Meeting the Psychological Needs of Astronauts in the Flourishing Human Spaceflight Frontier:

The Case for Astronaut-Trained Psychologists

by

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A Dissertation Presented in Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

Liberty University

March, 2023

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ABSTRACT

Space psychology (i.e., astronaut psychological counseling and support) has remained largely unchanged since the onset of long-duration low-Earth-orbit (LEO) human spaceflight missions, with teletherapy utilized as the primary means of psychotherapy delivery. However, with NASA's plans to establish a permanent human presence on the Moon, the suitability of teletherapy – as well as astronaut-trained psychologists, an alternative space psychology method suggested for human spaceflight beyond LEO – must be ascertained. The aim of this novel space psychology investigation was to identify and compare the effectiveness of three astronaut psychotherapy treatment conditions (i.e., teletherapy with a 2 second Earth to LEO latency, teletherapy with a 10 second Earth to Moon latency, and in-person astronaut trained psychologist delivered therapy with practically no latency) at reducing stress levels among astronauts/astronaut-surrogates in an analogue human spaceflight environment. 24 screened astronaut-surrogates randomly underwent each of the astronaut psychotherapy treatments, and no astronaut-surrogate received repeated treatments. Stress indicators (i.e., heart rate, blood pressure, and self-reported perceived stress questionnaire scores) were measured at multiple intervals throughout the psychotherapy treatment sessions and were analyzed via repeated measures ANOVA. By all metrics, the astronaut-trained psychologist treatment significantly outperformed both teletherapy treatments at reducing stress; and teletherapy with 10 second latency was deemed unsuitable for astronauts. Thus, astronaut-trained psychologists appear to be the most efficacious feasibly integrable space psychology solution for improving wellbeing and reducing stress among individual astronauts and astronaut crews in future long duration human spaceflight operations and missions beyond LEO (e.g., NASA's Artemis Lunar mission).

Additionally, astronaut-trained psychologists appear to be highly effective when operating in LEO as well, and therefore are also ideal for space tourism and commercial astronaut applications.

Keywords: space psychology, astronaut-trained psychologist, teletherapy latency, long duration human spaceflight beyond LEO, aerospace human factors

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Dedication

The overtone of this space psychology investigation is how to overcome some of the most daunting challenges imaginable for human beings. Outside of writing this dissertation manuscript, my family too faced very daunting challenges.

I dedicate this dissertation manuscript to my family,

and dedicate my work to God.

Acknowledgments

The pace of my dissertation was particularly vigorous, and the topic novel, requiring more innovation and agility than would normally be needed from a PhD candidate and dissertation committee. Despite this, both my committee members, Dr. Mims-Beliles and Dr. Beiler, were on board with me even at 20,000 miles an hour. Their work and care throughout the entirety of this dissertation was incredible, and I am so grateful for their help.

The input from my second committee member, Dr. Beiler, was thorough and immensely beneficial, which greatly enhanced the quality of this manuscript. Though Dr. Beiler served on multiple dissertation committees concurrently, she nonetheless invested in my success and was there for me when it mattered.

Also tremendously impressive was Dr. Mims-Beliles, who despite accepting me as her first PhD candidate, took on her role as dissertation chair admirably, and conducted herself both eloquently and expertly. She is a true advocate, an exceptional academic, and friend.

I could not have asked for a more capable and supportive dissertation committee.

Thank you both so much.

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CHAPTER 1: INTRODUCTION TO THE STUDY

Introduction

The topic of this dissertation pertains to space psychology, which is the field of psychology that is implemented to select, train, and support individual astronauts and astronaut crews/teams via a combination of counseling psychology, engineering psychology/human factors engineering, and industrial organizational psychology (Landon et al., 2020). Specifically, the aim of this space psychology investigation is to identify the efficacies of multiple psychological counselling and support methods – namely, telepsychotherapy (teletherapy) and astronaut-trained psychologist delivered psychotherapy – by discerning how the therapies' delivery approach and respective latencies impact participant stress level indicators (i.e., heart rate, blood pressure, and self-reported stress level score). Worth noting is that space psychology and human spaceflight experiments are regularly and successfully conducted analogously on Earth, and that these analogous investigations inform space psychology and human spaceflight research and operations in a similar manner to studies carried out in situ in space (De La Torre et al., 2012).

Background

Though numerous human spaceflight and aerospace psychology/human factors investigations have been conducted and published – albeit minuscule in comparison to Earth-based psychology literature – there is practically no research regarding the application of and comparisons between different psychotherapy methods and their efficacies at reducing stress among astronauts in space. This gap in literature is due in large part to the difficulty associated with conducting space psychology research in situ, resulting from the extreme elevational distances (i.e., the distance that astronauts and their spacecraft/habitat are from the Earth) in which human spaceflight operations and missions occur (Antonsen et al., 2022). With that said, though reaching and sustaining life in space is difficult, human spaceflight in low-Earth orbit (LEO) is the most common and least difficult elevational distance to achieve. Therefore, it is no wonder that the majority of space psychology research and operations have been developed primarily for LEO applications. Excluding the Apollo missions which were relatively limited in number compared to the space shuttle and International Space Station (ISS) missions, the average distance that astronauts orbit the Earth is 250 miles from our planet's surface (NASA, 2020). Again, though that is certainly a significant distance, it does not seem quite as large or daunting when compared to the distances that astronauts on the Moon experienced, at an average of 238,855 miles from Earth (i.e., nearly 1,000 times farther respectively; NASA, 2021).

When contemplating these distances and the vastness of space, particularly living exposed in this vastness away from Earth and the security our planet provides, it is important to acknowledge that astronauts are humans too. Thus, it can be understood that as humans, albeit highly trained humans well suited for spaceflight, these astronauts are more likely than not going to experience a slew of negative effects and stressors which can be exacerbating and/or downright unbearable, and in turn risk astronaut performance, wellbeing, and mission success (Friedman & Bui, 2017; Genta, 2016; Sipes et al., 2016). Due to this inherent problem and being that human spaceflight missions are voyaging progressively deeper into space for longer durations, it is crucial that astronauts be de-stressed with the appropriate techniques and tools, which is where psychological counseling and support takes centerstage (Kessler et al., 2022). Filling this necessity is not a new development. In fact, psychological counseling and support has been implemented among astronauts since the onset of long-duration missions, as it was recognized as being essential for reducing stress and subsequently maintaining and improving astronaut happiness, health, performance, and the likelihood of mission success (Friedman &

Bui, 2017; Vakoch, 2011). Strangely, as mentioned previously, given the importance of psychological counseling and support for astronauts, there is a clear lack of research pertaining to the actual psychotherapy methods themselves. This lack of space psychology research is punctuated when contrasted with the abundance of Earth-based psychology research, which is an environment where the associated stressors and dangers pale in comparison to its space-based counterpart (Szocik, 2019).

Though human spaceflight is an extremely stressful endeavor regardless of how far astronauts live and work from Earth, it appears that this stress is magnified the farther away the astronauts are from their home the Earth (Clark, 2021; Heppener, 2019). Considering this, much of the malaise experienced in space can be thought of in part as a form of homesickness at an astronomically grand scale. It should be noted however that not all stressors are a result of this nor are they purely psychological in nature, since much of the stress and space-related disorders are due to the environment inside the spacecraft/habitat, the physical nature of space itself, and other threats (e.g., collisions with space debris and micrometeorites, potential for war and attacks on spacecraft/astronauts and supporting ground stations, etc.; Sokolski, 2022; Stewart & Rappaport, 2021; Thirsk et al., 2009).

One caveat to this notion however is that though astronauts do experience extreme stress and changes to their mood, behavior, cognition, and physiology, these changes and experiences are not entirely negative (Collett et al., 2020; Doarn et al., 2019; Sipes et al., 2016; 2016). Specifically, many astronauts have also reported astoundingly positive, spiritual even experiences in the spaceflight environment that have stayed with them for the rest of their lives, which have been coined the Overview Effect (Kanas, 2020; Weibel, 2020b). Along with the scientific and economic benefits that human spaceflight brings about, the Overview Effect also gives credence to the worthiness of human spaceflight from a psychological and spiritual/biblical perspective (Edwards, 2020; Weibel, 2020a).

Currently on the ISS, a spacecraft in LEO where astronauts from nations around the globe with different beliefs and cultures live and largely work together, psychological counseling and support is delivered via teletherapy, a virtual psychotherapy delivery method (NASA, 2018). Worth mentioning is that with teletherapy administered to astronauts aboard the ISS, and with any virtual communication with the ISS or any spacecraft for that matter, the distance between the spacecraft and the psychologist/personnel located on Earth determines the lag/delay (i.e., latency) between communication signals. Therefore, as human spaceflight missions extend beyond LEO (e.g., to the Moon), the latency experienced during teletherapy will balloon. As a result of this of this, and because of the stress-magnifying effects that farther distances from Earth have on astronauts, an alternative psychological counseling and support delivery method may be more effective than the standard teletherapy method currently implemented between the Earth and the ISS (Szocik, 2019). Specifically, one of the most promising alternative psychological counseling and support deliver methods proposed is in-person delivered psychotherapy, which incorporates an astronaut-trained psychologist to deliver psychotherapy and support to fellow astronaut crewmembers in-person (Szocik, 2019).

Problem Statement

Based on current literature, it is evident that long latencies have cascading negative impacts on communications/interactions, the primary communicators, and secondary/surrounding personnel (Blackett et al., 2021). Since latency is inherent in teleoperations and teletherapy, and being that teletherapy is currently the primary psychotherapy delivery method for astronauts, the likelihood that astronauts become exposed to these negative impacts is elevated (Feldstein & Ellis, 2021; NASA, 2018). When this occurs, the negative impacts can be compounded in a snowball-like manner, whereby – along with impairing astronauts' cognition, understanding, and performance – the ability for astronauts to efficiency and effectively complete teleoperated tasks (e.g., teletherapy, ground station-guided spacewalks, etc.) diminishes, whereby making subsequent and follow-up teletherapy sessions less impactful (Freer et al., 2020).

Moreover, under these circumstances, astronauts will likely be at significantly increased risk of emotional disorders, frustration, susceptibility to task loading, effort required to accomplish tasks in general, and mental demands (Kim et al., 2021). Furthermore, based on conventional teletherapy, virtual reality, and teleoperations research, it is clear that latency diminishes individual and group level performance as well as the quality of experiences in cooperative activities (Blackett et al., 2021; Geelhoed et al., 2009; Howard et al., 2014). If these effects are present in human spaceflight-based teletherapy applications, the team dynamics (e.g., team cohesion, performance, mood, etc.) of astronaut crews might degrade, which could potentially be catastrophic for crew wellbeing and mission success (Bell et al., 2019).

With regard to current teletherapy applications with astronauts on the ISS, though the associated latency for two-way communications is approximately two seconds, the applicability of this method appears to already be near its limit (i.e., the latency is long enough that negative cascading impacts can occur; Blackett et al., 2021). Also, as mentioned, since further distances between communicators (i.e., increased distances between the therapist and the astronaut) results in longer latencies, it is likely that teletherapy with Moon-based astronauts would be plagued with significant cascading issues that affect astronauts individually and crews as a whole. Notably, accounting for the physical and technological constraints of telecommunication relaying, two-way latency between the Earth and the Moon is approximately 10 seconds (McHenry et al., 2021).

Considering this long latency and its associated impacts, it is apparent that there is an insufficient amount of research/understanding pertaining to how teletherapy will reduce the stress levels of astronauts beyond LEO, let alone the stress levels of space tourists and commercial astronauts near LEO (Bushnell, 2021). These inherent incompatibilities and potential risks are why the astronaut-trained psychologist approach has been suggested in place of teletherapy (Szocik, 2019). Worth mentioning is that though at first glance the astronaut-trained psychologist approach seems to be ideal for psychotherapy delivery among astronauts, this new approach is particularly under-researched. Being that NASA plans to establish a permanent human presence on the Moon by the end of this decade, these unknowns pose huge issues for current and future human spaceflight operations (Heppener, 2019; Kessler et al., 2022; Reynolds, 2019). Therefore, it is not yet known whether or not teletherapy will be effective at reducing stress among astronauts operating beyond LEO, or if astronaut-trained psychologist delivered therapy is necessary.

Purpose of the Study

The purpose of this study is to quantitatively identify whether teletherapy or astronaut-trained psychologist delivered psychotherapy is more effective at reducing astronaut/astronaut-surrogate stress levels (i.e., heart rate, blood pressure, and self-reported stress level/PSQ scores) beyond LEO. Thus, the aim of this investigation is to identify whether teletherapy (with a 10 second Earth to Moon latency) or astronaut-trained psychologist delivered therapy (with no perceptible latency) is more effective at reducing stress among astronauts operating beyond LEO.

Research Question(s) and Hypotheses

Research Questions

Astronaut-Trained Psychologists Versus Earth-LEO (2 Second Latency) Teletherapy

The following research questions and hypotheses align with the problem statement by establishing a baseline comparison between the Earth-LEO teletherapy control with a 2 second latency (i.e., what is administered to astronauts on the ISS) and astronaut-trained psychologist-based therapy.

RQ1. Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 2 second Earth-LEO latency at reducing heart rate among astronaut-surrogates operating in simulated LEO conditions?

RQ2. Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 2 second Earth-LEO latency at reducing blood pressure among astronaut-surrogates operating in simulated LEO conditions?

RQ3. Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 2 second Earth-LEO latency at improving Perceived Stress Questionnaire (PSQ) scores among astronaut-surrogates operating in simulated LEO conditions?

Astronaut-Trained Psychologists Versus Earth-Moon (10 Second Latency) Teletherapy

The following research questions and hypotheses align with the problem statement by directly evaluating the effectiveness of astronaut-trained psychologist-delivered therapy versus teletherapy with a 10 second Earth-Moon latency.

RQ4. Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 10 second Earth-Moon latency at reducing heart rate among astronaut-surrogates operating in simulated Lunar conditions?

RQ5. Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 10 second Earth-Moon latency at reducing blood pressure among astronaut-surrogates operating in simulated Lunar conditions?

RQ6. Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 10 second Earth-Moon latency at improving PSQ scores among astronaut-surrogates operating in simulated Earth-Moon conditions?

Earth-LEO Teletherapy Versus Earth-Moon Teletherapy

The following research questions and hypotheses align with the problem statement by directly evaluating the effectiveness of Earth-LEO teletherapy (i.e., the control treatment method currently implemented with astronauts in LEO) versus teletherapy with a 10 second Earth-Moon latency. I.e., identifying if the amount of latency experienced by astronaut-surrogates during teletherapy has a significant effect on reducing stress.

RQ7. Is teletherapy with 10 second Earth-Moon latency less effective than conventional Earth-LEO teletherapy with 2 second latency at reducing heart rate among astronaut-surrogates operating in simulated Lunar conditions?

RQ8. Is teletherapy with 10 second Earth-Moon latency less effective than conventional Earth-LEO teletherapy with 2 second latency at reducing blood pressure among astronaut-surrogates operating in simulated Lunar conditions?

RQ9. Is teletherapy with 10 second Earth-Moon latency less effective than conventional Earth-LEO teletherapy with 2 second latency at improving PSQ scores among astronaut-surrogates operating in simulated Earth-Moon conditions?

Hypotheses

Note that the hypothesis number corresponds to the respective research question number identified above.

Hypothesis 1: Corresponding to RQ1

H_0. The type of therapy administered to astronaut-surrogates in Earth-LEO analogue conditions has no effect on their heart rate.

H_1. The type of therapy administered to astronaut-surrogates in Earth-LEO analogue conditions has a significant effect on their heart rate.

Hypothesis 2: Corresponding to RQ2

H_0. The type of therapy administered to astronaut-surrogates in Earth-LEO analogue conditions has no effect on their blood pressure.

H_1. The type of therapy administered to astronaut-surrogates in Earth-LEO analogue conditions has a significant effect on their blood pressure.

Hypothesis 3: Corresponding to RQ3

H_0. The type of therapy administered to astronaut-surrogates in Earth-LEO analogue conditions has no effect on their PSQ scores.

H_1. The type of therapy administered to astronaut-surrogates in Earth-LEO analogue conditions has a significant effect on their PSQ scores.

Hypothesis 4: Corresponding to RQ4

H_0. The type of therapy administered to astronaut-surrogates in Earth-Moon analogue conditions has no effect on their heart rate.

H_1. The type of therapy administered to astronaut-surrogates in Earth-Moon analogue conditions has a significant effect on their heart rate.

Hypothesis 5: Corresponding to RQ5

H_0. The type of therapy administered to astronaut-surrogates in Earth-Moon analogue conditions has no effect on their blood pressure.

H_1. The type of therapy administered to astronaut-surrogates in Earth-Moon analogue conditions has a significant effect on their blood pressure.

Hypothesis 6: Corresponding to RQ6

H_0. The type of therapy administered to astronaut-surrogates in Earth-Moon analogue conditions has no effect on their PSQ scores.

H_1. The type of therapy administered to astronaut-surrogates in Earth-Moon analogue conditions has a significant effect on their PSQ scores.

Hypothesis 7: Corresponding to RQ7

H_0. The amount of latency experienced by astronaut-surrogates during teletherapy has no effect on heart rate.

H_1. The amount of latency experienced by astronaut-surrogates during teletherapy has a significant effect on heart rate.

Hypothesis 8: Corresponding to RQ8

H_0. The amount of latency experienced by astronaut-surrogates during teletherapy has no effect on blood pressure.

H_1. The amount of latency experienced by astronaut-surrogates during teletherapy has a significant effect on blood pressure.

Hypothesis 9: Corresponding to RQ9

H_0. The amount of latency experienced by astronaut-surrogates during teletherapy has no effect on PSQ scores.

H_1. The amount of latency experienced by astronaut-surrogates during teletherapy has a significant effect on PSQ scores.

Assumptions and Limitations of the Study

This study could be considered somewhat limited in its scope as it is quantitative, and therefore qualitative perspectives are left out. Also worth mentioning is that this study is conducted on Earth as an analogue to human spaceflight rather than in space, and though this too could be considered a limitation, the assumption is that this is not a limiting factor. This assumption is based on current human spaceflight and space psychology studies which are regularly and successfully conducted analogously on Earth (Casini et al., 2020; Gruber et al., 2019; Lester et al., 2017; Maria Kołodziejczyk & Harasymczuk, 2022; McMenamin et al., 2020; Ong et al., 2021; Poulet et al., 2021; Sauro et al., 2021). Therefore, it can be assumed that this analogue-based investigation will inform/contribute to space psychology research as well as human spaceflight operations in a similar manner to studies carried out in situ in the spaceflight environment.

Another limitation is participant availability. As the number of participants required for the study is N = 24, it would have been difficult to source a sufficient number of professional astronauts. To overcome this potential limitation, astronauts-surrogates (i.e., screened participants who work in aerospace-relevant careers such as pilots, space systems engineers, aerospace human factors engineers, aerospace experimental psychologists, etc.) have been included as participants in this study instead. Additionally, because there does not appear to be significant differences in performance/test scores in cognition-based experiments between astronaut-surrogates and actual astronauts, it is assumed that astronaut-surrogates are suitable for analogue human spaceflight studies, and that they adequately stand-in for their astronaut counterparts (Casario et al., 2022). Also worth mentioning is that because the sample is relatively small compared to other psychological studies, it might be more difficult to identify significant trends/results in the data.

Additionally, it is worth mentioning that astronauts are a very small population. Furthermore, to become a NASA and/or DOD astronaut, candidates must undergo rigorous screening/training that most people would not pass/be able to endure. It takes a special kind of person to be an astronaut, and therefore the population itself can be considered unique, with many factors and traits (e.g., genetics, having to overcome existentially difficult and/or traumatic experiences, upbringing, etc.) playing a role in their mindset, abilities, determination, etc.

With regards to the PSQ score dependent variable, though it is a suitable and commonly administered test, it is nonetheless subjective due to its self-reported nature. Therefore, in some ways the PSQ could be considered somewhat flawed as it may leave room for subjective error and bias (Montero-Marin et al., 2014). With that said, because quantitative stress-related biometric data is also at the center of this experiment, it is assumed that the PSQ's potentially impaired construct validity has not disqualify it from being used in the study (Schmidt et al., 2020).

With regards to the hypothesized results of the experiment, it was predicted that the astronaut-trained psychologist treatment condition would outperform the 10 second latency Earth-Moon teletherapy treatment condition. This prediction is based on the assumption that a 10 second latency is simply too long for virtually delivered therapy to be effective. Moreover, the astronaut-trained psychologist method has the added advantage of being delivered in person, and therefore is inherently more personable than virtually delivered therapy (Szocik, 2019). Additionally, there were no assumptions made with the control treatment (i.e., the 2 second latency Earth-LEO teletherapy treatment condition). It should also be mentioned that though astronaut-surrogates are fitting stand-ins for astronauts in this study, they themselves have not actually been prepped for a Lunar mission, nor have they agreed to the terms, conditions, and consequences of said mission/s. Therefore, the astronaut-surrogates' aversion and incompatibility with such latencies, if present, could potentially differ to those experienced by actual astronauts' in said human spaceflight environments.

