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Human Behavior During Spaceflight: Evidence from an Analog Environment

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HUMAN BEHAVIOR DURING SPACEFLIGHT - EVIDENCE FROM AN ANALOG ENVIRONMENT

by

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Abstract

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Spaceflight offers a multitude of stressors to humans living and working in space, originating from the external space environment and the life-support system. Future space participants may be ordinary people with different medical and psychosocial backgrounds who may not receive the intense spaceflight preparation of astronauts. Consequently, during a mission, a space participant's mood and behavior could differ from a trained astronaut. This study was an exploratory research project that used an artificial habitat to replicate an orbital environment and the activities performed by humans in space. The study evaluated whether the type of environment affects mood and temperament. Two male participants were enclosed in an artificial habitat where they performed Profile of Mood States 2nd Edition™ tests and Keirsey Temperament Sorter®-II tests. The participants later reproduced those tests in their normal living environment. Results from descriptive statistics, paired-samples *t*-tests, and a comparative study suggested that the type of environment affects mood and temperament. In addition, anecdotal information collected through personal logs confirmed the aforementioned results. The researcher concluded that further research must be conducted to test larger sample-sizes using a structured schedule.

Table of Contents

Page

Thesis Review Committee ii

Acknowledgements iii

Abstract iv

List of Tables xi

List of Figures xii

Chapter

I Introduction 1

Significance of the Study 2

Statement of the Problem 3

Purpose Statement 3

Research Question 4

Hypotheses 4

Delimitations 4

Limitations and Assumptions 5

Definitions of Terms 6

List of Acronyms 7

II Review of the Relevant Literature 10

Extended-Duration Spaceflight 10

Long-term Exposure 11

The Space Environment 11

External Space Environment Stressors 12

Microgravity 12
Circadian Rhythm Shifts.......................................12
Life-support System Stressors 13
Noise 13
CO_2 Levels 14
Confinement..14
Isolation...15
Human Performance 15
Task Performance 16
Motor Performance 17
Cognitive Processing 17
Psychological Stress..18
Workload..18
Space Participants 19
Astronauts 20
Skylab 20
Mir Space Station...21
Space Shuttle...21
International Space Station 22
NEEMO 22
Mars500 23
Artificial Habitat Risks 23
Space Human Factors and Habitability Risks...................23

Behavioral Health and Performance Risks 24
Human Health Countermeasures Risks 24
Fire 24
Pathogenic Viruses..24
Temperament 25
Mood States 26
Internal Factors 26
External Factors 26
Summary 27
III Methodology 29
Research Approach 29
Design and Procedures..29
IRB Approval..29
IRB Constraints...30
Habitat Environment..31
Vehicle 32
Living Conditions 32
Hygiene 33
Working Conditions..33
Exercise Bicycle...33
Space Participant Activities 33
Entertainment...34
Mission Elapsed Time (MET) 34

Schedule 35
Visual Effects 36
Mission Control 37
Communications 37
AOH Data Collection 38
The Keirsey Temperament Sorter®-II 38
Reliability and Validity 38
Profile of Mood States 2nd Edition™ 38
Positive Mood States 39
Negative Mood States 39
Reliability and Validity 39
POMS 2™ and KTS®-II Administration 40
Normal Environment 41
Normal Environment Data Collection 41
Population 42
Treatment of the Data 42
Descriptive Statistics 43
Hypothesis Testing 44
Qualitative Data 44
IV Results 45
Descriptive Statistics 45
Hypothesis Testing 50
Mood Based on Type of Environment 51

Temperament Based on Type of Environment 51
Qualitative Data 52
Flight Director and CAPCOM 52
Seminal Study Contingencies 53
Launch Preparations 53
Radio Frequency Interference 53
Window Covers 53
Camera Dislodging 54
Camera Disconnecting 54
Computer Updates 54
POMS 2™ Contingencies 55
Managing Water and Waste 55
V Discussion, Conclusions, and Recommendations 56
Discussion 56
Descriptive Statistics 56
Total Mood Disturbance 56
Positive Mood States 58
Negative Mood States 58
Hypothesis Testing 59
Conclusions 62
Recommendations 63
Structured Schedule 63
POMS 2™ and KTS®-II Tests 63

Emergency Scenarios 64

Camera and Video Feed 64

Artificial Habitat Recommendations 64

Gender 65

Participant Recommendations 65

References 67

Appendices

A Permission to Conduct Research 79

B Solicitation of Participants 81

C Participant Interview Form 85

D Participant Briefing 88

E Consent Form 96

F Participant Release Form 99

G Emergency Procedures 102

H Mission Control Schedule 104

I Participant Debriefing 106

J Normal Environment Data Collection Protocol 108

List of Tables

Page

Table

1 Participant A POMS 2™ Data in the Habitat Environment 46

2 Participant A POMS 2™ Data in the Normal Environment.................................47

3 Participant B POMS 2™ Data in the Habitat Environment 48

4 Participant B POMS 2™ Data in the Normal Environment.................................49

5 Participant A Paired-Samples *t*-Test Between Types of Environment..................50

6 Participant B Paired-Samples *t*-Test Between Types of Environment 51

7 Participant A KTS®-II Results in the Habitat and Normal Environments............51

8 Participant B KTS®-II Results in the Habitat and Normal Environments............52

H1 Professor Schedule...105

H2 CAPCOM Schedule 105

List of Figures

Page

Figure

1 Participant A’s Evolution of TMD Scores in the Habitat Environment 46

2 Participant A’s Evolution of TMD Scores in the Normal Environment................47

3 Participant B’s Evolution of TMD Scores in the Habitat Environment 48

4 Participant B’s Evolution of TMD Scores in the Normal Environment................49

Chapter I

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], 2011e). The United States of America (USA) soon followed on the path of manned space exploration with Project Mercury. Although this program began with suborbital flights, manned spacecraft were soon launched into orbit around the Earth (NASA, 2012c). With President Kennedy setting the goal of landing a man on the Moon, NASA focused on short-duration orbital flights as a stepping-stone. Under Project Gemini, astronaut crews remained in space for several days, and developed the skills to dock with other spacecraft (NASA, 2012c). Lunar missions shortly followed with Project Apollo, allowing the USA to gain knowledge in the long-range exploration of 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, 2012c). The modern International Space Station (ISS) was built during NASA's Space Shuttle program, and hosts astronaut crews for extended-durations, up to a full year in space (NASA, 2013a).

Looking toward the future, the U.S. government announced 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 resources on deep-space exploration (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).

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 (Space Discovery Institute, 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); consequently, it is vital for private industry and the government to understand the relationship between mood and the environment. With longer and more complex space missions on the horizon, it is essential for private companies and NASA to understand this relationship to design better missions. With this knowledge, the government could develop countermeasures to the environment with new regulations, and the astronauts and spaceflight participants could prepare better for their missions. Research on individual and team performance is necessary to increase the probability of future mission success (Musson & Helmreich, 2005).

Statement of the Problem

Spaceflight participants who will venture into space will be exposed to an environment they have never encountered before. These individuals may be ordinary citizens who have not received advance spaceflight preparation (as opposed to astronauts). Consequently, they may react differently to the space environment. The space environment is a zone outside the Earth's atmosphere that is characterized by multiple stressors (such as noise, heat, cold, zero gravity, isolation, confinement, etc.) (Sauer, Wastell, & Hockey, 1997). Similarly, astronauts and cosmonauts who live and work on the ISS are subject to the space environment. To better prepare spaceflight participants and astronauts for their missions in low-Earth orbit or future missions into deep space, the relationship between environmental factors and behavior should be examined.

As defined by Watson (2000), human behavior consists of mood and temperament. 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. 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).

Purpose Statement

The purpose of this study was to collect quantitative and qualitative data on how living in an environment, analogous to that of a space environment, affects mood and temperament compared to living in a normal environment (home, work, etc.).

Research Questions

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?

Hypotheses

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

The focus of this study was to analyze data involving mood and temperament of participants living in an analog environment compared to living in the spaceflight environment. The collected data were neither modified nor criticized. Due to limited financial resources, the researcher and collaborators rented a small recreational vehicle (RV) and configured it to replicate an artificial orbital habitat that would support two participants. In an effort to mitigate the effects of other factors (e.g., non-environmental) on their mood, participants were required to meet a set of research standards: participants were selected from a pool of students pursuing a Commercial Space Operations (CSO) degree at Embry-Riddle Aeronautical University (ERAU), Daytona Beach campus.

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. The ERAU Institutional Review Board (IRB) required the participants to be male, claiming that the more complicated and sensitive female cycles could have added complications to the study that were not necessary for an exploratory research project. The participants also had to 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. The GPA requirement increased the probability that participants would possess better writing skills, thus improving the quality of feedback in the personal logs and reducing the likelihood that the participants' long-term GPA would be impacted. 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.

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 ERAU IRB requirements. The ERAU IRB also required that the RV's door be left unlocked to allow participants to leave if necessary for safety considerations.

To minimize the effects of participating in 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). To meet IRB requirements, the researcher and collaborators agreed that, should an emergency arise, the research would be terminated immediately, and the participants would be evacuated from the RV. An assumption was made that the selected participants were similar in nature to space participants and were compatible. Another assumption was made that the participants felt physically isolated from the rest of the world, and thus had no ability to receive physical external assistance during their simulated space mission. The researcher assumed that the activities of the participants in the artificial habitat 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.

Definitions of Terms

Analog Environment An environment that presents physical similarities with the extreme space environment (NASA, 2011f).

Astronaut A person who works aboard spacecraft (Astronauts, 2014).

Cosmonaut The Russian equivalent of astronaut (Masalkova, 2014).

Habitat	An artificial environment where people can live together, and includes living quarters, workspaces, and laboratories to conduct research and activities (NASA, 2012b).
Life-support system	A group of systems that supplies air, water, and food to astronauts, and maintains comfortable temperatures and air pressures inside a spacecraft (NASA, 2014b).
Mood	A state of emotions that reflect an individual's current impressions about the world (Clark, 2005).
Performance	A combination of cognitive and motor abilities (Beregovoy, Krylova, Solov'yeva, & Shibanov, 1974).
Space	A zone outside Earth's atmosphere that is constituted of multiple stressors (noise, heat, zero gravity, etc.) (Sauer et al., 1997).

