EMBRY-RIDDLE Aeronautical University
SCHOLARLY COMMONS

Journal of Aviation/Aerospace Education & Research

Volume 25
Number 1 *JAAER Fall 2015*

Article 2

Fall 2015

# Human Behavior During Spaceflight - Evidence From an Analog Environment

Kenny M. Arnaldi
*Embry-Riddle Aeronautical University*, arnaldi.k@monaco.mc

Guy Smith
*Embry-Riddle Aeronautical University*, smithabc@erau.edu

Jennifer E. Thropp
*Embry-Riddle Aeronautical University - Daytona Beach*, throppj@erau.edu



## Scholarly Commons Citation

Arnaldi, K. M., Smith, G., & Thropp, J. E. (2015). Human Behavior During Spaceflight - Evidence From an Analog Environment. *Journal of Aviation/Aerospace Education & Research, 25*(1). https://doi.org/10.15394/jaaer.2015.1676

## Introduction

Four years after the launch of Sputnik, the world's first artificial satellite, Yuri Gagarin became the first human to reach space (National Aeronautics and Space Administration [NASA], 2011a). The United States soon followed on the path of manned space exploration with Project Mercury. Although this program began with suborbital flights, manned spacecraft were subsequently launched into orbit around the Earth (NASA, 2012). With President Kennedy setting the goal of landing a man on the moon, NASA focused on short-duration orbital flights as a stepping-stone to lunar missions. Under Project Gemini, astronaut crews remained in space for several days, and developed the skills to dock with other spacecraft (NASA, 2012). Lunar missions shortly followed with Project Apollo, marking the first time human beings left Earth's orbit and travelled into deeper space. This set the stage for NASA's Skylab program and the Soviet Union's Salyut and Mir programs. These programs were designed for long-duration missions, to prove that humans could live in space for months at a time (NASA, 2012). The International Space Station (ISS) was designed and constructed during NASA's Space Shuttle program, and hosts astronaut crews for extended durations, up to a full year in space (NASA, 2013).

Looking toward the future, the U.S. government announced in 2009 a Commercial Crew Program, which is a partnership with private industry to provide transportation for astronauts to and from low-Earth orbit (NASA, 2014a). This program will allow NASA to focus its financial resources on deep-space exploration rather than low-Earth orbit (NASA, 2014a). The Commercial Crew Program introduced the concept of *spaceflight participant*, which is a new type of space traveler. Spaceflight participants are ordinary individuals with no particular academic or medical background (National Aerospace Training and Research [NASTAR], 2014). Spaceflight participants undergo physical training with private companies to qualify for commercial human spaceflight (NASTAR, 2014). The Federal Aviation Administration (FAA) Space Participant Certification Program (SPCP) allows the public to participate in spaceflight training with the prospect of flying into space, either as a crewmember or as a space tourist (Space Discovery Institute [SDI], 2014).

Successful manned space missions are largely dependent on effective human performance, such as the operation of complex technology and equipment. Daily mood variations affect the performance of humans at work (Fox, 2006). However, few studies have attempted to assess how task performance varies under the different workloads and stress conditions inherent to spaceflight (Diaz & Adam, 1992). Conversely, past research demonstrated that human performance is not an *all or nothing* concept; rather, it is dynamic and evolves over time under the influence of multiple stressors (Diaz & Adam, 1992). Consequently, understanding the relationship between mood, human performance, and space environment stressors is becoming increasingly important as longer and more complex missions to other planets and asteroids are planned for future manned space exploration (Diaz & Adam, 1992). With the advent of spaceflight participants, it is equally important to understand the relationship between environmental stressors, mood, and human performance. Spaceflight participants meet more lenient medical standards and have received less intense physical and mental training compared to astronauts, and thus may react differently to the space environment (SDI, 2014). To qualify for a pilot position in the spaceflight participant program, the only requirement is to possess an FAA pilot certificate, while flight crew applicants only need to possess a valid FAA 2nd-class medical certificate (SDI, 2014).

## Significance of the Study

Research by Fox (2006) stated that limited research has been conducted to analyze the effects of mood on work performance. Mood itself constitutes a reaction to environmental settings (Fox, 2006). With longer and more complex space missions on the horizon, it is essential for private companies and NASA to understand this relationship. NASA and private companies could develop countermeasures to the environment with new regulations. Astronauts and spaceflight participants could also better prepare for their missions using relevant training methods tailored to their task objectives, personalities, and skills. Research on individual and team performance in a spacecraft environment is necessary to increase the probability of future mission success (Musson & Helmreich, 2005).

## Review of the Relevant Literature

The space environment, to include the life-support system, offers many challenges to the astronauts living in space during short or extended time periods. Among these daily challenges are isolation, confinement, high workloads, and weightlessness (Diaz & Adam, 1992). Even though limited research has been conducted to understand the effects of these conditions on human mood variations during U.S. space missions, data has been gathered in analog habitats, such as submarines, polar expeditions, underwater laboratories, and (former) Soviet Union (U.S.S.R.) space missions (Diaz & Adam, 1992). Future missions to the ISS or to deep-space destinations may increase the number and magnitude of stressors to which astronauts are exposed, such as extended durations, flight crews composed of different cultural backgrounds, more complex tasks, and decreases in motivation over time (Diaz & Adam, 1992).

## Extended-Duration Spaceflight

An extended-duration spaceflight is defined as lasting months or years, as opposed to days or weeks (Kanas, 1990). NASA's plans for future space exploration include sending humans to deep space (e.g., Mars) using the Orion spacecraft (NASA, 2014a). With current technology, the trip time to send humans to the red planet would take about eight months, although newer technologies are being investigated to reduce this duration (NASA, 2014b).

Human spaceflight inherently creates conditions of isolation and confinement, among other stressors (Genik, Green, Graydon, & Armstrong, 2005). Consequently, psychosocial health is a concern for missions that last one or two years (Musson & Helmreich, 2005).

## The Space Environment

The space environment is characterized by multiple stressors, such as noise, heat, cold, confinement, etc. These stressors can threaten mission success by acting individually or by interacting with others (Sauer, Wastell, & Hockey, 1997).

**External space environment stressors.** Similar to undersea habitats, such as the NASA Extreme Environment Mission Operations (NEEMO) lab, or the Mars500 habitat, spacecraft or space stations are "sealed habitats within a hostile external environment" (Manzey & Lorenz, 1997, p. 930). The external space environment possesses a number of hazards to humans, such as microgravity, high levels of radiation, etc. The current study investigated the effects of circadian rhythm shifts.

***Circadian rhythm shifts.*** Compared to life on Earth, in the space environment, astronauts must adapt to shorter cycles of daytime and nighttime. In low-Earth orbit, a full sunrise-sunset-sunrise cycle occurs every 90 minutes (Manzey & Lorenz, 1997), which can affect an astronaut's circadian rhythm and sleep pattern quality. McClung (2007) revealed that ultimately, circadian rhythm shifts may affect mood or lead to mood disorders.

**Life-support system stressors.** The sealed habitat that protects astronauts from the harsh external environment is a source of stressors as well. Examples of such stressors include, but are not restricted to, noise, increased risk of habitat fires, high $CO_2$ levels, pathogenic viruses, etc. (Manzey & Lorenz, 1997). The current study investigated the effects of confinement and isolation on behavioral health.

***Confinement.*** Living in an artificial life-support system (such as a spacecraft) inherently requires astronauts to adapt to conditions of confinement (Lorenz, Manzey, Schiewe, & Finell, 1995). The small space available to astronauts in the spacecraft significantly limits their ability to move freely, which reduces their overall physical activity (Manzey & Lorenz, 1997). Furthermore, relieving stress is more difficult in small spaces compared to Earth due to the limited space to perform stress-relieving activities. The continuous presence of the work area also adds to the stress level (Sauer et al., 1997). Laverne, Williams, and Stern (1972) noted that small groups in confinement are susceptible to lower levels of motivation, which was linked to a poor ability to study or perform purposeful activities. More extended periods of confinement may lead to greater reductions in performance. Thus, more research should be conducted to determine the magnitude of physiological variations during long-term confinement (Laverne et al., 1972).