Theoretical Foundations of the Study

As mentioned, this study is quantitative in nature, which was purposely selected because of the apparent gap in space psychology relevant research which has been primarily qualitative (Le Scanff et al., 1997; Romero & Francisco, 2020; Suedfeld et al., 2018). Furthermore, to better assess astronauts'/astronaut-surrogates' stress levels in real time, tracking biometric data (i.e., heart rate and blood pressure) during therapy sessions was determined to be more appropriate/better suited than implementing qualitative approaches (e.g., interviews, focus groups, subjective observations, etc.). The theoretical foundation of this study is based on current space psychology and astronaut research where the experiments are conducted on Earth in human spaceflight analogous environments rather than in space (e.g., with long-duration human spaceflight, Lunar, and Martian analogue studies conducted in simulated spacecraft/astronaut habitats under water, in high deserts, Antarctica, etc.; (Casini et al., 2020; Gruber et al., 2019; Maria Kołodziejczyk & Harasymczuk, 2022; McMenamin et al., 2020; Ong et al., 2021; Poulet et al., 2021; Sauro et al., 2021). This is actually very common with human spaceflight investigations as it is typically less expensive to run and logistically simpler to conduct on Earth than in space (Weiss et al., 2012).

With regards to theories, the primary theories implemented in space psychology include: Self-Determination Theory, as well as Eastern and Western (Cold War era) space psychology theory. Note that much of these space psychology theories focus on/pertain to astronaut selection, testing, training, as well as experimentation, and less so with the administration of psychotherapy during human spaceflight. As mentioned, this study aims to address this gap in the literature. With regards to Self-Determination Theory, Goemaere et al. (2016) identifies the approach as,

> a macro theory of human motivation, behavior, and well-being, which investigates people′s innate psychological needs that are at the basis of their motivation and personality integration, as well as the conditions that foster those positive processes. The theory can be used to make predictions about the way social environments can be designed to optimize people′s development, performance and well-being. SDT is strongly embedded in positive psychology, as the theory helps to explain how people′s natural tendency for growth and learning can be enhanced and elevated. At the same time, it accounts for ill-being and maladaptive behavior by regarding them as outcomes of encountered frustration of these same psychological needs. In doing so, SDT goes beyond most positive psychological theories because it provides a dialectic account of both the positive and negative processes in human development.
>
> According to SDT, people have three inherent psychological needs: competence, relatedness and autonomy.
>
> 1. When people experience *competence*, they feel effective and successful in dealing with the environment. It is the belief that one has the ability to influence important outcomes.

2. When people experience *relatedness*, they feel connected and experience care for important others, through satisfying, supportive social relationships.
3. When people experience *autonomy*, they experience a sense of personal choice, volition and psychological freedom, through acting upon personally endorsed values and interests.

> Different from other motivational frameworks, including the Motive Disposition Perspective, 2 which consider the needs to be personal preferences acquired through different childhood experiences. SDT considers these needs to be inherent and universal. (p.134)

The universality of this theory suggests that space psychology research is applicable regardless of the people's/participant's gender, cultural background, socio-economic status, etc. Thus, incorporating astronaut-surrogate participates into the study is grounded in tried-and-true theory.

With regards to the Cold War era theories, namely, the Eastern and Western theories (i.e., space psychology theories implemented by the Soviet Union and the Unites States of America respectively), the two's theories were fundamentally different. Specifically, the Eastern psychological approach was heavily influenced by biophysical and biorhythmic theory, which the West waived off as pseudoscience. Conversely, the Western space psychology approach was adopted from the United States' aviation practices, which were primarily personality- and performance-based. With that said, unlike Western theory which focused primarily on pre-flight/launch psychological testing, Eastern theory focused on psychotherapy-like support before and during the human spaceflight mission/s. This approach was later adopted and expanded by the West at the onset of long-duration human spaceflight missions; Musson, 2006).

The scientific/psychological theories and spiritual/biblical perspectives investigated and presented in this study are done so through a Levels of Explanation model. Levels of Explanation was selected because of its universal nature, ensuring that this space psychology study does not become more esoteric than need be. (von Ehrenfried, 2017; Weibel, 2016) It should also be noted that within Levels of Explanation, science/psychology and spirituality are not separate tiers but rather axis, since tiers imply a hierarchy. Moreover, science/psychology and spirituality are treated objectively, separate yet equal. Therefore, the multi-axial nature of Levels of Explanation accommodates an array of unique modalities that might otherwise appear incompatible through a less universal framework. To expand further, thanks to the multi-axial nature of Levels of Explanation, the biblical perspective of human spaceflight exploration and motivation can be evaluated alongside the scientific perspective.

One example that illustrates the importance of human spaceflight and space psychology viewed through this multi-axial worldview is the story of Noah's Ark. Through this viewpoint, consider the Ark as a spacecraft, the flood as the space environment which envelopes the Earth, and Noah as an astronaut. While he himself was a capable individual – as are astronauts – it can be seen than that were it not for Noah's family (i.e., his support crew), he likely would have failed to carry out the mission tasked to him by God. Therefore, it is apparent that astronaut support, namely, psychological support, is vital for mission success. Furthermore, this comparison is particularly applicable as it illustrates the importance of survival when faced with an existential threat. One such existential threat is the potential for an asteroid impact with the Earth (Beard et al., 2020). With respect to this comparison, the multi-axial importance of Ark-like protection/s (i.e., a permanent presence in space and on other celestial bodies) is evident, where countermeasures are made to ensure the survival of humanity in the event that life on

Earth is not feasible/survivable for some period. Of course, the importance of space psychology is not limited to such extreme cases. Simply comforting astronauts, enhancing their capabilities, and furthering the United States' space preeminence is reason enough.

Definition of Terms

The following is a list of definitions of terms that are used in this study:

Astronaut-Trained Psychologists

Astronaut-trained psychologists are individuals with doctorates in psychology who have completed extensive astronaut training, enabling them to work in space with their fellow astronaut crewmembers. In space, astronaut-trained psychologists provide in-person psychological counseling and support to fellow astronauts, as well as complete other astronaut tasks.

Earth-LEO

A system involving the Earth and the orbital space near Earth known as low-Earth orbit.

Earth-Moon

A system involving the Earth and the Moon.

EVA

Extravehicular Activity. Traveling and operating outside the confines of a spacecraft/habitat.

DOD

Department of Defense. The Department of Defense is the governing agency that oversees the branches of the United States' military.

ISS

International Space Station. The International Space Station is currently the largest and longest operating spacecraft orbiting the Earth. It orbits the Earth at approximately 250 miles above the planet's surface, and is ran jointly by multiple nations, though primarily the United States.

Latency

With respect to human spaceflight telecommunication, latency is the lag/delay that it takes telecommunication signals to travel between communicators/transceivers. Latency is inherent with telecommunication and teletherapy, and the magnitude of latency is a result of technological constraints (e.g., computation, processing, and handling of communication signals between space vessels, satellites, communication hubs, and ground stations, etc.) and physical constraints (i.e., the time that it takes light to travel between telecommunication transceivers/communicators).

LEO

Low-Earth orbit. Low-Earth orbit is the orbital space near the Earth.

NASA

National Aeronautics and Space Administration. The National Aeronautics and Space Administration is the United States' preeminent civilian space organization.

Teletherapy

Telepsychotherapy. Teletherapy is a virtually delivered form of psychotherapy, counseling, and support.

Significance of the Study

This research is particularly important as there is currently a research gap pertaining to the administration of psychological counseling and support for astronauts beyond LEO (e.g., to the Moon and Mars). Furthermore, of the research that does exist, quantitative studies are few and far between, and many studies are simply reviews or calls for further investigations, making no experiment-based contributions. Being that NASA plans to establish a permanent human presence on the Moon by this decade, it is imperative to identify what psychological support tools are most effective for reducing astronaut stress (Goemaere et al., 2019; Oluwafemi et al., 2021; Witze, 2017).

Along with improving astronaut-delivered psychological support to Lunar-based astronauts, the results of this study can also be applied to and benefit space tourism and commercial human spaceflight operations. This perspective is particularly impactful as both of these private nontraditional astronaut platforms are flourishing. Moreover, this influx of space tourism and commercial astronauts equates to more people in space who are typically less trained, less experienced, and not as well suited for human spaceflight compared to their NASA and military astronaut counterparts (Bushnell, 2021). Therefore, it can be assumed that these space tourists and commercial astronauts will be more reliant upon advanced psychological aids such as astronaut-trained psychologists so as to cope with the stressors of human spaceflight. Moreover, this study helps to identify if a more effective and hands-on psychotherapy delivery method (i.e., the astronaut-trained psychologist method) is required to sustain space tourism and commercial astronaut activities near LEO as well as on the Moon and Mars.

As mentioned, this study will contribute to space psychology literature/theories by filling the current in-flight astronaut-delivered psychology research gap. Note that given the esoteric nature of this space-psychology study, though the contributions can be applied to Earth-based teletherapy/telecommunications, the contributions will predominantly gravitate to space-based applications. Therefore, from an organizational perspective, space agencies such as NASA, DOD space operations, and commercial human spaceflight organizations will be impacted the largest.

Summary

Human spaceflight is spiritual/biblical, scientific, and technical in nature (Newell, 2019). To adequately carryout this dual natured research, a Levels of Explanation approach was selected. While the engineering and scientific aspects go without saying, the spiritual/biblical aspect of human spaceflight has been observed in the form of the overview effect, which radically changes astronauts' worldviews on an emotional and spiritual level (Weibel, 2020b). Of course, the profound experiences of operating and living in space are not without their challenges (Young & Sutton, 2021). Specifically, while in space, astronauts face extremely stressful conditions and hazards in their daily lives (Ganse & Ganse, 2020). Thus, adequate psychological counseling and support is necessary for astronaut wellbeing and mission success (Goemaere et al., 2019).

Based on current literature, it is not clear if teletherapy will adequately the reduce the stress levels of astronauts living and working beyond LEO, or if the hands-on/in person astronaut-trained psychologist method is required instead (NASA, 2018; Szocik, 2019). Therefore, the aim of this study is to quantitatively identify whether teletherapy or astronaut-trained psychologist delivered psychotherapy is more effective at reducing astronaut/astronaut-surrogate stress levels (i.e., heart rate, blood pressure, and self-reported stress level/PSQ scores) beyond LEO. Note that the three levels of the independent variable are: Earth-LEO teletherapy with a 2 second latency, Earth-Moon teletherapy with a 10 second latency, and in-person astronaut trained psychologist delivered psychotherapy with practically no latency perceptible to the astronaut/astronaut-surrogate.

To reiterate, NASA plans to establish a permanent human presence on the Moon by this decade. However, there is currently a research gap pertaining to the administration of psychological counseling and support for astronauts beyond LEO. This study is significant because, along with closing the aforementioned research gap, it also identifies whether teletherapy or astronaut-trained psychologists are more effective at reducing astronaut stress during LEO and Lunar human spaceflight operations/activities. A literature review was conducted in order to better construct the research methodologies and approaches carried out in this study. The literature search strategy, review of literature, as well as biblical and psychological foundations of the study are identified and discussed at length in Chapter 2.

CHAPTER 2: LITERATURE REVIEW

Overview

The primary focus of this literature review serves to identify the currently well researched stressors regarding human spaceflight, as well as identify what research gaps are present in space-based teletherapy-relevant literature. Particular attention was placed on latencies and their impacts on individuals and groups. Upon reviewing the literature, it became evident that there were practically no studies which investigated/assessed the impact/s of communication latency on astronaut wellbeing. In fact, even with Earth-based teletherapy research, there was somewhat of a research gap. So as to better understand the variety and intensity of stressors that astronauts are faced with on a daily basis in space, the known stressors are presented and discussed below. Also discussed are the stress level indicators and their suitability for the study.

Description of Search Strategy

A comprehensive literature search was implemented on multiple databases (e.g., Scholar, PubMed, etc.). Scholarly literature and grey literature were the primary types searched for. Additionally, current literature (i.e., published within 5 years) was treated preferentially. Moreover, space psychology research conducted/reviewed through a biblical worldview/framework was particularly sparse, likely due to its extremely esoteric nature. Note that bible sources were pulled from the New American Standard and English Standard versions. Thus, through the Levels of Explanation approach, scientific/psychological and spiritual/biblical works were more often than not assessed separately, with premises analyzed and reconstituted post-search.

Review of Literature

Astronauts-Surrogates

Compared to other professions, astronauts comprise a very small population. Therefore, many analogue studies opt for astronaut-surrogate participants in addition to/instead of astronauts (Casario et al., 2022; Scully et al., 2019). As the name suggests, astronaut-surrogates are participants that have astronaut/aerospace relevant experiences (e.g., pilots, aerospace engineers, scientists, etc.), but are not actually professional astronauts. With that said, it has been shown that if participants are screened/selected appropriately, there does not appear to be significant differences between astronaut-surrogates and actual astronauts regarding their responses/performance in cognition-based experiments/evaluations (Casario et al., 2022). Therefore, it is assumed that astronaut-surrogates are suitable for analogue human spaceflight studies and that they simulate/represent their astronaut counterparts well.

Human Spaceflight Analogous Environments

As mentioned, analogue-based human spaceflight studies are very common. These analogue studies are not limited to smaller and less funded research groups however, as they are often conducted by giants like NASA and DOD (AFTC History Office Edwards United States, 2018; Landon, 2020). Partial gravity analogue experiments (i.e., experiments in the simulated Lunar environment) are particularly well suited for Earth-based testing (Hoppenbrouwers et al., 2017). This is because like the Earth, the Moon also has significant gravitational force, albeit quite weak compared to the Earth’s (NASA, 2022).

Due to the extreme differences in gravitational force (i.e., gravity on Earth is substantial, whereas the force of microgravity in space is practically zero), microgravity analogue experiments, though commonly conducted on Earth, are not as closely matched in comparison to Earth-based Moon/partial gravity analogues. To overcome these large differences, experiments can be conducted underwater, where participants are typically submerged in pools such as

NASA's Neutral Buoyancy Laboratory (Gerzer & Cromwell, 2021; Vu et al., 2022). However, this approach is not feasible for this space psychology study, and therefore the entire experiment has been conducted on land in an altitude test chamber specifically developed for aerospace testing and training.

Known Stressors

Abnormal/Altered Microbiome

To reduce the risk of contaminating the ISS and the astronauts aboard with Earth-based illnesses, viruses, etc., astronauts complete a one-to-two-week preflight quarantine on Earth in a controlled environment prior to boarding the rocket/spacecraft and launching to space (Pavletić et al., 2022; Peake, 2017). Though this method is effective at reducing said transmissions, dramatic environmental changes such as undergoing lengthy quarantine can also impede the biodiversity and abundance of beneficial microbes in the astronaut's microbiome (Domingues et al., 2020; Makedonas et al., 2020).

As an additional precaution to reduce the risk of transmission/contamination, the launch payload and the items within them (e.g., food and water, instruments, etc.) sent from Earth to the ISS are disinfected/sterilized (Seedhouse, 2016). Due to the chronic preflight quarantines and sterilization, the astronauts' microbiomes and the microbiome present in the ISS habitat can become compromised, resulting in poor biodiversity and an unbalanced abundance of harmful microbes (Siddiqui et al., 2020; Tesei et al., 2022). When this occurs, astronauts become more at risk of contracting/suffering from skin irritation, infections, compromised gut microbiome, as well as issues with immunity, digestion, metabolism, bones, muscles, and the brain (Siddiqui et al., 2020). Furthermore, compromised gut microbiomes are linked to mood/mental disorders, depression, and anxiety (Schrodt et al., 2022; Sumich et al., 2022; Winter et al., 2018). Sarkar et al. (2018, p. 611) states that, “gut microbes are associated with important psychophysiological functions, including neurodevelopment and neurotransmission, emotion and stress, learning and memory, social behavior, autism, and aging.” In fact, microbes play such a large role in neurophysiology that, in animal models, microbes have been shown to regulate blood pressure (Al Khodor et al., 2017). Thus, the altered microbiome present in the ISS adds an additional quasi-invisible element in astronaut stress dynamics (Van Houdt & Leys, 2019).

Extreme Temperatures

Temperatures on the day/sun facing side of the ISS can reach 121°C, whereas the night/shaded side can reach -157°C (NASA, 2001). Similarly, the Moon’s day/sun facing side can reach 127°C, and the night/shaded side can reach -173°C (NASA, 2022). Without adequate protection, humans would not be able to survive in these temperatures, which is why redundant and robust thermal protection (e.g., multi-layer insulation, heaters, heat pipes, radiators, louvers, etc.) is used on the ISS (NASA, 2001). When it comes to extravehicular activities (EVA) and spacesuits, thermal protection is largely similar to that on the ISS, except for being more compact and including an embedded water-based heat exchanger to prevent overheating and heat disorders (NASA, 2019a). Though these spacesuits do provide thermal protection, their operation has not been without failure (Holschuh & Newman, 2021). For example, in the event that an astronaut’s spacesuit is compromised during an EVA, not only is the astronaut exposed to extreme temperatures, but they can also face unintended secondary risks/dangers such as: gas leaks/depressurization which reduce the effectiveness of convection and may lead to suffocation, as well as water/liquid leaks that may result in drowning (Meyer & Bartush, 2018).

From a thermal comfort perspective, the presence of ≥ 5°C temperature swings and sustained elevated temperatures of only 1°C above normal ambient temperatures may lead to an increase in mental health issues (Palinkas & Wong, 2020). Moreover, these temperature extreme fluctuations in the ambient environment are linked to increased rates of aggressive behavior and crime (e.g., physical assaults and homicides), as well as suicide (Palinkas & Wong, 2020). Additionally, excessive heat can result in dehydration and functional hypothyroidism, which can bring about lethargy, mood disorders, as well as cognitive impairment (Palinkas & Wong, 2020). As space tourism continues to grow (i.e., as people who potentially have underlying health issues and/or people who would not normally pass NASA and DOD health screenings make their way to space), extreme heat may become a more pressing stressor, resulting in elevated risk of morbidity and mortality (Kanas, 2015; Kluge et al., 2013; Palinkas & Wong, 2020).

Space Radiation

There are three primary sources of ionizing radiation in space (i.e., space radiation): solar flares and coronal mass ejections emitted by the Sun, galactic cosmic rays produced outside of the solar system, and radiation belts/magnetic fields of celestial bodies (e.g., the Earth, Jupiter, Saturn, Uranus, Neptune, etc.) that trap charged particles (NASA, 2019b). Worth mentioning is that though radiation belts/magnetic fields themselves can be dangerous from a radioactivity standpoint, they also shield the host celestial body and its inhabitants from space radiation (e.g., how the Earth’s magnetosphere blocks space radiation from damaging the cells of biological lifeforms) (Buis, 2021; Koskinen & Kilpua, 2022). From a human spaceflight perspective, the radioactive dose imparted upon spacecrafts and astronauts by radiation belts/magnetic fields is largely based on orbital inclination (i.e., the angle at which the orbital plane of the spacecraft and/or astronaut intersects the plane of the radiation belt/magnetic field) and orbital altitude (i.e., the distance between the spacecraft/astronaut and the celestial body) (NASA, 2004).

Therefore, astronauts aboard the ISS are still largely protected by Earth's magnetosphere, albeit less so than humans on Earth (Benton & Benton, 2001). However, even with this protection, astronauts are still at elevated risk of radiation induced: cardiovascular diseases, cancer, decreased immunity, issues related to the nervous system, gastrointestinal syndrome, impaired learning and memory, loss of coordination, cognitive disfunction and behavioral issues, alterations to DNA and chromosomes, death, etc. (Collett et al., 2020; Elgart et al., 2018; Hellweg & Baumstark-Khan, 2007; Mhatre et al., 2022).

Furthermore, as human spaceflight missions extend beyond LEO to the Moon – which provides significantly less protection against space radiation than the Earth – the astronauts stationed on the Moon will be exposed to nearly three times more radioactivity from galactic cosmic rays alone (Zhang et al., 2020). What makes matters worse is that psychological stress appears to play a role in radiation sensitivity, where psychologically stressed individuals become more susceptible to radiocarcinogenesis (Wang et al., 2016). Thus, it appears that stress and radiation might have a compounding/snowball effect.