List of Acronyms

AH	Anger-Hostility
AOH	Artificial Orbital Habitat
CAPCOM	Capsule Communicator
CB	Confusion-Bewilderment
CO_2	Carbon Dioxide
CSO	Commercial Space Operations
DD	Depression-Dejection
EI	Extroversion-Introversion
EIGA	European Industrial Gases Association
ERAU	Embry-Riddle Aeronautical University

ESA	European Space Agency
F	Friendliness
FAA	Federal Aviation Administration
FI	Fatigue-Inertia
fMRI	Functional Magnetic Resonance Imaging
GPA	Grade Point Average
HRP	Human Research Program
IRB	Institutional Review Board
ISS	International Space Station
JAXA	Japan Aerospace Exploration Agency
JP	Judging-Perceiving
KTS®-II	Keirsey Temperament Sorter®-II
MBTI	Myers Briggs Type Indicator
MET	Mission-Elapsed Time
MHS	Multi-Health Systems
NASA	National Aeronautics and Space Administration
NASTAR	National Aerospace Training and Research
NEEMO	NASA Extreme Environment Mission Operations
OAC	Online Assessment Center
POMS 2™	Profile of Mood States, 2nd Edition™
ROSCOSMOS	Russian Federal Space Agency
RV	Recreational Vehicle
SDI	Space Discovery Institute

SN	Sensing-Intuiting
SPCP	Space Participant Certification Program
STS	Space Transportation System
TA	Tension-Anxiety
TF	Thinking-Feeling
TMD	Total Mood Disturbance
USA	United States of America
USSR	Union of Soviet Socialist Republics
VA	Vigor-Activity

Chapter II

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 challenges are isolation, confinement, high workloads, and weightlessness. These affect the astronauts every day during their mission (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, heterogeneous flight crews, more complex tasks, and decreases in the appeal of these tasks 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). During the Space Shuttle program, spaceflight missions generally lasted one or two weeks. With the advent of the ISS, the permanent orbiting laboratory allows astronaut crews to remain in space for several months. Currently, the average ISS mission duration is six months, however, a year-long mission is scheduled for 2015 (NASA, 2013a). 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, 2014c).

Long-term exposure. Human spaceflight inherently creates conditions of isolation and confinement, among other stressors. It is important to take into account the cumulative effects of extended-duration spaceflight (Genik, Green, Graydon, & Armstrong, 2005). Consequently, psychosocial health is a concern for missions that last one or two years. Missions of this length play an increasingly important role in national space programs (Musson & Helmreich, 2005). Indeed, current technology would require that a round-trip mission to Mars last between one and three years, including time spent on the Martian surface (Diaz & Adam, 1992). To ensure mission success, "complete preparation and proper crew monitoring" is necessary (Genik et al., 2005, p. B212).

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 et al., 1997). Their effects on humans over an extended period can lead to the collapse of the body's regulatory mechanisms, though trained and physically fit crewmembers are less likely to suffer from performance degradation (Sauer et al., 1997). Research involving terrestrial environments similar to that of spaceflight has produced valuable data, particularly missions to the Antarctic or to underwater habitats; both locations generate situations of isolation and confinement. The existing danger that the protective environment (i.e., spacecraft structure) could fail is also found in space (Sauer et al., 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 stressors found in the space environment are as follows.

Microgravity. NASA (2014d) defines microgravity as being a very small amount of gravity, giving astronauts an illusion of weightlessness. Manzey and Lorenz (1997) considered microgravity as the most prominent stressor originating from the space environment. Bluth and Helppie (1987) revealed that microgravity affects the human body in several ways, such as a decrease in bone density, congestion, space sickness, etc., which has the potential to affect astronaut performance (as cited in Sauer et al., 1997). The absence of gravity can also induce motion sickness due to changes in the vestibular system (Manzey & Lorenz, 1997). This is due to the absence of a constant linear force (gravity), which prevents the otoliths from providing vertical orientation (Paloski, Black, Reschke, Calkins, & Shupert, 1993). Microgravity also causes body fluids to shift towards the upper parts of the body, which in turn results in a reduction in plasma volume and central venous pressure, and an increase in intracranial blood pressure (Manzey & Lorenz, 1997).

Circadian rhythm shifts. Compared to life on Earth, in the space environment astronauts must adapt to shorter cycles of daytime and nighttime (compared to Earth). 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. According to Gundel, Polyakov, and Zulley (1997), studies conducted on the

Mir space station revealed that the use of clocks or schedules, in an attempt to maintain a regular circadian rhythm over time had little beneficial effect, and sleep quality degraded over time (as cited in Manzey & Lorenz, 1997). 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, limited space, and high carbon dioxide (CO_2) levels (Manzey & Lorenz, 1997).

Noise. According to Bauer, Korpert, Neuberger, Raber, and Schwetz (1991), research indicated that continuous exposure to noise in excess of 85-90 decibels results in hearing loss (as cited in Abel et al., 2004). The ISS environment does not produce these levels of ambient noise, however, cases of temporary and permanent hearing loss have been reported after extended-duration spaceflights (Abel et al., 2004).

Noise can affect the performance of tasks that require vigilance or sustained attention. In particular, higher levels of noise result in a greater number of errors than moderate levels of noise (Abel et al., 2004). Noise also affects sleep quality, such as the ability to fall asleep and stay asleep. Thiessen's (1978) study illustrated that poor sleep quality has been associated with slower reaction times during task performance the following day (as cited in Abel et al., 2004).

The study performed by Abel et al. (2004) revealed that short-term (70 hours) exposure to noise below 87 decibels resulted in no temporary or permanent hearing loss. While these results were inconsistent with reports of astronauts suffering hearing loss after extended spaceflight, Abel et al. (2004) believed that hearing loss in space could be due to loud noises and vibration during liftoff or exposure to microgravity. While ambient noise may not cause the hearing loss suffered by astronauts, higher volumes of sound emitted from the crew's headsets could affect their hearing abilities (Abel et al., 2004).

CO_2 levels. Generally, the amount of CO_2 present in the artificial atmosphere within a spacecraft is higher than the amount on Earth (0.03% on Earth opposed to 1.5% in space habitats) (Manzey & Lorenz, 1997). The life-support system on the ISS is designed to provide oxygen and remove CO_2 (a natural by-product of human respiration) from the ambient air. Due to technical limitations, the life-support system is unable to reduce the amount of CO_2 in the ambient air down to normal Earth levels. High levels of CO_2 can cause the human body to become intoxicated (European Industrial Gases Association [EIGA], 2011). If the volume of CO_2 in the air reaches 3%, intoxication can cause reduced hearing ability, headaches, and an increase in blood pressure; between 5% and 10%, loss of judgment may occur. With CO_2 levels above 10%, the intoxication can result in unconsciousness and ultimately death (EIGA, 2011).

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).

Human Performance

The operation of current 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). Decreased performance can be counteracted through motivation and increased effort (Sauer et al., 1997). Previously, astronaut performance in space has been evaluated using psychological metrics, as well as recording observable performance using "techniques little advanced from clipboard, stopwatch, and fill-in the blank subjective rating scales" (Genik et al., 2005, p. B208).

According to Beregovoy et al. (1974), the tasks conducted by astronauts in space rely on a more automated *human-spacecraft* interface compared to other fields of work. Consequently, astronauts must be able to "accomplish the functions of observer, operator, repairman, and ergative system reserve" (pp. 2-3). In order to measure the astronauts' performance quality while executing these tasks, Beregovoy et al. (1974) divided the structure of the activities into four phases:

1. Search, perception, and decoding of information.
2. Estimating the situation according to the totality of isolated signals.
3. Formulating the conceptual model and making the decision.
4. Practical realization of the decision taken. (p. 3)

Understanding how the space environment affects human performance can improve the design of flight hardware and software that would enable 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). Lorenz et al. (1995) analyzed data collected before, during, and after a record 14-month stay onboard the Mir space station. They compared the results with past data, which was collected during and after an eight-day joint Russian-German mission on Mir. The purpose of the study was to crosscheck data on subjective workload and potential performance decrements between the eight-day and 14-month missions (Lorenz et al., 1995). The main findings of this study are briefly described next.

***Motor performance*.** A tracking task was used to measure the ability of a person to move a cursor horizontally with a joystick and center it in the middle of the screen (Lorenz et al., 1995). Results showed that control performance was significantly affected by exposure to the space environment, and the astronaut took three weeks to adapt to the new environment and reach baseline levels that were established on Earth prior to launch. These changes in performance levels may have been due to the effects of microgravity on the sensorimotor system (e.g., ‘reduced accuracy of proprioceptive cues’) (Lorenz et al., 1995, p. 964), which led the astronaut to rely more on visual cues for motor adjustments.

***Cognitive processing*.** Cognitive processing was measured through an assessment of short-term memory in the study performed by Lorenz et al. (1995). An astronaut’s reaction time was measured using a memorization exercise, during which the astronaut was required to identify a set of letters within a series. 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).

Hockey (1986) explained that when accompanied by fatigue, cognitive processing might be hampered, particularly in terms of attention span. The brain can no longer handle all duties at once, resulting in a state of attentional selectivity in which the number of sensory cues that can be handled at once is reduced (as cited in Lorenz et al., 1995).

The results obtained by Lorenz et al. (1995) indicated that motor performance, rather than cognitive processing, was the element of human performance that was most affected by exposure to the space environment. The astronaut subjected to the study was able to adapt and recover baseline motor performance after three weeks in space, and no evidence of prolonged effects during an extended stay on orbit was found (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). During phases of high cognitive workload, the optimum performance (particularly optimum decision-making ability) is expected to occur when stress is neither elevated nor low (Genik et al., 2005). In a study conducted by Genik et al. (2005), it was possible to measure the optimum level of stress by observing the extent and location of brain activation, which indicated the degree of cognitive involvement during a task. Functional Magnetic Resonance Imaging (fMRI) determined that one astronaut experienced two consecutive onsets of cognitive overload after six months 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). Lorenz et al. (1995) described that astronauts are required to perform executive functions as part of scientific experiments and maintenance duties on their spacecraft. Added to the limited help provided by ground controllers when tools or instruments fail, the astronauts are faced with tasks requiring high mental workload (Lorenz et al., 1995). 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).