***Isolation.*** Social isolation is linked to performance problems in automated work environments. Isolation is known to increase the number of decision-making mistakes during routine tasks, as well as reduced memory and attention span capabilities (Sauer et al., 1997). After gathering data from a long-term Soviet isolation study in space, Bluth and Helppie (1987) noticed that the level of cognitive performance decreased significantly after 40 days in space, then recovered just before the end of the mission. According to Sauer et al. (1997), isolation over time can lead to boredom, which in turn affects motivation and crew performance. This is particularly relevant in routine and repetitive tasks; uninterested astronauts are more prone to making small mistakes. To counteract isolation, astronauts can be provided with political, cultural, and sporting events news. They can also communicate with family and friends via e-mail and receive personal gifts through resupply missions (Manzey & Lorenz, 1997).

***Behavioral health and performance risks.*** While living in an artificial orbital habitat, people may be exposed to risky behavioral and psychiatric conditions due to the isolated and confined environment, or risks of committing performance errors due to sleep loss, and circadian desynchronization (NASA, 2010).

## Artificial Habitats

Artificial habitats on Earth can be used to replicate living conditions experienced by humans in space at much lower cost and involving fewer risks.

**NEEMO.** The NASA Extreme Environment Mission Operations, or NEEMO, is a project in which astronauts, scientists, and engineers are sent to live and work in Aquarius, an undersea research laboratory located in the Florida Keys, for up to three weeks (NASA, 2011b). NEEMO offers an analog setting to space, including a hostile external environment, confinement, and the ability to simulate different gravity conditions (NASA, 2011b).

**Mars500.** The Mars500 project was a European Space Agency (ESA) experiment conducted in Russia that simulated a mission to Mars (European Space Agency [ESA], 2011). The purpose of this experiment was to gather data on mental and physical needs of astronauts exposed to long-duration missions. Particularly, the study investigated the effects of isolation on psychological and physiological needs (e.g., stress, sleep quality, etc.), providing information to develop countermeasures to these effects (ESA, 2011).

**Human Performance**

The operation of spacecraft technology requires the complex combination of cognitive and motor tasks (Sauer et al., 1997). When added to the unfamiliar and stressful spaceflight environment, high levels of human performance are required (Diaz & Adam, 1992). Keeping the flight crew motivated and requiring them to make increased effort can help maintain high levels of human performance (Sauer et al., 1997).

According to Beregovoy, Krylova, Solov'yeva, and Shibanov (1974), the tasks conducted by astronauts in space rely on a more automated *human-machine* interface compared to other fields of work. Understanding how the space environment affects human performance can improve the design of flight hardware and software, enabling astronauts to achieve "optimal human performance, while providing safe human-machine interfaces" (Morris & Whitmore, 1993, p. 516).

**Task performance.** Thornton, Moore, Pool, and Vanderploeg (1987) divided astronaut task performance into two categories: motor performance and cognitive processing (as cited in Lorenz et al., 1995).

Results from a study conducted by Lorenz et al. (1995) showed that motor performance was significantly affected by exposure to the space environment due to the presence of microgravity, and the astronaut took three weeks to adapt to the new environment and reach baseline performance levels that were established on Earth prior to launch. Cognitive processing was also measured through an assessment of short-term memory (Lorenz et al., 1995). Data gathered on the ground and in space showed little variation in the speed and accuracy of the short-term memory task, suggesting this area of human performance was not affected by exposure to microgravity and other space environment characteristics (Lorenz et al., 1995).

**Psychological stress.** Psychological stress can produce positive, as well as negative effects on human performance (Genik et al., 2005). High levels of stress are associated with reduced motivation, which in turn increases the risk of error (e.g., shortcuts in decision-making) (Sauer et al., 1997). Functional magnetic resonance imaging (fMRI) determined that one astronaut experienced two consecutive onsets of cognitive overload during his time in space. In order to remedy the issue, the astronaut's nonessential activities were replaced with aerobic exercises in order to produce natural endorphins (Genik et al., 2005, p. B212).

**Workload.** In space, astronauts are required to maintain the operational status of technical systems and conduct experiments, which occasionally involve the astronauts themselves as the subjects (Manzey & Lorenz, 1997). Due to tight schedules and time limitations, as well as high levels of mental and physical workload imposed by the experiments, astronauts can quickly become overloaded (Manzey & Lorenz, 1997). Periods of increased workload result in narrowed attention, amplified tension, fatigue, lower flexibility and reduced information-processing abilities (Sauer et al., 1997). To handle the busy schedule that paces the astronauts' days in space, eight-hour working days are not sufficient, and tasks are inevitably rescheduled for a later time, which can lead to increased fatigue (Lorenz et al., 1995).

## Temperament

Temperament is a term used to represent a set of personality traits, which include "habits of communication, patterns of action, and sets of characteristic attitudes, values, and talents" (Keirsey, 2014a, para. 1). As stated by Thompson, Winer, and Goodvin (1999), an individual's

https://commons.erau.edu/jaaer/vol25/iss1/2
DOI: https://doi.org/10.15394/jaaer.2015.1676

temperament develops early during childhood and is consistent over a lifetime, in contrast with an individual's mood or emotions, which are transient.

The Keirsey Temperament Theory supports that four temperament groups exist: Artisans, Guardians, Rationals, and Idealists (Keirsey, 2014b). *Artisans* are people who live in the present. They see what is right in front of them and focus on short-term advantages without giving too much importance to long-term consequences. *Guardians* represent people who value their duties and responsibilities, obey laws, follow rules, and respect other people's rights. *Rationals* focus on current problems and come up with solutions; they are pragmatic in nature and go against conventions and rules in the name of efficiency. Lastly, *Idealists* have a greater tendency to see what possibilities lie ahead, and attempt to reach their goals without going against their personal ethics (Keirsey, 2014a).

Each temperament group consists of a collection of four Character Types. The four Artisan character types are *Promoters*, *Crafters*, *Performers*, and *Composers*. The four types of Guardians are *Supervisor*, *Inspector*, *Provider*, and *Protector*. The four Rational character types encompass the *Fieldmarshals*, the *Masterminds*, the *Inventors*, and the *Architects*. Finally, the four types of Idealists include the *Teachers*, the *Counselors*, the *Champions*, and the *Healers* (Keirsey, 2014b).

**Mood States**

Research conducted by Clark (2005) established that mood is a state of emotions that reflect an individual's current impressions about the world, which may last for a given time period, but are not permanent. Mood variations have the ability to alter a person's perceptions and judgment, affecting their behavior and ability to perform effectively (Clark, 2005). Mood is affected by multiple factors, which can be internal to the human body or to external events.

**Internal factors.** Lieberman, Waldhauser, Garfield, Lynch, and Wurtman (1984) determined that melatonin, a hormone secreted generally at night by the pineal gland, possesses sedative properties, which in turn have an adverse effect on human performance (specifically, reaction time). Low levels of serotonin, a blood compound that acts as a neurotransmitter, resulted in increased irritability and aggression (Young & Leyton, 2002). In turn, this led to poor social interactions between individuals and impulsivity. Consuming doses of serotonin can help reduce aggressive behavior and promote social interactions (Young & Leyton, 2002).

**External factors.** External factors range from types of food ingested to circadian rhythms. Although anecdotal evidence suggests that caffeine affects mood, Lieberman, Wurtman, Emde, Roberts, and Coviella (1987) did not find any significant changes in mood (e.g., fluctuations in anxiety or impulsivity). Lieberman et al. (1987) tested different doses of caffeine, but found no noteworthy mood variations.

Biological rhythm variations can occur at different levels of magnitude (seasonal changes or daily circadian rhythm fluctuations). According to Wirz-Justice (2006), humans feel more depressed in the winter, but mood also suffers from poor sleep quality (e.g., sleep-wake cycle disturbances). Light therapy, as well as new types of medicine, have proven to improve sleep quality and resist better to biological rhythm fluctuations, resulting in improved mood (Wirz-Justice, 2006).

