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Understanding Behavioural Psychology in the Context of Long-Duration Spaceflight

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What could have been going through Alan Shepard's mind? Perched atop 20 tonnes of liquid oxygen, about to get catapulted into space across the Karman Line, in a modified intercontinental ballistic missile. Fear and anxiety, surely? Actually, his most pressing issue was his need to urinate. In the summer of 1963, the first American in space had to launch with a slightly damp seat and lower-back. In the 55 years of manned spaceflight that followed, attitudes and desirable characteristics of astronauts have changed immensely. Despite his distinguished test pilot record, Alan Shephard would probably not be the most fitting candidate for a 22 month round-trip to Mars, given the test pilot culture of "flying and drinking and drinking and driving"[1]. This essay will explain why not, and examine the understanding of the behaviour necessary to survive such an ordeal.

It is important to understand that the phrase behavioural psychology is an extremely ambiguous term, and for the purposes of this essay it shall be used to describe the study of emotions, behaviours and actions of an individual in a certain environment. Long duration spaceflight will be regarded as anything upwards of six months spent in space. There will be a great deal of focus on how opinions relating to the behavioural health of astronauts have changed over time, and how they will have to when humans embark on even more ambitious projects like colonizing Mars. Ever since the first cosmonauts were sent up in what can only be described as sealed cannonballs, engineers have been in constant conflict with doctors and psychologists over the treatment of their precious test pilots. It is time the doctors and psychologists had more clout.

Three broad topics will be covered. The first will relate to the study of the working environment of the astronauts, and focus on how much research is being conducted in order to assess the effects of isolation, and other stimuli astronauts may encounter.

Secondly, the stress induced by working in such an environment will be examined as well as broader psychological issues crewmembers may encounter. This will be done in order to determine how best to deal with these problems, and how current approaches to astronaut psychology might have to change.

The third area to be covered will be the significance of crew cohesion and interactions among individuals with regards to completing the current mission and tasks. The relationship between astronauts and mission control will be particularly scrutinized; if a conflict is to arise it is most likely to be between these two parties.

It is a simple fact that as mankind explores the cosmos, outposts will become more remote, and harder to access. The furthest mankind has been from Earth was during the Apollo Space Program, when the moon was 393,000 km from Earth. When a venture to Mars is finally

[1] *The Right Stuff* by Tom Wolfe pg. 50

realised, at one point the astronauts will be exactly a thousand times further away from Earth. The environment in which an organism interacts with is a crucial part of explaining its behaviour – astronauts and their spacecraft are no different. This part of the essay will discuss early space station environments, current studies into the effects of isolation, and hypothesize on the kind of environment astronauts could be living in during future missions.

The first official space station, christened Salyut 1, was launched on the 19th of April 1971 by the USSR, with crew first entering on June 7th [2]. The three cosmonauts entered a station that by today's standards would have to be evacuated immediately; a reek of burning plastic, faint wisps of smoke drifting about the interior, and an unsettling whistling noise. They stayed on board for 22 days, yet this milestone was marred in tragedy when the return capsule depressurised on re-entry, thus suffocating the crew. The psychological relevance to this disaster was limited – of course, the crew were never debriefed. It is important to note that at this time the Russians were taking a more comprehensive approach to their cosmonauts' mental health than NASA, and this will be discussed later. However, throughout the mission the Russian state newspaper *Pravada* [3] reported that the cosmonauts were quite upbeat and excited to be contributing to scientific discovery.

Forty-five years later, the current physical environment that astronauts operate in has changed dramatically, yet the stimuli that might affect their actions have not transformed as much. These stimuli would obviously consist of microgravity, rattles of various components and isolation. In the days before regular six-month deployments aboard the ISS, the majority of space stations were designed to support the crew for a period of approximately 40 days (partly because constant resupply missions were not guaranteed to be successful and were expensive), and with regards to a Mars mission habitats will have to be designed to last 16 times longer.

One of the most positive changes in the approach to understanding psychology in space has been the mimicking of isolation and confinement here on Earth. For example, in the last decade several fascinating experiments have been undertaken specifically focused on the effects of isolation and confinement on skills required in a long duration space mission. Three of the most prominent will be examined.