Meister (1985) defined workload as constituted by two concepts (as cited in Diaz & Adam, 1992):

1. A time limit is imposed on each task. The degree of workload is the ratio of time taken to complete the task to time available to complete the task.
2. The attention span of a human performing a task is limited. Consequently, when multiple tasks must be performed at once, the tasks compete for the human's attention. This competition increases the human's workload. (p. 6)

Space Participants

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 pilot or as a flight crew participant (Space Discovery Institute [SDI], 2014). One of the responsibilities of a flight crew participant is to ensure the safety of the mission.

To qualify for the SPCP, individuals applying for a pilot's position must possess an FAA pilot certificate with at least one rating appropriate to the type of aircraft flown during the mission. Individuals applying for any other flight crew position, as well as the pilot position, will be required to possess an FAA 2nd class medical certificate (SDI, 2014).

Astronauts

The use of the word astronaut represents people who are trained to operate or work aboard spacecraft (Astronauts, 2014).

To qualify as United States astronauts, applicants must have at least a Bachelor's degree in engineering, biological science, physical science, or mathematics; followed by three years of professional experience in the aforementioned fields or 1,000 hours of pilot-in-command time in jet aircraft. Finally, applicants are required to pass a long-duration spaceflight physical examination, which requires distant and near visual acuity to be correctable to 20/20 for both eyes, blood pressure lower than 140/90 in a sitting position, and a height between approximately 158 and 191 centimeters (NASA, 2013b).

Skylab

Skylab was the first American long-duration space station. It was designed to demonstrate that humans could live in space for extended durations and allow solar astronomy to be performed outside of the Earth's atmosphere (NASA, 2009). Launched in 1973, Skylab consisted mainly of the empty third stage of a Saturn V launch vehicle, providing a relatively large living area for visiting crews of three astronauts who travelled aboard Apollo capsules. Scientific experiments were conducted over the course of three separate missions, including human adaptation to microgravity. Skylab was deorbited in 1979 and fell into the Indian Ocean and Western Australia (NASA, 2009).

Mir Space Station

Meaning ‘peace’ and ‘community’ in Russian, the Mir program started in 1986 when the first module of the space station was boosted into orbit from the plains of Kazakhstan (NASA, 2004). It took 10 years to assemble the space station while in orbit; however, astronauts living and working inside Mir conducted science experiments from the beginning. The station was resupplied with visiting Progress vehicles and space shuttles, and crews of three astronauts maintained human presence in space until 1999. Mir was the size of approximately six school buses. The station was deorbited on March 23, 2001 and fell into the South Pacific (NASA, 2004). During the Mir and Skylab missions, astronauts experienced variations in mood. In one instance, “there is anecdotal evidence the Russians once launched a rescue mission to the Mir space station for the purpose of returning one stress-stricken cosmonaut to Earth” (Seedhouse, 2009, p. 152).

Space Shuttle

Officially named the Space Transportation System (STS), the space shuttle was NASA’s first reusable launch vehicle, comprised of three elements. These were the orbiters (Enterprise, Columbia, Challenger, Discovery, Atlantis, and Endeavour), the solid-rocket boosters, and the external tank (NASA, 2011b). Between 1981 and 2011, 135 missions took teams of up to seven astronauts into space to conduct scientific experiments or assemble the ISS (NASA, 2012a). The space shuttle stands out from other spacecraft due to its ability to launch like a rocket and land like an airplane (NASA, 2011b). STS-135, flown by space shuttle Atlantis, ended on July 21, 2011. This mission brought the space shuttle program to an end when the orbiter landed at NASA's Kennedy Space Center in Florida (NASA, 2012a).

International Space Station

The International Space Station is the current space station used as a science laboratory by long-duration crews of up to six astronauts (NASA, 2011c). The first module was launched in 1998 aboard a Russian rocket; over the next 14 years, the space station was assembled in orbit. Currently, the ISS is as large as a football field, containing multiple laboratories from the United States, Russia, Japan, and Europe, to conduct research that could not be performed on Earth due to gravity (NASA, 2011c). Although a typical mission lasts an average of six months, NASA is preparing for a year-long mission aboard the ISS which will launch in March 2015 (NASA, 2013a). The lessons learned will allow space agencies to send humans into deep space to explore our solar system. Since the year 2000, humans have lived and worked onboard the ISS continuously (NASA, 2011c).

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, 2011d). NEEMO offers an analog setting to space, including a hostile external environment, confinement, and the ability to simulate different gravity conditions. The primary research conducted in Aquarius is to simulate space missions to asteroids, planets, or moons, and analyze life in spacecraft and testing spacewalk techniques (NASA, 2011d).

Mars500

The Mars500 project was a European Space Agency (ESA) experiment conducted in Russia that simulated a mission to Mars (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). Six subjects were enclosed in a chamber for 520 days from June 2010 to November 2011, simulating a round-trip to Mars. Part of the chamber was built to resemble the Martian surface. This allowed for extra-vehicular activities when the subjects simulated arriving on Mars. Communication delays, lasting 25 minutes, were simulated to reflect actual communication delays that would occur on deep-space missions (ESA, 2011).

Artificial Habitat Risks

According to NASA's Human Research Program (NASA, 2010), living in a closed environment during extended durations involves a multitude of crew health and safety risks. These risks include space human factors and habitability, behavioral health and performance, space radiation, exploration medical capability, and human health countermeasures.

Space human factors and habitability risks. NASA's Human Research Program (NASA, 2010) affirmed that habitat crewmembers may be exposed to risks of error due to inadequate information and poor task design. There were also risks of reduced safety and efficiency due to an inadequately designed vehicle, environment, tools, or equipment, and risks of inadequate food supply. NASA's Space Human Factors

Engineering portfolio aims at reducing these risks by creating models that predict "the effects of interface designs on human performance" (NASA, 2013c, para. 2).

Behavioral health and performance risks. While living in an artificial orbital habitat, people may be exposed to risky behavioral and psychiatric conditions, risks of committing performance errors due to sleep loss, and circadian desynchronization. Other risks include fatigue and work-overload, risks of performance errors due to poor team cohesiveness and performance, inadequate selection/team composition, inadequate training, and poor psychosocial adaptation (NASA, 2010).

Human health countermeasures risks. NASA's Human Research Program (NASA, 2010) upheld that subjects living in a closed environment for an extended duration are exposed to risks of reduced physical performance capabilities due to reduced aerobic capacity, malnutrition, and therapeutic failure due to ineffectiveness of medicine. There was also a risk of inability to adequately treat an ill or injured crew member when confined to living in an artificial habitat (NASA, 2010).

Fire. Ushakov et al. (1990) have determined that a risk of fire in a closed environment exists. A fire creates toxic gases, and the risk level depends on the quantity and chemical composition of the burnt materials, time of exposure to humans, and the size of the habitat (Ushakov et al., 1990).

Pathogenic viruses. According to Brion, Gerba, and Silverstein (1994), the habitat in which astronauts live for extended missions provides recycled air and water. The longer the mission, the higher the probability that astronauts may suffer from a viral infection by consumption of recycled water and air.

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 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 (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 has 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).

Summary

As manned space exploration programs prepare for deep-space exploration of the solar system, in particular Mars, Lagrange points, and Near-Earth Asteroids (NASA, 2011a), the effects of exposure to the space environment on human mood variations is becoming an area of greater concern. Future missions will require extended stays in space (up to three years); thus, understanding the cumulative effects of the space environment is critical.

Two elements constitute the harsh space environment to which astronauts are exposed: the external, or ambient environment, and the life-support system. Microgravity and continuous changes in day/night cycles are part of the external space environment, whereas the life-support system, which is the spacecraft itself, imposes its own set of threats to the crew. Among these threats are noise from the on-board operating hardware, higher CO_2 levels due to human respiration, and confinement and isolation resulting from the small size of spacecraft and the physical separation between astronauts and their families and friends.

Temperament, as described by the literature, should not change significantly when exposed to the space environment. Temperament reflects an individual's personality traits, attitudes, and values, which have been acquired over months or years at a time. Conversely, one's temperament type (Artisan, Guardian, Rational, or Idealist) may affect an individual's motivation, interest, or method of performing a task, resulting in differences in task performance.

Human mood is affected by factors internal to the human body and environmental events that regulate an individual's daily life. Among the internal factors, unusual hormone levels (such as melatonin and serotonin) affect an individual's calmness and eagerness, and can lead to irritability and aggression. This can degrade task performance and social interaction, leading to poor team cohesion. Environmental factors encompass isolation and confinement, which may lead to feelings of depression. An altered circadian rhythm may degrade sleep quality, which leads to multiple mood disorders and increased stress.

High levels of human performance are required in space; the astronauts conduct tasks that require a complex combination of cognitive and motor skills, which can be hampered during the phase of adaptation to the new space environment, or after long-term exposure. Although stress can have positive or negative effects on human performance, the emotional fatigue over time suffered by astronaut crews may hinder their ability to perform tasks effectively. Finally, high levels of workload, associated with limited resources and time, can quickly overload the astronauts and lead to selective attention and the omission of potentially critical tasks.

Chapter III

Methodology

Research Approach

The purpose of this research was to determine if space participants suffered mood or temperament variations while exposed to the space environment, and compare the results with normal mood and temperament variations they experienced on Earth. To fulfill the research objective, the participants were both subjected to two different environments: a controlled, artificial orbital habitat environment and a normal living environment. This study employed a quasi-experimental research design, due to the high level of control the researcher and collaborators possessed over the Habitat 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 statistics were used to describe the data for each of the variables collected in both environments (Normal and Habitat).

Design and procedures. The researcher and collaborators first decided to collect data from an Artificial Orbital Habitat (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). The researcher and the collaborators developed an explanation of the background of the research for the IRB, stating that its purpose was to collect data on some of the effects of the space environment on human behavior during long-term deep space travel. To achieve this goal, an artificial environment was used to create an analogous environment to that of space travel (specifically, an orbital environment). Using a ground-based habitat (in this case, a rented RV) offered a safe, cheap, and reliable way of measuring common variables between the Earth and space environments (e.g., feelings of isolation, energy, motivation, mood, etc.).