Isolation and Confinement

Being that humans and their ancestors have spent their entire physical lives on Earth, it is no surprise that leaving the planet and living in space can be met with astounding feelings of change and/or visceral mental and emotional discomfort (Doarn et al., 2019; Szocik et al., 2018). Moreover, the potential for profound homesickness and discomfort can also be further exacerbated by the habitability- and comfort-related issues inherent with human spaceflight (Musso et al., 2017). For example, spacecrafts and human spaceflight habitats have traditionally been made to fit within small form factors and low mass designs so as to minimize launch expenses (Chen et al., 2021; Shao et al., 2016). Due to these imposed design requirements, many ergonomically beneficial features (e.g., numerous large windows/viewports, spacious common and private rooms/areas, sensory stimulating spatial designs/architectures and haptic surfaces, greenhouses, etc.) are forgone, resulting in barren habits that leave astronauts wanting (Häuplik-Meusburger & Bishop, 2021; Ko et al., 2020; Szocik et al., 2018).

The negative emotional responses of isolation and confinement in space are particularly prominent in the first and third quarters of human spaceflight missions (i.e., when the astronauts initially experience the spaceflight environment and while astronauts are in the thick of their mission respectively) (Alfano et al., 2018). Additionally, negative emotional responses appear to increase with longer duration missions, and anger/aggression increases significantly in the second half of these missions (Alfano et al., 2018). Along with irritability and anger, living in isolated, confined, and extreme environments has been shown to significantly increase the likelihood of mood disorders and depressive symptoms (e.g., sadness, irritability, hostility, etc.) (Alfano et al., 2018).

Lack of Atmospheric Pressure

As there is practically no atmosphere in space or on the Moon, the vacuum of space is inherently incompatible and deadly to humans (Reynolds, 2019). To enable human survival in these extreme hypobaric environments, astronauts live in artificial habitats which are pressurized and must maintain their structural integrity throughout the entirety of their operational lifecycle (Chisabas et al., 2018; Russell et al., 2019). This fragile existence is understood by the astronauts, and can subsequently take a large emotional toll on the astronauts' psyches (Sgobba et al., 2017; Szocik et al., 2018).

Sunlight Exposure

Astronauts living on the ISS are limited to only two options for natural lighting/sunlight exposure (NASA, 2010). The first option is in the cupola observational module, which is the only module on the ISS with large viewing windows/ports (Burattini et al., 2016). However, the volume of this module is small, only able to fit several astronauts. Moreover, due to the astronauts' work schedules, they cannot stay/rest in the cupola for long (Mesmer-Magnus et al., 2020). The second is when wearing a spacesuit while performing EVAs. With this option however, only the astronauts' faces are exposed to sunlight (Tadesse & Abate, 2022). Furthermore, due to the particularly high-risk nature of EVAs, astronauts must stay on task and cannot use EVAs as leisure like they might in the cupola (Belobrajdic et al., 2021). On top of that, since the astronauts are not protected by the atmosphere and its light scattering properties, sunlight can be uncomfortably bright and hot (Tribble, 2020). To prevent this optical and thermal discomfort, visors and windows/viewports are typically equipped with a protective gold-laminated/-coated layer (Dervay et al., 2020).

With all this said, the more pressing and chronic issue is not too much light exposure, but rather too little. Specifically, inadequate exposure to sunlight can increase the likelihood of: sleep problems, impaired daytime functioning, obesity, diabetes, depression, cardiovascular diseases, and cancer (Münch et al., 2020). These effects are not only felt by astronauts, but by humans all over the globe as well, as seen by the disproportionately elevated rates of depression, mood disorders, and psychiatric hospitalizations in countries with relatively lower sunlight intensity and fewer hours of sunlight per day (Bedrosian & Nelson, 2017; Burns et al., 2021; Kent et al., 2009).

Microgravity and Partial Gravity

Gravity on Earth is substantial, and biological life on Earth has physiological features to cope with its force. For example, were it not for the cardiovascular system, blood would pool around the legs and feet under Earth's gravity. Additionally, the heart behaves as a pump and circulates blood throughout the body so as to deliver freshly oxygenated blood and refresh deoxygenated blood (i.e., remove CO_2 and add O_2). Therefore, without this strong circulatory system on Earth, the head would be starved of blood since it is the uppermost part of the body, and the human body would subsequently be unresponsive.

However, in space where there is microgravity or on the Moon where there is partial gravity (i.e., a substantial amount of gravitational force that is less than Earth's gravity), the heart has miniscule resistance acting upon it, and therefore excess blood is pumped to the head. This fluid shift can cause changes and issues in the brain (e.g., intracranial pressure, cerebral blood velocity, neurologic dysfunction, cerebrospinal fluid volume increase, etc.) and eyes (e.g., intraocular pressure, globe deformation, neuro-ocular syndrome, etc.) (Alperin & Bagci, 2018; Iwasaki et al., 2020; Limoli et al., 2018; Yang et al., 2022). Along with these physiological impacts, there are also subsequent impacts on astronaut mood as temporary and/or permanent impairments to neurology and vision are not warmly welcomed by astronauts.

Microgravity and partial gravity can also hinder mood, behavior, and cognition by reducing astronauts' quality of sleep and time slept. Though astronauts can train for microgravity and partial gravity via simulators, with neutral buoyancy suits underwater, and parabolic flights on aircraft, the experiences are relatively brief and do not accommodate for full-length sleep training. Therefore, when in space, many astronauts experience difficulty acclimating, suffer from motion sickness, and difficulty sleeping (Chokroverty, 2017). To overcome these issues, astronauts are administered over-the-counter and prescription medications (Kast et al., 2017).

Noteworthy is that these medications are not the end all be all, and that sleep therapy and mindfulness are also helpful tools used by astronauts (Eyal & Derendorf, 2019; Pagnini et al., 2019).

Micrometeorites

As mentioned with the space vacuum/lack of atmospheric pressure stressor, it is vital that the structural integrity of spacecrafts, spacesuits, and habitats are not compromised (Thomas & McMann, 2011). From a frequency standpoint, micrometeorites pose the largest threat here, as impacts are so common that they are considered routine (Cesari, 2022). Being that micrometeorites travel at a velocity of 10 to 20 kilometers per second (i.e., approximately 25 times faster than a bullet), were it not for impact-protective shielding, the potential for damage caused by impacts with micrometeorites and roque space debris could be catastrophic (Rickman et al., 2017). The astronauts are aware of the potential for these collisions, and some have even experienced near miss incidents firsthand during EVAs (Shayler, 2019). Knowing that this danger looms and can strike at any moment is difficult to cope with, which can subsequently cause increased stress and be detrimental to work productivity and team dynamics (Palinkas & Suedfeld, 2021; Roma & Bedwell, 2017).

Space Psychology and Research Gaps

Teletherapy and Latency

Though numerous teletherapy studies have been conducted on Earth, there appears to be a research gap with non-Earth-based teletherapy applications (e.g., teletherapy delivered to humans in the microgravity spaceflight environment and in partial gravity environments such as the Moon and Mars) (North & North, 2016). To supplement this gap, literature from Earth-based teletherapy studies can be extrapolated to inform space psychology investigations. However, it should be noted that though there is an abundance of Earth-based psychology and teletherapy literature, very little of that literature discusses latency and its effect/s on therapy efficacy.

With that said, it is known that three important aspects of the telecommunication process are particularly prone to latency-based space operational issues. These aspects are:

Time—how to track the timing of individual messages; how to know when to expect a response from a remote team member.

Thread—how to keep track of conversational threads to ensure that topics are synchronized and messages are aligned correctly.

Transmission Efficiency—how to ensure shared situation understanding (common ground) between remote partners in as few messages as possible (Mosier and Fischer 2021, pp. 2-3).

Thus, it is clear that latency does impact the quality and efficiency of telecommunications and interactions. With that said, based on the current literature, it is not yet fully known what effects said latencies have on space-based teletherapy and its efficacy, particularly beyond LEO (Blackett et al., 2021; Geelhoed et al., 2009). Though latency for two-way communications between the Earth and LEO – as is the case for teletherapy delivered to astronauts on the ISS – is approximately two seconds, the farther the distances between communicators (e.g., the distance between the therapist and the astronaut), the larger the latency becomes (Sargsyan et al., 2005). For example, accounting for technological communication relaying (e.g., computation, processing, and handling of communication signals between space vessels, satellites, communication hubs, and ground stations, etc.), latency between the Earth and the Moon is approximately 10 seconds (McHenry et al., 2021). While the 2 seconds of latency associated with Earth-LEO teletherapy might seem irritating, a 10 second delay could be downright infuriating and counterproductive, actually making the astronauts more stressed, irritated, worse behaved, less stable, and underperform (Yang & Dorneich, 2017). Worth mentioning is that teletherapy delivered to astronauts on the ISS is administered 1 to 3 times per week, with sessions typically lasting 15 minutes to an hour, with an associated latency of 2 seconds (Beven, 2017; Sargsyan et al., 2005; 2005).

Simulated Latencies

When conducting analogue human spaceflight trainings and experiments, the presence of a simulated latency is a key component which should be included. These latencies are often simulated through Playbook's Mission Log and/or other similar human spaceflight analogue communication support software. Marquez et al. (2019) identifies Playbook's Mission Log as,

> An enabling capability for analog missions that simulate deep space, exploration missions with communication transmission latency. Playbook is a planning and execution web-application for mission operations, aggregating multiple sources of information for astronauts to execute the mission in one place: timeline, procedures, chat interface. Playbook's Mission Log provides a multimedia chat software interface with unique features and functionalities that support asynchronous communication between analog astronauts and ground support teams (p. 1).

As mentioned, simulated latency in human spaceflight analogues can be accomplished through a variety of approaches, and is therefore not limited to Playbook. These approaches can range from sophisticated software applications such as Playbook's Mission Log and the like, to more rudimentary methods such as inducing latency via more commonplace telecommunication software and timers. In the latter approach, latency is induced manually by the communicators who purposefully delay their responses by a set duration.

Therapy Techniques and Tools

Guided Meditation. Though teletherapy between Earth and astronauts operating in LEO is somewhat accommodating, it stands to reason that it is not as personable, nor does it have as much access to the wellspring of psychotherapy techniques and tools as do astronaut-trained psychologists. Due to the research gaps in space psychology, as well as the novel nature of this investigation, a standardized psychotherapy treatment technique has not yet been established to be readily incorporated into such studies. Instead, identification and implementation of a therapy technique that is flexible and effective, as well as administrable both virtually and in-person is required for this investigation. One such technique that appears to fit particularly well for this application is guided meditation (i.e., mindfulness meditation and guided imagery). Note that guided meditation is already a major component of space psychology, and is currently used with astronauts during all phases of human spaceflight (Pagnini et al., 2019; Pal et al., 2021).

Recreational Therapy. Another approach which can be used in combination with guided meditation is recreational therapy, which is described by the American Therapeutic Recreation Association (2016) as:

> A systematic process that utilizes recreation and other activity-based interventions to address the assessed needs of individuals with illnesses and/or disabling conditions, as a means to psychological and physical health, recovery and well-being. Further, ‘Recreational Therapy’ means a treatment service designed to restore, remediate and rehabilitate a person’s level of functioning and independence in life activities, to promote health and wellness as well as reduce or eliminate the activity limitations and restrictions to participation in life situations caused by an illness or disabling condition.

> Recreational therapy is not all fun and games. There is a purpose behind the activities that are specifically targeted to each patient. When individuals are suffering from a physical injury or mental illness, they need help learning, not only how to live with their disability, but to enhance their quality of life by reducing the isolation that patients experience and helping them to participate in leisure activities.
>
> Recreational therapists (RTs) seek to reduce depression, stress and anxiety in their clients and help them build confidence and socialize in their community."

Thus, recreational therapy is particularly applicable to space psychology experiments as it is adept in dealing with disabling conditions, isolation, and stress. This applicability is due to the ease at which these aspects directly translate over from the conventional Earth- to space-environment. For instance, when applying recreational therapy to human spaceflight, the disabling conditions become the known stressors identified in this literature review. These stressors include: abnormal/altered microbiomes, extreme temperatures, extremes in sunlight exposure, lack of atmospheric pressure, microgravity and partial gravity, potential impacts with micrometeorites, as well as space radiation.

The second aspect of recreational therapy identified by the American Therapeutic Recreation Association (2016) is isolation. Like the aforementioned disabling conditions, isolation is also a known stressor associated with human spaceflight. As discussed, when exposed to extreme isolation and confinement (i.e., astronauts working in small and potentially deadly habitats away from their home planet, and unable to leave freely), the potential for feelings of existential unease as stress increases. Worth briefly mentioning is the third aspect, stress, which has already been discussed above.

The fourth aspect, leisure activities, is a great approach in dealing with therapy. Specifically, because astronauts' daily schedules and tasks are stringently planned and managed by Earth-based support teams, it is important to make therapy enjoyable rather than more mundane work. Lastly, the fifth aspect is socialization within the community (i.e., healthy communication between astronaut crewmembers). As identified in this literature review, stress and long telecommunication latencies can lead to cascading effects which negatively impact groups. Given the close quarters of space habitats and the importance of effective teamwork for both astronaut safety and mission success, the necessity for healthy communication and socialization is clear. Therefore, guided meditation through the scope of recreational therapy appears to satisfy the prerequisites for implementation as a psychotherapy technique in this space psychology investigation.

Biblical Foundations of the Study

Along with being highly scientific, human spaceflight is also biblically and spiritually founded at its essence. This perspective can be seen in Genesis 1:15 (*New American Standard Bible*, 1998), "And they [the stars] shall serve as lights in the expanse of the heavens to give light on the earth'; and it was so". When contemplating this premise from the biblical perspective, it is apparent that the stars/starlight are physical manifestations of God and the divine realm, whereas Earth-bound humans are subjugated by physical manifestations of sin in the fallen Earthly realm (Wolters, 2005). Furthermore, by striving for off-planet access and living in space, humanity too is striving to leave the fallen Earthly realm. Thus, human spaceflight is akin to redemption, and righteously pursuing the proliferation of human spaceflight is innately redemptive.

Moreover, along with scriptural evidence as identified above, this premise is supported by peer-reviewed scientific literature pertaining to astronauts' firsthand accounts of their spiritual/religious experiences in the spaceflight environment (Edwards, 2020; Kanas, 2020; Weibel, 2016; 2020a; 2020b). These spiritual experiences which occur during human spaceflight are coined as the Overview Effect. Experienced by astronauts during human spaceflight, the Overview Effect is described as a profound cognitive, emotional, and/or spiritual transformation that results from observing Earth while in space, and may illicit a lifelong enhanced sense of connectivity with humanity, the world, and God (Kanas, 2020; Weibel, 2020b).

Worth reiterating is that it would be interesting to assess space psychology and human spaceflight through other more distinctively biblical worldviews such as strong and week Integration, etc. However, as mentioned, the application of such distinctively biblical worldviews would more likely than not make this study overly esoteric due to the already complex nature of human spaceflight and space psychology (Gilley, 2020; Johnson, 2013). Moreover, if the scope of this study were too confined, the contribution made to the whole of space psychology and human spaceflight too might be lessened.

From a biblical perspective, since human spaceflight is a redemptive endeavor, limiting the scope and therefore the impact of this investigation could be construed as indirectly placing a bottleneck on the path to redemption. It is for this reason that Levels of Explanation was selected, whereby providing the most universal (i.e., the largest and most accommodating) model to contribute to and enhance human spaceflight, astronaut wellbeing and performance, as well as redemption (Johnson, 2013). One of the primary benefits of Levels of Explanation is that aspects of this study (e.g., stress and psychological support) can be evaluated from an array of frameworks, namely, scientific and biblical vantages. Building upon the biblical importance and scriptural support of human spaceflight, as established above with Genesis 1:15, there are two other passages that further indicate the important relationship between human spaceflight and the wellbeing of astronauts and humanity.

Hebrews 12:1 (*English Standard Bible*, 2001) states, “Therefore, since we are surrounded by so great a cloud of witnesses, let us also lay aside every weight, and sin which clings so closely, and let us run with endurance the race that is set before us.” In this passage, the great cloud appears to represent those of the redemptive path who embrace God’s light. Through the framework already established with Genesis 1:15, the great cloud of witnesses may be perceived vast nebulas of ever-watching stars which emanate God’s light. With regards to the biblical foundation of this study, both interpretations are valid, since righteous human spaceflight endeavors are innately redemptive as well as illuminated by the stars with pathways of divine light. As for the sin that clings so closely, this portion of the passage is akin to Earth’s gravity, which literally binds matter together with tumultuous force in a manner that feels counter to starlight’s ethereal redemptive nature. Furthermore, there is quite literally no place better suited than space and its weightless microgravity environment to lay aside every weight. Keeping with the same framework, the endurance identified in this passage relates to humans traveling further from Earth (i.e., out of the fallen Earthly realm) for extensively longer mission durations.

Malachi 4:2 (*English Standard Bible*, 2001) states, “But for you who fear my name, the sun of righteousness shall rise with healing in its wings. You shall go out leaping like calves from the stall.” It should be noted that this passage opens directly acknowledging celestial bodies (i.e., the sun) and associates this celestial environment with both fear and healing, which gives further credence to the biblical human spaceflight and space psychology framework implemented in this study. The fear represents the stress and inherent dangers associated with human spaceflight, whereas the healing wings represent its redemptive nature. Moreover, these wings can be viewed as both divine (i.e., of the divine realm), as well as allude to the space lift capabilities of spacecraft which deliver astronauts from the fallen Earthly realm to the relatively more divine manifestation that is space. Also worth mentioning is that the leaping identified in this passage is akin to the famous statement made by astronaut Neil Armstrong during his experience on the Lunar surface, “That’s one small step for man, one giant leap for mankind” (NASA, 2019c). As identified through the logical and biblical premise above, this framework and study brings glory to God. In fact, this framework provides a step-by-step approach of how to redeem oneself and society in an age of rapid technological advancements.

With that said, obviously redemption is not an easy path. If it were, matter in this physical world would not trend towards entropy. Considering this challenge, it is all the more important that strides to and/or on the redemptive path be eagerly supported. The importance and validity for supporting the redemptive path and those who traverse its light bridge should be viscerally evident and known by all truly spiritually attuned and mindful people. Magnanimously helping oneself and others brings glory to God, and there are few actions – if any – more righteous than redemption, altruistically rising above physical, emotional, and spiritual transgression/s.

As mentioned, ascending physically in space as well as of mind is not easy, as even astronauts experience sunken states of being (e.g., stress, anxiety, etc.) while on this journey. This is exactly why space psychology investigations such as this one are vital, as they aim to support the astronauts on their journey away from Earth. Through this approach, both physical and spiritual bridges are built and strengthened toward the heavens. It is this action, with unified intent of soul, mind, and body, that brings glory to God. It is through this unified higher self that we are redeemed, shining as ambassadors in and of God’s light, inspiring others to rise above with attunement to their higher calling. Therefore, this framework brings glory to God by serving as a scholarly and spiritual bridge which supports transit from the Earthly realm to the weightless divine realm of space and its celestial bodies.

Psychological Foundations of the Study

From a psychological perspective, when contemplating the field of space psychology, it is important to acknowledge that though astronauts in general are highly trained individuals well suited for the rigors of human spaceflight, astronauts are also humans and require de-stressing, psychological support, and counseling (Kanas et al., 2012; NASA, 2018). Furthermore, as previously identified, this necessity for psychological counseling and support is magnified due to the high-stress, high-risk, confined, and isolated human spaceflight environment where astronauts work and live (Roma & Bedwell, 2017; Thirsk et al., 2009). As discussed in Chapter 1, there are two primary theories implemented with human spaceflight, namely: Self-Determination Theory, as well as Eastern and Western theory. Note that these two human spaceflight theories largely focus on/pertain to astronaut selection, testing, training, as well as experimentation, and less so with the administration of psychotherapy during human spaceflight. As mentioned, there is a clear gap in space psychology research, and this investigation aims to fill that gap.

Self-Determination Theory was introduced in 1985 by Edward Deci and Richard Ryan. It was developed to identify how self-determination (i.e., a person's ability to make choices and manage their life) affects their motivation (Deci & Ryan, 2013). Self-Determination Theory is based on two assumptions: that people are actively directed toward growth (i.e., a person will face challenging experiences so as to gain mastery over their self), and that autonomous/intrinsic motivation (i.e., motivation that arises within) is essential for growth. Koole et al. (2018, p. 30) states that modern Self-Determination Theory's "emphasis on need satisfaction provides the most solid scientific basis for motivational interventions". Being that astronauts are comprised of highly motivated individuals with a history of overcoming extremely challenging experiences, Self-Determination Theory is particularly applicable to human spaceflight.

The Eastern and Western theories were developed during the Space Race in the Cold War, with Eastern denoting the Soviet Union, and Western denoting the United States. These theories arose for similar reasons, with the aim being the respective country's dominance in space. Both theories were relatively similar in that they were administered on cosmonauts/astronauts during selection and training before flight. With that said, the Eastern approach also accounted for the in-flight phase, whereas the Western approach did not. Additionally, the testing and training methods differed as well. Specifically, the Eastern approach opted for a biophysical and biorhythmic approach which the West deemed as pseudoscience. The Western approach instead adopted from the United States' aviation practices, which were primarily personality- and performance-based. Modern day human spaceflight and space psychology has adopted the Western science-based approach (e.g., biometrics, psychology, medicine, etc.) and blended them with an expanded version of the Eastern multi-phase application (i.e., administration to pre-flight, in-flight, and post-flight; Musson, 2006).