## Methodology

### Research Questions and Hypotheses

The following research questions were formulated for this study:

1. How do environmental conditions and constraints affect a human's mood?
2. How do environmental conditions and constraints affect a human's temperament?

https://commons.erau.edu/jaaer/vol25/iss1/2
DOI: https://doi.org/10.15394/jaaer.2015.1676

The following hypotheses were formulated for this research:

1. There will be a difference in mood based on environmental constraints (isolated habitat vs. normal conditions).
2. There will be a difference in temperament based on environmental constraints (isolated habitat vs. normal conditions).

**Delimitations**

Due to the exploratory nature of this research project, only two participants were used to generate the data. A small recreational vehicle (RV) was configured to replicate an artificial orbital habitat (AOH) that would support the two participants.

The researcher and collaborators chose not to simulate many aspects of the space environment (weightlessness, radiation exposure, extreme temperatures, space food, scientific experiments, etc.) due to limited financial resources and IRB requirements. The IRB also required that the RV's door be left unlocked to allow participants to leave for safety considerations, if necessary.

To minimize the effects of this experiment on the participants' abilities to study and attend class, the duration of the experiment was limited to 50 consecutive hours.

**Limitations and Assumptions**

For the purpose of the research, participants were enclosed in a ground-based habitat with no communication with the outside world (with the exception of a simulated mission control). An assumption was made that the selected participants were similar in nature to space participants and were compatible with each other. Another assumption was made that the experimental environment made the participants feel physically isolated from the rest of the world. The researcher assumed that the activities of the participants in the AOH reflected those of the astronauts living in space for extended mission durations. To meet the needs of the investigation, the researcher also assumed that the participants would willingly follow all procedures and cooperate with the scenarios.

## Research Approach

The purpose of this research was to determine if space participants experienced mood or temperament variations while exposed to the space environment, and compare the results with the mood and temperament variations they experienced on Earth. To fulfill the research objective, the participants were both subjected to two different environments: a controlled AOH environment and their normal daily living environments. This study employed a quasi-experimental research design, due to the high level of control the researcher and collaborators possessed over the AOH environment (specifically, the design and structure of the environment, and the protocol). On the other hand, nothing within the Normal Environment was manipulated except for the data collection protocol. This study was considered an exploratory study designed to test procedures, protocols, and data collection methodology. Consequently, the study was limited to a single crew of participants. Descriptive and inferential statistics were used to describe the data for the mood and temperament variables collected in both environments.

**Design and procedures.** The researcher and collaborators first decided to collect data from the AOH. After completing the data collection in the AOH, the researcher and collaborators set out to collect data from a normal environment. The steps in creating both environments were as follows.

***IRB approval.*** The first step in developing an AOH experiment was to lay out its fundamental characteristics and have the project approved by the Institutional Review Board (IRB). After reviewing the research proposal, the IRB required that, before the start of the mission, the participants received a full briefing, including information on the hazards and risks associated with this experiment, and were given the right to refuse participation. The participants were also briefed that, should a problem arise, it would be treated as an emergency by the mission controllers, and the participants would be evacuated. At the end of the briefing, both participants completed Keirsey Temperament Sorter®-II K (KTS®-II) (Keirsey, 2014c) and a Profile of Mood States 2nd Edition™ (POMS 2™) (Multi-Health Systems [MHS], 2014) test to serve as a pre-test collection of data. These tests provided a baseline against which to identify variations in mood and temperament during and after the experiment.

The IRB required the participants to be male, be 18 years of age or older, be able to read, write, and speak English, and have a 3.0 grade point average (GPA) or higher. Furthermore, the participants were required to be in healthy condition and to have no scheduled class exams in the 48 hours that followed the experiment. Furthermore, participants could not be claustrophobic or suffer from food allergies. Participants also needed to be willing to live in a closed environment with another person.

Following the IRB’s guidelines, the researcher and collaborators briefed the participants that post-experimental fatigue could result from living in a closed environment and from performing the required physical exercise. To mitigate any consequences, the researchers ensured the participants were able to return safely to their domiciles after the experiment, and offered transportation to them.

Information about the participants remained confidential. No personal information was revealed during the writing of this research paper, and participants were identified through scientific enumeration (e.g., Participant A and Participant B). All personal information was retained by the researcher and the collaborators.

## Habitat Environment

The AOH environment consisted of an RV that was configured to mimic an orbital environment and meet the needs of the research objective. A team of two participants was isolated in the artificial habitat. Their work schedule was an open-ended participant-controlled schedule.

**Vehicle.** An RV was rented from a reputable local dealer and was inspected to meet habitability code and specifications. The RV was equipped with a smoke detector, a carbon monoxide detector, external exhaust capabilities, and a fire extinguisher. The doors and windows of the RV were closed, but left unlocked.

**Living conditions.** The habitat was set up with separate sleeping accommodations, a private toilet facility, a kitchen area, a desk, and a control station. The windows of the habitat were covered to prevent light from flowing through during the artificial night cycle, while, at the same time, preventing the participants from seeing outside. The participants were prohibited from bringing certain items inside the habitat, such as personal electronic devices, watches, and weapons.

***Hygiene.*** The design of the habitat also allowed for the replenishment of clean air, and large quantities of food and water.

**Working conditions.** During the experiment inside the AOH, the participants were required to complete a certain amount of physical exercise and accomplish specific tasks. These elements reflected the activities that occur on the ISS and increased the realism of the experiment.

https://commons.erau.edu/jaaer/vol25/iss1/2
DOI: https://doi.org/10.15394/jaaer.2015.1676

***Exercise bicycle.*** In order to simulate the space environment, in which astronauts are required to exercise regularly, the participants were required to exercise on an exercise bicycle a minimum of 2 hours on Day 2 and 90 minutes on Day 3.

***Space participant activities.*** The participants were required to complete certain activities during the mission. The team activities included designing a mission patch to commemorate the first artificial habitat study conducted by Embry-Riddle Aeronautical University (ERAU), as well as solving NASA's "Lost on the Moon" exercise ("NASA Exercise", 1999). This exercise consists of having the participants work together to rank by order of importance several objects in an attempt to survive a crash landing on the Moon.

The individual activity required each participant to monitor gauges to verify the system status of their simulated spacecraft. These gauges were displayed on a screen located inside the AOH. The participants had to work with mission control to determine the normal operating parameters of those gauges, scan the gauges, and notify mission control of any anomalies or deviations.

***Visual effects.*** When not used for the gauge monitoring exercise, the screen described above was used to display a live video feed of the orbit of the ISS around planet Earth, revealing a view of our planet from above. The mission controllers monitored this view as well to synchronize the day/night cycle or the simulated orbit of the AOH. This gave the participants the illusion that they were looking through a window at the Earth below them in real time.

**Mission elapsed time (MET).** To maintain a log of the evolution of the experiment, mission control possessed a computer dedicated to making entries on Microsoft Notepad. Each entry was time-stamped according to MET.

MET was known using a mission clock on an iPad® that was installed inside the AOH. The iPad® displayed MET, and was oriented towards the camera, thus visible from mission control's perspective. The MET clock was the only indication of the passing of time. This served to separate the participants from the Earth cycle; they were not allowed to bring watches, and the clock on the laptop inside the AOH was disabled. Consequently, the participants did not have any indications of the current local time.

**Schedule.** The experiment was designed so that no more than 50 consecutive hours were required of each participant. The informed consent form used deception to give participants the impression they could be confined in the AOH for up to 100 hours. The purpose of this deceptive information was to avoid feelings of relief as the MET neared 50 hours (the true end time of the experiment). The researcher believed such feelings would adversely affect the POMS 2™ test results. Following the experiment, the participants were debriefed on the reason why the informed consent form stated the experiment could last up to 100 consecutive hours (see Appendix).