IRB constraints. The specific purpose of the study was to research and produce quantitative and qualitative data on mood and temperament variations for ordinary citizens who have no special training in space-mission preparation. Only males were eligible for this experiment; according to the IRB, the more complicated and sensitive female cycles could have added complications to the study that were not necessary for an exploratory research project. Participants were required to be 18 years of age or older, be able to read, write, and speak English, be enrolled in a Commercial Space Operations (CSO) academic course at Embry-Riddle Aeronautical University (ERAU), Daytona Beach campus, and have a 3.0 GPA or higher. The GPA requirement increased the probability that participants possessed better writing skills, and thus improved the quality of feedback in their personal logs and reduced the likelihood that the participants' long-term GPA would be impacted. 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 for up to 100 hours.

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. This was accomplished prior to having the participants sign a consent form (Appendix E) and a participant release form (Appendix F). This briefing served to indicate to the participants that the researchers would not knowingly or purposefully put them in a hazardous situation during the experiment. 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 a KTS®-II (Keirsey, 2014c) and a POMS 2™ (Multi-Health Systems [MHS], 2014) test to serve as a pre-test collection of data.

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 a rented 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. The participants were subjected to a controlled environment, in which the artificial habitat was protected within a hangar.

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, and external exhaust capabilities to mitigate the risk of fire and smoke. To control this risk, the researcher and the collaborators ensured a fire extinguisher was available to the participants. The door of the RV was closed (but left unlocked), and the participants were told that the door was sealed with tape to simulate a closed environment in space. The design of the RV included unlocked windows that were easily accessible to the participants, which could be opened in the event of fire or smoke.

Living conditions. The habitat was set up with separate sleeping accommodations, a private toilet facility (including a shower), a kitchen area, a desk, and a control station (representing the main living quarters). The windows of the habitat were covered with cardboard planks and blankets to prevent light from flowing through during the artificial night cycle, while, at the same time, preventing the participants from seeing outside. The RV was equipped with air conditioning and heating, allowing for continuous replenishment of clean air.

The participants were allowed to bring a small number of personal items, such as toilet articles, medications, etc., subject to approval by the researchers. Conversely, some items were prohibited inside the habitat, such as personal electronic devices (to create a greater sense of isolation), watches (to simulate mission elapsed time), and weapons (for safety considerations).

Hygiene. The design of the habitat also allowed for the replenishment of clean air, and large quantities of food and water. The food provided was normal and commercially purchased; participant preferences were considered. There were emergency procedures in place, and both the mission controllers and participants were fully briefed on them. Both parties kept a record of the emergency procedures with them for reference in the event a potentially harmful situation arose (see Appendix G).

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.

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. The participants were not required to perform this activity at a high level of intensity; rather, they could ride at their own pace.

Space participant activities. The participants were required to complete certain activities during the mission (both team activities and individual activities). The team activities included designing a mission patch to commemorate the first artificial habitat study conducted by ERAU, as well as solving NASA's "Lost on the Moon" exercise ("NASA Exercise," 1999). This exercise is a discussion game during which it is assumed the participants are lost on the Moon and must rank space equipment by order of importance with the goal of returning to base camp.

The individual activity required each participant to monitor gauges to verify the system status of their simulated spacecraft. These gauges consisted of PowerPoint presentations, which displayed a series of changing numbers on digital gauges, displayed on a screen inside the AOH. The participants had to work with mission control to determine the normal operating parameters of those gauges, and notify mission control of any anomalies or deviations. When not used for the PowerPoint presentation, this screen 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.

Entertainment. The participants were not allowed to have any personal communication devices with them in the habitat (cell phone, iPad®, laptop computer, etc.) The habitat was equipped with a laptop computer (not Wi-Fi enabled, to remove access to social media and reinforce the illusion of isolation), a DVD player, and a supply of DVDs for entertainment.

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 I).

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. This interval requirement ensured enough time would pass between tests to allow mood fluctuations to occur and be measured.

The list of tasks given to the participants was as follows: on Day 1, the participants had to make time for dinner and one POMS 2™ test. On Day 2, each participant had to make time for breakfast, lunch, and dinner, three POMS 2™ tests (each separated by at least 4 hours and 30 minutes), 2 hours of bicycle riding, two hours of gauge monitoring, and to complete the NASA Lost on the Moon team exercise. On Day 3, each participant had to make time for breakfast, lunch, and dinner, three POMS 2™

tests (each separated by at least 3 hours), 90 minutes of bicycle riding, and 90 minutes of gauge monitoring. The mission controllers asked the participants to monitor the duration and intervals at which they had to accomplish these tasks. However, mission control also kept track of the times, to be able to remind the participants to take the POMS 2™ tests if they forgot, or notify them of how long they had been riding the stationary bicycle. To give the participants the illusion they could be enclosed in the AOH for up to 100 hours (equivalent to five mission days), their list of tasks expanded to a fourth and fifth day, each respectively mirroring Days 2 and 3.

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

Visual effects. A day/night cycle, different from the Earth's cycle, was created to reflect the orbital environment (the cycle was synchronized to a live video feed from the ISS, with sunrise and sunset occurring approximately every 90 minutes instead of every 24 hours). This artificial light cycle was augmented with a lamp outside of the habitat shining through an opaque habitat window.

A screen was installed inside the habitat, and was linked to an external console to which mission controllers had access. The participants had no control over what was presented on the screen. This screen was used to display the PowerPoint gauges as well as the live ISS video feed of planet Earth.

To keep track of the gauge anomalies, the participants were provided with pens and paper sheets that were preformatted to fit the needs of the gauge-monitoring exercise.

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) (see Appendix H). 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 (simulating the presence of a mission control similar to that of NASA). 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 (the sleeping areas and restrooms were not visible). The video feed was set-up for the sole purpose of ensuring the health and safety of the participants. There was constant video feed and open communication between the habitat and mission control. No recordings of the video feed were made or kept, and no audio feed from the camera was used.

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 use only in an emergency). Finally, the participants were instructed to use specific body language, visible by video to the mission controllers in order to request help in case both audio modes of communication failed. The habitat was also equipped with speakers to allow mission control to interrupt the participants in their activities in case there was a need to contact them quickly.

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 the most popular personality evaluation instrument in use (Keirsey, 2014b). The Keirsey Temperament Sorter®-II (KTS®-II) consists of 70 questions that help measure an individual's personality type. The questions are based on Keirsey Temperament Theory, developed by Dr. David Keirsey (Keirsey, 2014b). After completion of the KTS®-II test, the results reveal an individual's temperament and character type.

Reliability and validity. 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 2nd Edition™. The Profile of Mood States 2nd Edition™ (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 up 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).

Positive mood states. VA embodies how vigorous and energetic a person feels. This score is influenced by positive feelings and level of energy. The F scale is a separate measurement (it is not involved in determining TMD). Friendliness is considered a mood state that may affect the quality of interpersonal relations. The F score, being a positive feeling, can be used as an indicator of a person's adaptability to their surroundings (MHS, 2012).

Negative Mood states. AH signifies how angry a person is, or how much animosity they feel towards others. CB characterizes the level of confusion, disorganization, or perplexion a person may feel. DD embodies feelings of depression and of personal inadequacy. FI denotes how much apathy or weariness a person feels. Finally, TA indicates the level of anxiety a person feels (e.g., feeling stressed), accompanied by musculoskeletal tension (e.g., shaking) (MHS, 2012).

Reliability and validity. 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).

In order to assess the validity of the POMS 2™, MHS (2012) conducted confirmatory factor analyses to ensure the factor structure was appropriate. MHS (2012) also tested and confirmed the POMS 2™ assessments possessed discriminative validity, convergent validity, and generalizability across race and ethnicity.

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).

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 three-and-a-half to four 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 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 potential future experiments.

The mission controllers also maintained a log, with a time stamp, of major activities going on inside the habitat. This ensured that the mission controllers were aware of the progress made by the participants throughout the simulated mission. These logs were also kept confidential among the researchers; they will inform future research, but the logs were not used in this study for research purposes.

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 and collaborators determined that the participants should start these tests on a Sunday and finish on a Tuesday.

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. Once completed, the researcher and collaborators collected the data from the participants, evaluated it, and prepared it for statistical analysis.

Population

The population of this exploratory study consisted of two participants carefully chosen based on the selection criteria outlined in Appendix B. Among the key elements considered in their selection was the requirement to be enrolled in a CSO academic course at ERAU's Daytona Beach campus, and not to suffer from any medical conditions or food allergies.

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).

Treatment of the Data

The data collected during the habitat environment and the normal environment was separated into two categories, POMS 2™ data and KTS®-II data.

The POMS 2™ tests produced ordinal data that was collected electronically during the AOH phase of the research and manually during the normal environment phase. The electronic data from the AOH was automatically gathered and scored on the Online Assessment Center (OAC) on the MHS website. The researcher and collaborators selected the generate report option. The OAC website created a report containing test results for Total Mood Disturbance (TMD) and six other mood clusters which were: (a)

Anger-Hostility (AH), (b) Confusion-Bewilderment (CB), (c) Depression-Dejection (DD), (d) Fatigue-Inertia (FI), (e) Tension-Anxiety (TA), and (f) Vigor-Activity (VA). A separate score was provided for Friendliness (F). TMD was calculated by adding together the Negative Mood State scales (AH, CB, DD, FI, and TA) and subtracting the Positive Mood State scale (VA).

The POMS 2™ data, collected manually during the normal environment phase of the research, was entered by hand into the OAC website. Next, the researcher and collaborators used the website to score the responses and generate a report. This report provided the same results as the report created for the AOH environment.

The researcher created an Excel spreadsheet and manually entered the POMS 2™ test results for each variable listed above into a table format. The data was organized by participant and type of environment (AOH or Normal).

The Keirsey Temperament Sorter®-II test provided the researcher and collaborator with nominal data. This data was a personality-type/character-type combination (e.g., Guardian Protector or Artisan Crafter). The researcher created an Excel spreadsheet and manually entered each personality/character-type combination into a table format. The data was also organized by participant and type of environment.

Descriptive Statistics

Descriptive statistics were used to describe the POMS 2™ data collected in the habitat environment and the normal environment. The researcher used SPSS to calculate the means, medians, maximums and minimums of the POMS 2™ test results for TMD, AH, CB, DD, FI, TA, VA, and F. Tables were used to describe the data. A linear chart was created to represent the evolution of each participant's TMD test results for both environments.