To alleviate the elevated stress levels of astronauts, psychological counseling and support has traditionally been delivered to astronauts virtually via teletherapy, a method that was implemented at the onset of long-duration human spaceflight missions due to the emergence of psychological and psychophysiological issues (Friedman & Bui, 2017; Kanas et al., 2012; NASA, 2018; Vakoch, 2011). As mentioned, along with being the current psychological counseling and support delivery method for astronauts on the ISS, teletherapy is also a popular form of psychotherapy on Earth (North & North, 2016). Moreover, the research and implementation of teletherapy on Earth has increased drastically as a result of the COVID-19 pandemic, where life for many became dramatically more virtually oriented (Johnson & Aldea, 2021). With that said, there is still not a definitive consensus whether or not teletherapy is as effective as traditional in-person psychotherapy, though it is often reported in many of the most recent studies that in-person therapy is more impactful and of higher quality (Giovanetti et al., 2022; Lin et al., 2022; Lin et al., 2021).

On the plus side, teletherapy gives immobile/confined and/or remote/isolated people the option to receive therapy virtually. However, because of its virtual nature, technological issues (e.g., internet outages, lag/latency, poor resolution, poor audio quality, hardware/software issues, hacking, etc.) are inherent to its delivery (Jones et al., 2020). In-person psychotherapy on the other hand is not associated with any of these issues and is also generally perceived as the more personable approach (Honig & Hannibal, 2022). These positive and negative aspects hold true for human spaceflight applications as well.

It should be noted however that given the significantly larger distances and latencies as well as the technical complexities associated with space-based astronaut communications with Earth compared to the relatively simple virtual communications between Earth-based people, the magnitude of teletherapy's inherent issues balloon in space applications (Marquez et al., 2019; Zhan et al., 2020). With respect to teletherapy and virtual communications, latency is the lag/delay that occurs when relaying communication signals. This space-based latency is the result of the physical constraints (i.e., the time it takes light to traverse the distance/s in space between communicators/transceivers) and technological constraints (i.e., the total computational time incurred from relaying and processing data across all satellites/communication systems) associated with space-based communication. In the case of two-way communication between the Earth and the ISS (i.e., communication between the astronaut onboard the ISS and the Earth-based psychotherapist), the physical constraint accounts for < 1 second of latency, and the technological constraint imparts an additional latency, resulting in a total latency of approximately 2 seconds (Sargsyan et al., 2005). Note that these constraints have an inverse relationship (i.e., when communication signals travel increasingly further distances, the proportion of latency due to technological constraints decreases, whereas the proportion of latency due to physical constraints increases). Additionally, though the technological constraints of space-based telecommunication can be reduced through improved space systems architectures and computational advancements, the physical constraints of telecommunication (i.e., the speed that light travels and the geometry of space) cannot, at least not through the current understanding/framework of physics and engineering.

Also worth mentioning is that long latencies (i.e., latencies > ~2 seconds) can have a cascading effect that negatively impacts cooperative interactions/interfaces (Blackett et al., 2021; Geelhoed et al., 2009). This is to say that if an astronaut receives teletherapy with a latency merely a fraction of a second longer than the latency currently experienced with Earth-LEO teletherapy on the ISS, the negativity and stress that the astronaut was supposed to receive treatment for can actually spread, affecting fellow astronaut crew members' stress levels, moods, behaviors, and performances (Howard et al., 2014). Though much of the research into cascading impacts and latency pertain to virtual cooperative experiences, the detrimental effects of long latencies identified in these studies should be taken seriously. This is because virtual and augmented cooperative experiences are often used as simulators and training tools for NASA and DOD astronauts, military personnel, etc.(Amaguaña et al., 2018; Salamon et al., 2018).

Additionally, these cooperative teleoperated activities are often used as predictors for real-life participation and physical activity among adults (Adachi & Willoughby, 2015). Therefore, these findings are directly transferable to space psychology applications.

Noteworthy is that while latency can reduce the quality and enjoyment of the participants' experiences considerably, these detrimental effects are magnified when individuals are under particularly challenging and stressful conditions (Jörg et al., 2012). Therefore, based on the literature presented, though teletherapy appears to be a satisfactory delivery method for astronauts aboard the ISS in LEO, due to the aforementioned physical and technological constraints of telecommunication – paired with the challenging nature of human spaceflight beyond LEO – teletherapy will likely not be suitable for missions beyond LEO such as the Artemis Lunar return mission (Kessler et al., 2022). Also worth mentioning is that with the influx of space tourists and commercial astronauts who are typically less trained, less experienced, and not as well suited for human spaceflight compared to their NASA and DOD astronaut counterparts, a more effective and hands-on psychotherapy delivery method may be required for these LEO human spaceflight activities as well (Bushnell, 2021). Furthermore, it has been postulated that the current teletherapy method is not sufficient for space tourism and commercial human spaceflight operations, regardless of the operational distances from Earth (i.e., it is likely that even when implemented in LEO, teletherapy is poorly suited for administration to space tourists and commercial astronauts) (Orme, 2017).

As mentioned, being that NASA plans to return humans to the Moon and establish a permanent human presence on the Lunar surface by the end of this decade, it is imperative that a suitable psychotherapy treatment/delivery method be identified and developed for these rapidly approaching missions. One particularly promising psychotherapy approach identified by Szocik

(2019) suggests that psychological counseling and support be delivered on-site and in-person via astronaut-trained psychologists. These astronaut-trained psychologists are individuals with doctorates in psychology who have completed extensive astronaut training and may provide psychotherapy to their fellow astronaut crewmembers in situ.

Furthermore, being that most astronauts are prior service military, it is likely that many of these astronaut-trained psychologists will be military officers assigned from relevant military psychological career fields such as aerospace experimental psychologists (Corlett et al., 2020; Graver et al., 2020). These DOD assigned astronaut-trained psychologists may also have the bonus of being able to prescribe and administer psychiatric medications to their fellow astronaut crewmembers (Linda & McGrath, 2017). Being that astronauts are commonly prescribed medications (e.g., psychiatric medications, sleeping aids, etc.) aboard the ISS – and given the large launch costs associated with non-reusable human spaceflight systems which send astronauts to space and support them while in space – having an astronaut-trained psychologist who can fulfill multiple roles (e.g., serve as the on-site psychologist, clinical psychopharmacologist, as well as an astronaut, etc.) reduces the need for additional astronaut personnel, and therefore reduces costs and required resources (Gudmundsson, 2018; Shayler & Burgess, 2020; Shelhamer, 2017; Wotring, 2015). Thus, the astronaut-trained psychologist approach is attractive in that along with being cost effective, it eliminates issues associated with latency, is more personable than teletherapy, and is beneficial for the astronauts' wellbeing and productivity which subsequently increases the likelihood for successful human spaceflight missions.

Summary

Human spaceflight experiments can be successfully conducted on Earth analogously and still make large contributions to in situ space operations (Gerzer & Cromwell, 2021). Moreover, along with analogue environments, astronaut participants too can be substituted for astronaut-surrogate participants (Casario et al., 2022). When screened/selected correctly, these astronaut-surrogates perform/test similarly to astronauts in cognition-based experiments, making them well suited as participants in space psychology studies (Casario et al., 2022).

With regards to human spaceflight and the space environment, hazards and risks are serious and abundant. Specifically, during their daily lives aboard the ISS, astronauts are faced with: extreme temperatures, space radiation, space debris and micrometeorites, abnormal/altered microbiomes, isolation and confinement, lack of atmospheric pressure, extremes in sunlight exposure, and altered gravity (Tesei et al., 2022). Each of these risks alone can be dangerous and/or deadly, and since astronauts are exposed to a majority of them daily, albeit with countermeasures in place, it is clear to see why adequate psychological counseling and support is necessary for astronaut wellbeing. Also worth acknowledging is that more likely than not, the negative effects of these stressors will be magnified as astronauts leave LEO for habitation on/around the Moon (Anderton et al., 2019). What makes matters worse is that some of these stressors have synergistic interactions with psychological stress, making astronauts more susceptible to a variety of issues ranging from mood disorders to cancer (Wang et al., 2016).

Currently in the ISS, astronauts receive virtually delivered psychological counseling and support via teletherapy. Teletherapy is administered 1 to 3 times per week, with sessions typically lasting 15 minutes to an hour, accompanied by approximately 2 seconds of communication latency (Beven, 2017; Sargsyan et al., 2005; 2005). It has been shown that latencies > ~2 seconds can have cascading impacts, and therefore if the latency of teletherapy delivered to astronauts on the ISS were to increase by merely a fraction of a second, it could potentially result in the stress and negative feelings/behaviors of one astronaut to spread throughout the entire astronaut crew, whereby increasing their stress levels, as well as hampering their moods, behaviors, and performances (Blackett et al., 2021; Geelhoed et al., 2009; Howard et al., 2014).

It should be acknowledged that a portion of this latency is due to the technical constrains of telecommunication, which can be lessened through space systems architecture improvements and computational advancements. Latency is also determined in large part by the physical constraints of telecommunication (i.e., the speed of light and the geometry of space). Unlike the technical constraints however, nothing can feasibly be done to lessen the impact that these physical constraints have on latency. Therefore, latency will always be present in telecommunications and teletherapy. What makes matters worse is that as astronauts voyage beyond LEO to the Moon, latency too increases. This increase is substantial enough to assume that the use of teletherapy will no longer be satisfactory for astronauts living and working on the Moon.

It is for this reason an alternative psychological counseling and support delivery method has been suggested, namely, the astronaut-trained psychologist approach (Szocik, 2019). Though this approach appears to be extremely promising, there is a clear research gap regarding it. Thus, further investigation is necessary to identify what psychotherapy method is best suited for human spaceflight at and beyond LEO. Note that the information identified and discussed in this chapter was utilized in order to better construct the research methodologies and approaches carried out in this study. These research methods, questions and hypotheses, study procedures, instrumentation and measurements, variables, and analyses are identified and discussed at length in Chapter 3.

CHAPTER 3: RESEARCH METHOD

Overview

In this chapter, the research methodologies (i.e., the research questions and hypotheses, research design, participant criteria and selection, study procedures, instrumentation, measurements, operational variables, data analysis, as well as delimitations, assumptions, and limitations) of the study and its findings are discussed.

Research Questions and Hypotheses

Research Questions

Astronaut-Trained Psychologists Versus Earth-LEO (2 Second Latency) Teletherapy

The following research questions and hypotheses align with the problem statement by establishing a baseline comparison between the Earth-LEO teletherapy control with a 2 second latency (i.e., what is administered to astronauts on the ISS) and astronaut-trained psychologist-based therapy.

RQ1. Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 2 second Earth-LEO latency at reducing heart rate among astronaut-surrogates operating in simulated LEO conditions?

RQ2. Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 2 second Earth-LEO latency at reducing blood pressure among astronaut-surrogates operating in simulated LEO conditions?

RQ3. Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 2 second Earth-LEO latency at improving Perceived Stress Questionnaire (PSQ) scores among astronaut-surrogates operating in simulated LEO conditions?

Astronaut-Trained Psychologists Versus Earth-Moon (10 Second Latency) Teletherapy

The following research questions and hypotheses align with the problem statement by directly evaluating the effectiveness of astronaut-trained psychologist-delivered therapy versus teletherapy with a 10 second Earth-Moon latency.

RQ4. Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 10 second Earth-Moon latency at reducing heart rate among astronaut-surrogates operating in simulated Lunar conditions?

RQ5. Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 10 second Earth-Moon latency at reducing blood pressure among astronaut-surrogates operating in simulated Lunar conditions?

RQ6. Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 10 second Earth-Moon latency at improving PSQ scores among astronaut-surrogates operating in simulated Earth-Moon conditions?

Earth-LEO Teletherapy Versus Earth-Moon Teletherapy

The following research questions and hypotheses align with the problem statement by directly evaluating the effectiveness of Earth-LEO teletherapy (the control treatment method currently implemented with astronauts in LEO) versus teletherapy with a 10 second Earth-Moon latency.

RQ7. Is teletherapy with 10 second Earth-Moon latency less effective than conventional Earth-LEO teletherapy with 2 second latency at reducing heart rate among astronaut-surrogates operating in simulated Lunar conditions?

RQ8. Is teletherapy with 10 second Earth-Moon latency less effective than conventional Earth-LEO teletherapy with 2 second latency at reducing blood pressure among astronaut-surrogates operating in simulated Lunar conditions?

RQ9. Is teletherapy with 10 second Earth-Moon latency less effective than conventional Earth-LEO teletherapy with 2 second latency at improving PSQ scores among astronaut-surrogates operating in simulated Earth-Moon conditions?

Hypotheses

Note that the hypothesis number corresponds to the respective research question number identified above.

Hypothesis 1: Corresponding to RQ1

H_0. The type of therapy administered to astronaut-surrogates in Earth-LEO analogue conditions has no effect on their heart rate.

H_1. The type of therapy administered to astronaut-surrogates in Earth-LEO analogue conditions has a significant effect on their heart rate.

Hypothesis 2: Corresponding to RQ2

H_0. The type of therapy administered to astronaut-surrogates in Earth-LEO analogue conditions has no effect on their blood pressure.

H_1. The type of therapy administered to astronaut-surrogates in Earth-LEO analogue conditions has a significant effect on their blood pressure.

Hypothesis 3: Corresponding to RQ3

H_0. The type of therapy administered to astronaut-surrogates in Earth-LEO analogue conditions has no effect on their PSQ scores.

H_1. The type of therapy administered to astronaut-surrogates in Earth-LEO analogue conditions has a significant effect on their PSQ scores.

Hypothesis 4: Corresponding to RQ4

H_0. The type of therapy administered to astronaut-surrogates in Earth-Moon analogue conditions has no effect on their heart rate.

H_1. The type of therapy administered to astronaut-surrogates in Earth-Moon analogue conditions has a significant effect on their heart rate.

Hypothesis 5: Corresponding to RQ5

H_0. The type of therapy administered to astronaut-surrogates in Earth-Moon analogue conditions has no effect on their blood pressure.

H_1. The type of therapy administered to astronaut-surrogates in Earth-Moon analogue conditions has a significant effect on their blood pressure.

Hypothesis 6: Corresponding to RQ6

H_0. The type of therapy administered to astronaut-surrogates in Earth-Moon analogue conditions has no effect on their PSQ scores.

H_1. The type of therapy administered to astronaut-surrogates in Earth-Moon analogue conditions has a significant effect on their PSQ scores.

Hypothesis 7: Corresponding to RQ7

H_0. The amount of latency experienced by astronaut-surrogates during teletherapy has no effect on heart rate.

H_1. The amount of latency experienced by astronaut-surrogates during teletherapy has a significant effect on heart rate.

Hypothesis 8: Corresponding to RQ8

H_0. The amount of latency experienced by astronaut-surrogates during teletherapy has no effect on blood pressure.

H_1. The amount of latency experienced by astronaut-surrogates during teletherapy has a significant effect on blood pressure.

Hypothesis 9: Corresponding to RQ9

H_0. The amount of latency experienced by astronaut-surrogates during teletherapy has no effect on PSQ scores.

H_1. The amount of latency experienced by astronaut-surrogates during teletherapy has a significant effect on PSQ scores.

Informed by the literature review, the hypothesis held prior to analyzing the data was that: among psychological counseling and support delivery treatment methods, in-person astronaut-trained psychologists have the highest efficacy for decreasing astronaut stress levels (i.e., heart rate, blood pressure, and PSQ scores). Furthermore, it was predicted that Earth-Moon teletherapy with an associated 10 second latency is the worst suited method for decreasing astronaut stress levels.

Research Design

Implemented in this study is an experimental quantitative research design, where biometric stress level data (i.e., heart rate and blood pressure) were collected via monitoring and tracking devices. Participants also self-reported their stress levels via the PSQ. A quantitative approach was selected for this study because of the apparent research gap in quantitative space psychology literature, as the majority of space psychology literature has been qualitative up to this point. The experiment itself consisted of three therapy treatment groups, and all participants underwent each of the three treatments individually at random order so as to reduce the risk of carryover effects between treatments. Note that therapy was conducted in private, with one participant per respective therapy session. The three separate treatment groups were treated as three factors/levels of the independent variable and were designed to be inherently compatible with the repeated measures ANOVA. After the data had been checked for normality and combed for univariate outliers, it was then analyzed via repeated measures ANOVA. Considering the relatively small population size of astronauts and astronaut-surrogates, the repeated measures ANOVA was particularly well suited and convenient for this application, allowing each participant to undergo all three of the treatment conditions rather than necessitating more participants. This design revealed differences between the treatment methods' effectiveness at reducing astronaut stress, and therefore helped to identify what approach is best suited for astronaut-delivered psychotherapy.

Participants

The participants included in the study consisted of NASA, DOD, and aerospace personnel with astronaut-relevant experiences (i.e., professionals from aerospace-focused agencies/organizations with aerospace-relevant careers such as: pilots, space systems engineers, aerospace experimental psychologists, etc.). Furthermore, the participant inclusion criteria required that participants be: 18 years of age or older, have a body mass index less than 30, not habituated to illicit drug use, attained a bachelor's degree or equivalent, open to receive therapy, as well as reported being comfortable in confined/isolated environments and work well in team environments while also being self-reliant. The number of participants deemed appropriate for this study was 24. This number was informed by the literature review of human spaceflight-relevant research as well as metadata, and was calculated via G*Power software (Barak et al., 2008; Brcic, 2010; Ritsher et al., 2005; Voski, 2020). Also note that a 15% attrition rate was accounted for. Additionally, all of the necessary permissions (e.g., IRB informed consent and participation agreements, etc.) to include said people as participants in this study were secured through the appropriate channels (e.g., through IRB, from the participants themselves, etc.). See appendix A for more information about informed consent.

Study Procedures

Participants received all three treatment conditions (i.e., Earth-LEO teletherapy, Earth-Moon teletherapy, and in-person astronaut-trained psychologist administered therapy), and each treatment session was conducted individually (i.e., no other participants were present during the respective treatment sessions). Note that the order of treatment conditions assigned to participants was randomized, and each participant underwent each treatment condition once, without repeats. This method of randomization is called counterbalancing, which reduced the risk of carryover effects between treatments (Webster, 2019). Note that the administration of recreational therapy carried out by the researcher did not require specialized qualifications. The researcher who administered therapy had a post-master's diploma in psychology, and approximately a decade of space psychology experience. Additionally, a confidentiality agreement was required prior to treatment, and cost of treatment was waived for participants. Also noteworthy is that among all therapy sessions, regardless of the treatment condition, the therapy technique/tool used was guided meditation (i.e., mindfulness meditation and guided imagery) administered by the researcher.

Prior to the start of the therapy session, a monitor which actively tracked and recorded heart rate was attached to the respective participant. Note that within each session, heart rate was tracked from that point onwards (i.e., from the start [T0] to the end [T15] of the respective session). The participant's blood pressure was also measured via cuff with digital display, with three measurements made and averaged. Immediately afterwards the participant was asked to complete a pre-therapy session PSQ. The therapy session began after these steps were completed. Halfway through the session, blood pressure was measured again, followed by the second half of the therapy session. After the session, a post-therapy session blood pressure measurement was taken, with three measurements made and averaged. Then the participant was asked to complete a post-therapy session PSQ. Finally, the heart rate monitor was removed from the participant and the session ended.

These steps were applied to each of the participants and were repeated for each of the treatment conditions. Note that in the astronaut-trained psychologist treatment, the researcher/therapist was physically present in the same room with the participant. However, with the teletherapy treatments, the researcher/therapist was not physically present, and interacted with the participant virtually. Furthermore, the specified 2 and 10 second latencies were achieved through a Playbook Mission Log-like approach (i.e., simulated through the computer), which simulated the latencies experienced at LEO and the Moon (Marquez et al., 2019).

Note that the pre- and post-measurements were carried out so as to identify how effective the treatment/s were at reducing participant stress levels. A secondary benefit of the pre- and post-measurements were that, if desired by the researcher, they could be used to establish adjusted/normalized baselines of the data which could potentially result in a more accurate assessment of the data/results. After the data was collected, it was checked for normality and combed for univariate outliers, and then analyzed via repeated measures ANOVA. Note that the analyses were computed via SPSS. Also noteworthy is that for each respective participant, their therapy treatment sessions were spaced out by ~2.5 day intervals (i.e., after completing their first respective treatment session, the participant then underwent their second treatment session ~2.5 days later, and then again with their third treatment session). This duration was selected and based on the frequency that astronauts typically receive teletherapy on the ISS, which is approximately two to three times per week. Thus, the entire experiment was designed to occur over a period of approximately 14 days.