While in the AOH, the participants were subjected to an uncontrolled schedule with a list of tasks to accomplish throughout the mission, but they had the freedom to choose when to accomplish those tasks. The only exception was the completion of the POMS 2™ tests, for which a 4 hour and 30 minute interval was required between tests on Day 2 and a 3-hour interval between tests on Day 3.

After their time inside the AOH ended, the participants were debriefed on the accomplishments of the mission (see Appendix). They also completed a post-test KTS®-II and POMS 2™.


DOI: https://doi.org/10.15394/jaaer.2015.1676

**Mission control.** An external console (dubbed mission control) was set-up nearby the AOH, and was manned 24/7 by two people; one of them was a professor, considered a flight director, and the other was an undergraduate student, considered a capsule communicator (CAPCOM). The purpose of mission control was to monitor the health and safety of the participants during all phases of the experiment and to coordinate with them in times of need for research purposes. To achieve this purpose, a live video feed of the participants inside the artificial habitat was installed, allowing the mission controllers to see the crew in action in the public areas of the RV.

**Communications**. A primary mode of communication was available to the mission controllers and to the participants (walkie-talkies with spare batteries and back-up walkie-talkies). A secondary mode of communication was available as a backup (a cell phone, left in the off position, and for emergency use only).

**AOH data collection.** The participants were required to complete two types of surveys. The surveys were accomplished prior to the start of the experiment, during the experiment, and after the experiment. This organization was developed to gather baseline temperament and mood measurements and collect data on their evolution throughout and after the mission.

***The Keirsey Temperament Sorter®-II.*** This test is a personality evaluation instrument (Keirsey, 2014b). The KTS®-II consists of 70 questions that help measure an individual's personality type. After completion of the KTS®-II test, the results reveal an individual's temperament and character type.

According to Spies and Plake (2005), the reliability and validity of the KTS®-II was determined with reference to basic bipolar personality preferences: (a) Sensing-Intuiting (SN), (b) Thinking-Feeling (TF), (c) Judging-Perceiving (JP), and (d) Extroversion-Introversion (EI).

The KTS®-II possesses internal consistency reliability, and test-retest reliability as demonstrated with a Pearson's correlation coefficient. The validity of the KTS®-II was verified through a correlation test with the Myers Briggs Type Indicator® (MBTI) (Spies & Plake, 2005).

***Profile of Mood States (POMS) 2nd Edition™.*** The POMS 2™, developed by McNair, Lorr, and Droppleman (1971) is an instrument that evaluates the mood states of individuals. The test consists of self-report scales, which assess both temporary and changing feelings, and more durable mood conditions. The test is comprised of 65 items (MHS, 2014). The results are expressed using two categories of scale scores. These are Positive Mood State scales and Negative Mood State scales. The Positive Mood State scales are Vigor-Activity (VA) and Friendliness (F). The Negative Mood State scales are Anger-Hostility (AH), Confusion-Bewilderment (CB), Depression-Dejection (DD), Fatigue-Inertia (FI), and Tension-Anxiety (TA) (MHS, 2012).

A Total Mood Disturbance (TMD) score is calculated by adding the Negative Mood State scales and subtracting VA. The TMD score represents the degree to which a person experiences a negative effect (e.g., anger, hostility, and anxiety) (MHS, 2012).

After conducting several test-retest reliability analyses, MHS determined the POMS 2™ assessment showed "strong reliability in terms of alpha coefficients and test-retest reliability that is consistent with a measure of mood states" (MHS, 2012, p. 41). One can administer the POMS 2™ test with confidence that the scores are consistent and reliable (MHS, 2012).

***POMS 2™ and KTS®-II administration.*** The KTS®-II test was given as a pre-test and a post-test, during the pre-brief and post-brief. A computer was set-up in the briefing room and the participants used the KTS®-II website to conduct the test (Keirsey, 2014c).

https://commons.erau.edu/jaaer/vol25/iss1/2
DOI: https://doi.org/10.15394/jaaer.2015.1676

The participants were required to complete the POMS 2™ test pre- and post-experiment, as well as at least twice a day during the experiment, with each test separated by at least 3½ to 4 hours.

All mission control flight directors were trained to understand and interpret the POMS 2™ test results. They reviewed the results each time a test was completed to determine if the participants were experiencing any unusual mood changes and to monitor their psychological health.

The participants were also required to maintain individual logs of their personal thoughts, feelings, and accomplishments throughout the experiment. These logs were not shared between the participants and remained confidential. The purpose of these logs was to allow the researcher to gain feedback on the quality of the experiment and to improve future experiments.

**Normal Environment**

Once the data collection phase in the AOH was complete, the researcher developed a protocol for collecting data in the Normal Environment. This type of environment encompassed the daily living and working conditions the participants are usually exposed to in their personal lives.

**Normal Environment data collection.** The procedure consisted of having the same two participants complete multiple POMS 2™ and KTS®-II tests from their home computer over three consecutive days, matching the duration of their time in the AOH.

The researcher provided the participants with a web link to complete the KTS®-II test and enough paper POMS 2™ forms to comply with the protocol. The participants were asked to complete a KTS®-II and a POMS 2™ test on Sunday around 15:00 local time, in order to reflect the pre-test that was accomplished for the AOH. Next, the protocol required the participants to complete a second POMS 2™ test later that evening. On Monday and Tuesday, the participants completed three POMS 2™ tests. Tuesday's last POMS 2™ test was supplemented by a final KTS®-II test, in order to reflect the post-test data collection that occurred for the AOH.

The protocol outlined that each POMS 2™ test should be separated by at least 4 hours and 30 minutes, in an effort to reflect the procedure that was used during the AOH.

**Population**

The sample of this exploratory study consisted of two participants carefully chosen based on the selection criteria required by the IRB.

The target population of the research was the space participants who take part in the FAA Space Participant Training Program. This program allows the public to participate in spaceflight training with the prospect of flying into space, either as a pilot or as a flight crew participant (SDI, 2014).

## Results

After organizing the data by Participant and Type of Environment, the researcher entered the data into the Statistical Package for the Social Sciences (SPSS) program, a software designed for data collection and statistical analysis. The researcher used SPSS to conduct descriptive statistics on the POMS 2™ data. The confidence interval was set to 95% ($\alpha = .05$). Due to the exploratory nature of this research project, only two participants were used to generate the data. More participants are necessary to draw any conclusions based on the statistical results. Consequently, the results obtained in this research project are considered anecdotal evidence. The results are as follows.

https://commons.erau.edu/jaaer/vol25/iss1/2
DOI: https://doi.org/10.15394/jaaer.2015.1676

**Descriptive Statistics**

The researcher conducted descriptive statistics on each mood variable measured by the POMS 2™ tests. The researcher illustrated the evolution of Participant A's TMD POMS 2™ test results in the AOH and Normal Environment by a line chart (Figure 1). All TMD scores were rated out of 100 points.

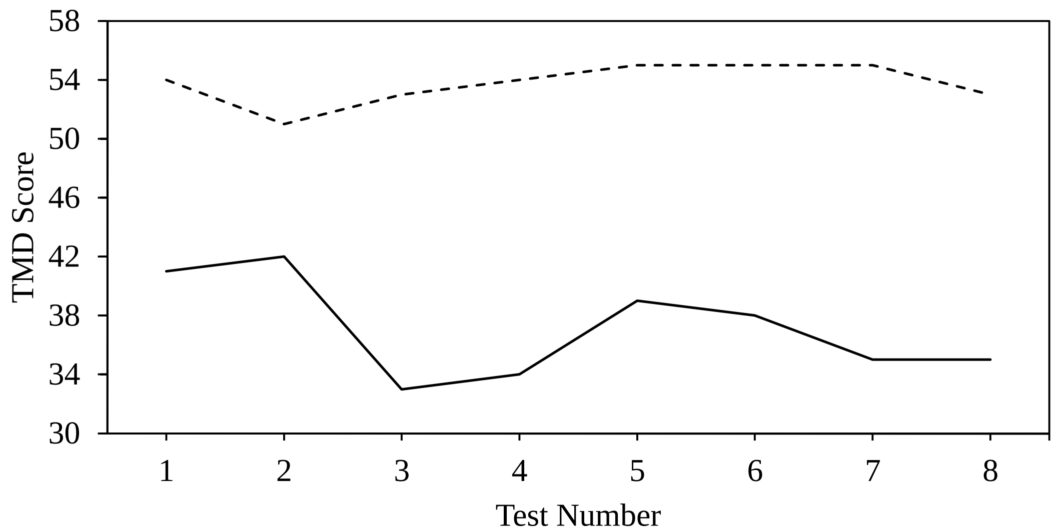


*Figure 1.* Participant A's evolution of TMD scores in the AOH (solid line) and Normal Environment (dashed line).