Hypothesis Testing

A paired-samples *t*-test was used to test the first hypothesis (whether the type of environment affects mood). Each mood cluster data generated by the POMS 2™ test, as well as the TMD test results, were grouped by participant (Participant A and Participant B). For each participant's mood clusters and TMD test results, a paired-samples *t*-test was performed between the two types of environment (Habitat and Normal). A total of 16 *t*-tests were conducted. A *p*-value of less than 0.05 meant that there was evidence to reject the null hypothesis.

To evaluate the second hypothesis (whether the type of environment affects temperament), the researcher and collaborators grouped the KTS®-II data by participant (Participant A and Participant B). The researcher used a table to compare the data collected as a pre-test and post-test for both environments.

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 that has been de-identified to protect the privacy of the participants and mission controllers. This data was not used for the purpose of the research, however, it was used to guide future studies and inform prospective researchers of the challenges and improvements they can bring to their own research.

Chapter IV

Results

After organizing the data by Participant and Type of Environment, the researcher entered the data into SPSS. 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.

Descriptive Statistics

The researcher conducted descriptive statistics on each mood variable measured by the POMS 2™ tests. The data were organized by Participant and Type of Environment. Table 1 shows the results of the descriptive statistics for Participant A's POMS 2™ test results while in the Habitat Environment. For each mood cluster, the score was rated out of 100 points. The researcher illustrated the evolution of Participant A's POMS 2™ test results in the Habitat Environment by a line chart (shown in Figure 1).

Table 1

Participant A POMS 2™ Data in the Habitat Environment

	N	Mean	Standard Deviation	Minimum	Maximum
TMD	8	37.12	3.36	33	42
AH	8	37.38	0.52	37	38
CB	8	34.38	1.19	33	36
DD	8	39.00	0.35	39	39
FI	8	46.63	11.40	32	64
TA	8	31.25	1.58	30	35
VA	8	52.88	5.14	46	61
F	8	54.50	3.63	50	61

Note. TMD = Total Mood Disturbance, AH = Anger-Hostility, CB = Confusion-Bewilderment, DD = Depression-Dejection, FI = Fatigue-Inertia, TA = Tension-Anxiety, VA = Vigor-Activity, F = Friendliness.

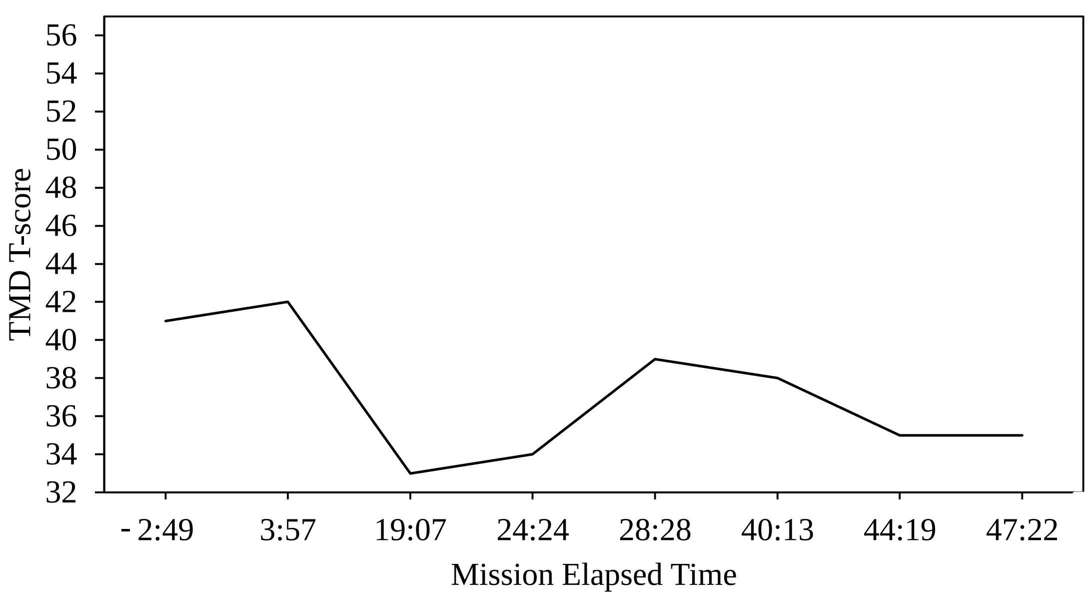

Figure 1. Participant A's evolution of TMD scores in the Habitat Environment.

Table 2 shows the results of the descriptive statistics for Participant A's POMS 2TM test results while in the Normal Environment. The researcher illustrated the evolution of Participant A's POMS 2TM test results in the Normal Environment by a line chart (shown in Figure 2).

Table 2

Participant A POMS 2TM Data in the Normal Environment

	N	Mean	Standard Deviation	Minimum	Maximum
TMD	8	53.75	1.39	51	55
AH	8	39.63	1.51	37	42
CB	8	42.75	3.06	39	49
DD	8	42.63	0.91	41	44
FI	8	72.00	3.42	66	75
TA	8	38.63	2.72	35	42
VA	8	29.75	2.31	28	34
F	8	33.50	5.07	26	39

Note. TMD = Total Mood Disturbance, AH = Anger-Hostility, CB = Confusion-Bewilderment, DD = Depression-Dejection, FI = Fatigue-Inertia, TA = Tension-Anxiety, VA = Vigor-Activity, F = Friendliness.

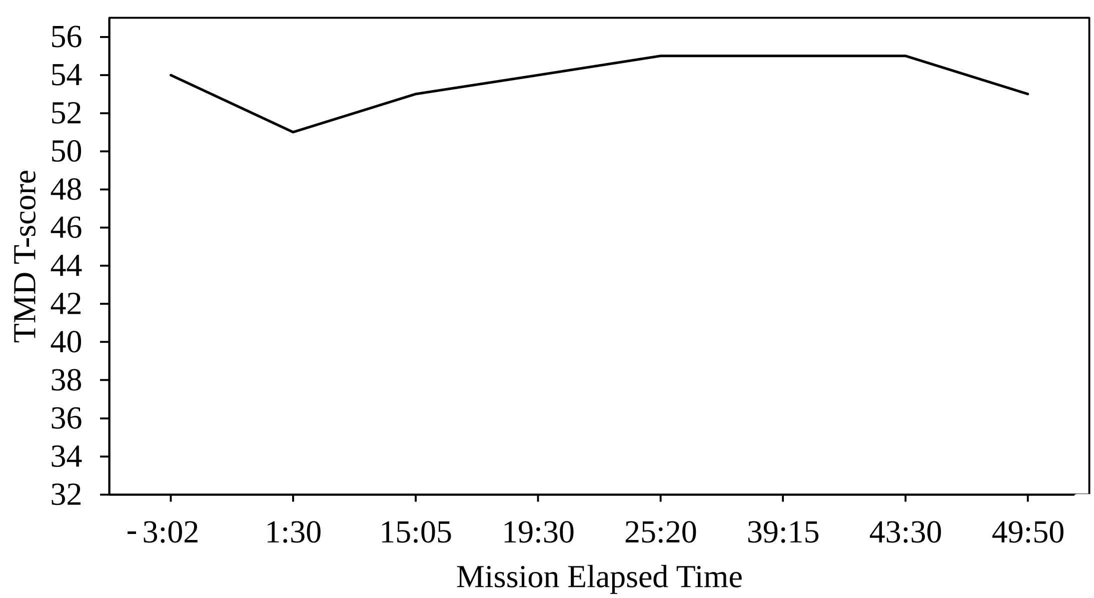

Figure 2. Participant A's evolution of TMD scores in the Normal Environment.

Table 3 shows the results of the descriptive statistics for Participant B's POMS 2TM test results while in the Habitat Environment. The researcher illustrated the evolution of Participant B's TMD POMS 2TM test results in the Habitat Environment by a line chart (shown in Figure 3).

Table 3

Participant B POMS 2TM Data in the Habitat Environment

	N	Mean	Standard Deviation	Minimum	Maximum
TMD	8	40.50	2.89	35	44
AH	8	37.13	0.35	37	38
CB	8	37.88	3.18	33	42
DD	8	40.63	1.06	39	42
FI	8	41.63	5.53	34	53
TA	8	35.25	4.28	31	45
VA	8	44.88	4.70	39	54
F	8	44.38	4.72	39	53

Note. TMD = Total Mood Disturbance, AH = Anger-Hostility, CB = Confusion-Bewilderment, DD = Depression-Dejection, FI = Fatigue-Inertia, TA = Tension-Anxiety, VA = Vigor-Activity, F = Friendliness.

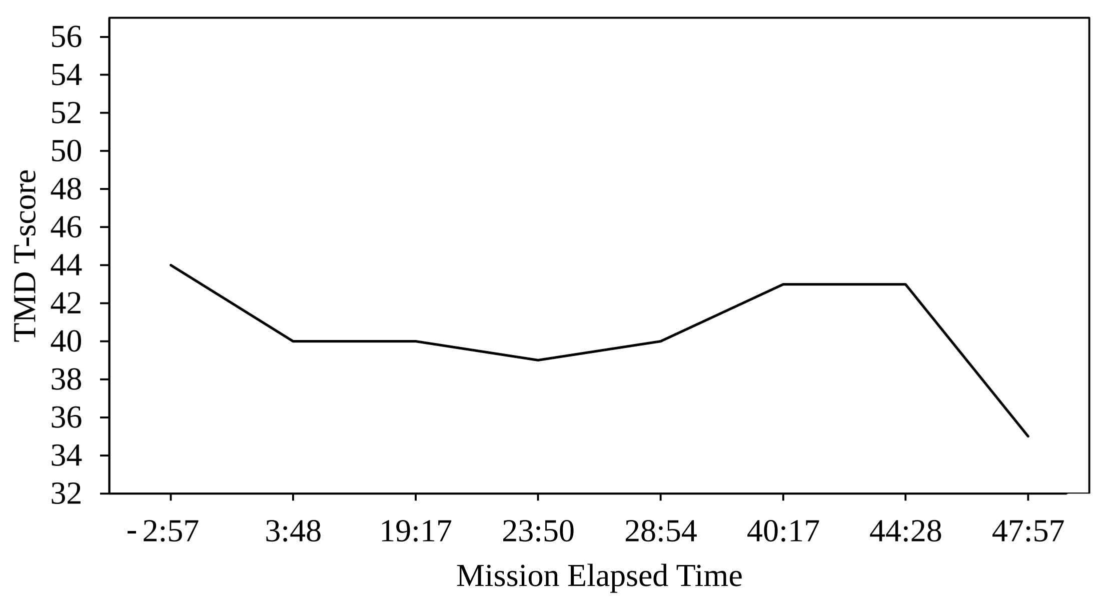

Figure 3. Participant B's evolution of TMD scores in the Habitat Environment.

