The risks and rewards of human deep-space travel

It is not the lack of advance in space technology that is holding back manned missions but concerns about how humans will survive in space, writes Akhil Kadidal

For all of the clamour around Elon Musk's prognostications of a human colony on Mars by 2026, experts said that the limiting factor of humanity's aspirations to reach other worlds is still dictated by the frailty of the human body.

At a recent talk organised by the French Embassy and Institut Francais, a panel of authorities pointed out any attempt to reach other planets and celestial bodies is massively challenged by the task of protecting and sustaining astronauts during long-haul space missions.

Among the obstacles are solar radiation, the need for safe habitations plus concocting ways to carry out agriculture or storing food on the austere new world or spacecraft, addressing the fearsome battery of physiological and psychological problems associated with long-term space travel worsened by a sense of disconnect from Earth and even the disposal of food and human waste that 'earthlings' take for granted.

It is this set of challenges that leaves Mathieu J Weiss, Space Counsellor and the Bengaluru representative of the French Space Agency, the National Centre for Space Studies, convinced that it is not so much advances in space technology or even propulsion systems holding back a deluge of human-crewed missions into space, but concern about how humans will survive missions that could take months or years to complete.

"The space sector has gone through tremendous changes these last years. Look at reusable technologies, look at sustainable technologies, solutions with artificial intelligence," Weiss said.

At the same time, Weiss cautioned that living on the moon or on Mars presents technical challenges which have never really been addressed by the earlier generations of space travel or even current missions at the International Space Station.

"We are at the cusp of a major leap in human space flight to other celestial bodies. We need to now understand the physical limits of sending humans out there, which raises questions such as: How will they rehab from the prolonged flight duration and how will they fare from a physiological point of view and from a psychological point of view?" he said.

Physiological changes

What is known is that within four to six hours of a human being going to space, the individual starts to experience changes in the body's cardiovascular system involving the heart and blood acid, according to Wing Commander Dr Stuti Mishra, a Flight Surgeon and Instructor at the Institute of Aerospace Medicine in Bengaluru where the Gaganyaan astronauts are being trained.

"The moment we put a human behind a machine for a long duration, the human becomes the limiting factor," she said.

This is because something similar to osteoporosis, instantaneous fractures that happen in the elderly, occurs in space as does muscle wasting in the lower limbs. "Demineralisation in the bones is one issue. The other is radiation because it has a long-term effect on cells," Dr Mishra said, adding that natural sensors in the human body known as vero-receptors also are de-conditioned in low gravity.

This has particular resonance for India, whose long-term aspirations beyond the Gaganyaan-manned missions is to set up a space station in low-earth orbit with the eventual aim of going to the moon.

"Gaganyaan is just the foundation of a sustained manned space program and it will act as a stepping stone," said V R Lalithambika, Director of ISRO's Human Spaceflight Programme. "Beyond this programme, we would be thinking of permanent presence in low-earth orbit first, and we need to develop a lot of enabling technologies for that, which we do not have at the moment — on the engineering side, docking technologies, on the human side, bio-statistics [in space] is one area where we do not have any expertise."

"We need to develop that expertise and all the associated technology which would be required for a sustained presence in space," she added.

Although data exists, going back some 60 years to the early US and Russian-manned missions showing how space travel impacts the human body, ISRO officials told *DH* that the country would like to collect its own data through space expeditions because it could present new findings on how solar radiation affects Indians on a genetic level.

This is a statement corroborated by Dr Audrey Berthier, Executive Director of Medes, (the French Institute for Space Medicine and Physiology at Toulouse) who said that there is still a long way to go before "individual susceptibility" to solar radiation can be established.

In ongoing French-Australian trials at Sydney, for example, scientists have been using a heavy-ion synchrotron to test new radiation-protective light materials for spaceflight on animal meat samples. "In our study, we found out that different people are reacting totally differently to radiation," Weiss added.

New lessons to learn

Dr Berthier stressed that additional data, such as that to be generated by Gaganyaan will help complete the picture. But for some facets of future space travel such as deep-space isolation, there is even less quantifiable data.

How this will play out in a mission going to Mars where all one will see is darkness and blinking stars for six to nine months is anyone's guess, added the space entrepreneur, Dr Susmita Mohanty, the founder of Liquifer System Group (LSG), an aerospace architecture and design firm based in Vienna.

"When in isolation, sometimes even fungus or mold can become your pet or friend," she said, pointing to a brief stint in Antarctica where she felt that sunlight had an otherworldly quality. "It affects your mind and it starts to disorient you a bit in terms of time and space. Little things happen which have a big psychological impact," she added.

But even if one survives the perils of spaceflight, there are more to follow on planetary surfaces. Future Indian astronauts who take up station on the moon may encounter problematic living conditions, according to Dr Mohanty.