The first of these was the somewhat underreported Mars500 project based in Moscow[4]. The crew comprised of Russian, Chinese, and European members. Locked inside a windowless environment, the crew spent a total of 520 days, the longest experiment of its type, performing scientific experiments, a mock-landing on Mars, and even a short excursion across a sandy

[2] Nasa Space Science Data Coordinated Archive (NSSDCA)
[3] *Pravada* is a state newspaper, and it should be recognised that any reporting would have been strongly manipulated to make the Salyut 1 mission appear successful.
[4] Conducted at The Institute of Biomedical Problems in Moscow , 3rd June 2010 – 4th November 2010

courtyard in spacesuits to mimic exploring the Martian surface. The reasons for the shrouded publicity of the experiment lie in the fact that it was not a total success; owing to poor experiment design, many of the crew were idle for the majority of the day, passing the time by playing computer games or exercising. In space, a mixture of idleness and isolation has proven to lead to volatility. The crew's sleep patterns were reported to become extremely disrupted due to inactivity, with some members sleeping for 20% of the time they were meant to be awake. Nonetheless, the extent to which the "mission" provided results was enough to satisfy the psychologists and excellent data was collected. Given that it was the first experiment of its type, it has allowed similar studies to be better designed as well as paving the way for a more comprehensive approach to psychological assessments of spaceflight.

Antarctica has been home to several international research stations, and its genuine isolation makes a fitting testbed for a psychological study of space travel. One member of the BAS [5] even said it might be more isolated than the ISS itself [6]. Commencing on the 1st of January 2015, wintering staff at the Halley VI and Concordia research stations[7] are using a cockpit modelled on the Soyuz capsule to determine how skills are maintained over long periods of isolation [8]. Specifically, variations of the standard docking procedure with the ISS are the benchmark test. In addition to this, "crew" members regularly undergo a psychological test modelled on the Psychomotor Vigilance Test (PVT, a psychological test used by NASA to assess astronauts aboard the ISS [9]) to investigate the effects of long term fatigue and isolation. Meanwhile, a similar group of subjects are doing exactly the same procedures as an experimental control at an ESA centre in Stuggart, Germany, and the results of the two experiments will be compared. Staff are even making daily video diaries, which are then assessed by computer software to detect things like stammers, unusual word choice or pauses that could indicate stress that a normal psychiatrist may overlook. It is hoped similar software could be used to assess how astronauts feel on a mission. The entire experiment hopes to assess the specific effects of hypoxia and isolation on the staff, as well as lighting conditions. The resulting data will be crucial in order to understand how astronauts might perform in future missions. It is a much better constructed study than the Mars500 project, as the genuine isolation mimics an outer-space mission much more closely. However, the luxuries that the Halley VI members enjoy (examined later) by no means accurately represent the conditions that Martian astronauts would be living in - 16 wintering staff at this research station will be living in quarters designed to accommodate 70 in summer.

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[5] British Antarctic Survey

[6] This was a remark made in casual conversation with a member of the BAS at a Space exploration fair at the Farnborough 2016 Air show

[7] Halley VI is a British research station currently located on the Brunt Ice Shelf in Antarctica. The Concordia is a French-Italian station located on the other side of Antarctica.

[8] Titled "SIMSKILL", a standard mock-up of a Soyuz capsule is used

[9] This test was used during Scott Kelly's "Year in Space" Mission, see link for more information on the PVT

Most recently, a NASA-sponsored Mars simulation in Hawaii has concluded after exactly 365 days of isolation [10] for six international subjects, with the crew being closely modelled on what occupations Martian astronauts could have, including an astro-biologist, pilot, physicist and a soil scientist. During the mission, the crew were only allowed outside with a spacesuit on, had limited privacy, and were left to their own devices to solve personal conflicts. Additionally, their day was run on a tight schedule, as is that of astronauts aboard the ISS. Out of the three experiments examined here, this was probably the most similar to an actual Mars mission given the crew composition and tasks the astronauts performed.

All of these experiments demonstrate a comprehensive and necessary approach to behaviour in space and isolation, and it is important to note the range of nationalities of participants, which would be the case for a Mars mission. It is paramount that, alongside the safety, the environment astronauts occupy in the future are as comfortable as possible.