Table 4 shows the results of the descriptive statistics for Participant B's POMS 2^{TM} test results while in the Normal Environment. The researcher illustrated the evolution of Participant B's POMS 2^{TM} test results in the Normal Environment by a line chart (shown in Figure 4).

Table 4

Participant B POMS 2^{TM} Data in the Normal Environment

	N	Mean	Standard Deviation	Minimum	Maximum
TMD	8	46.00	5.95	39	56
AH	8	37.88	1.13	37	40
CB	8	44.25	7.29	36	58
DD	8	41.13	2.64	39	47
FI	8	45.00	8.40	36	57
TA	8	38.75	7.44	31	49
VA	8	36.75	5.31	29	42
F	8	33.75	3.58	28	39

Note. TMD = Total Mood Disturbance, AH = Anger-Hostility, CB = Confusion-Bewilderment, DD = Depression-Dejection, FI = Fatigue-Inertia, TA = Tension-Anxiety, VA = Vigor-Activity, F = Friendliness.

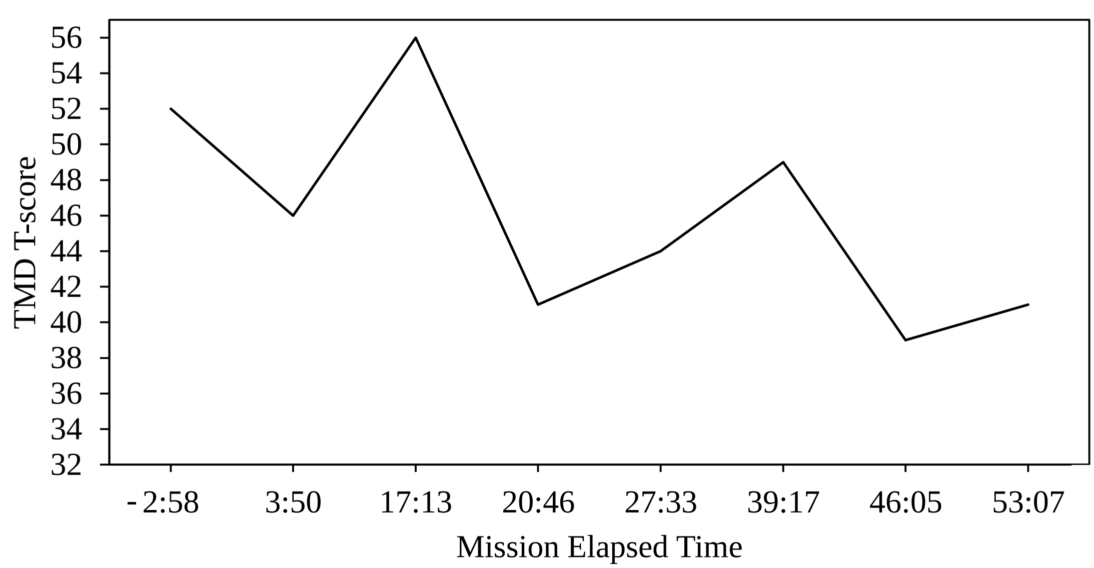

Figure 4. Participant B's evolution of TMD scores in the Normal Environment.

Hypothesis Testing

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

Table 5 presents the paired-samples *t*-test results for Participant A's POMS 2^{TM} test results in the Habitat and Normal Environments. The results were all statistically significant. Thus, the paired-samples *t*-tests provided evidence to reject the null hypothesis.

Table 5

Participant A Paired-Samples t-Test Between Types of Environment

	Habitat Env. Mean	Normal Env. Mean	N	*t*-value	Significance
TMD	37.13	53.75	8	-11.98	.000
AH	37.38	39.63	8	-5.46	.000
CB	34.38	42.75	8	-7.39	.000
DD	39.13	42.63	8	-10.69	.000
FI	46.63	72.00	8	-5.30	.001
TA	31.25	38.63	8	-7.98	.000
VA	52.88	29.75	8	10.55	.000
F	54.50	33.50	8	9.29	.000

Note. TMD = Total Mood, AH = Anger-Hostility, CB = Confusion-Bewilderment, DD = Depression-Dejection, FI = Fatigue-Inertia, TA = Tension-Anxiety, VA = Vigor-Activity, F = Friendliness.

Table 6 presents the paired-samples *t*-test results for Participant B's POMS 2^{TM} test results in the Habitat and Normal Environments. Half of the results were statistically significant.

Table 6

Participant B Paired-Samples t-Test Between Types of Environment

	Habitat Env. Mean	Normal Env. Mean	N	*t*-value	Significance
TMD	40.50	46.00	8	-2.76	.028
AH	37.13	37.88	8	-1.66	.141
CB	37.88	44.25	8	-2.91	.022
DD	40.63	41.13	8	-0.55	.598
FI	41.63	45.00	8	-0.89	.401
TA	35.25	38.75	8	-1.54	.167
VA	44.88	36.75	8	4.50	.002
F	44.38	33.75	8	8.39	.000

Note. TMD = Total Mood, AH = Anger-Hostility, CB = Confusion-Bewilderment, DD = Depression-Dejection, FI = Fatigue-Inertia, TA = Tension-Anxiety, VA = Vigor-Activity, F = Friendliness.

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

Table 7 shows Participant A’s pre- and post-test KTS®-II results for the Habitat and Normal Environments. The pre- and post-test results were different for both Environments.

Table 7

Participant A KTS®-II Results in the Habitat and Normal Environments

	Pre-Test	Post-Test
Habitat Environment	Artisan Crafter	Guardian Inspector
Normal Environment	Guardian Protector	Guardian Inspector

Table 8 shows Participant B's pre- and post-test KTS®-II results for the Habitat and Normal Environments. The pre- and post-test results were the same for both Environments.

Table 8

Participant B KTS®-II Results in the Habitat and Normal Environments

	Pre-Test	Post-Test
Habitat Environment	Artisan Performer	Artisan Performer
Normal Environment	Guardian Provider	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.

Flight director and CAPCOM. Mission control consisted at any given time of a flight director and a CAPCOM. The flight director was represented by the researcher and collaborators, who took turns according to the schedule depicted in Table H1 (Attachment H). The role of the flight director was to ensure the safety of the participants and oversee the progress of the experiment. CAPCOM was represented by undergraduate students who also took turns according to the schedule depicted in Table H2 (Attachment H). The role of CAPCOM was to relay communications between the participants and the flight director, as well as maintain a log of all activities occurring inside the AOH. This allowed the researcher and collaborators to focus on the research goals and the quality of the data being collected.

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 on the ISS.

Launch preparations. The participant briefing occurred on time at 14:00 (local time) and the experiment was scheduled to start at 16:00. The participants were given a list of tasks to accomplish each day; their first task was to attend their 16:30 class through a GoToMeeting (“GoToMeeting,” 2014) video connection. However, due to complications in the set-up of the AOH, the start time was delayed until 21:00. Consequently, the participants attended class physically 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.

Radio frequency interference. During the participants’ first rest period, mission control heard incomprehensible chatter originating from the walkie-talkies (between 13:15 and 13:30 MET). This did not wake-up the participants. Later, when the participants were awake, mission control requested a frequency change to avoid further interference with somebody else’s frequency.

Window covers. During the participant’s first rest period, mission control noticed on the computer’s video feed that the rear RV windows, although covered on the outside, were letting some light through. Mission control proceeded to quietly add more covers to the exterior of the RV to filter out the light entirely without alerting the participants in any way.

Camera dislodging. During the participant's first rest period (around 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 up. Later, around 14:33 MET, one of the participants woke up, noticed the camera was dislodged, and proceeded to reinstall it.

Camera disconnecting. At 21:29 MET, the AOH video feed camera disconnected. Mission control maintained audio communications with the participants while working on a fix for the camera. After several attempts to reinstall the camera software on mission control's computer, mission control found that the cable linking the camera inside the RV to mission control's computer had been disconnected. Mission control reconnected the cable and the video feed was re-established.

Computer updates. Prior to the participants' second rest period (around 27:50 MET, midnight local time), mission control's computer shut down and began several rebooting sequences to update the computer's software. Mission control contacted Information Technology support, who advised that all campus computers undergo this update sequence every Saturday at midnight. During this time, the video feed from the AOH camera was lost. Mission control maintained audio communication with the participants using the walkie-talkies to ensure their safety. One hour into the update sequence, mission control was able to link the camera feed to a mission controller's personal laptop. The campus computer finished its update sequence several hours later, allowing the video feed to be re-established on the campus computer.

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. Mission control attempted to generate new links and send them to the participants via e-mail. This temporary fix only worked on occasion. Several attempts later, mission control came up with a consistent solution: CAPCOM communicated the link via walkie-talkie to the participants, who manually typed it into the browser. Using this technique, no further POMS 2^{TM} incidents occurred.

Managing water and waste. 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. Although only three hours remained before the end of the mission, returning the water system to working order reinforced the participants' belief that the mission could continue for more than 50 hours.

Chapter V

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 comparative study.

Discussion

Due to the preliminary nature of this research, the sample size used in the study was limited to two male participants. The researcher and collaborators rented an RV and configured it to replicate an artificial orbital habitat that would support the two participants. The duration of the experiment was limited to 50 consecutive hours to minimize the amount of time that participants were absent from their studies and class.

Descriptive statistics. The descriptive statistics generated an average TMD score for both participants in each Environment. This study was also able to identify fluctuations in positive and negative mood states for individuals living in a Habitat Environment and in a Normal Environment.