Fifteen minutes of therapy was administered per therapy session to each participant. Again, this duration was informed by the teletherapy approach currently administered to astronauts on the ISS, with sessions typically lasting 15 minutes to an hour. Note that each therapy session was held to 15 minutes ± approximately 30 seconds, excluding the time it took to make measurements and the resume therapy session.. Also note that per IRB guidelines, the data collected during the experiment is stored for a minimum of two years. The data are stored by the researcher on/in a locked location (e.g., on a password-locked computer, in a locked drawer, and in a locked filing cabinet) accessible only to the researcher.

Treatment Conditions

The three treatment conditions of interest in this investigation included: a simulated Earth to LEO (Earth-LEO) teletherapy control with a 2 second latency, a simulated Earth to Moon (Earth-Moon) teletherapy treatment with a 10 second latency, and a simulated in-person astronaut-trained psychologist delivered treatment with no added latency. Note that the latencies assigned to each of the treatments were informed by Lester's and Thronson's work (2011), as well as Sargsyan et al. (2005), and McHenry et al. (2021).

Earth to LEO Teletherapy

A treatment condition where therapy was delivered virtually by a remotely located therapist. In this treatment, there was a small 2 second additional latency, and communication was delivered virtually to participants via computer. Note that though virtually delivered, the participants themselves were physically located in the altitude test chamber, with the researcher located outside several feet away.

Earth to Moon Teletherapy

A treatment condition where therapy is delivered virtually by a remotely located therapist. In this treatment, there was a large 10 second additional latency, and communication was delivered virtually to participants via computer. Note that though virtually delivered, the participants themselves were physically located in the altitude test chamber, with the researcher located outside several feet away.

In-person Astronaut-Trained Psychologist Psychotherapy

A treatment condition where psychotherapy was delivered in-person directly by the researcher. In this treatment, there was no additional latency (i.e., the natural human to human latency is ~150 milliseconds, and is therefore practically imperceptible), and communication/interaction was done face-to-face in-person with the participant/s and the researcher both physically located in the altitude test chamber.

Testing and Therapy Environment

Participants underwent testing in an altitude test chamber located in Gardena, California. The altitude test chamber could replicate pressures experienced in the vacuum of space and has been used for astronaut and high-altitude pilot training. Note that for the safety of the participants, the extreme barometric capabilities of the altitude chamber were not utilized during the treatment sessions.

Instrumentation and Measurement

Instruments

The materials and instruments used in this study included teleoperations communication systems (i.e., computer/s with appropriate software), timers, heart rate monitor, blood pressure monitor/cuff, a sufficient number of PSQs, and other generic psychological testing instruments (e.g., pen, paper, etc.). Also note that sanitizer, cleaning supplies, and personal protective equipment (PPE) were present.

Measurements

Heart Rate

Heart rate and heart rate variability are commonly used to assess/infer stress levels. Along with being a reliable indicator of stress, heart rate is also relatively straightforward, inexpensive, and quick to measure (Brown et al., 2020; Khanade & Sasangohar, 2017). Furthermore, heart rate is particularly well suited at identifying anxiety and even symptoms of depression (Hartmann et al., 2019; Khanade & Sasangohar, 2017).

Heart rate measurements in this study were made automatically via Fitbit heart rate monitor. The maximum heart rate that could be measured by this device was 220 beats per minute, which equates to a 0.27 second sensor resolution. Note that in order to adequately track heart rate as a stress level indicator, heart rate measurements needed to be made at least once every two minutes (Somers, 2019). Therefore, a 1-minute heart rate measurement/datapoint collection frequency was selected (i.e., heart rate was measured once every minute in each of the therapy sessions).

Note that prior to the start of each therapy session, the heart rate monitor was mounted around the wrist of the participant. Once attached, heart rate was measured continuously throughout the entirety of each treatment session. The heart rate monitor was then removed at the very end of the therapy session, after blood pressure and PSQ scores were collected.

Blood Pressure

Though not as commonly used to assess stress levels as heart rate, blood pressure can be used successfully to accomplish this (Borstel et al., 2017; Charlton et al., 2018). This somewhat less common application of stress level assessment is likely due to the longer measurement times associated with blood pressure readings compared to heart rate. Additionally, blood pressure measurements are made intermediately rather than continuously, which may make measurements more difficult to collect depending on the experiment.

Blood pressure measurements in this study were made via blood pressure monitor/cuff. Though slower to measure than heart rate, each blood pressure measurement took no longer than 1 minute to collect. Worth noting is that in addition to being slower to measure, blood pressure measurements are typically not as precise as heart rate measurements. This is because blood pressure itself can vary depending on the position of the body, and the measurements can vary depending on the monitor/cuff used, the size of the cuff, the tightness of the cuff, etc. So as to improve precision, blood pressure measurements were recorded three times at each interval (i.e., before treatment, in the middle of treatment, and after treatment). The three measurements were then averaged, and the average values were input at each respective interval. This approach was carried out among all sessions and treatments.

PSQ

In terms of administration of the PSQ, a stress assessment that implements a 4-point Likert scale, participants were requested to select one of the item response-scores (1 = Almost Never, 2 = Sometimes, 3 = Often, 4 = Usually) for each of the items in order to describe how stressed they felt. Furthermore, the participants were encouraged to work quickly, not overthink their responses, and not frequently recheck their responses (Levenstein et al., 1993). Worth mentioning is that the PSQ was particularly well suited for implementation in this investigation, as its application is valid for healthy adults, which the astronaut-surrogate participants can be considered as (Fliege et al., 2005).

In terms of data and validation, the PSQ provided an additional standardizable data source which can be analyzed. The PSQ was carried out at two intervals per therapy session, namely before and after the actual therapy itself. Note that the pre-session PSQ was administered after the heart rate monitor was attached and blood pressure had been measured, whereas the post-session PSQ was administered before the heart rate monitor was removed and blood pressure had been measured. In this way, potential changes in biometric data, not only from therapy, but from additional tasks like the PSQ could be observed. This also helped further simulate task loading experienced by astronauts in space. The specific items comprised within the PSQ are identified in appendix C.

Operationalization of Variables

The independent variables were operationally defined as: Earth-LEO teletherapy (2 seconds), Earth-Moon teletherapy (10 seconds), and in-person astronaut trained psychologist therapy (150 milliseconds). Note that the Earth-LEO teletherapy treatment served as the control. The dependent variables in this investigation are heart rate, blood pressure, and PSQ score.

Independent Variable

The independent variable was psychotherapy treatment. The independent variable had three levels:

Earth-LEO Teletherapy

Latency = 2 seconds. Note that the Earth-LEO teletherapy treatment served as the control.

Earth-Moon Teletherapy

Latency = 10 seconds.

Astronaut-Trained Psychologist Therapy

Latency = 0 or ~150 milliseconds.

Dependent Variable

The dependent variables were stress level indicators. These included:

Heart Rate

Heart rate is actually discrete, and the data were treated as discrete and/or continuous.

Blood Pressure

Blood pressure is continuous, and the data were treated as continuous.

PSQ

PSQ scores are based on the 4-point Likert scale, and therefore the data were treated as ordinal.

Data Analysis

Data analysis was carried out on SPSS, with the data first checked for normality and combed for univariate outliers, then analyzed via repeated measures ANOVA. The repeated measures ANOVA was selected as it was ideal for the research design of this study. Specifically, the repeated measures ANOVA allows for comparisons to be made within and/or between treatments/groups. In this way, all of the participants were able to undergo each of the treatments, and the effects of each treatment was then compared.

Delimitations, Assumptions, and Limitations

In terms of delimitations (i.e., the deliberate boundaries placed on the study which refer to the choices made to study a certain population or a certain segment of behavior), because the astronaut population itself can be considered unique with many distinctive and special factors and traits that play a large role in their mindset, abilities, determination, etc., it was important to screen for and select appropriate participants, namely, astronaut-surrogates. Though not necessarily astronauts themselves, it was assumed that these participants represented the astronaut population in this study at a satisfactory level. With regards to the dependent variables, it was also assumed that heart rate, blood pressure, and PSQ score satisfactorily indicated participant stress levels. Additionally, it was assumed that the findings in this study, though conducted analogously on Earth rather than in space, may inform and be directly applied to space psychology best practices and astronauts in the human spaceflight environment.

Restating the limitations and assumptions discussed in Chapter 1, the quantitative research approach of this study could be considered a minor limitation by some. However, being that there is a clear lack of quantitative space psychology research and a relative abundance of qualitative research, it is assumed that this is not a limitation in actuality. With that said, the sample size (N = 24) could have been a potential limitation, which might have made the identification of significant differences between treatment conditions more difficult. Lastly, it was assumed that with regards to therapy administered to astronaut-surrogates, the astronaut-trained psychologist approach would significantly outperform the 10 second latency teletherapy treatment.

Summary

The participants included in the study consisted of NASA, DOD, and aerospace personnel with astronaut-relevant careers/experiences. Worth mentioning is that though this investigation was quantitative study rather than qualitative, the exclusion of qualitative data was not a limitation per say, since there have been relatively fewer quantitative space psychology studies published in comparison. Therefore, this investigation was designed to be both novel and impactful,as it filled in the current gaps in quantitative space psychology research, as well as informs current and future Lunar human spaceflight missions and potentially other space tourism and commercial human spaceflight activities near LEO.

Note that the independent variable in this study was the psychotherapy treatment condition, which consists of three levels: a teletherapy-based 2 second simulated Earth-LEO latency, as teletherapy-based 10 second simulated Earth-Moon latency, and an astronaut-trained psychology therapy treatment with no perceptible latency. The dependent variables were heart rate, blood pressure, and PSQ scores. To ascertain the efficacies and compare teletherapy with astronaut-trained psychologist delivered psychotherapy, an Earth-based analogue experiment was conducted with astronaut-surrogate participants standing in for astronauts. Moreover, all participants underwent each of the three treatments individually at random order. Also noteworthy is that the experiment was conducted in an altitude test chamber, which was purposefully designed for human aeronautical and spaceflight analogue studies such as this one. After the data were checked for normality and combed for univariate outliers, they were then analyzed via repeated measures ANOVA. This this approached was developed to reveal significant differences, where present, in stress reduction among psychotherapy treatment conditions, and therefore helped identify what treatment is best suited for astronauts operating on the Moon. These aforementioned research methods were carried out by the researcher. The results are presented in the next chapter.

CHAPTER 4: RESULTS

Overview

In this chapter, the data collection process/es are described, both the purpose of the study and the research questions that guided the study are restated, and the results from the repeated measures ANOVA as well as descriptive statistics are presented and summarized.

Purpose of the Study

The purpose of this study was to quantitatively identify whether teletherapy or astronaut-trained psychologist delivered psychotherapy is more effective at reducing astronaut stress levels (i.e., heart rate, blood pressure, and self-reported stress level/PSQ scores) beyond LEO. Thus, this investigation identifies whether teletherapy (with a 10 second Earth to Moon latency) or astronaut-trained psychologist delivered therapy (with no perceptible latency) is more effective at reducing stress among astronauts operating beyond LEO.

Data Collection Process

Participants were escorted into the altitude test chamber by the researcher and were directed to sit comfortably. A heart rate monitor was then strapped to the wrist of the respective participant. Note that within each session the heart rate data began recording from then onwards until the end of the respective session. A blood pressure monitor/cuff was then placed around the respective participant’s arm, and 3 pre-session blood pressure measurements were made and averaged to control for variation. Afterwards, the blood pressure cuff was removed from the respective participant’s arm, and a pre-session PSQ was administered.

Following these pre-treatment procedures, the recreational therapy (i.e., guided meditation) began. Note that depending on the treatment condition (i.e., whether the guided meditation was delivered virtually or in person) the researcher either left the altitude test chamber and administered the therapy outside or remained inside with the participant. Also note that therapy in virtual treatments was delivered via computer.

After 7.5 minutes of therapy/guided meditation (i.e., halfway through the session), the researcher reentered the altitude test chamber and/or reapplied the blood pressure monitor. After 3 intra-session blood pressure measurements were averaged and recorded, the researcher returned to their designated location (i.e., out or inside the altitude test chamber). Immediately afterwards, the second half of the session resumed. After another 7.5 minutes, the respective session concluded, and a post-session PSQ was administered. Following the PSQ, the blood pressure monitor/cuff was placed around the respective participant's arm and 3 post-session blood pressure measurements were averaged and recorded. Finally, the blood pressure cuff and heart rate monitor were removed, and the respective participant was escorted out of the altitude test chamber. Note that between participants and sessions, the biometric instruments and sitting area in the altitude test chamber were sanitized. Additionally, the researcher was equipped with PPE and replaced disposable PPE between sessions.

Research Questions that Guided the Study

Astronaut-Trained Psychologists Versus Earth-LEO (2 Second Latency) Teletherapy

Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 2 second Earth-LEO latency at reducing stress level indicators (i.e., heart rate, blood pressure, and PSQ scores) among astronaut-surrogates operating in simulated human spaceflight conditions?

Astronaut-Trained Psychologists Versus Earth-Moon (10 Second Latency) Teletherapy

Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 10 second Earth-Moon latency at reducing stress level indicators (i.e., heart rate, blood pressure, and PSQ scores) among astronaut-surrogates operating in simulated human spaceflight conditions?

Earth-LEO Teletherapy Versus Earth-Moon Teletherapy

Is teletherapy with 10 second Earth-Moon latency less effective than conventional Earth-LEO teletherapy with 2 second latency at reducing stress level indicators (i.e., heart rate, blood pressure, and PSQ scores) among astronaut-surrogates operating in simulated human spaceflight conditions?

Descriptive Results

Included below are two descriptive statistics tables representing the dependent variables (i.e., heart rate, blood pressure, and PSQ score), as well as age demographics. In table 1, the mean and standard deviation of each measurement at their respective treatment and time point are displayed. The labels in column 1 are comprised of three designators which denote the measurement, treatment, and time point respectively. The first designator in the label denotes the specific measurement. I.e., heart rate (HR), systolic blood pressure (BP S), diastolic blood pressure (BP D), and Perceived Stress Questionnaire score (PSQ). The second designator in the label denotes the specific treatment. I.e., astronaut-trained psychologist therapy (T1), Earth-LEO teletherapy (T2), and Earth-Moon teletherapy (T3). The third designator in the label denotes the time point that the measurement was made. PSQ time points are denoted as the following: pre-therapy (1) and post-therapy (2). Blood pressure time points are denoted as: pre-therapy (1), intra-therapy (2), and post-therapy (3). Lastly, Heart rate time points are denoted from the start of the therapy session (0) to the end of the session (15), with a time point denoting each minute of the 15-minute therapy session.

Table 1

Descriptive Statistics

Label	Mean	Std. Deviation	N
PSQ_T1_1	57.13	5.973	24
PSQ_T2_1	58	6.072	24
PSQ_T3_1	57	6.407	24
PSQ_T1_2	54.75	5.487	24
PSQ_T2_2	56.96	5.916	24
PSQ_T3_2	57	6.269	24
BP_S_T1_1	133.88	10.8	24
BP_S_T2_1	133.29	10.585	24
BP_S_T3_1	133.54	10.371	24
BP_S_T1_2	128.29	10.002	24
BP_S_T2_2	132.21	9.736	24
BP_S_T3_2	136.38	10.745	24
BP_S_T1_3	124.08	8.732	24
BP_S_T2_3	128.5	9.745	24
BP_S_T3_3	135.33	10.913	24
BP_D_T1_1	80.58	4.652	24
BP_D_T2_1	80.83	4.743	24
BP_D_T3_1	81.33	4.27	24
BP_D_T1_2	79.25	4.416	24
BP_D_T2_2	80	4.881	24
BP_D_T3_2	82.83	4.469	24
BP_D_T1_3	78.08	4.064	24
BP_D_T2_3	79.71	4.732	24
BP_D_T3_3	83.08	4.096	24
HR_T1_0	89.46	9.528	24
HR_T2_0	90.46	8.663	24
HR_T3_0	90.33	7.173	24
HR_T1_1	88.46	6.122	24
HR_T2_1	89.75	9.433	24
HR_T3_1	91.04	9.096	24
HR_T1_2	87.13	7.663	24
HR_T2_2	88.08	7.052	24
HR_T3_2	90.54	6.685	24
HR_T1_3	84.21	5.124	24
HR_T2_3	84.21	7.083	24
HR_T3_3	89.83	7.245	24
HR_T1_4	81.67	5.976	24
HR_T2_4	83.08	6.573	24
HR_T3_4	88.12	5.728	24
HR_T1_5	81.37	6.446	24
HR_T2_5	82.54	8.011	24
HR_T3_5	86.87	9.219	24
HR_T1_6	80.42	6.206	24

HR_T2_6	81.17	7.927	24
HR_T3_6	85.04	6.919	24
HR_T1_7	79.08	5.587	24
HR_T2_7	82.13	6.131	24
HR_T3_7	84.75	5.479	24
HR_T1_8	81	7.009	24
HR_T2_8	89.08	5.702	24
HR_T3_8	93.83	5.387	24
HR_T1_9	80.75	7.537	24
HR_T2_9	85.04	5.179	24
HR_T3_9	91.21	5.413	24
HR_T1_10	77.88	6.209	24
HR_T2_10	81.42	4.149	24
HR_T3_10	88.04	7.457	24
HR_T1_11	78.17	7.245	24
HR_T2_11	82.67	4.565	24
HR_T3_11	86.25	4.989	24
HR_T1_12	77.71	6.444	24
HR_T2_12	82.63	6.02	24
HR_T3_12	84.75	5.892	24
HR_T1_13	76.96	6.075	24
HR_T2_13	81.29	5.528	24
HR_T3_13	83.25	5.628	24
HR_T1_14	74.92	7.575	24
HR_T2_14	82.08	6.814	24
HR_T3_14	85.25	7.77	24
HR_T1_15	73.58	7.729	24
HR_T2_15	80.04	4.237	24
HR_T3_15	84.5	6.193	24

Age and Sex

Age In table 2, the mean, median, and mode participant age is displayed. Also included are other statistics such as the minimum and maximum participant age, etc.

Table 2

Age Demographics

		Statistic	Std. Error
Mean		40.04	2.74
95% Confidence Interval for Mean	Lower Bound	34.37	
	Upper Bound	45.71	

5% Trimmed Mean	39.27	
Median	36	
Mode	29	
Variance	180.129	
Std. Deviation	13.421	
Minimum	25	
Maximum	70	
Range	45	
Interquartile Range	22	
Skewness	0.939	0.472
Kurtosis	-0.403	0.918

Sex

Of the 24 participants, 12 were female and 12 were male. Note that in the analysis, 1 denotes female, and 2 denotes male.

Astronaut-Surrogate Screening

Also worth mentioning is that per the astronaut-surrogate screening questionnaire, at the time of participation, all participants: were 18 years of age or older, had a body mass index less than 30, were not habituated to illicit drug use, attained a bachelor's degree or equivalent, worked in an aerospace-relevant career field (e.g., pilot, space systems engineer, aerospace experimental psychologist, etc.), were open to receiving therapy, as well as reported being comfortable in confined/isolated environments and work well in team environments while also being self-reliant.

Study Findings

Astronaut-Trained Psychologists Versus Earth-LEO (2 Second Latency) Teletherapy

RQ1

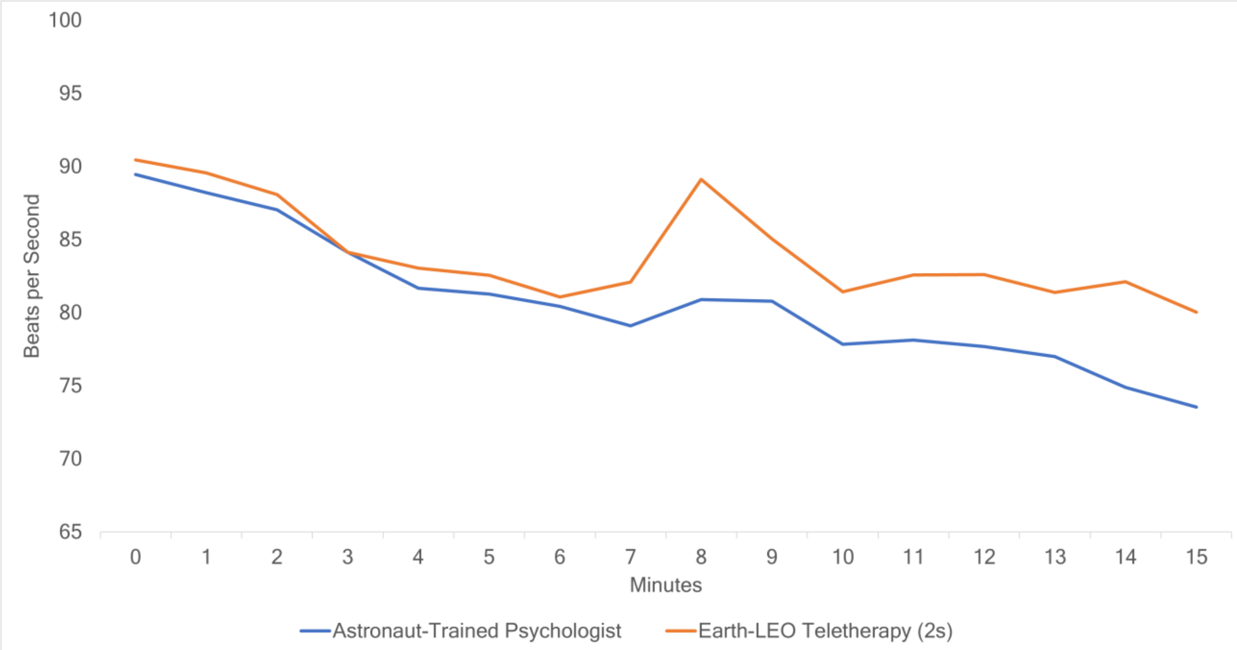
Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 2 second Earth-LEO latency at reducing heart rate among astronaut-surrogates operating in simulated LEO conditions?