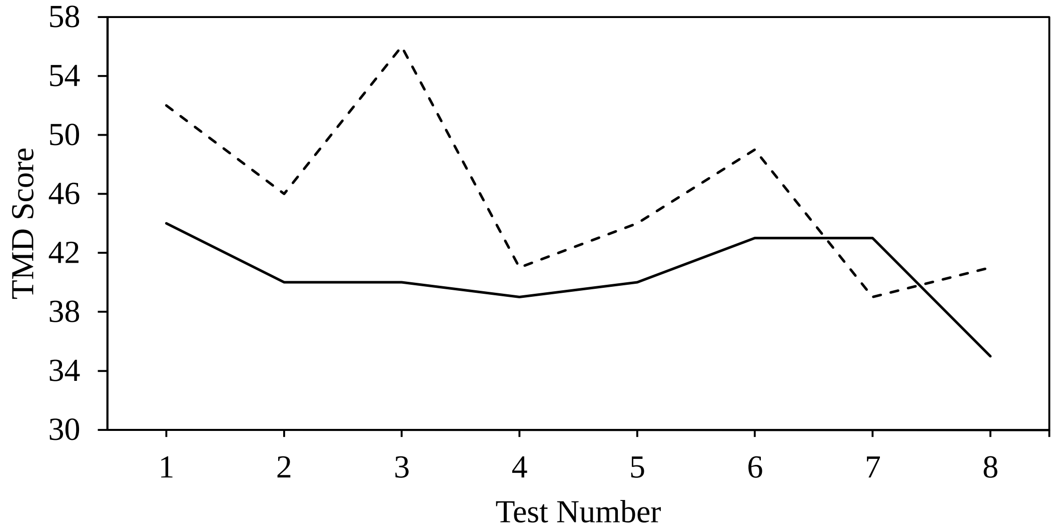


*Figure 2.* Participant B's evolution of TMD scores in the AOH (solid line) and Normal Environment (dashed line).

**Hypothesis Testing**

**Mood based on Type of Environment**. A paired-samples *t*-test with equal variances was used to test the null hypothesis that Type of Environment will not affect Mood. The confidence interval percentage was set to 95%.

The first paired-samples *t*-test was conducted for Participant A's mood constructs in the AOH and in the Normal Environment. The results for TMD and all other mood const generated *p*-values less than 0.001.

The second paired-samples *t*-test analyzed the mood constructs for Participant B in the AOH and in the Normal Environment. The results for TMD, CB, VA, and F yielded significant results. The researcher observed that Participant B's Negative Mood States always scored lower in the Habitat Environment than in the Normal Environment. Similarly, Participant B's Positive Mood States scored always higher in the AOH than in the Normal Environment. Participant B's *t*-tests for AH, DD, FI, and TA were not significant.

**Temperament based on Type of Environment.** The researcher grouped the data by participant and compared the data collected as a pre-test and post-test for both environments, to test whether Type of Environment affected Temperament.

In the pre- and post-tests for the Habitat Environment, Participant A's KTS®-II results were different: Artisan Crafter (pre-test) and Guardian Inspector (post-test). In the Normal Environment, Participant A's KTS®-II results were also different: Guardian Protector (pre-test) and Guardian Inspector (post-test).

On the other hand, Participant B's KTS®-II pre- and post-test results were identical in both Environments. In the AOH, Participant B's pre-test and post-test results were Artisan Performer. In the Normal Environment, Participant B's pre-test and post-test results were Guardian Provider.

## Qualitative Data

During the experiment, the participants were required to complete personal logs, describing their thoughts and feelings about the mission. The mission controllers were also required to keep track of, and time-stamp, all the events occurring during the mission. This process generated qualitative data used for the sole purpose of guiding future studies and informing prospective researchers of the challenges and improvements they can bring to their own research.

**Exploratory study contingencies.** Due to the exploratory nature of this research project, no contingencies or simulated emergencies were planned for the experiment. However, unplanned contingencies occurred, which reflected real-life unexpected incidents that occasionally happen onboard the ISS.

***Launch preparations.*** Due to complications in the set-up of the AOH, the start time, scheduled at 16:00 local time, was delayed until 21:00. Consequently, the participants attended class physically (instead of viewing it online, as originally planned) and met with the researcher and collaborators after class to begin the experiment. This also affected the total duration of the experiment, which was reduced to 45 hours.

***Camera dislodging.*** During the participant's first rest period (approximately 13:37 MET), the camera providing video feed of the AOH dislodged and fell to the ground. Mission control considered this a minor problem and did not contact the participants to avoid waking them. At approximately 14:33 MET, one of the participants woke up, noticed the camera was dislodged, and reinstalled it.

***Camera disconnecting.*** At 21:29 MET, the AOH video feed camera disconnected. Mission control maintained audio communications with the participants to ensure their safety while working on a fix for the camera. Mission control found that the cable linking the camera inside the RV to mission control's computer had been disconnected.

***Computer updates.*** Prior to the participants' second rest period (approximately 27:50 MET, midnight local time), mission control's computer shut down and began several rebooting sequences to update the computer's software due to scheduled maintenance by the Information Technology department. During this time, the video feed from the AOH camera was lost. Mission control maintained audio communication with the participants using the walkie-talkies. The live video feed was resumed at the conclusion of the computer updates.

***POMS 2$^{TM}$ contingencies.*** The first few POMS 2$^{TM}$ tests created frustrations for the participants and mission control. The participants were unable to open the web links provided to them in an Excel spreadsheet and launch the tests. To fix this problem, CAPCOM communicated the link via walkie-talkie to the participants, who manually typed it into the Internet browser.

***Managing water and waste.*** The RV's used waste water is routed and stored in a grey water tank. During the final hours of the mission, the RV's grey water tank became full. The researcher and collaborators quietly emptied the grey water tank using buckets, without alerting the participants in any way, allowing the participants to continue using the bathroom and shower.

## Discussion, Conclusions, and Recommendations

The data collected though this research allowed the researcher and collaborators to make crucial discussion points. Educated conclusions were drawn from the results of the descriptive statistics, paired-samples *t*-test, and comparison of the KTS®-II results.

### Discussion

**Total Mood Disturbance.** Participant A's POMS 2™ test results determined the average TMD score was lower in the AOH (37.12) than it was in the Normal Environment (53.75). Similarly, Participant B's average TMD score in the AOH (40.50) was lower than it was in the Normal Environment (46.00). The researcher believed this may be due to the isolation experienced by the participants while inside the AOH. With limited exposure to social, educational, professional, and family-related stressors, Participant A's mood was less disturbed. In the Normal Environment, the participants were exposed to daily life stressors again, which may explain the increased mood disturbance recorded by the POMS 2™ tests.

Figures 1 and 2 depicted Participant A and B's TMD variations in the AOH. The researcher and collaborator noticed that the TMD scores from the first two POMS 2™ tests were elevated. These tests were achieved on Day 1 of the AOH experiment, during which the participants were introduced to their constricted and isolated environment. It is possible that this significant change in environment heightened the participants' TMD scores.

The third POMS 2™ test, which was the first one completed on Day 2 of the AOH experiment, registered a drop in TMD for both participants. The researcher concluded that, after a good night's sleep in the new environment, the participants felt relaxed and experienced much lower levels of mood disturbance. POMS 2™ tests four and five yielded higher levels of TMD, reflecting increased stress and mood disturbance as Day 2 unfolded. The participants were required to accomplish several tasks and perform physical exercise, which the researcher believed could be related to the higher levels of mood disturbance.