Total Mood Disturbance. As depicted by Tables 1, 2, 3, and 4, the descriptive statistics acquired from Participant A's POMS 2^{TM} test results determined the average TMD score was lower in the Habitat Environment (37.12) than it was in the Normal Environment (53.75). Similarly, Participant B's average TMD score in the Habitat Environment (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 justify the increased mood disturbance recorded by the POMS 2™ tests.

Figures 1 and 3 depicted Participant A and B's TMD variations in the Habitat Environment. 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 Habitat Environment 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 4 illustrated Participant B's TMD variations in the 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 Habitat Environment, resulting in more unpredictable and variable mood disturbance levels.

Positive Mood States. According to Tables 1, 2, 3, and 4, both participants recorded higher scores for the two positive mood states (VA and F) in the Habitat Environment 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 helped each other out 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 also admitted to finding relief in being paired up with a fellow classmate whom they already knew.

The participants' Positive Mood States scores from the Habitat Environment 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 Habitat Environment 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 Habitat Environment. 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 Habitat Environment 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 Habitat Environment (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. The researcher concluded this may have affected Participant A's FI score in the Normal Environment.

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.

The first paired-samples *t*-test was conducted for Participant A's mood constructs in the Habitat Environment and in the Normal Environment. The results for TMD and all other mood constructs generated *p*-values less than 0.001. The researcher concluded that, in the Habitat Environment, Participant A felt insulated from daily life stressors (social, educational, professional, and family-related 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.

The second paired-samples *t*-test analyzed the mood constructs for Participant B in the Habitat Environment 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 scored always lower in the Habitat Environment than in the Normal Environment. Similarly, Participant B's Positive Mood States scored always higher in the Habitat Environment than in the Normal Environment. The researcher concluded that, in the Habitat Environment, 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 Habitat Environment compared to the Normal Environment.

Participant B's *t*-tests for AH, DD, FI, and TA 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. Overall, the researcher concluded that Participant B experienced fewer changes in mood between the two types of Environment, compared to Participant A.

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 Habitat Environment, Participant A's KTS®-II results were different: Artisan Crafter (pre-test) and Guardian Inspector (post-test). According to Keirsey (2014a), the difference between the two types of temperament is significant: Artisan Crafters are down to Earth and possess good skills in the use of tools, equipment, machines, and instruments (Keirsey, 2014d). Guardian Inspectors possess a very cooperative temperament with a great sense of duty and teamwork (Keirsey, 2014e). While the two types of temperaments were not incompatible, the researcher gathered that the experience of living in the Habitat Environment may have 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 were closer in similarity, compared to the temperaments experienced by Participant A in the Habitat Environment. Guardian Protectors are caring of their family, friends, and coworkers, and find comfort in ensuring safety and security of their loved ones (Keirsey, 2014f). 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 in both Environments. In the Habitat Environment, Participant B's pre-test and post-test results were Artisan Performer. This type of temperament reflects people who share their loving personality with others and stimulate growth in their family, friends, and coworkers (Keirsey, 2014g). In the Normal Environment, Participant B's pre-test and post-test results were Guardian Provider. People who possess a Guardian Provider personality type feel responsible for the well-being of their loved ones and coworkers. They willingly sacrifice their energy to ensure the needs of their kin are met (Keirsey, 2014h). The researcher theorized that the two types of temperament were compatible, and that Participant B's temperament was consistent during each type of Environment. The differences in temperament experienced between 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. Both Participant A and Participant B experienced lower levels of Negative Mood States in the Habitat Environment than in the Normal Environment. Similarly, both participants experienced higher levels of Positive Mood States in the Habitat Environment than in the Normal Environment. The researcher concluded that there is a possibility a closed and isolated environment insulates its inhabitants from external daily life stressors, and fosters teamwork and cohesion. 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.

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.

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 were to ensure the POMS 2™ links provided to the participants were not corrupt, and have back-up plans to allow the participants to access their POMS 2™ tests (e.g., type the link manually or use paper versions of the tests). While conducting the POMS 2™ tests, the participants complained about the lack of information concerning the mood constructs that composed the test (in particular, the word dynamic). The participants recommended that future participants be told what each mood construct means during the pre-briefing.

An additional recommendation was to use a better instrument than the KTS®-II to measure Temperament. The KTS®-II only provided the researcher with nominal data (specifically, the results only presented an individual's temperament type). Future researchers should investigate what type of results could be obtained using 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 evaluate whether this is true for space participants as well.

Emergency scenarios. 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 on the ISS. Should future research be conducted, it may be necessary to prepare simulated emergencies or abnormal scenarios built-into the schedule.

Camera and video feed. To avoid any 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 the campus' 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 (particularly while showering) to prevent the grey water tank from filling to capacity. Should the mission duration be planned for longer than 50 hours, potential researchers should plan to dump the grey water tank overboard.

Secondary recommendations included the use of a permanent artificial habitat designed to reflect a space station environment better. Its permanent nature would help prevent last-minute set-up contingencies from delaying the launch of the mission. This permanent artificial habitat should also support more than two participants. Other secondary recommendations included using male and female participants, multicultural crews, and to increase the duration of the experiment beyond 50 consecutive hours.

Gender. Due to the exploratory nature of this research, an all-male crew of participants was used. The researcher and collaborator recommended that all-female and mixed crews be used for future studies. Studying both genders would allow extending the scope of such research, and determining if gender affects mood or temperament.

Participant recommendations. During the post-habitat experiment debrief, the participants made a few recommendations of their own. While the AOH experiment was on-going, the 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 the advertisements being played before each video started. This reduced their impressions of isolation.

The participants also noticed occasional background chatter coming from the walkie-talkies, as another group of individuals was using the same audio frequency. The participants suggested that the researcher and collaborators plan to use a back-up frequency in case this problem were to reoccur in future experiments.

Finally, 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.

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Appendix A

Permission to Conduct Research

EMBRY-RIDDLE
Aeronautical University
DAYTONA BEACH, FLORIDA

Office of the
Chief Academic Officer

Tel: 386-226-6216
Fax: 386-226-6299

March 11, 2014

Dr. Guy Smith
College of Aviation
Daytona Beach

Mr. Kenny Arnaldi

Reference: Institutional Review Board Approval – 14-078 IRB
Human Behavior during Spaceflight – Evidence from an Analogue Environment

Dear Dr. Guy and Mr. Arnaldi:

In compliance with Embry-Riddle Aeronautical University's policy on Human Subjects and PHS 45 CFR 46.110, in my capacity as the Co-Chair of the Institutional Review Board, the Institutional Review Board has reviewed the **Plan for the Protection of the Rights and Welfare of Human Subjects** for the proposed research project entitled ***Human Behavior during Spaceflight – Evidence from an Analogue Environment*** and has determined that this research can be conducted as presented.

Any significant systematic deviation from the approved protocol must be submitted to the IRB for approval prior to implementation and any adverse events must be reported to the IRB promptly.

Best of luck in your endeavors.

Sincerely,

J. French

Dr. Jon French
Co-Chair of the Institutional Review Board

CC: Kenny Arnaldi

600 S. Clyde Morris Blvd.
Daytona Beach, FL 32114-3900

Appendix B

Solicitation of Participants

Human Behavior during Spaceflight - Evidence from an Analog Environment

Solicitation of Participants

Project Overview

The purpose of this experiment is to complete a research project on the effects of the space environment on human performance during long-term deep space travel. To achieve this goal, a ground-based artificial environment (such as a trailer) will be used to create an analog environment to that of space travel (specifically, an orbital environment). Participants will live in this artificial environment with another male crewmember for at least 2 days. During their time inside the habitat, participants will be required to accomplish specific tasks, monitor gauges, and maintain a personal log of their experiences and feelings. Participants will also be required to complete two types of mood/temperament surveys. The first type is the Keirsey Temperament Sorter®-II, which will be completed prior to the start of the experiment and at its conclusion. The second type is the Profile of Mood States 2nd Edition™, which will be completed several times throughout the experiment.

Research Design

Participant comfort and safety will be ensured during the experiment. Separate sleeping accommodations, private toilet facilities, food, water, and an exercise bike will be provided. To simulate space travel, no external contact will be allowed (e.g., no use of cell phones or internet). To mimic an orbital environment, exterior lighting capabilities will place the habitat in a sunrise/sunset cycle equal to 90 minutes. The habitat will be equipped with a live video feed to a monitoring station (manned 24/7) for the sole purpose of safety. Audio communication capabilities (along with two back-up systems) will be made available between the participants and the monitoring station. None of the video and audio information will be used in the research. Personal information from the participants will remain confidential and will not be used in the research either.

Eligibility Requirements

Only males will be eligible for this experiment. Participants must meet the following requirements;

- → Be 18 years of age or older
- → Be able to read, write and speak English
- → Be enrolled in an academic Commercial Space Operations course at Embry-Riddle Aeronautical University, Daytona Beach Campus
- → Must have a 3.0 grade point average or greater
- → Must not suffer from claustrophobia
- → Must not suffer from food allergies
- → Are willing to live in a closed environment with others participants

Preference will be given to members of a Commercial Space Operations degree with good writing skills, a higher grade point average, and a higher academic standing.

Potential Discomfort to Participants

During the experiment, participants may experience feelings associated with living in an enclosed environment, such as boredom and isolation. Participants may also experience discomfort and frustration, if their personalities strongly contrast.

Time Requirements and Rewards

The experiment is scheduled to last at least 50 consecutive hours, and may be extended to no more than 100 hours. Participants will be financially compensated per the

ERAU undergraduate rate of $7.50/hour. The total amount at 50 hours is $375.00. The total amount at 100 hours is $750.00.

Appendix C

Participant Interview Form

Participant Interview Form

Name: ___________________________________

1. Write a short paragraph about yourself. Your writing skills will be assessed. Use no more than 200 words.

2. What is your Grade Point Average? ________________

3. What is your college standing (freshman, sophomore, junior, senior)? _____________________

4. Do you have classes scheduled on Monday __, Tuesday __ and Wednesday __? If so, please list the times and if you are schedule to take an exam on each day (we will make the necessary arrangements to give you enough time to prepare for your exam).