Research stations like Haley VI have been designed to create the most psychologically warming atmosphere possible; Lebanese Cedar was chosen as the wooden veneer for the stairs because it gives of a strong natural scent, psychologists designed the colour scheme of the station, and some modules are even equipped with LED mood lighting. The three cosmonauts aboard Salyut 1 would be understandably envious. Whilst it may be impossible to replicate an outpost like Haley VI on the surface of Mars, it is crucial that space habitat designers understand the importance of creating a relaxing and comfortable work environment. At the time of writing, NASA has just announced which contractors it will be using to build the habitat the astronauts will be living and working in during their journey to and from Mars – it will be interesting to see in the coming months if such considerations are prioritized.

One of the most prominent themes across psychology is that of stress, and this will be the focus of the next part of this essay. Having established what sort of environment astronauts work in and will be experiencing, it is important to examine one of the most likely behaviours resulting from these experiences. Our reactions and emotions are affected by a range of factors, leading us to experience how our body copes with these stimuli, thus affecting our health and interpersonal skills. Three broad areas of stress are used to define the experience, consisting of assessing stress as a response, a product of environment, and how to deal with it. [11]

Stress can be induced over a short or long-term period, as a result of stimuli such as noise, temperature or light. With regards to studying stress as a natural response, Hans Seyle's 1956 theory of *General Adaptation Syndrome* is used to define the various psychological and physiological reactions of our bodies. Divided into three distinct phases (alarm, resistance, and

[10] Conducted by the University of Hawaii, funded by NASA, 29th August 2015 – 29th August 2016
[11] The theory of stress used here is presented in *A First Course in Psychology* by Nicky Hayes, pgs. 399-404

exhaustion), the theory can be applied to a variety of instances, and in this context, a long-duration space mission.

The first phase is the alarm response that results in the release of adrenaline in the subject, raising the heart rate and blood pressure leading to the common "fight or flight" instinct. This would be as a result of a short term problem, and something that requires physical action to solve. The energy produced by the adrenaline would be used to carry out a physical solution, like running away, before adrenaline levels return to normal. In an environment like the ISS, events that cause such responses are limited, and all astronauts are excellently prepared to deal with them, meaning they can remain calm. However, from a psychological perspective, worrying about family or long term problems can also produce adrenaline, and if this is a recurring issue, it can lead to the second stage of GAS.

Relating to longer term issues, the resistance phase would still consist of large amounts of adrenaline being produced, but with a normal heart rate and blood pressure. It is harder to see if someone is obviously affected, as they may have found some way of coping with the problem, yet in this stage people are often jumpy, nervous, and exhibit volatility at the slightest annoyance. This is where the software to determine Astronaut's mood is even more critical; many people would not openly admit they are stressed (they might not even realise it), yet by measuring the time between phrases, pauses between words or the speed at which someone is talking it is possible to identify stress in a seemingly calm individual. This stage of hypersensitivity and nervousness has even been categorised by Russian cosmonauts as "asthenia" [12]. At this stage consistently high adrenaline levels will lead to the third stage of GAS, the collapse.

Having been releasing adrenaline and finding it difficult to cope with stressful stimuli, the subject will "collapse", usually by succumbing to a physical illness like influenza or a cold. Stress reactions use up large reserves of the body's energy (explaining why people might lose weight when stressed) meaning the immune system is not as supported, so a subject is therefore more susceptible to disease. Other conditions like stomach ulcers or heart disease strongly correlate with high amounts of stress. Stress is further exacerbated by lowering the body's fitness levels, which supports the argument that keeping fit and healthy is a good way of sustaining mental wellbeing.

Astronauts were encouraged to keep journals and diaries before video-logging; aboard the 211-day Salyut 7 mission in 1982, it was obvious that some cosmonauts fell into the second stage of *GAS*. Valentine Lebedev, one of the cosmonauts, wrote two months into the mission that "my

[12] *"Asthenia is a state characterized by heightened susceptibility to fatigue, fast onset of exhaustion, and partial or total loss of capacity for prolonged physical activity or mental exertion"* Tiganov, 1975

nerves are always on edge, I get jumpy at any minor irritation" [13], such symptoms strongly associated with *GAS*. The goal is to develop specific coping mechanisms in an environment to deal with stress, and to do that one must understand how an individual's surroundings influence the levels of stress they experience.