The last POMS 2™ test for the AOH was conducted as a post-test after the participants evacuated the AOH. The researcher and collaborators noted a drop in TMD for both participants. The personal logs and discussions during the debriefing revealed that, although the participants were disappointed that the mission had come to an end, they felt relaxed and relieved to no longer live in an isolated and constricted environment. The researcher concluded these sensations could be connected to the lower TMD scores registered during the last POMS 2™ test.

Figure 2 illustrated Participant B's TMD variations in the AOH and Normal Environment. The researcher noted the evolution of Participant B's TMD scores was erratic and unstable. It is possible that Participant B experienced stressors in the Normal Environment (social, educational, professional, and family-related stressors) that were absent in the AOH, resulting in more unpredictable and variable mood disturbance levels.

**Positive Mood States.** Both participants recorded higher scores for the two Positive Mood States (VA and F) in the AOH than in the Normal Environment. It is possible that the participants sought cooperation with one another and made efforts to instill a friendly atmosphere while inside the AOH. As noted in mission control's logs, the participants assisted each other during the gauge monitoring exercises. The participant logs also revealed that they were excited to participate in such an experiment and eager to perform well. Both participants expressed relief in being paired with a fellow classmate whom they already knew.

The participants' Positive Mood States scores from the AOH may also have been influenced by mission control's moral support and friendliness throughout the mission. The participants commented multiple times that the occasional joking and humorous exchanges between mission control and the participants, as well as hearing female CAPCOM voices, helped lighten the mood inside the AOH.

**Negative Mood States.** Each Negative Mood State yielded lower scores in the AOH than in the Normal Environment for both participants. The researcher surmised the participants were exposed to daily life stressors in the Normal Environment that were absent in the AOH. Furthermore, it is possible that the goal-oriented atmosphere during the AOH experiment lowered the participants' CB scores, as they were required to work with mission control to solve problems. This may have fostered open and clear communication between the two parties and reduced confusion. Similarly, the participants were required to work as a team inside the AOH and put any differences aside, which could explain the lower AH scores compared to the Normal Environment.

The researcher and collaborators noted that Participant A experienced much higher levels of fatigue in the Normal Environment (72) than in the AOH (46.63), as depicted by the FI scores. Participant A revealed that he had been experiencing personal complications while the Normal Environment testing was taking place, which increased his stress level.

**Hypothesis testing.** The first hypothesis (that there will be a difference in mood based on environmental constraints) was tested using a paired-samples *t*-test.

Based on Participant A's paired-samples *t*-test results for TMD and all other mood constructs, the researcher concluded that, in the AOH, Participant A felt insulated from daily life stressors, compared to the Normal Environment, in which Participant A was subjected to these stressors. The presence of external stressors in the Normal Environment could explain why Participant A's mood was significantly better in the Habitat Environment.

Participant B's paired-samples *t*-test results indicated that, in the AOH, Participant B's mood was more positive and conducive to team work and problem solving. To achieve this mood, the researcher believes that Participant B felt more vigorous and friendly in the AOH compared to the Normal Environment.

Since Participant B's negative mood state results were not significant, the researcher established that Participant B felt indifferent to being secluded inside an artificial habitat with another person, compared to living in the Normal Environment.

The second null hypothesis (that there will be no difference in temperament based on environmental constraints) was tested by comparing the pre-test and post-test KTS®-II results for Participant A and Participant B.

In the pre- and post-tests for the AOH, Participant A's KTS®-II results were different: Artisan Crafter (pre-test) and Guardian Inspector (post-test). While the two types of temperaments were not incompatible (Keirsey, 2014a), the researcher gathered that the experience of living in the AOH may have temporarily refined Participant A's temperament type.

In the Normal Environment, Participant A's KTS®-II results were also different: Guardian Protector (pre-test) and Guardian Inspector (post-test). These two temperament types


DOI: https://doi.org/10.15394/jaaer.2015.1676

were closer in similarity, compared to the temperaments experienced by Participant A in the AOH. The researcher concluded that Participant A's temperament did not experience significant evolution while in the Normal Environment.

On the other hand, Participant B's KTS®-II pre- and post-test results were identical within each Environment, but different across Environments. The researcher theorized that the two types of temperament were compatible, and that Participant B's temperament was consistent during each type of Environment (Keirsey, 2014d; Keirsey, 2014e). The differences in temperament experienced across the two types of Environment may be due to daily stressors that were absent during the AOH experiment (social, educational, professional, and family-related stressors).

**Conclusions**

In addition to anecdotal evidence collected through the participants' logs, the data obtained during this research, and the majority of the analyses conducted thereon, support the researcher's conclusions that the type of environment affects an individual's mood. The results derived from the descriptive statistics were amazingly consistent with each other. Both Participant A and Participant B experienced lower levels of Negative Mood States in the AOH than in the Normal Environment. Similarly, both participants experienced higher levels of Positive Mood States in the AOH than in the Normal Environment. The researcher concluded that there is a possibility that a closed and isolated environment insulates its inhabitants from external daily life stressors, and fosters teamwork and cohesion. However, further research must be conducted to determine if the lowered TMD would persist beyond a 50-hour period of living inside the AOH. Considering the participants were two male college students, it is possible these anecdotal results are case-specific, and do not reflect how space participants' mood would behave in the space environment. The researcher surmises that the space participant selection process should assess the individual mood of each applicant prior to his or her selection, in order to seek out or avoid certain mood types.

The anecdotal data collected in this study regarding temperament did not reflect findings from a review of existing literature. Past research suggested that an individual's temperament does not evolve over time, and stays constant regardless of the type of environment. Both participants obtained different temperament types across types of environments and testing times. The researcher concluded that space participant applicants should be monitored for temperament variations before, during, and after a space mission, using a reliable temperament-measuring tool. Further research on the advantages and disadvantages of temperament stability could improve the screening process of space participant applicants.

**Recommendations**

Based on the lessons learned from this study, the researcher, collaborators, and participants made several recommendations to improve the quality of future research.

**Structured schedule.** The primary recommendation was to conduct further research using a structured schedule for the participants inside the AOH. The unstructured schedule used in this research gave the participants freedom to complete the tasks in the order they preferred, which may have influenced their mood variations. A more structured schedule would match the type of psychological pressure to which the astronauts are subjected onboard the ISS.

**POMS 2™ and KTS®-II tests.** Other important recommendations include ensuring the POMS 2™ links provided to the participants were not corrupt. The participants also expressed frustration regarding the lack of information for the mood constructs that composed the test (in


DOI: https://doi.org/10.15394/jaaer.2015.1676

particular, the word *dynamic*), and recommended that future participants be told what each mood construct means during the pre-briefing.

An additional recommendation was to use the Myers Briggs Type Indicator® (The Myers & Briggs Foundation, 2014), or use a different temperament-measuring instrument that would present the researchers with quantitative data. Most importantly, past research suggested that an individual's temperament should be stable across different environments. Future researchers should also evaluate whether this is true for space participants. Measuring temperament over a period greater than 50 hours may also yield more consistent results.

**Emergency scenarios.** Due to the exploratory nature of this research project, unplanned contingencies occurred, which reflected real-life unexpected incidents that occasionally happen onboard the ISS. Should future research be conducted, it may be beneficial to include simulated emergencies or abnormal scenarios in the schedule.

**Camera and video feed.** To avoid problems with the video, future researchers should ensure the camera inside the habitat is installed and secured to prevent dislodging. To avoid losing the video feed, the cable linking the camera to mission control's computer should be protected to prevent accidental dislocation. Finally, future researchers should communicate with their Information Technology center to prevent computer shutdowns or update sequences.

**Artificial habitat recommendations.** If using an RV, future researchers should require the participants to use as little water as possible to prevent the grey water tank from filling to capacity, or plan a strategy for periodic drainage of the tank to prevent reaching capacity.