5. Do you have any food allergies?

6. Do you suffer from claustrophobia? ____________________________________

7. Do you possess any pre-existing conditions that could become a serious problem during the experiment (e.g., cardiovascular/hypertension or neurological/epilepsy problems) or medical conditions (e.g., diabetes)?

____
____
____

8. Do you take any medication/drugs that may interfere with your mood or health during the experiment, to the extent that the test results may be altered or the safety of all participants may be jeopardized?

____
____
____

9. Do you prefer a structured lifestyle or would you rather live according to a loose schedule?

____
____
____

I acknowledge that the information entered above is true.

Signature: ___________________________

Once completed, please return this document to Kenny Arnaldi.

Appendix D

Participant Briefing

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.

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. The habitat will also be equipped with speakers to allow the command station to interrupt you in your activities should need be to quickly get in touch with you.

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 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. Your habitat will also be equipped with a fire extinguisher. The door will be locked to simulate a closed environment in space; however, the design of the habitat will include translucent windows that will not be locked. The windows can be opened in the event of fire or smoke. The windows will also be large enough to allow a human body to exit the artificial habitat through them in the case of an emergency.

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

Dr. Guy M. Smith
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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

Appendix E

Consent Form

CONSENT FORM

Embry-Riddle Aeronautical University

I consent to participating in the research project entitled: **Human Behavior during Spaceflight – Evidence from an Analog Environment.**

The principle investigator of the study is**: Kenny Arnaldi with supervision of Graduate thesis Chair, Dr. Guy M. Smith.**

The purpose of this experiment is to complete a research on the effects of the space environment on human performance during long-term deep space travel. To achieve this goal, a ground-based artificial environment (such as a trailer) will be used to create an analog environment to that of space travel (specifically, an orbital environment).

To be eligible for this experiment, participants must be 18 years of age or older. Participants must be able to read and speak English, and be good writers. They must have at least a 3.0 grade point average. Preference will be given to students of higher academic standing. Finally, participants must not suffer from Claustrophobia and are willing to live in a closed environment with others. During the experiment, participants may experience feelings associated with living in an enclosed environment, such as boredom and isolation.

The experiment is scheduled to last at least 50 consecutive hours, and may be extended to no more than 100 hours. Participants will be financially compensated per the ERAU undergraduate rate of $7.50/hour.

My personal information will be confidential. None of my information shall be revealed during the writing of the research paper. Participants will be identified through scientific enumeration (e.g., Subject 1 and Subject 2). All personal information shall be retained by the researcher and the collaborators by person.

The individual above, or their research assistants, have explained the purpose of the study, the procedures to be followed, and the expected duration of my participation. Possible benefits of the study have been described, as have alternative procedures, if such procedures are applicable and available. I acknowledge that I have received an entry briefing and an emergency briefing prior to the start of the experiment.

I acknowledge that I have had the opportunity to obtain additional information regarding the study and that any questions I have raised have been answered to my full satisfaction. Furthermore, I understand that I am free to withdraw consent at any time and to discontinue participation in the study without prejudice to me.

Finally, I acknowledge that I have read and fully understand the consent form and the participation release form. I sign it freely and voluntarily. A copy has been given to me.

Name (print): _____________________
(Participant)

Signed: __________________________
(Participant)

Signed: __________________________
(Researcher/Assistant)

Date: ____________________________

Appendix F

Participant Release Form

PARTICIPANT RELEASE FORM

Human Behavior during Spaceflight – Evidence From an Analog Environment

I, (name), hereby acknowledge that I will participate in the use of an Artificial Orbital Habitat (AOH) in order to experience and learn about the psychological and physiological effects of living in a closed environment. These effects are usually temporary, but since each person is different and has their own unique medical circumstances, I recognize that ERAU makes no representations as to how use of the AOH may affect me.

I agree that I am medically and otherwise fit to participate in the use of the Artificial Orbital Habitat, and that I am free to decline to participate in any activity I deem too risky, dangerous, or ill advised. My use of the AOH shall be conclusive evidence that I am fit and qualified to participate therein.

I understand that the experiment in the AOH will include a live video feed which will be monitored by research collaborators solely for safety purposes, and that no video/audio recordings will be kept or used without my consent. The video feed will only monitor public areas of the trailer and will not violate my privacy.

In consideration of permission to use the AOH, I hereby release, discharge, and hold harmless ERAU, its Trustees, Directors, officers, employees, agents, representatives, and successors in interest (indemnified parties) from any and all claims of whatever kind or nature, including serious bodily injury or death, for any and all claims, demands, obligations, and liabilities arising from, connected with, or related to my participation in or use of the AOH or any activity or event connected therewith.

I agree to defend and indemnify the indemnified parties on demand from any and all related claims, demands, obligations, and liabilities of whatever kind or nature. Additionally, I will not file, cause to be filed, participate in, permit, or cooperate with or in any action, claim, or demand against the indemnified parties for any act or event arising from, connected with, or related to my use of the AOH.

Any disputes arising from, related to, or in connection with this release or the activities to which it pertains shall be exclusively subject to the laws, jurisdiction, and venue of the State of Florida and County of Volusia. I agree to resolve any disputes between ERAU and me by means of mediation using a mutually agreed mediator. In the event of a failure of mediation for any reason, I agree that, in lieu of litigation in a court of law, the dispute shall be resolved by means of binding arbitration in which each side shall select an arbitrator to serve on an arbitration panel, and those selectees shall chose a third member of the arbitration panel who shall preside. The arbitration panel shall conduct the arbitration in accordance with the rules of the American Arbitration Association, and its ruling shall be final and binding upon the parties. Any part of this agreement that is deemed void or voidable shall be excised from this agreement and the remaining terms shall remain in full force and effect as though the excised term had never been included.

Signed: ______________________________________
Participant (print): _____________________________ Date: _______________
Witness: _____________________________________
(Printed): ____________________________________ Date: _______________

ERAU OGC Approved
1-030609-7/000 (01/13/2010)

Appendix G

Emergency Procedures

Emergency Procedures

Use standard caution when using the kitchen or any electrical appliances.

- In case the smoke detector alarms, determine that the cause of the smoke is eliminated and remove the smoke with the kitchen ventilating system. Notify the command station.
- In case the carbon monoxide detector alarms, turn on the kitchen ventilating system. Notify the command station immediately.
- In case of a hazardous situations that does NOT require immediate evacuation:
    1. Contact the command station via the walkie-talkies provided to you in the artificial habitat.
    2. If the walkie-talkies fail, contact the command station via the back-up telephone system installed in the artificial habitat.
    3. If the backup telephone system fails, wave at the video camera using both arms and wait for a collaborator to contact you.
- If the situation warrants an immediate evacuation:
    1. Do not lose time gathering your belongings.
    2. Open the door by pushing against its tape seal and exit the artificial habitat.
    3. Walk to a safe distance away from the artificial habitat and wait for a collaborator to come meet you.
    4. If required, verify the command station controllers have called 911
        - If you are unable to verify, then call 911 yourself.

Appendix H

Mission Control Schedule

Tables

H1 Professor Schedule

H2 CAPCOM Schedule

Table H1

Professor Schedule

Date	Time	Mission Elapsed Time	Professor
Friday X-X-XX	16:00	00:00	A
Friday X-X-XX	20:00	04:00	B
Saturday X-X-XX	06:00	14:00	C
Saturday X-X-XX	12:00	20:00	B
Saturday X-X-XX	18:00	26:00	A
Sunday X-X-XX	00:00	32:00	B
Sunday X-X-XX	06:00	38:00	C
Sunday X-X-XX	12:00	44:00	A

Table H2

CAPCOM Schedule

Date	Time	Mission Elapsed Time	Student
Friday X-X-XX	16:00	00:00	1
Friday X-X-XX	18:00	02:00	2
Friday X-X-XX	22:00	06:00	3
Friday X-X-XX	02:00	10:00	4
Saturday X-X-XX	08:00	16:00	1
Saturday X-X-XX	15:00	23:00	5
Saturday X-X-XX	19:00	27:00	4
Sunday X-X-XX	04:00	36:00	2
Sunday X-X-XX	11:00	43:00	5
Sunday X-X-XX	15:00	47:00	4

Appendix I

Participant Debriefing

Participant Debriefing

Human Behavior during Spaceflight - Evidence from an Analog Environment

Kenny Arnaldi (Principal Investigator)

Dr. Guy M. Smith (Faculty Advisor)

The experiment is now officially complete. You have spent a total time of 50 hours inside the Artificial Orbital Habitat. The informed consent form stated that the duration of the experiment might last up to 100 consecutive hours, although in reality the experiment was never planned to last longer than 50 consecutive hours. The purpose of this deceptive statement was to give you the impression that you may be isolated in the Artificial Orbital Habitat for longer than 50 hours, in an effort to prevent you from having feelings of excitement/relief as the 50-hour mark of mission elapsed time neared. I (the researcher) believe that knowing the true end time of the experiment would have influenced your mood, which in turn would have had an impact on your POMS 2™ tests.

Your POMS 2™ test results, KTS®-II test results, and participant log entries will remain confidential. The POMS 2™ and KTS®-II test results will solely be used for the purpose of the research, while your participant log entries will be reviewed in order to better develop future habitat studies.

You may gather all of your personal belongings. We will provide transportation to your vehicle/residence once you are ready.

Should you experience any after-effects of the experiment, please contact Dr. Smith immediately. We will meet with you on Monday to determine if there are any after-effects. Should you need immediate medical attention, contact 911 or a doctor.

Appendix J

Normal Environment Data Collection Protocol

Normal Environment Data Collection Protocol

Sunday X-X-XX

→ One POMS 2™ and one KTS®-II around P.M.
→ One POMS 2™ before bedtime.

Monday X-X-XX

→ One POMS 2™ in the morning.
→ One POMS 2™ after noon (or middle of the day).
→ One POMS 2™ in the evening.

Tuesday X-X-XX

→ One POMS 2™ in the morning.
→ One POMS 2™ after noon (or middle of the day).
→ One POMS 2™ and one KTS®-II in the evening.

Notes:

❖ Each POMS 2™ should be separated by 4 hours at least if possible.
❖ E-mail on Saturday X-X-XX with links to POMS 2™ and KTS®-II.
❖ Call Kenny Arnaldi immediately should there be any issues.