Results: Corresponding to RQ1

There were significant differences in heart rate between the two therapy treatments at the following time points: T8, T10, T11, T12, T13, T14, and T15. At T8, the mean difference between the astronaut-trained psychologist treatment and the Earth-LEO teletherapy treatment was -8.083, with a significance of 0.002. At T10, the mean difference was -3.542, with a significance of 0.038. At T11, the mean difference was -4.500, with a significance of 0.034. At T12, the mean difference was -4.917, with a significance of 0.035. At T13, the mean difference was -4.333, with a significance of 0.009. At T14, the mean difference was -7.167, with a significance of 0.006. Lastly, at T15, the mean difference between the astronaut-trained psychologist treatment and the Earth-LEO teletherapy treatment was -6.458, with a significance of 0.005. Therefore, astronaut-trained psychologist delivered therapy with no perceptible latency was more effective than teletherapy with 2 second Earth-LEO latency at reducing heart rate among astronaut-surrogate participants. These differences are displayed in figure 1.

Figure 1

Astronaut-Trained Psychologist vs Earth-LEO Teletherapy: Heart Rate



RQ2

Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 2 second Earth-LEO latency at reducing blood pressure among astronaut-surrogates operating in simulated LEO conditions?

Results: Corresponding to RQ2

There were significant differences in blood pressure between the two therapy treatments. For systolic blood pressure, significant differences occurred at T2 and T3 (i.e., at the intra-therapy and post-therapy time points). At T2, the mean difference in systolic blood pressure was -3.917, with a significance of 0.010. At T3, the mean difference in systolic blood pressure was -4.417, with a significance of < 0.001.

For diastolic blood pressure, there was a significant difference between the astronaut-trained psychologist treatment and the Earth-LEO teletherapy treatment at T3. Specifically, at T3, the mean difference was -1.625, with a significance of 0.001. Therefore, astronaut-trained psychologist delivered therapy with no perceptible latency was more effective than teletherapy with 2 second Earth-LEO latency at reducing blood pressure among astronaut-surrogate participants. These systolic and diastolic differences are displayed in figures 2 and 3 respectively.

Figure 2

Astronaut-Trained Psychologist vs Earth-LEO Teletherapy: Systolic Blood Pressure

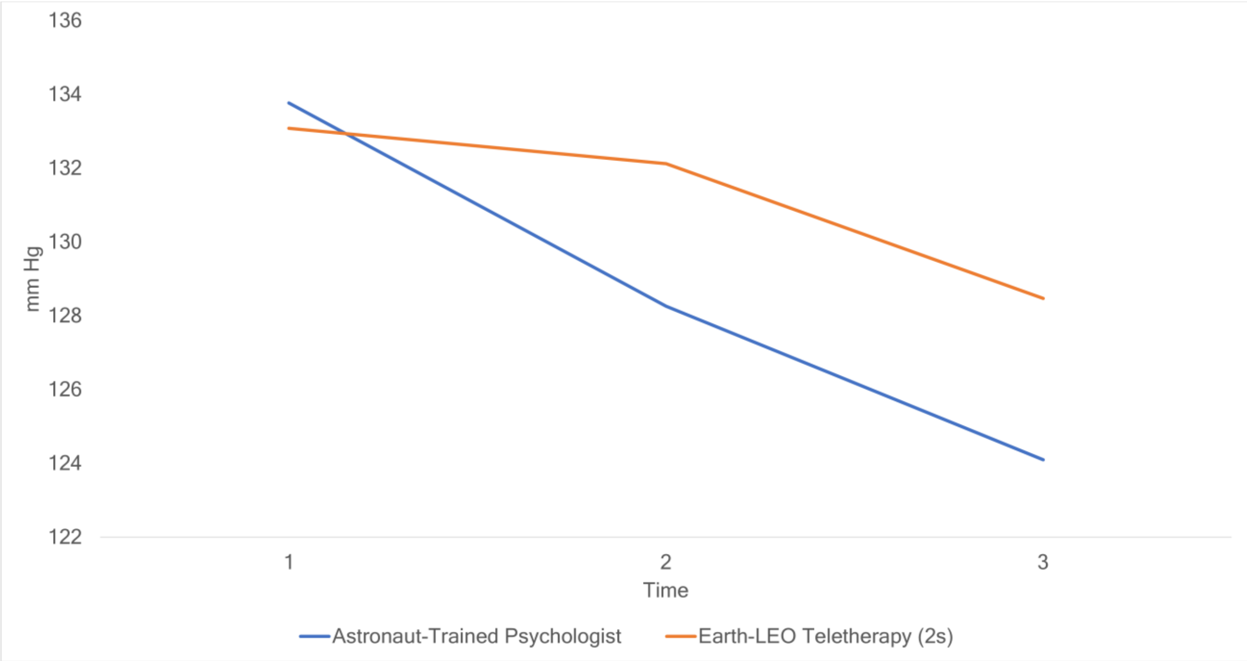
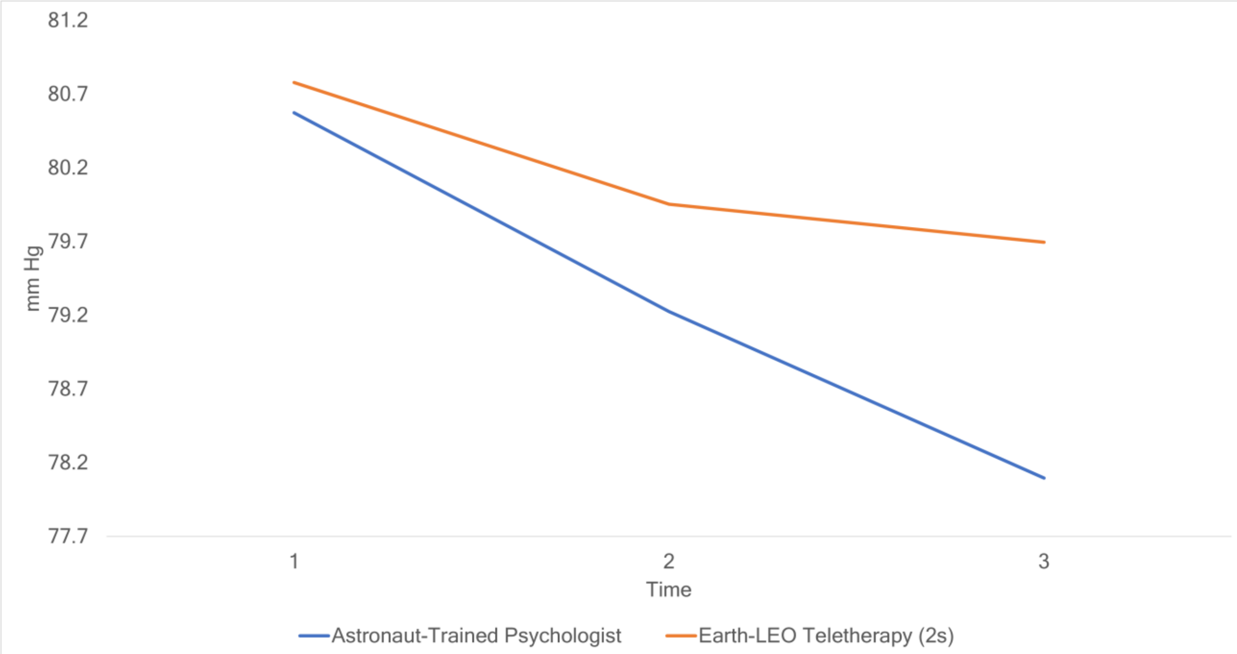


Figure 3

Astronaut-Trained Psychologist vs Earth-LEO Teletherapy: Diastolic Blood Pressure



RQ3

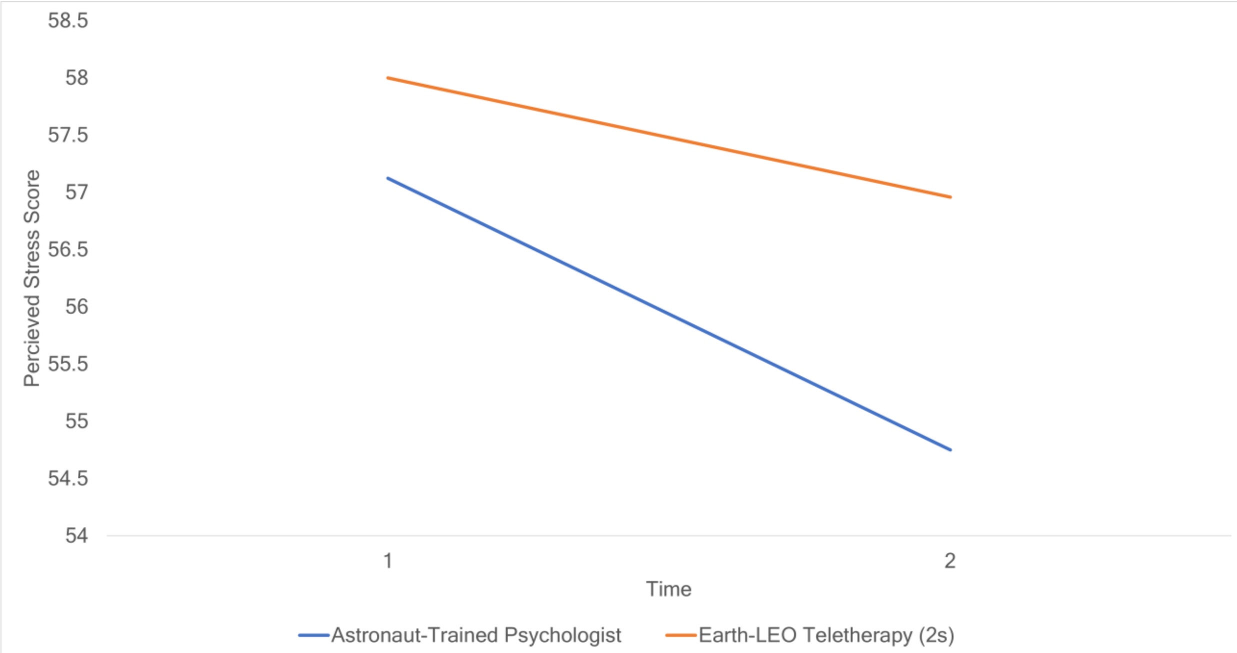
Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 2 second Earth-LEO latency at improving Perceived Stress Questionnaire (PSQ) scores among astronaut-surrogates operating in simulated LEO conditions?

Results: Corresponding to RQ3

There was a significant difference in PSQ scores between the astronaut-trained psychologist treatment and the Earth-LEO teletherapy treatment. Specifically, at T2 (i.e., the post-therapy PSQ) the mean difference was -2.250, with a significance of < 0.001. Therefore, astronaut-trained psychologist delivered therapy with no perceptible latency was more effective than teletherapy with 2 second Earth-LEO latency at reducing PSQ scores among astronaut-surrogate participants. This difference is displayed in figure 4.

Figure 4

Astronaut-Trained Psychologist vs Earth-LEO Teletherapy: PSQ



Astronaut-Trained Psychologists Versus Earth-Moon (10 Second Latency) Teletherapy

RQ4

Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 10 second Earth-Moon latency at reducing heart rate among astronaut-surrogates operating in simulated Lunar conditions?

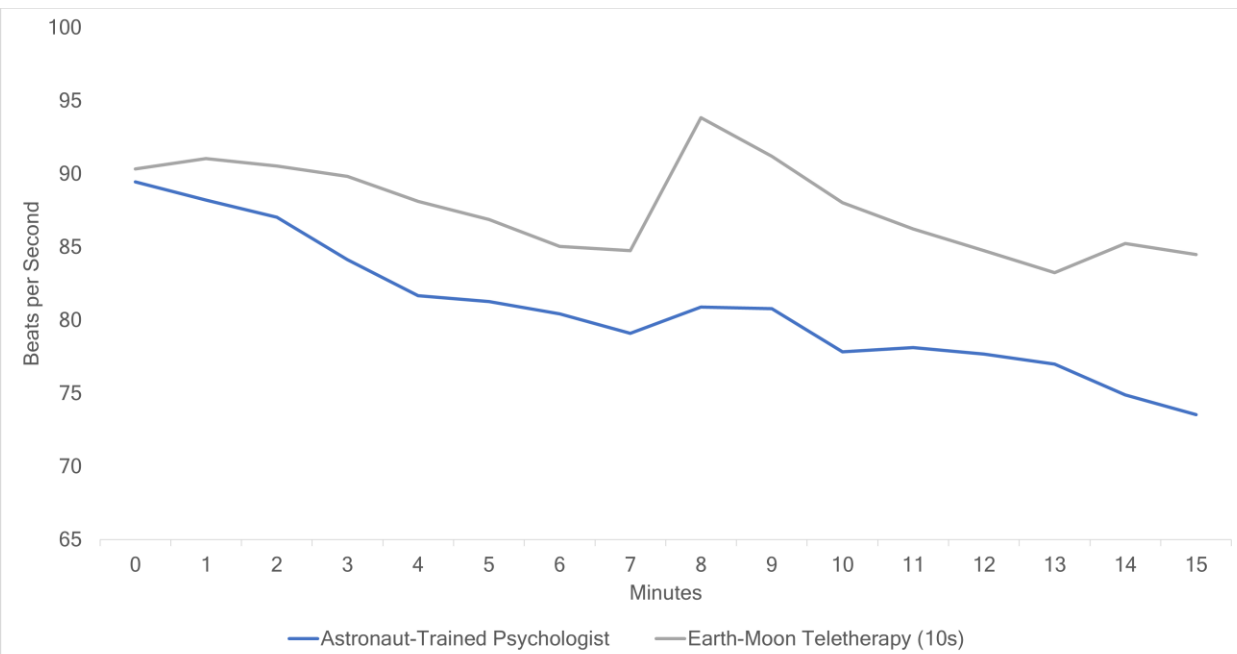
Results: Corresponding to RQ4

There were significant differences in heart rate between the two therapy treatments at the following time points: T3, T4, T7, T8, T9, T10, T11, T12, T13, T14, and T15. At T3, the mean difference between the astronaut-trained psychologist treatment and the Earth-Moon teletherapy treatment was -5.625, with a significance of 0.006. At T4, the mean difference was -6.458, with a significance of 0.004. At T7, the mean difference was -5.667, with a significance of < 0.001. At T8, the mean difference was -12.833, with a significance of < 0.001. At T9, the mean difference was -10.485, with a significance of < 0.001. At T10, the mean difference was -10.167, with a significance of < 0.001. At T11, the mean difference was -8.083, with a significance of 0.001. At

T12, the mean difference was -7.042, with a significance of < 0.001. At T13, the mean difference was -6.292, with a significance of 0.006. At T14, the mean difference was -10.333, with a significance of < 0.001. Lastly, at T15, the mean difference between the astronaut-trained psychologist treatment and the Earth-Moon teletherapy treatment was -10.917, with a significance of < 0.001. Therefore, astronaut-trained psychologist delivered therapy with no perceptible latency was more effective than teletherapy with 10 second Earth-Moon latency at reducing heart rate among astronaut-surrogate participants. These differences are displayed in figure 5.

Figure 5

Astronaut-Trained Psychologist vs Earth-Moon Teletherapy: Heart Rate



RQ5

Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 10 second Earth-Moon latency at reducing blood pressure among astronaut-surrogates operating in simulated Lunar conditions?

Results: Corresponding to RQ5

There were significant differences in blood pressure between the two therapy treatments, which occurred at T2 and T3 for both systolic and diastolic. For systolic blood pressure at T2, the mean difference was -8.083, with a significance of < 0.001. The mean difference in systolic blood pressure at T3 was -11.250, with a significance of < 0.001.

As for diastolic blood pressure, the mean difference between the astronaut-trained psychologist treatment and the Earth-Moon teletherapy treatment at T2 was -3.583, with a significance of < 0.001. At T3, the mean difference in diastolic blood pressure was -5.000, with a significance of < 0.001. Therefore, astronaut-trained psychologist delivered therapy with no perceptible latency was more effective than teletherapy with 10 second Earth-Moon latency at reducing both systolic and diastolic blood pressure among astronaut-surrogate participants at intra- and post-therapy time points. These systolic and diastolic differences are displayed in figures 6 and 7 respectively.

Figure 6

Astronaut-Trained Psychologist vs Earth-Moon Teletherapy: Systolic Blood Pressure

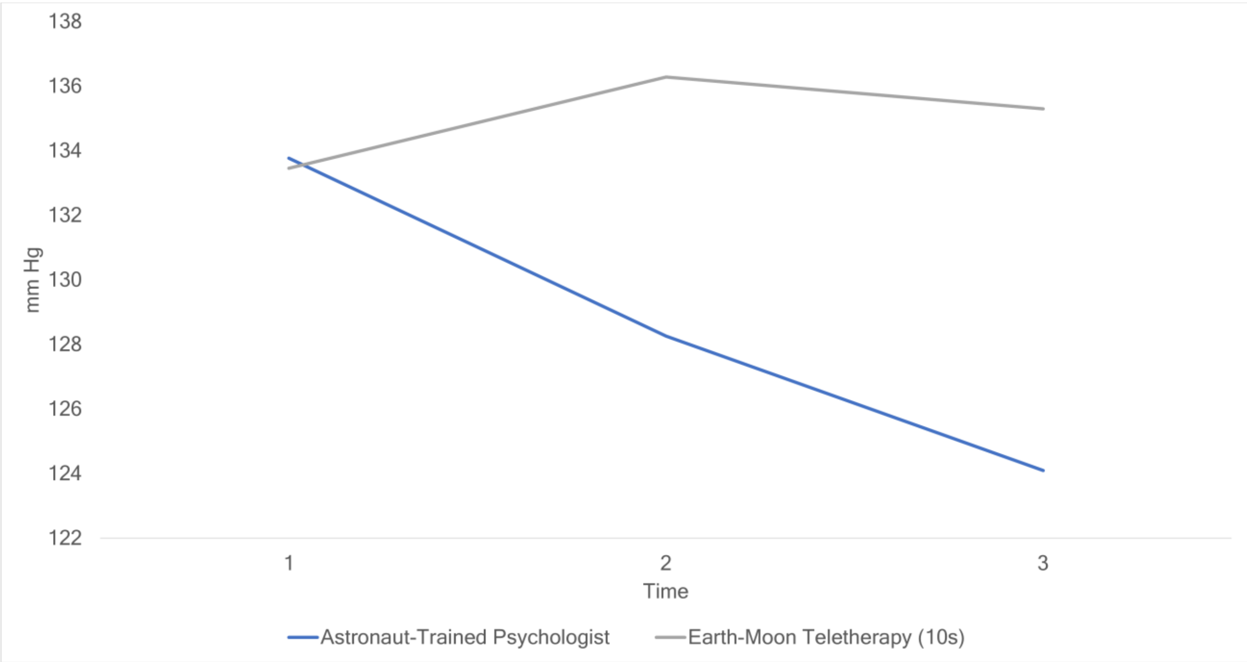
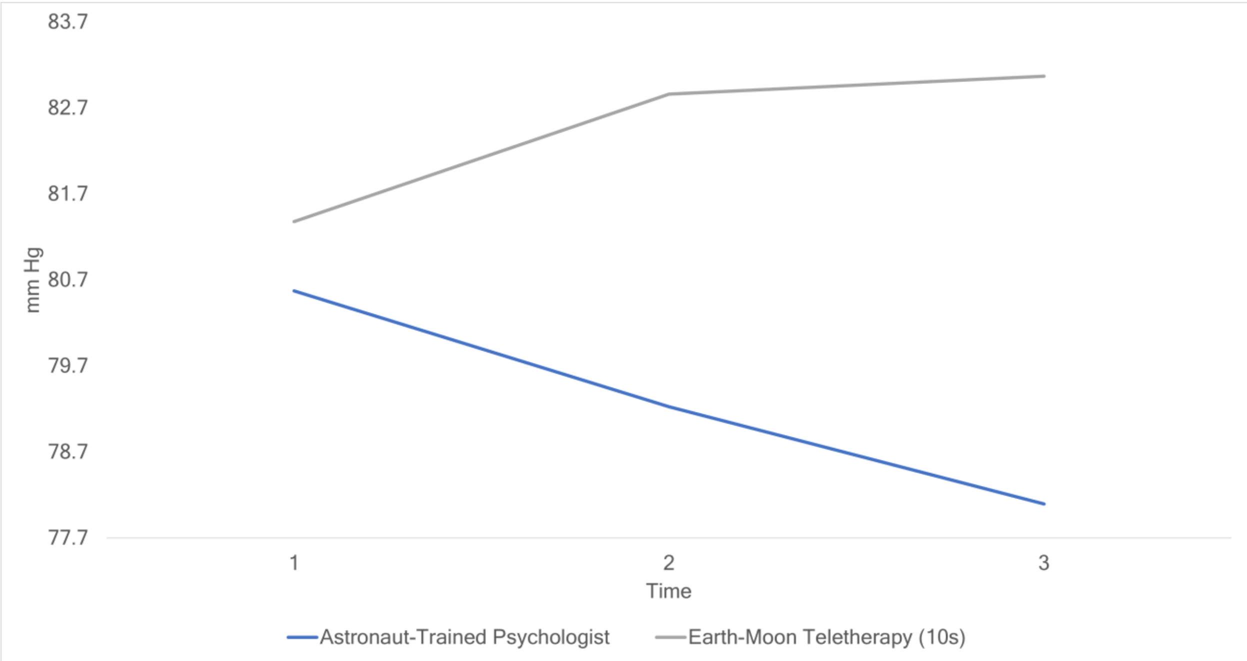