Stress is almost always a product of environment. Broadly speaking, if an individual has control over the stimuli that may exhibit symptoms of stress, they are less likely to fall into the category of *GAS*. This was the conclusion reached after a study in 1972 by the psychologists David Glass and Jerome Singer. Two groups of subjects were exposed to loud and piercing noises to produce a short-term amount of stress, and then asked to perform a set of problems. One of the groups was provided with a button which would stop the noises that, interestingly, no one actually pressed. This group did much better than the first, and suggested those who have control over the stimuli, even if they take no action to prevent them, will be less affected. In space it might be slightly difficult to control certain stimuli, but by allowing astronauts control over simple things like the amount of light in their environment might make them more comfortable. This perception of control is examined later. Noise is an interesting stimulus that can easily become habituated, meaning we become so used to it that we might not notice it. This is similar to the hum of a refrigerator or air conditioning – we only notice it when it turns off. The ISS is actually not that quiet an environment, as ventilation or temperature control systems are constantly operating, but for a prolonged period of time it can easily become habituated, as long as it is not too loud. Other stimuli like temperature are important to taken into account; hot, stuffy environments will produce irritation or aggression, which are the types of behaviour you would not want in an astronaut who might be trying to berth three tonnes of cargo to the ISS. Coping with these stimuli in an environment is crucial, yet that could be down to the type of individual.

Dealing with stress is the third way to approach the experience, and often the most critical. In 1966 Julian Rotter proposed that it might not be the severity of the stressors that determine how severely an individual is affected, but their own perceptions of what causes stress and how they might deal with it. Rotter issued a questionnaire that asked participants to choose between statements that divided stress as being internal (e.g. "What happens to me is my own doing") or something completely external to one's own actions. People consistently divided the statements as Rotter had written them, thus leading him to adopt the belief that people with different attitudes towards stress will react differently. The term "locus of control" [14] was used to describe this belief. If one were to have an internal locus of control, they are generally able to deal with stress much more positively as they believe they can overcome the annoyance or stressor. However, someone with an external locus of control will often believe that it is luck,

[13] *Safe Passage: Astronauts Care for Exploration Missions* – chap. 5, John R. Ball and Charles J. Evans, 2001
[14] Pg. 404, *A First Course in Psychology, Nicky Hayes*

and will develop a mentality that portrays them as a helpless victim of some external force. Ideally, an astronaut candidate will be the former. In 1975 another psychologist named Martin Seligman drew parallels between an external locus and depression, often characterized by people being passive and feeling helpless in a stressful situation.

It is important to note that stress or irritation can be the result of variation in workloads; too many tasks will lead to things being rushed and appear stressful, yet too little to do will result in boredom and idleness, which can have dire consequences. A NASA psychologist said that "the situation of work underload is one of the worst situations you can ask a high-achieving, bright, interested astronaut to subject himself to" [15]. On a journey to Mars, it is critical that astronauts are occupied so as not to subject themselves to this experience.

Having approached the experience of stress in these ways, one must determine the best way to resolve such issues by being open to crewmembers and mission control. Crew cohesion stands as one of the most salient issues for any space mission. The term cohesion will be defined as the closeness and solidarity of a group of individuals working together to complete a task. The effects of gender composition and cultural diversity on crew cooperation will be examined, and how these factors contribute to what may be described as the "perfect" team. Significant also is the presence of mission control.

Tom Wolfe's novel "The Right Stuff" accurately describes the social environment the first American astronauts lived and worked in. As Alan Shepard entered the Mercury capsule for "the holy first flight", the book reaches a climax of describing Shepard at the peak of fighter pilot heaven ("he would be up there at the apex of the pyramid if he survived the flight"). Explaining the culture surrounding the Mercury astronauts requires more context than can be provided here, but essentially it consisted of the most elite fighter pilots not trying to please their country, instead attempting to maintain their reputation as idols of the sky among their peers.

Current crew members would benefit from having a healthy dose of The Right Stuff, but studies have proven that crew cohesion does not lie in people possessing similar qualities; a diversity of personalities and backgrounds is just as likely to guarantee mission success.