Secondary recommendations included the use of a permanent artificial habitat designed to better replicate a space station environment and to support more than two participants. A permanent artificial habitat would help prevent last-minute set-up contingencies from delaying the launch of the mission. Other secondary recommendations included using male and female participants, and multicultural crews.

**Recommendations from participants.** During the post-AOH experiment debrief, the participants provided a few recommendations. During the AOH experiment, mission controllers played a space shuttle launch sequence video, as well as a landing sequence video. The controllers also played occasional music videos to serve as wake-up calls when the participants were napping. These videos were accessed from the internet at the control station outside the RV. The participants could see the video on their monitor and hear the audio through the habitat's speakers. The participants recommended that the speakers be muted when the mission controllers loaded the internet videos, as they could hear advertisements being played before each video started. This reduced their impressions of isolation.

The participants claimed that they enjoyed the occasional, non-mission related chatter with the mission controllers. The participants suggested that the mission controllers continued lightening the atmosphere with occasional jokes, and more frequent comments about which area of the Earth was currently visible on the monitor inside the habitat.


DOI: https://doi.org/10.15394/jaaer.2015.1676

References

Beregovoy, G. T., Krylova, N. V., Solov'yeva, I. B., & Shibanov, G. P. (1974). *Estimating the effectiveness of human working capacity under spaceflight conditions* (NASA Technical Translation No. TT F-16,019). Washington, DC: National Aeronautics and Space Administration.

Bluth, B. J., & Helppie, M. (1987). *Soviet space stations as analogs* (NASA Report NAGW-659). Washington, DC: National Aeronautics and Space Administration.

Clark, A. V. (2005). *Causes, role and influence of mood states.* Hauppauge, NY: Nova Science Publishers, Inc.

Diaz, M., & Adam, S. (1992, April). *Development of task network models of human performance in microgravity.* Paper presented at the AIAA Space Programs and Technologies Conference, Huntsville, AL. http://dx.doi.org/10.2514/6.1992-1311

European Space Agency (ESA). (2011). *Information kit: Mars500 isolation study.* Retrieved from http://esamultimedia.esa.int/docs/Mars500/ESA_Mars500InfoKit.pdf

Fox, K. E. (2006). *Affect and job performance: The effect of daily mood states on employees' overall and contextual performance* (Doctoral dissertation). Retrieved from ProQuest. (UMI Number: 3285673)

Genik, R. J., Green, C., Graydon, F. X., & Armstrong, R. (2005). Cognitive avionics and watching spaceflight crews think: Generation-after-next research tools in functional neuroimaging. *Aviation, Space, and Environmental Medicine, 76,* B208-212.

Kanas, N. (1990). Psychological, psychiatric, and interpersonal aspects of long-duration space missions. *Journal of Spacecraft and Rockets*, *27*(5), 457-463. http://dx.doi.org/10.2514/3.26165

Keirsey. (2014a). *Overview of the four temperaments.* Retrieved from http://www.keirsey.com/4temps/overview_temperaments.asp

Keirsey. (2014b). *The Keirsey Temperament Sorter (KTS-II).* Retrieved from http://www.keirsey.com/aboutkts2.aspx

Keirsey. (2014c). *Welcome to the Keirsey Temperament Sorter (KTS-II).* Retrieved from http://www.keirsey.com/sorter/register.aspx

Keirsey. (2014d). *Artisan portrait of the Performer (ESFP).* Retrieved from http://www.keirsey.com/4temps/performer.asp

Keirsey. (2014e). *Guardian portrait of the Provider (ESFJ).* Retrieved from http://www.keirsey.com/4temps/provider.asp

Laverne, C. J., Williams, H. L., & Stern, J. A. (1972). *Motivation, cognition, and sleep-work factors; Central- and autonomic-nervous-system indices.* San Diego, CA: Ft. Belvoir Defense Technical Information Center.

Lieberman, H. R., Waldhauser, F., Garfield, G., Lynch, H. J., & Wurtman, R. J. (1984). Effects of melatonin on human mood and performance. *Brain Research, 323*(2), 201-207. http://dx.doi.org/10.1016/0006-8993(84)90290-7

Lieberman, H. R., Wurtman, R. J., Emde, G. G., Roberts, C., & Coviella, I. L. G. (1987). The effects of low doses of caffeine on human performance and mood. *Psychopharmacology, 92,* 308-312. http://dx.doi.org/10.1007/BF00210835

Lorenz, B., Manzey, D., Schiewe, A., & Finell, G. (1995). Human performance during a short- and long-term stay in space. In R. S. Jensen & L. A. Rakovan (Eds.), *Proceedings of the Eighth International Symposium on Aviation Psychology*, Columbus, OH, April 24-27, 1995. Columbus, OH: The Ohio State University.

Manzey, D., & Lorenz, B. (1997). Human performance during spaceflight. In R. S. Jensen & L. A. Rakovan (Eds.), *Ninth International Symposium on Aviation Psychology*. Columbus, OH, April 27-May 1, 1997. Columbus, OH: The Ohio State University.

McClung, C. A. (2007). Circadian genes, rhythms and the biology of mood disorders. *Pharmacology & Therapeutics, 114*(2), 222-232. http://dx.doi.org/10.1016/j.pharmthera.2007.02.003

McNair, D. M., Lorr, M., & Droppleman, L. F. (1971). *Manual for the Profile of Mood States.* San Diego, CA: Educational and Industrial Testing Services.

Morris, R. B., & Whitmore, M. (1993). Measuring human performance on NASA's microgravity aircraft. *Sixth Annual Workshop on Space Operations Applications and Research, 2,* 516-521.

Multi-Health Systems (MHS). (2012). *Profile of mood states (2nd ed.).* Toronto, ON: Multi-Health Systems Inc.

Multi-Health Systems (MHS). (2014). *POMS 2.* Retrieved from http://www.mhs.com/product.aspx?gr=cli&id=overview&prod=poms2

Musson, D. M., & Helmreich, R. L. (2005). Long-term personality data collection in support of spaceflight and analog research. *Aviation, Space and Environmental Medicine, 76,* B119-B125.

The Myers & Briggs Foundation. (2014). *Myers-Briggs Type Indicator® basics.* Retrieved from http://www.myersbriggs.org/my-mbti-personality-type/mbti-basics/

NASA exercise: Lost on the moon. (1999, July). *The NightTimes.*

National Aeronautics and Space Administration (NASA). (2010). *Crew health and safety risks.* Retrieved from the Human Research Program website: https://www.nasa.gov/pdf/488115main_2010-09-13_ISS_as_an_Exploration_Testbed%28Neumann%29.pdf

National Aeronautics and Space Administration (NASA). (2011a). *Yuri Gagarin: First man in space.* Retrieved from http://www.nasa.gov/mission_pages/shuttle/sts1/gagarin_anniversary.html

National Aeronautics and Space Administration (NASA). (2011b). *About NEEMO (NASA Extreme Environment Mission Operations).* Retrieved from http://www.nasa.gov/mission_pages/NEEMO/about_neemo.html

National Aeronautics and Space Administration (NASA) (2012). *History.* Retrieved from http://spaceflight.nasa.gov/history/

National Aeronautics and Space Administration (NASA) (2013). *The joint U.S.-Russian one-year mission: Establishing international partnerships and innovative collaboration.* Retrieved from http://www.nasa.gov/mission_pages/station /research/news/one_year_mission.html#.U5SG_CiiUzI

National Aeronautics and Space Administration (NASA). (2014a). *Commercial space transportation.* Retrieved from http://www.nasa.gov/exploration/ commercial/index.html#.U5SJMCiiUzI

National Aeronautics and Space Administration (NASA). (2014b). *What is microgravity?* Retrieved from http://www.nasa.gov/audience/forstudents/k-4/stories/what-is-microgravity-k4.html#.U5y-qiiiUzI

National Aerospace Training and Research (NASTAR). (2014). *Spaceflight participant.* Retrieved from http://www.nastarcenter.com/aerospace-training/space/passengers/

Sauer, J., Wastell, D. G., & Hockey, R. J. (1997). Skill maintenance in extended spaceflight: A human factors analysis of space and analog works environments. *Acta Astronautica, 39*(8), 579-587. http://dx.doi.org/10.1016/S0094-5765(97)00006-4

Space Discovery Institute (SDI). (2014). *Space participant program*. Retrieved from http://www.eruniversity.com/space_participant.htm

Spies, R. A., & Plake, B. S. (2005). *The sixteenth mental measurements yearbook.* Lincoln, NE: The University of Nebraska Press.