Figure 7

Astronaut-Trained Psychologist vs Earth-Moon Teletherapy: Diastolic Blood Pressure



RQ6

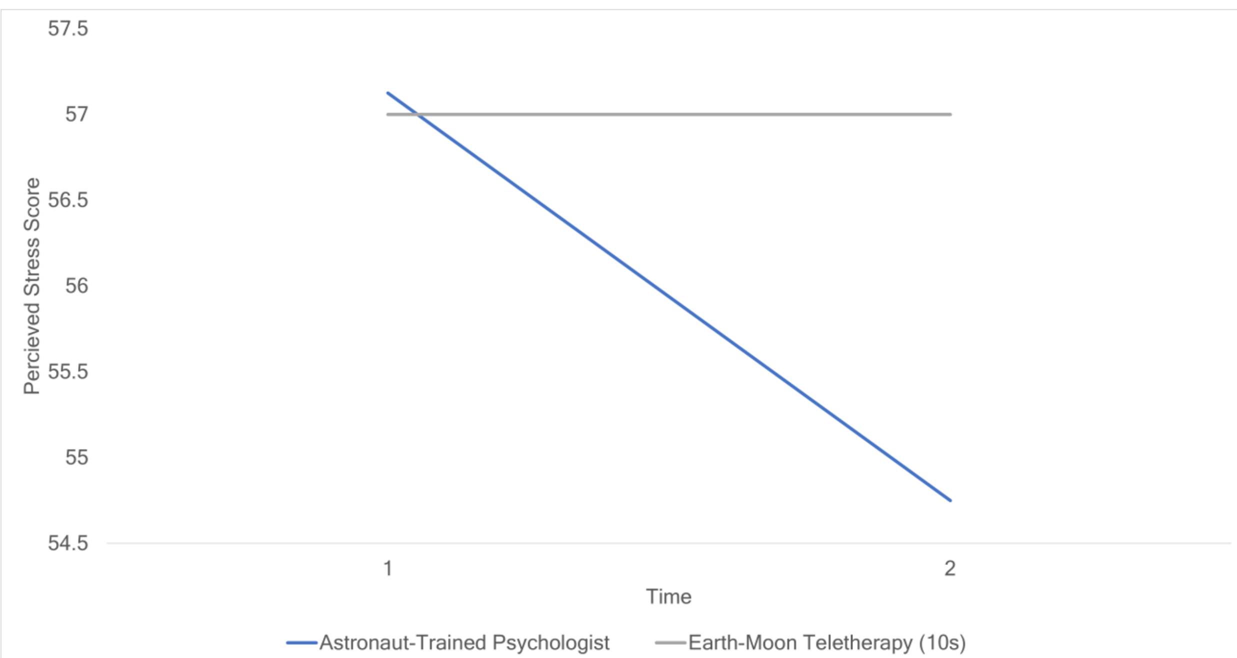
Is astronaut-trained psychologist delivered therapy with no perceptible latency more effective than teletherapy with 10 second Earth-Moon latency at improving PSQ scores among astronaut-surrogates operating in simulated Earth-Moon conditions?

Results: Corresponding to RQ6

There was a significant difference in PSQ scores between the astronaut-trained psychologist treatment and the Earth-Moon teletherapy treatment. Specifically, at T2 the mean difference was -2.250, with a significance of 0.005. Therefore, astronaut-trained psychologist delivered therapy with no perceptible latency was more effective than teletherapy with 10 second Earth-Moon latency at reducing PSQ scores among astronaut-surrogate participants. This difference is displayed in figure 8.

Figure 8

Astronaut-Trained Psychologist vs Earth-Moon Teletherapy: PSQ



Earth-LEO Teletherapy Versus Earth-Moon Teletherapy

RQ7

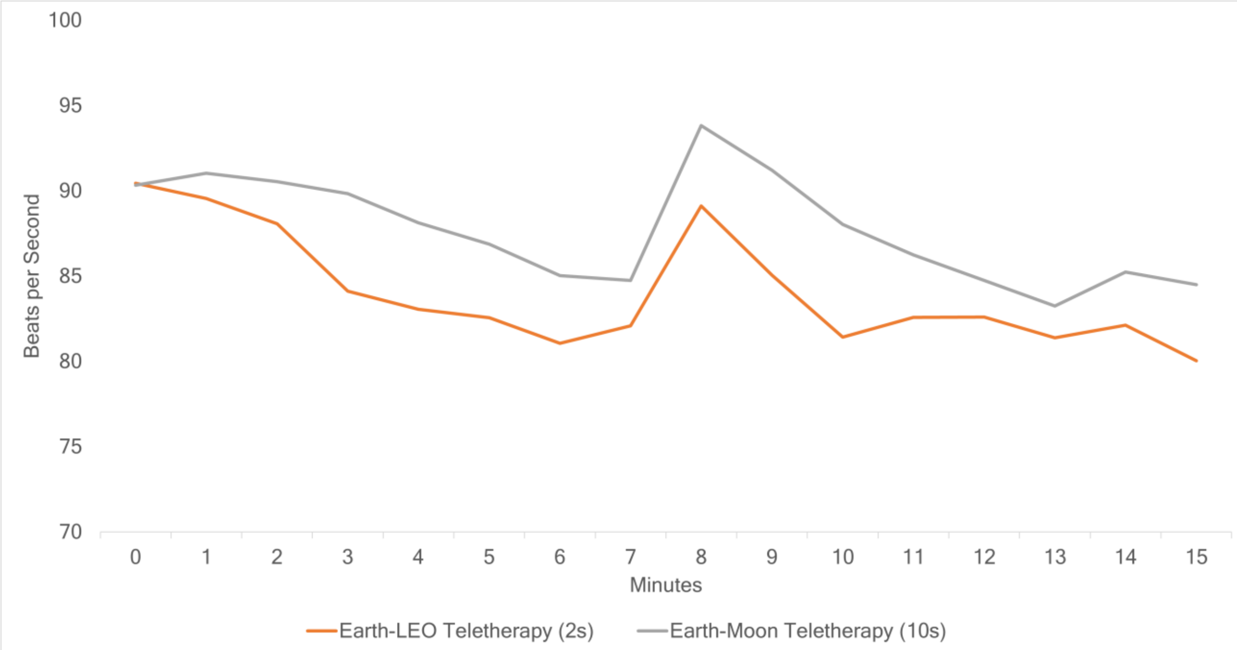
Is teletherapy with 10 second Earth-Moon latency less effective than conventional Earth-LEO teletherapy with 2 second latency at reducing heart rate among astronaut-surrogates operating in simulated Lunar conditions?

Results: Corresponding to RQ7

There were significant differences in heart rate between the two teletherapy treatments at the following time points: T4, T8, T9, T10, and T15. At T4, the mean difference between the Earth-LEO teletherapy treatment and the Earth-Moon teletherapy treatment was -5.042, with a significance of 0.003. At T8, the mean difference was -4.750, with a significance of 0.020. At T9, the mean difference was -6.167, with a significance of 0.002. At T10, the mean difference was -6.625, with a significance of 0.004. Lastly, at T15, the mean difference between the two teletherapy treatments was -4.458, with a significance of 0.029. Therefore, teletherapy with 10 second Earth-Moon latency was less effective than conventional Earth-LEO teletherapy with 2 second latency at reducing heart rate among astronaut-surrogate participants. These differences are displayed in figure 9.

Figure 9

Earth-LEO vs Earth-Moon Teletherapy: Heart Rate



RQ8

Is teletherapy with 10 second Earth-Moon latency less effective than conventional Earth-LEO teletherapy with 2 second latency at reducing blood pressure among astronaut-surrogates operating in simulated Lunar conditions?

Results: Corresponding to RQ8

There were significant differences in blood pressure between the two teletherapy treatments, which occurred at T2 and T3 for both systolic and diastolic. For systolic blood pressure at T2, the mean difference was -4.167, with a significance of < 0.001. The mean difference in systolic blood pressure at T3 was -6.833, with a significance of < 0.001.

As for diastolic blood pressure, the mean difference between the Earth-LEO teletherapy treatment and the Earth-Moon teletherapy treatment at T2 was -2.833, with a significance of < 0.001. At T3, the mean difference in diastolic blood pressure was -3.375, with a significance of < 0.001. Therefore, teletherapy with 10 second Earth-Moon latency was less effective than conventional Earth-LEO teletherapy with 2 second latency at reducing heart rate among astronaut-surrogate participants. These systolic and diastolic differences are displayed in figures 10 and 11 respectively.

Figure 10

Earth-LEO vs Earth-Moon Teletherapy: Systolic Blood Pressure

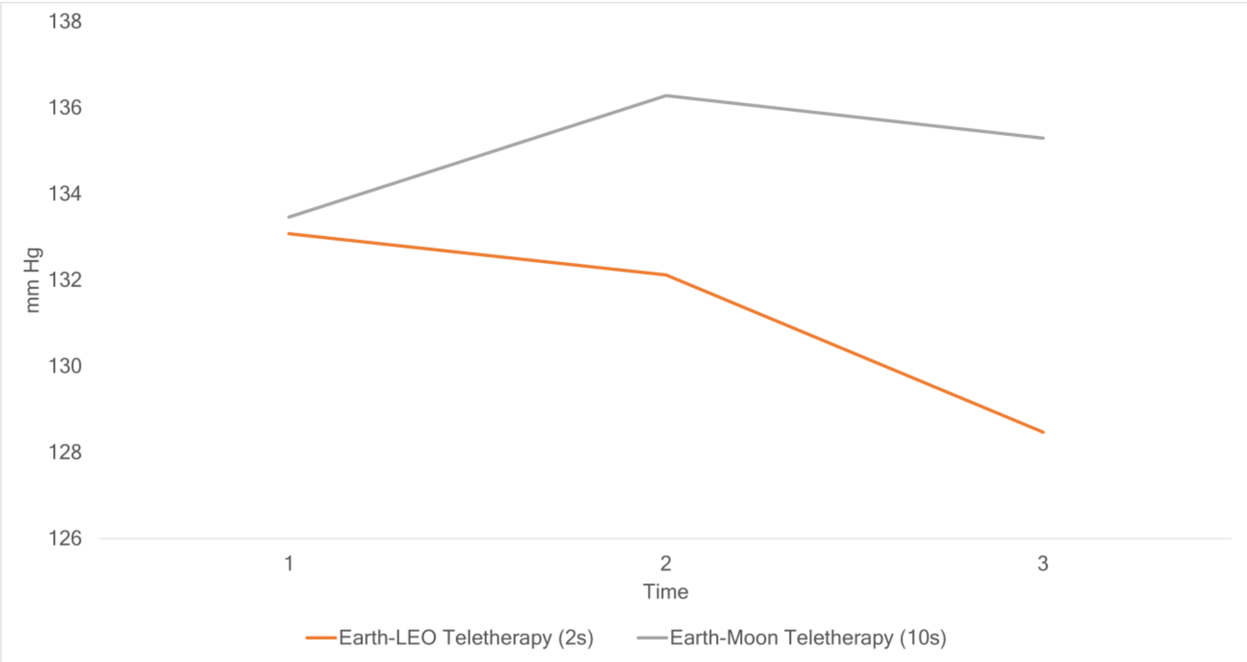
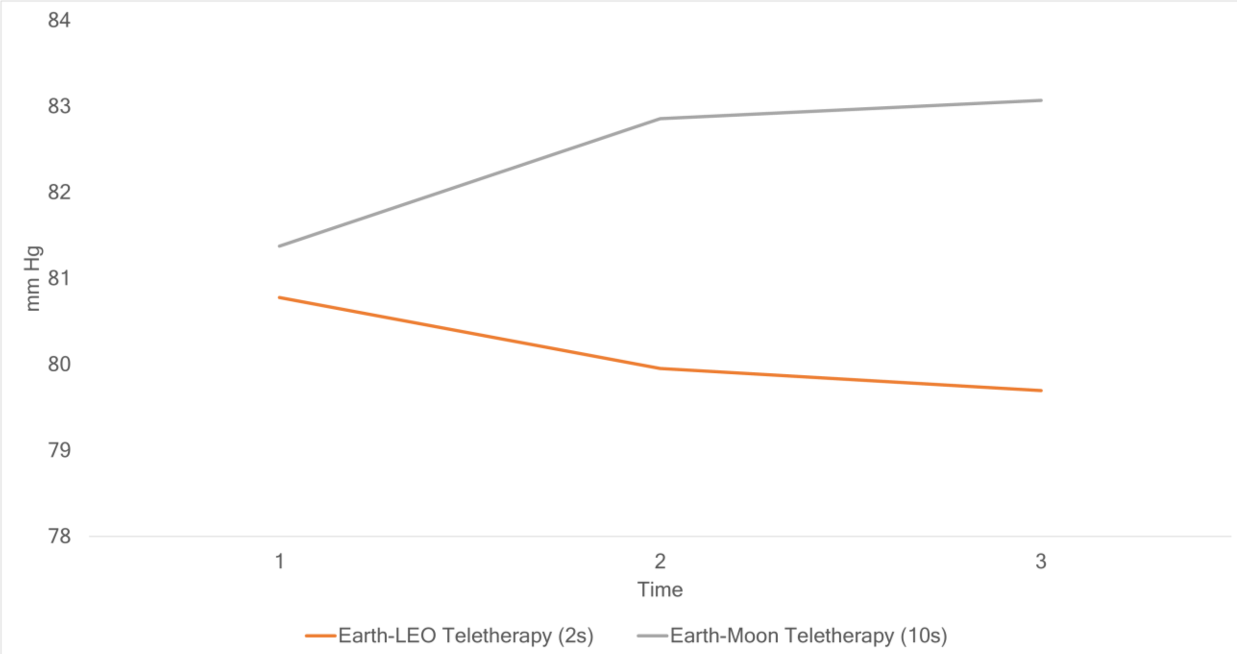


Figure 11

Earth-LEO vs Earth-Moon Teletherapy: Diastolic Blood Pressure



RQ9

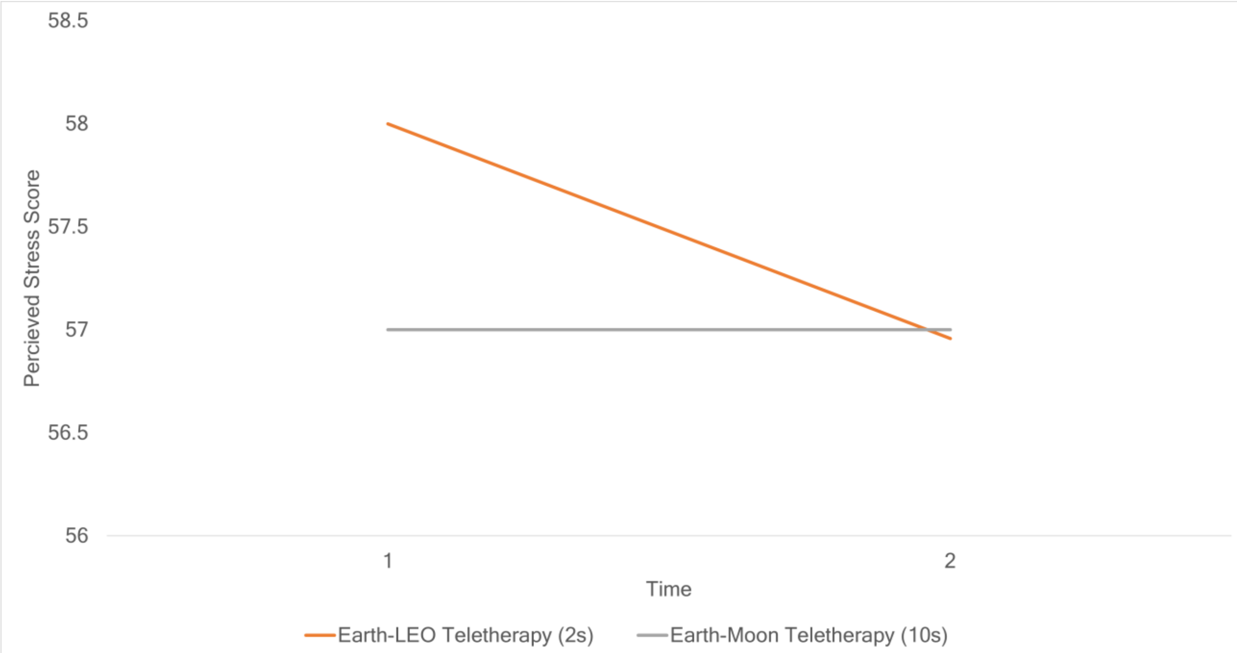
Is teletherapy with 10 second Earth-Moon latency less effective than conventional Earth-LEO teletherapy with 2 second latency at improving PSQ scores among astronaut-surrogates operating in simulated Earth-Moon conditions?

Results: Corresponding to RQ9

Unlike the heart rate and blood pressure results, there were no significant differences in PSQ scores found between the two teletherapy treatments. Therefore, teletherapy with 10 second Earth-Moon latency was not less effective than conventional Earth-LEO teletherapy with 2 second latency at improving PSQ scores among astronaut-surrogate participants. This result is displayed in figure 12.

Figure 12

Earth-LEO vs Earth-Moon Teletherapy: PSQ



Summary

Of the three therapy treatment conditions, astronaut-trained psychologist delivered therapy performed best on every metric, with significant improvements observed in heart rate, blood pressure, and PSQ scores. Between the two teletherapy treatment conditions, the Earth-LEO control with 2 second latency outperformed the 10 second latency Earth-Moon treatment, with significant improvements observed in heart rate and blood pressure. With that said, though PSQ scores were better with Earth-LEO teletherapy than Earth-Moon teletherapy, these differences were not significant. In the following chapter, the implications and limitations of these results are discussed, and recommendations for future research are presented.

CHAPTER 5: DISCUSSION

Overview

The purpose of this study is to quantitatively identify whether teletherapy or astronaut-trained psychologist delivered psychotherapy is more effective at reducing astronaut/astronaut-surrogate stress levels (i.e., heart rate, blood pressure, and self-reported stress level/PSQ scores) beyond LEO. Thus, the aim of this investigation is to identify whether teletherapy (with a 10 second Earth to Moon latency) or astronaut-trained psychologist delivered therapy (with no perceptible latency) is more effective at reducing stress among astronauts operating beyond LEO.

Summary of Findings

Astronaut-Trained Psychologists Versus Earth-LEO (2 Second Latency) Teletherapy

Astronaut-trained psychologist delivered therapy with no perceptible latency was more effective than teletherapy with 2 second Earth-LEO latency at reducing heart rate, systolic and diastolic blood pressure, as well as PSQ scores among astronaut-surrogate participants. For heart rate, significant differences occurred at the following minutes into therapy: 8, 10, 11, 12, 13, 14, and 15. For both systolic and diastolic blood pressure, significant differences occurred at the intra-therapy time point. Additionally, significant mean differences in systolic blood pressure were also present at the post-therapy time point. For PSQ scores, significant mean differences were present at the post-therapy time point as well.