One of the most prominent features for any crew would be gender composition. To date, 56 women have flown in space (little under 10% of the total number of people to have done so) and it is firmly believed that crews containing females are likely to be more successful on missions. Both genders offer unique skills and abilities to a mission, and it is the range of skills that will benefit a crew the most instead of the quality of those skills. A report from the NCBI [16]

[15] Al Holland, on Long Duration Psychology
[16] National Centre for Biotechnological Information (USA)

detailed that a female presence at wintering artic stations "seems to have positive effects on the general climate of the groups by partly limiting men's rude behaviour"[17]. Additionally, a former US naval commander at these stations said that "women had a stabilizing effect on personnel and [I believe] these heterogeneous groups were more productive than all-male groups". One of the many downfalls for the Mars500 mission was the fact that the crew were all male, and on several occasions observing psychologists noted aggressive or violent behaviour that could have been limited if there were women present.

Russia was the first country to make efforts to diversify its crews ever since Valentina Tereshkova piloted the Vostok 6 capsule around the Earth. It would be a fair observation to say that the vast majority of space missions have been dominated by Russian and American presences. Earlier, it was mentioned the Russians were more focused on the psychological side of space travel; indeed, they had conducted 40,000 hour of studies in space. No studies have been conducted to specifically focus on the effects of such cultural dominance on crew members, but it is perfectly clear from various memoirs and accounts that there have been cultural clashes between crewmembers of other nationalities. This became apparent during the Interkosmos programme, the Russian led initiative to include allies of the USSR in space exploration. The programme led to many milestones in the history of spaceflight: the first black, Hispanic, Muslim and non-American or Russian astronauts all flew between 1978 and 1988. Despite this, a joke went around saying these astronauts would suffer "red hand syndrome"[18] – every time a non-Russian reached for a switch or control, a Russian crewmate would slap their hand away and tell them not to touch it.

This uneasy relationship between experienced cosmonauts and their crewmembers was not limited to the Interkosmos programme. During Shuttle-Mir operations, several American astronauts reported to have been ignored or declined permission to operate some of the space station systems. Notably, when the American astronaut Shannon Lucid spent six months aboard Mir, she was told not to touch anything by her Russian crewmates as they performed EVAs [19] – some switches were even taped down. Such a culture among astronauts would appear to have died down, but even Tim Peake made comments about how his Russian commander Yuri Malenchenko felt slightly uncomfortable with a relatively inexperienced British astronaut alongside him.

Having an uncooperative crew is a serious enough issue, but when relations between mission control and the space flight crew break down, the mission can be truly put in jeopardy. There have been several instances where this has occurred. After the Apollo 7 mission, the crew were

[17] Rosnet et al., "Mixed Gender Groups" : C12
[18] Journal of V. Lebedev, 1990
[19] Extra-vehicular Activities, otherwise known as spacewalks

grounded for the rest of their career because they were too conflicting with mission control. The Soyuz 21 to Salyut 5 was ended early due to nitric acid fumes in the cabin, but also due to "interpersonal issues among the crew". During the third and final mission to the American space station Skylab, the three astronauts complained about their workload continuously, up to the point where they conducted a day long strike. Although not life threatening, Skylab 4 was a classic example of an irritable and inexperienced crew being pushed to their mental limit. After the strike, their timetable was reorganised, and by the end of the mission they actually got more work done than NASA had originally planned. Since then NASA has taken a more flexible approach to astronauts' workload; on her return from the ISS, Susan Helms said that it was important to the crew's mental wellbeing that there "remains enough time to look out the window, do somersaults in weightlessness, watch movies, and sit around chatting."[20] In the context of a mission to Mars, astronauts may actually benefit from the 20-minute delay in communications.

For an individual, maintaining a positive relationship with the crew members and ground control is critical. It is the most important factor highlighted in this essay; if one is experiencing stress, they need to have an open relationship with their fellow crewmates in order to address the issue. In the context of the wider environment in which an astronaut lives and works, the social environment will have a stronger influence on the behaviour of a working individual.

Attitudes towards space exploration have shifted and contorted ever since Yuri Gagarin made the first voyage. Despite the immense engineering problems surrounding getting people in orbit, it is reassuring to see that a much more comprehensive and structured approach is being taken to monitor the most delicate piece of equipment on any manned space mission; the crew. As a concept, human spaceflight has kindled inspiration across the globe, and will continue to do so when humans land on Mars and in the years to come.

[20] pg. 10, *On Orbit and Beyond: Psychological Perspectives on Human Spaceflight*, Edited by Douglas Vakoch

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