet]. 2022 Feb [cited 2022 Jul 27];52(1):57-63. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8876783/.

[20] Reschke MF, Good EF, Clément GR. Neurovestibular symptoms in astronauts immediately afterspace shuttle and international space station missions. OTO Open [Internet]. 2017 Oct 23 [cited 2022 Jul 22];1(4):2473974X17738767. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6239149/.

[21] Russomano T, Rosa M da, Santos MA dos. Space motion sickness: A common neurovestibular dysfunction in microgravity. Neurology India [Internet]. 2019 May 1 [cited 2022 Jul 26];67(8):214. Available from: https://www.neurologyindia.com/article.asp?issn=0028-3886;year=2019;volume=67;issue=8;spage=214;epage=218;aulast=Russomano;type=0.

[22] What it's really like to sleep in space, according to a former astronaut who spent 520 nights doing it [Internet]. [cited 2022 Jul 26]. Available from: https://www.travelandleisure.com/trip-ideas/space-astronomy/what-its-like-to-sleep-in-space.

[23] Haynes A. Space motion sickness: Combating nausea in space [Internet]. [cited 2022 Jul 26]. Available from: https://pharmaceutical-journal.com/article/opinion/space-motion-sickness-combating-nausea-in-space.

[24] Heer M, Paloski WH. Space motion sickness: Incidence, etiology, and countermeasures. Auton Neurosci. 2006;129(1-2):77-79.

[25] Kanas N, Weiss DS, Marmar CR. Crewmember interactions during a Mir space station simulation. Aviat Space Environ Med. 1996;67(10):969-75.

[26] Psychological effects of space travel: How does being in space affect the psychology of astronauts? [Internet]. 2020 [cited 2022 Jul 25]. Available from: https://www.scienceabc.com/nature/universe/how-does-being-in-space-affect-the-psychology-of-astronauts.html.

[27] Nick Kanas MD. Psychiatric issues in space. Psychiatric Times [Internet]. 2016 Jun 15 [cited 2022 Jul 25];33(6). Available from: https://www.psychiatrictimes.com/view/psychiatric-issues-space.

[28] Kanas N. Psychiatric issues affecting long duration space missions. Aviat Space Environ Med. 1998;69(12):1211-16.

[29] Lalonde R, Strazielle C. The effects of altered gravity on the limbic system. In 2014. Pp. 39-56.

[30] Hartley T, Lever C, Burgess N, O'Keefe J. Space in the brain: How the hippocampal formation supports spatial cognition. Philosophical Transactions of the Royal Society B: Biological Sciences [Internet]. 2014 Feb 5 [cited 2022 Jul 25];369(1635):20120510. Available from: https://royalsocietypublishing.org/doi/10.1098/rstb.2012.0510.

[31] Olton DS, Becker JT, Handelmann GE. Hippocampus, space, and memory. Behavioral and Brain Sciences [Internet]. 1979 Sep [cited 2022 Jul 25];2(3):313-22. Available from: https://www.cambridge.org/core/journals/behavioral-and-brain-sciences/article/abs/hippocampus-space-and-memory/F9ABFA09F5AC96A64D15572521BD2C6C.

[32] Frantzidis CA, Kontana E, Karkala A, Nigdelis V, Karagianni M, Nday CM, et al. Current trends and future perspectives of space neuroscience towards preparation for interplanetary missions. Neurology India [Internet]. 2019 May 1 [cited 2022 Jul 26];67(8):182. Available from: https://www.neurologyindia.com/article.asp?issn=0028-3886;year=2019;volume=67;issue=8;spage=182;epage=187;aulast=Frantzidis;type=0.

[33] Johnson M. Keeping an eye on vision changes in space [Internet]. 2020 [cited 2022 Jul 26]. Available from: http://www.nasa.gov/mission_pages/station/research/news/iss-20-evolution-of-vision-research.

[34] Chamary JV. How an astronaut's eyes are damaged by a year in space [Internet]. [cited 2022 Jul 26]. Available from: https://www.forbes.com/sites/jvchamary/2021/04/30/human-body-space-astronaut-eye/.

[35] Zhang LF, Hargens AR. Spaceflight-induced intracranial hypertension and visual impairment: Pathophysiology and counter measures. Physiological Reviews [Internet]. 2018 Jan [cited 2023 Feb 4];98(1):59-87. Available from: https://journals.physiology.org/doi/full/10.1152/physrev.00017.2016.

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