"Because there's no weathering force on the moon, if you pick up dust, it's fine and sharp like glass. It gets into everything. It gets into the creases of your spacesuit, it gets into the mechanical parts of your buggy, if you breathe it and bring it into your habitat it goes into lungs, and it smells like burnt gunpowder," she said.

Ultimately, solutions to all these problems will be found, experts said, adding that this will yield advances applicable even on the Earth: Leapfrogging in the medical field, technical clues for adapting to climate change, new solutions to the conservation of the living and maybe new societal models. "There are intensive hopes in these programs to serve humanity," said Thierry Berthelot, General Consul of France in Bengaluru.

DID YOU KNOW?

Some bees eat meat

A little-known species of tropical bee, nicknamed vulture bees, has evolved an extra tooth for biting flesh and a gut that more closely resembles that of vultures rather than other bees. Typically, bees don't eat meat. However, a species of stingless bee in the tropics has evolved the ability to do so, presumably due to intense competition for nectar.

Honeybees, bumblebees, and stingless bees have guts that are colonised by the same five core microbes. "Unlike humans, whose guts change with every meal, most bee species have retained these same bacteria over roughly 80 million years of evolution," said Jessica Maccaro, an entomology doctoral student.

Normally, stingless bees have baskets on their hind legs for collecting pollen. However, the team observed carrion-feeding bees using those same structures to collect the bait. "They had little chicken baskets," said Quinn McFrederick, a UCR entomologist.

"The vulture bee microbiome is enriched in acid-loving bacteria, which are novel bacteria that their relatives don't have," McFrederick said. "These bacteria are similar to ones found in actual vultures, as well as hyenas and other carrion-feeders, presumably to help protect them from pathogens that show up on carrion."

One of the bacteria present in vulture bees is Lactobacillus, which is in a lot of humans' fermented food, like sourdough. They were also found to harbor Carnobacterium, which is associated with flesh digestion.

In addition, though they feed on meat, their honey is reportedly still sweet and edible. "They store the meat in special chambers that are sealed off for two weeks before they access it, and these chambers are separate from where the honey is stored," Maccaro said.

Phys.org

THE NERVOUS SYSTEM

The quiet scientific revolution that may cure chronic pain

DAVID DOBBS

Chronic pain is one of the world's most costly medical problems, affecting one in every five people, and one of the most mysterious. In the past two decades, however, discoveries about the crucial role played by glia — a set of nervous system cells once thought to be mere supports for neurons — have rewritten chronic pain science.

Although glia are scattered throughout the nervous system and take up almost half its space, they long received far less scientific attention than neurons, which do the majority of signalling in the brain and body.

When first discovered in the mid-1800s, glia — from the Greek word for glue — were thought to be just connective tissues holding neurons together. Later they were rebranded as the nervous system's janitorial staff, as they were found to feed neurons, clean up their waste and take out their dead. In the 1990s, they were likened to secretarial staff when it was discovered they also help neurons communicate. Research over the past 20 years, however, has shown that glia don't just support and respond to neuronal activity like pain signals — they often direct it, with enormous consequences for chronic pain.

In chronic pain, researchers now believe, glia drive a healthy pain network into a dysregulated state, sending false and destructive pain signals that never end. Pain then becomes not a warning of harm, but a source of it; not a symptom, but, as Stanford pain researcher Elliot Krane puts it, "its own disease."

Path of pain

The pain system generally works in three distinct stages.

First, when an injury or ailment causes damage, long nerve fibres in your finger sense the damage and shoot a pain message towards your brain. In the second

stage, those signals enter your spinal column and, in a handoff monitored and sometimes tweaked by nearby glia, jump to other neurons within the spinal cord. Finally, in this alarm system's third stage, those spinal cord neurons carry the signals to a spot in your cerebral cortex.

The first part of this alarm system — carrying the pain signal towards the central nervous system — runs largely on a highly efficient autopilot. Its main players are the long pain-sensitive neurons that run from finger to spinal cord and quickly trigger a reflex that makes you jerk back your hand.

In stage two, when these signals approach the brain and spinal cord, however, things get tangly. It is here, at the handoff from the peripheral to the central nervous system, that a profusion of glia heavily regulates pain signals by amplifying or decreasing their intensity or duration. And it's here that things can go amiss and trigger chronic pain.

It's still not clear exactly how or why this glial mismanagement develops. It can emerge either after an injury or seemingly out of nowhere. Pain from one or even multiple injuries, as in a car wreck, ordinarily lasts days or weeks and then tapers off to nothing. But sometimes the glia's regulatory system continues the pain signals after the tissue heals.

Glia can create a tough mess to untangle.

Is there a solution?

In theory, identifying glia as chronic pain's culprits should make it easier to find a solution. Unfortunately, it hasn't. You can't just knock glia out — they're too important — and current painkillers don't help because they target neurons, not glia.