Astronaut-Trained Psychologists Versus Earth-Moon (10 Second Latency) Teletherapy

Astronaut-trained psychologist delivered therapy with no perceptible latency was more effective than teletherapy with 10 second Earth-Moon latency at reducing heart rate, systolic and diastolic blood pressure, as well as PSQ scores among astronaut-surrogate participants. For heart rate, significant differences occurred at the following minutes into therapy: 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, and 15. For both systolic and diastolic blood pressure, significant differences occurred at the intra- and post-therapy time points. For PSQ scores, significant mean differences were also present at the post-therapy time point.

Earth-LEO Teletherapy Versus Earth-Moon Teletherapy

Teletherapy with 10 second Earth-Moon latency was less effective than conventional Earth-LEO teletherapy with 2 second latency at reducing heart rate, as well as systolic and diastolic blood pressure among astronaut-surrogate participants. With that said, there were no significant differences in PSQ scores observed between the two latencies. For heart rate, significant differences occurred at the following minutes into therapy: 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, and 15. Lastly, for both systolic and diastolic blood pressure, significant differences occurred at the intra- and post-therapy time points.

Discussion of Findings

Based on the results of this investigation, it is evident that teletherapy's effectiveness destressing astronauts has an inverse relationship with latency. That is, as latency increases, the effectiveness of teletherapy appears to decrease. This finding is corroborated by the literature reviewed and presented in chapter two, which indicates that latency is plagued with negative cascading effects that increase stress, as well as hinders mood, behavior and performance among individuals and groups (Blackett et al., 2021; Geelhoed et al., 2009; Howard et al., 2014).

In contrast to teletherapy, psychological counseling and support delivered via the astronaut-trained psychologist approach was the most efficacious and significantly outperformed both Earth-LEO and Earth-Moon teletherapy treatments. Note that this is not to say that Earth-LEO teletherapy was ineffective, as it did significantly outperform its longer latency counterpart (i.e., Earth-Moon teletherapy). However, it is clear that Earth-LEO teletherapy could not compete with astronaut trained psychologists. Additionally, based on these results, it appears that the Earth-LEO treatment sufficiently served as the control, which highlighted the significant benefits of astronaut-trained psychologists and the pitfalls of long latency teletherapy (e.g., Earth-Moon teletherapy).

Implications

Human Spaceflight

Based on the results of this investigation, it is evident that the conventional psychological counseling and support method (i.e., teletherapy) does not translate well when applied beyond LEO. Additionally, regardless of latency, teletherapy in general was outperformed by astronaut-trained psychologists. Therefore, space psychology and human spaceflight agencies cannot rely on teletherapy in this capacity. Considering the significantly superior performance of astronaut-trained psychologists at improving heart rate, blood pressure, and PSQ scores, it is logical that greater focus and investment be placed on astronaut-trained psychologist research and operational integration. Specifically, along with experimental research, feasibility studies that focus on the integration of astronaut-trained psychologists with current and future human spaceflight operations/missions will be necessary in order to sustain a permanent and high performing human presence on the Moon. Also noteworthy is that if/when astronaut-trained psychologists reach an inflection point where they are integrated as actual astronaut crewmembers, other aspects of astronautics such as astronaut selection, training, roles and responsibilities, scheduling and operations, etc. may have to evolve somewhat as well. Though the upfront costs – be they financial, logistical, etc. – of this this evolution might seem large at first in comparison to the same old same old of conventional teletherapy, the benefits far outweigh the costs. Therefore, incorporation and activation of astronaut-trained psychologists may very well revolutionize the United States' space fairing capabilities, enabling robust astronaut personnel support that is self-sustaining and not reliant on Earth-based interventions.

Biblical

Along with the biblical perspectives from other works cited in the literature review (e.g., the overview effect), the biblical foundations presented in this study infer that human spaceflight is a redemptive endeavor. Therefore, the support and pursuit of human spaceflight and its advancement further points the individual and the world toward God. In a spiritual sense, astronaut-trained psychologists help their comrades navigate off and out of the fallen Earthly realm to the divine realm, which is one of our roles in God's redemptive work that can and should be actualized.

Limitations

Participants

Though the participants in this study were functionally astronaut-surrogates, they were not actual astronauts. Therefore, it stands to reason that though a passable substitute, astronaut-surrogates do not perfectly represent the astronaut population. Worth mentioning is that more likely than not, astronaut-surrogates have not actually been prepped for a Lunar mission, nor have they agreed to the terms, conditions, and consequences of said mission/s. Therefore, the astronaut-surrogates' aversion and incompatibility with such latencies, where present, might have the potential to differ somewhat to those experienced by actual astronauts' in said human spaceflight environments and missions.

Sensors/Instruments

While the results of the biometric stress data are telling, it should be noted that the heart rate monitor and blood pressure cuff/monitor were not clinical/laboratory grade equipment. Therefore, there might be some minor imprecision and inaccuracy in the biometric data.

Simulated Human Spaceflight Environment

Worth mentioning is that this study was conducted on Earth as an analogue to human spaceflight rather than in space, and though this too could be considered a limitation, the assumption is that this is not a limiting factor. This is because current human spaceflight and space psychology studies are regularly and successfully conducted analogously on Earth, as identified in the literature review. Therefore, it can be assumed that this analogue-based investigation will inform/contribute to space psychology research as well as human spaceflight operations in a similar manner to studies carried out in situ in the spaceflight environment.

Therapy

Duration

Therapy sessions were 15 minutes long. Therefore, when making space psychology predictions informed by these findings, it is important to acknowledge that said predictions would be extrapolation when applied beyond a 15-minute duration. However, this does not invalidate the findings whatsoever, though it is important to mention nonetheless.

Recreational Therapy and Guided Meditation

It should be mentioned that the type of therapy the astronaut-surrogates received in this investigation was technically recreational therapy rather than psychotherapy. Furthermore, the actual therapeutic technique implemented each session regardless of the treatment type was guided meditation (i.e., mindfulness meditation and guided imagery). Though mindfulness and meditation are components of conventional astronaut therapy, the therapeutic approach carried out in this investigation with astronaut-surrogates was slightly narrower than the psychotherapy techniques that would normally be administered to astronauts.

Recommendations for Future Research

Feasibility

Worth identifying is the feasibility of incorporating astronaut-trained psychologists into the ranks of astronauts. It is important to identify what changes, if any, might occur/be necessary for this transition. For example, future studies might seek to answer if the inclusion of astronaut-trained psychologists impacts astronaut selection, training, roles and responsibilities, scheduling and operations, etc. during human spaceflight.

Measurements

Though heart rate and blood pressure are acceptable biometric stress level indicators, future investigations should nonetheless consider including additional biometric measurements. One such recommended measurement is electrodermal activity/galvanic skin response.

Participants

Being that the findings presented in this investigation are intended to be applied and guide space psychology approaches in the upcoming Lunar human spaceflight missions, the next logical step for future research is to include actual astronauts rather than astronaut-surrogate participants.

Psychotherapy

Rather than using recreational therapy and guided meditation solely, it might be beneficial to implement a broader range of psychotherapy techniques and tools. Another beneficial research goal might be the standardization of these psychotherapy approaches for greater replicability and application throughout space psychology research operations.

Additionally, it is recommended that therapy sessions extend beyond 15 minutes, perhaps to 1 hour.

Sensors/Instruments

Future studies would benefit from using clinical/laboratory grade biometric sensors/instruments, as the resulting data would almost certainly be more precise and accurate. Furthermore, it can be assumed that, given the high cost and risk of human spaceflight, the added assurance of higher quality instruments is necessary for space psychology findings/recommendations to be incorporated into future human spaceflight operations/missions.

Simulated Human Spaceflight Environment

It is recommended that more human spaceflight environmental conditions be simulated in future astronaut-trained psychologist research. While simulating space radiation, micrometeorites, etc. is not realistic due to the unnecessary risk to personnel health and safety, what can be simulated feasibly is microgravity and isolation/confinement. For this reason, future research should be conducted underwater, where neutral buoyancy experienced through scuba diving serves as an analogue for microgravity. Additionally, like other analogue Lunar and Martian research, participants can be isolated and confined to their mock astronaut habitat/s, vehicle/s, and suit/s.

Summary

Astronaut-trained psychologist delivered therapy with no perceptible latency was significantly more effective than both Earth-LEO and Earth-Moon teletherapy at reducing heart rate, systolic and diastolic blood pressure, as well as PSQ scores among astronaut-surrogates. Furthermore, the Earth-Moon teletherapy treatment with 10 second latency was significantly outperformed by the 2 second latency Earth-LEO control. Therefore, it is evident that teletherapy’s effectiveness at destressing astronauts has an inverse relationship with latency, making teletherapy unsuitable for Lunar human spaceflight operations and missions. The astronaut-trained psychologist approach on the other hand was far superior to teletherapy at reducing astronaut stress, and is particularly well suited for Lunar human spaceflight. Moreover, astronaut-trained psychologists appear to be the most efficacious space psychology solution which can readily be integrated into NASA’s Artemis mission design. Future space psychology research and feasibility studies are recommended in order to streamline the integration and activation of astronaut-trained psychologists into the human spaceflight domain. In conclusion, by meeting the psychological needs of astronauts in the flourishing human spaceflight frontier, astronaut-trained psychologists are poised to elevate the Unites States’ space fairing capabilities apart from the rest of the world, enabling robust astronaut personnel support that is self-sustaining and not reliant on Earth-based interventions.

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APPENDIX A: INSTITUTIONAL REVIEW BOARD

Included in Appendix A are the relevant Institutional Review Board documents, namely: informed consent, the counseling session outline, participant screening questions, and the email recruitment form.

Informed Consent

Title of the Project: Meeting the Psychological Needs of Astronauts in the Flourishing Human Spaceflight Frontier: A Case for Astronaut-Trained Psychologists

Principal Investigator: Skylar Jordan Laham, PhD Student, Liberty University

Invitation to be Part of a Research Study

You are invited to participate in a research study. To participate, you must be 18 years of age or older, have a body mass index of <30, not be habituated to illicit drugs, have attained a bachelor's degree or equivalent, work or have worked in an aerospace-relevant career field (e.g., pilots, space systems engineers, aerospace experimental psychologists, etc.), be open to receiving recreational therapy, be comfortable in confined and isolated environments, and work well in team environments while also being self-reliant. Taking part in this research project is voluntary.

Please take time to read this entire form and ask questions before deciding whether to take part in this research.

What is the study about and why is it being done?

The purpose of the study is to identify what therapy treatment method is best suited for reducing astronaut stress levels in space and on the Moon.

What will happen if you take part in this study?

If you agree to be in this study, I will ask you to do the following things:

1. Have heart rate recorded throughout the recreational therapy session (~15 minutes).

2. Have 3 pre-session blood pressure measurements recorded (~1 minute).
3. Complete a baseline self-assessment stress level questionnaire (~5 minutes).
4. Undergo 15 minutes of recreational therapy. Note that after the first 7.5 minutes, 3 intra-session blood pressure measurements are recorded, immediately after which the remaining 7.5 minutes of recreational therapy commence. (~16 minutes)
5. Complete a post-session self-assessment stress level questionnaire (~5 minutes).
6. Have 3 post-session blood pressure measurements recorded. Immediately after, the blood pressure and heartrate sensors are removed (1 minute).
7. Repeat twice (once per each respective treatment).

How could you or others benefit from this study?

Direct benefits may include calmness, as well as reduced stress and anxiety. Benefits to society include increasing the feasibility of human spaceflight beyond low-Earth orbit, which in turn advances the space economy (a multitrillion dollar sector), expands our understanding of the universe, and increases the survivability of humanity.

What risks might you experience from being in this study?

The risks involved in this study are minimal, which means they are equal to the risks you would encounter in everyday life.

How will personal information be protected?

The records of this study will be kept private. Published reports will not include any information that will make it possible to identify a subject. Research records will be stored securely, and only the researcher will have access to the records. Data collected from you may be shared for use in future research studies or with other researchers. If data collected from you is shared, any information that could identify you, if applicable, will be removed before the data is shared.

- Participant responses will be kept confidential through the use of codes. Interviews will be conducted in a location where others will not easily overhear the conversation.
- Data will be stored on a password-locked computer, in a locked drawer, or in a locked filing cabinet. The data may be used in future presentations. After three years, all electronic records will be deleted and all physical records will be shredded.

Is study participation voluntary?

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with Liberty University. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

What should you do if you decide to withdraw from the study?

If you choose to withdraw from the study, please contact the researcher at the email address/phone number included in the next paragraph. Should you choose to withdraw, data collected from you will be destroyed immediately and will not be included in this study.

Whom do you contact if you have questions or concerns about the study?

The researcher conducting this study is Skylar Jordan Laham. You may ask any questions you have now. If you have questions later, **you are encouraged** to email him at [redacted] You may also contact the researcher's faculty sponsor, Dr. Bethany Mims-Beliles, at [redacted].

Whom do you contact if you have questions about your rights as a research participant?

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Institutional Review Board, 1971 University Blvd., Green Hall Ste. 2845, Lynchburg, VA 24515 or email at irb@liberty.edu.

Disclaimer: The Institutional Review Board (IRB) is tasked with ensuring that human subjects research will be conducted in an ethical manner as defined and required by federal regulations. The topics covered and viewpoints expressed or alluded to by student and faculty researchers are those of the researchers and do not necessarily reflect the official policies or positions of Liberty University.

Your Consent

By signing this document, you are agreeing to be in this study. Make sure you understand what the study is about before you sign. You will be given a copy of this document for your records. The researcher will keep a copy with the study records. If you have any questions about the study after you sign this document, you can contact the study team using the information provided above.

I have read and understood the above information. I have asked questions and have received answers. I consent to participate in the study.

____

Printed Subject Name

____

Signature & Date

Counseling Session Outline

Table A1

IRB Counseling Session Outline

Session	Counselor /Therapist (Self or Other?)	Participant Group	Instruments Used	Length of Time	Standard Practice Procedures
Recreational teletherapy (2s latency)	Self	Astronaut surrogates	• Heart rate monitor (Fitbit) • Blood pressure monitor cuff • Perceived Stress Questionnaire (PSQ)	15 minutes	1. Participant enters testing site. 2. A heart rate monitor is strapped to participant's wrist and data recorded. Note that heart rate data is recorded from this point onwards until the end of the session. 3. Blood pressure monitor/cuff is placed around participant's arm. 3 pre-session blood pressure measurements are recorded. Then the blood pressure cuff is removed from participant's arm. 4. A pre-session PSQ is administered. 5. The recreational therapy session begins. 6. Halfway through the session (7.5 minutes), 3 intra-session blood pressure measurements are recorded. 7. Immediately afterwards, the second half of the session commences. 8. After 7.5 minutes, a post-session PSQ is administered. 9. Immediately after, a blood pressure monitor/cuff is placed around participant's arm. 3 post-session blood pressure measurements are recorded. After recorded, the blood pressure cuff is removed. 10. Immediately after, the heart rate monitor is finally removed. 11. Session ends.

Recreational teletherapy (10s latency)	Self	Astronaut surrogates	• Heart rate monitor (Fitbit) • Blood pressure monitor cuff • Perceived Stress Questionnaire (PSQ)	15 minutes	1. Participant enters testing site. 2. A heart rate monitor is strapped to participant's wrist and data recorded. Note that heart rate data is recorded from this point onwards until the end of the session. 3. Blood pressure monitor/cuff is placed around participant's arm. 3 pre-session blood pressure measurements are recorded. Then the blood pressure cuff is removed from participant's arm. 4. A pre-session PSQ is administered. 5. The recreational therapy session begins. 6. Halfway through the session (7.5 minutes), 3 intra-session blood pressure measurements are recorded. 7. Immediately afterwards, the second half of the session commences. 8. After 7.5 minutes, a post-session PSQ is administered. 9. Immediately after, a blood pressure monitor/cuff is placed around participant's arm. 3 post-session blood pressure measurements are recorded. After recorded, the blood pressure cuff is removed. 10. Immediately after, the heart rate monitor is finally removed. 11. Session ends.
In-person recreational teletherapy (no latency)	Self	Astronaut surrogates	• Heart rate monitor (Fitbit) • Blood pressure monitor cuff	15 minutes	1. Participant enters testing site. 2. A heart rate monitor is strapped to participant's wrist and data recorded. Note that heart rate data is recorded from this point onwards until the end of the session. 3. Blood pressure monitor/cuff is placed around participant's arm. 3 pre-session blood pressure

	• Perceived Stress Questionnaire (PSQ)	measurements are recorded. Then the blood pressure cuff is removed from participant's arm. 4. A pre-session PSQ is administered. 5. The recreational therapy session begins. 6. Halfway through the session (7.5 minutes), 3 intra-session blood pressure measurements are recorded. 7. Immediately afterwards, the second half of the session commences. 8. After 7.5 minutes, a post-session PSQ is administered. 9. Immediately after, a blood pressure monitor/cuff is placed around participant's arm. 3 post-session blood pressure measurements are recorded. After recorded, the blood pressure cuff is removed. 10. Immediately after, the heart rate monitor is finally removed. 11. Session ends.

Note. The counselor/therapist, participant group, instruments used, length of time, and standard practice procedures are the same among all sessions. Additionally, the order that a respective participant undergoes recreational therapy sessions is assigned randomly, with each participant undergoing all treatments/interventions (i.e., recreational teletherapy with 2 second latency, recreational teletherapy with 10 second latency, and in-person delivered recreational therapy) only once (i.e., no treatment session is repeated).

Astronaut-Surrogate Screening Questions

- Are you at least 18 years of age?
- Have you attained at least a bachelor's degree or its equivalent?
- Do you work or have you worked in an aerospace-relevant career field (e.g., pilot, space systems engineer, aerospace experimental psychologist, etc.)?

- Are you averse to psychotherapy/recreational therapy?
- Do you work well in team environments while also being self-reliant?
- What is your height?
- What is your weight?
- Are you habituated to illicit drugs?
- How frequently do you exercise?
- Do you have serious medical issues/conditions?
- Do you have uncorrectable poor vision?
- Do you have any other physiological issues/conditions and/or phobias?
- Are you comfortable in confined and isolated environments?

Recruitment: Email

Dear [Recipient]:

As a graduate student in the School of Behavioral Sciences at Liberty University, I am conducting research as part of the requirements for a doctoral degree. The purpose of my research is to identify what therapy treatment method is best suited for reducing astronaut stress levels in space and on the Moon, and I am writing to invite eligible participants to join my study.

Participants must be 18 years of age or older, have a body mass index of <30, are not habituated to illicit drugs, have attained a bachelor's degree or equivalent, work or have worked in an aerospace-relevant career field (e.g., pilots, space systems engineers, aerospace experimental psychologists, etc.), be open to receiving recreational therapy, be comfortable in confined and isolated environments, and work well in team environments while also being self-reliant. Participants, if willing, will be asked to undergo virtual and in-person recreational therapy sessions while wearing a biometric measuring device/s during the sessions, as well as complete self-assessment stress level questionnaires before and after the sessions. It should take approximately 30 minutes to complete the procedures listed. Names and other identifying information will be requested as part of this study, but the information will remain confidential.

To participate, please email me at [redacted].

A consent document will be given to you by email. The consent document contains additional information about my research. If you choose to participate, you will need to sign the consent document and return it to me by email.

Sincerely,

Skylar Jordan Laham

PhD Student

[redacted]

APPENDIX B: PERCEIVED STRESS QUESTIONAIRRE ITEM LIST

Included in Appendix B are the Perceived Stress Questionnaire items. There are 30 items in total, and the questionnaire was adapted for use in this investigation. Specifically, rather than ask the astronaut-surrogate/s to respond to how they felt over a one-month period, astronaut-surrogates were instead asked to respond to how they felt in the moment.

Table B1

Perceived Stress Questionnaire Items

Item Number	Item
1	You feel rested
2	You feel that too many demands are being made on you
3	You are irritable or grouchy
4	You have too many things to do
5	You feel lonely or isolated
6	You find yourself in situations of conflict
7	You feel you’re doing things you really like
8	You feel tired
9	You fear you may not manage to attain your goals
10	You feel calm
11	You have too many decisions to make
12	You feel frustrated
13	You are full of energy
14	You feel tense
15	Your problems seem to be piling up

16	You feel you're in a hurry
17	You feel safe and protected
18	You have many worries
19	You are under pressure from other people
20	You feel discouraged
21	You enjoy yourself
22	You are afraid for the future
23	You feel you're doing things because you have to not because you want to
24	You feel criticized or judged
25	You are lighthearted
26	You feel mentally exhausted
27	You have trouble relaxing
28	You feel loaded down with responsibility
29	You have enough time for yourself
30	You feel under pressure from deadlines

Note. For each sentence, circle the number that describes how applicable you feel the statement is *in this moment*. This is a 4-point scale, where a score of 1 represents what is least applicable and 4 represents the most applicable. Work quickly, without bothering to check your answers, and be careful to consider only the last month. Score 5 minus circled number for items 1, 7, 10, 13, 17, 21, 25, 29. Score circled number for all other items.