Thompson, R. A., Winer, A. C., & Goodvin, R. (1999). The individual child: Temperament, emotion, self, and personality. In M. Bornstein & M. Lamb (Eds.), *Developmental psychology: An advanced textbook* (427-468). Mahwah, NJ: Lawrence Erlbaum Associates.

Thornton, W. E., Moore, T. P., Pool, S. L., & Vanderploeg, J. (1987). Clinical characterization and etiology of space motion sickness. *Aviation, Space and Environmental Medicine, 58*(9, Suppl.), A1-A8.

Wirz-Justice, A. (2006). Biological rhythm disturbances in mood disorders. *International Clinical Psychopharmacology, 21,* S11-S15. http://dx.doi.org/10.1097/01.yic.0000195660.37267.cf

Young, S. N., & Leyton, M. (2002). The role of serotonin in human mood and social interaction: Insight from altered tryptophan levels. *Pharmacology Biochemistry and Behavior, 71*(4), 857-865. http://dx.doi.org/10.1016/S0091-3057(01)00670-0

Appendix

Participant Briefing

**Human Behavior during Spaceflight - Evidence from an Analog Environment**

Kenny Arnaldi (Principal Investigator)

Dr. Guy M. Smith (Faculty Advisor)

A. Purpose of the Research

The purpose of this research is to complete a thesis on the effects of the space environment on human performance during long-term deep space travel. To achieve this goal, we are going to use an artificial environment to simulate a space travel environment (specifically, an orbital environment). We will use a ground-based habitat (such as a trailer) in which you will live with one other male participant for at least 50 hours. We will not attempt to create a space environment within the habitat (weightlessness, etc.). The environment inside the space habitat will be an Earth environment with normal living conditions for eating, sleeping, working, and relaxing. You will be expected to perform tasks similar to those required by space flight crews – maintaining logs, checking instruments, responding to communications from a control console, doing fitness exercises, etc. To simulate an orbital environment, you will be exposed to a 90 minute day/night lighting cycle, compared to the Earth's 24 hour day/night lighting cycle.


DOI: https://doi.org/10.15394/jaaer.2015.1676

B. Structure of the Habitat

1. Sleeping Accommodations and Toilet Facilities

   You will be provided with separate sleeping accommodations and private toilet facilities inside the habitat.

2. Air Ventilation

   The design of the habitat will allow for continuous replenishment of clean air.

3. Food and Water

   You will be provided with enough food and water to last the entire duration of the experiment. If you tell us your food preferences and allergies, we will avoid foods that you are allergic to and will try to accommodate your preferences to the best of our abilities. The habitat is equipped with cooking facilities and a fire extinguisher in case of complications while you cook.

4. Exercise Bicycle

   There will be a stationary exercise bicycle inside the habitat for your exercise use. In order to simulate the space environment in which astronauts are required to exercise regularly, you will also be required to exercise on the bicycle a certain amount every day. This requirement will not be strenuous; rather something the average human being is capable of handling.

5. External Console

An external command station will be manned 24 hours a day to monitor a live video feed coming from the main living space of your habitat, with the sole purpose of ensuring your health and safety. No video or audio recordings will be kept or used for the research. There will be a primary and backup system so you can communicate with the console at any time to request assistance, request explanation in the completion of your tasks, or for the purpose of safety. You will receive a briefing on emergency procedures before the start of the experiment.

6. Audio Communications

The habitat will be equipped with a walkie-talkie to allow you to communicate with the command station. Should the walkie-talkie fail, there will be a back-up telephone to contact the command station at any time. The video camera will be a third (emergency) backup; you will wave your arms vigorously in front of the camera to signal the console.

7. Entertainment

You will not have any personal communication devices with you in the habitat (cell phone, I-pad, laptop computer, etc.) The habitat will be equipped with a laptop computer (not Wi-Fi enabled), a DVD player, and a supply of DVDs. You will be

https://commons.erau.edu/jaaer/vol25/iss1/2
DOI: https://doi.org/10.15394/jaaer.2015.1676

able to communicate with the Earth by relaying messages through the control console. You will be allowed to bring a small number of personal items, toilet articles, medications, etc.; subject to approval by the researchers (non-electronic college study materials will be approved).

C. Experiment Design

1. Activities

You will be required to complete certain activities, which can be either group activities or individual activities. Some examples include problem-solving tasks and monitoring gauges to verifying the health status of your simulated spacecraft.

2. Mood/Temperament Surveys

You will be required to complete two types of mood/temperament surveys for the purpose of the research. The first type is the Keirsey Temperament Sorter®-II, which you will complete prior to the start of the experiment and at its conclusion. This test measures your temperament, which reflects your personal nature.

The second type is the Profile of Mood States 2nd Edition™ (POMS 2™), which will be completed several times throughout the experiment; you will be instructed when to complete the POMS 2™ test. This test measures your mood at the time of the test.

Your inputs to both survey instruments will be part of the research report. However, publication data will not include your personal information, and will remain confidential.

3. Personal Logs

You will maintain a personal log of your experiences and feelings as the experiment goes on. The more information you can provide - the better. Your log must remain confidential, which means that your log the will not be shared with the other crewmember. Please write everything you can think of: things that you like and dislike, moments you appreciated during the experiment and those that worried you or concerned you, etc. The researchers will review the logs for lessons learned; however, your personal log entries will not be included in the research reports unless you explicitly give your permission.

D. Participant Rights To Refuse Participation

You are entitled to refuse participation at any time prior to or during the experiment, without penalty. During the experiment, if you terminate your participation for medical or safety concerns, you will be financially compensated for the hours spent participating in the research, rounded up to the nearest whole number (i.e., if your participation time was 37 hours and 17 minutes, you will be paid for a total of 38 hours). If you wish to terminate for personal comfort reasons (boredom, loss of interest, etc.); you will not be financially compensated.

E. Hazards and Risks Associated with the Research

Other than risks associated with living in a closed environment (such as cooking hazards), you will not be exposed to any health hazards. Fire and smoke are potential hazards in a normal kitchen environment. The habitat kitchen will have a smoke detector, a carbon monoxide detector, and external exhaust capabilities. The habitat will also be equipped with a fire extinguisher.

Other normal habitat risks include feelings associated with living in an enclosed environment, such as boredom and isolation. The researchers will not deliberately expose you to risks and there are no tricks built into the study. The habitat is designed to collect data on human responses to space travel in a confined space over an extended period. If any unusual or emergency situations occur, they will be treated by you and by the researchers as bona fide emergencies. The experiment will terminate immediately and you will be evacuated from the habitat in a safe and expeditious manner.

F. Duration of the Experiment

The total duration of the experiment may range from 50 consecutive hours to 100 consecutive hours. If you have classes and tests in the days following the start of the experiment, we will address these issues with your professors to ensure you will not be penalized for participating in our research. You will also be given ample time during the experiment to prepare/review for your exam.

G. Contact Information

If you wish to obtain additional information about the research experiment, please contact:

Kenny Arnaldi

Instructor Pilot

Embry-Riddle Aeronautical University

600 S. Clyde Morris Blvd.

Daytona Beach, FL 32114

Email: arnaldik@erau.edu

or,

Dr. Guy M. Smith

Department Chair, Applied Aviation Sciences

College of Aviation, Daytona Beach Campus


DOI: https://doi.org/10.15394/jaaer.2015.1676

Embry-Riddle Aeronautical University

COA Room 318

600 S. Clyde Morris Boulevard

Daytona Beach, FL 32114-3900

Office: 386-226-6842

Email: guy.smith@erau.edu