And glia are ludicrously versatile. They transmit information through dozens of communication pathways. "Pretty much every way that neurons communicate," said Doug Fields, a glia researcher with the National Institutes of Health, "glia also use."

David Clark, a Stanford pain researcher and clinician at the Palo Alto Veteran's Affairs hospital, suspected that part of the problem lies in the pain system's built-in redundancy. Glia seem to have so many ways to transmit pain signals that even if a treatment blocks one, they promptly find another. Clark believes that outwitting this vast system of glial regulation may require novel strategies.

"This is not going to offer up a target you can just hit with a drug or a genetic switch. It may require something wholly new, like figuring out how to turn off an entire family of genes at some crucial spot," Clark said.

Your pain has a source.

The realisation over the past 20 years that glia underlie chronic pain does offer two substantial sources of comfort.

For one, scientists now at least have some idea where to seek a solution — the glia. In a chronic-pain support group Steinberg runs, she said that people find it a huge affirmation to learn there's distinct biology underlying their pain. It confirms what they've long known but often see doubted by doctors and friends: That their pain is as real as any other.

The New York Times

SNIPPETS

Potential treatment for autism

For decades, parents of children with autism spectrum disorder were told that barring early interventions, there is no cure for the disorder which alters socialisation and communication skills. Now, a group of Indian researchers has found that a molecule could open the way for potential treatment.

According to Sundar Rajan, President of the Autism Society of India (Bengaluru chapter), one in 66 children has an autism spectrum disorder (ASD). Autism spectrum disorder is a wide range of symptoms varying in severity, related to brain development affecting perception, subsequently hobbling social interaction and communication. It is caused by disruptions to neuronal connections in the brain.

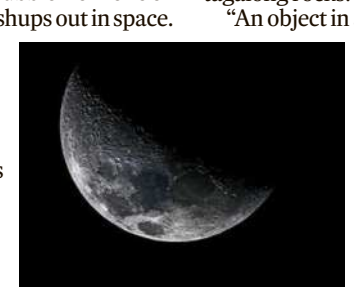
However, researchers at the Jawaharlal Nehru Centre for Advanced Research (JNCASR) in the city say that in animal studies, a new molecule called "6BIO" has improved neuronal function, learning and memory while reducing epileptic seizures.

6BIO was found to restore neural functions not only when administered during the developmental stage of mice (equivalent of a baby (1-2 years) and childhood stages (3-6 years) but also after mid-childhood (7-11 years) when most of the brain regions are considered to have formed properly. This has prompted the interest of drug companies.

DHNS

A rock that damaged the moon

The moon's violent history is written across its face. Now, for the first time, astronomers may have spotted rubble from one of those ancient smashups out in space. The mysterious object known as Kamo oalewa appears to be a stray fragment of the moon, researchers say in *Communications Earth & Environment*.



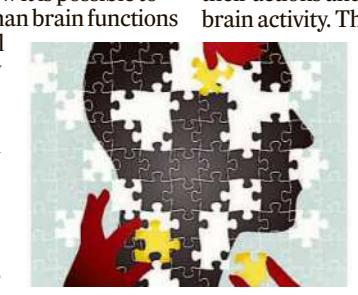
Discovered in 2016, Kamo oalewa is one of earth's five known quasisatellites. These are rocks that stick fairly close to the planet as they orbit the sun. Kamo oalewa is about the size of a Ferris wheel and strays between 40 and 100 times as far from Earth as the moon, as its orbit around the sun weaves in and out of Earth's. That has left astronomers to wonder about the nature of such tagalong rocks.

"An object in a quasisatellite orbit is interesting because it's very difficult to get into this kind of orbit — it's not the kind of orbit that an object from the asteroid belt could easily find itself caught in," says Richard Binzel, a planetary scientist at MIT not involved in the new work. Having an orbit nearly identical to Earth's immediately raises suspicions that an object like Kamo oalewa originated in the Earth-moon system, he says.

Science News

The brain can be stimulated

In a pilot human study, researchers from the University of Minnesota Medical School and Massachusetts General Hospital show it is possible to improve specific human brain functions related to self-control and mental flexibility by merging artificial intelligence with targeted electrical brain stimulation.



The study was published in *Nature Biomedical Engineering*. The findings come from a human study conducted among 12 patients undergoing brain surgery for epilepsy — a procedure that places hundreds of tiny electrodes throughout the brain to record its activity and identify where seizures originate.

The team developed algorithms, so that after stimulation through these electrodes, they could track patients' cognitive control abilities, both from their actions and directly from their brain activity. The controller method provided boosts of stimulation whenever the patients were doing worse on a laboratory test of cognitive control.

"This system can read brain activity, 'decode' from that when a patient is having difficulty, and apply a small burst of electrical stimulation to the brain to boost them past that difficulty," said Alik Widge, an assistant professor of psychiatry and member of the Medical Discovery Team on Addiction at the University.

Science Daily