Spring 2021

Music as Medicine: Supporting NASA's Advancement into Long-Duration Space Missions

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Senior Project Submitted to

The Division of Science, Math, and Computing

of Bard College

by

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Annandale-on-Hudson, New York

May 5, 2021

Acknowledgements

I would like to express my special thanks to my advisor, Tom Hutcheon, for providing invaluable guidance throughout my journey at Bard, for the continuous support and for helping me shape and navigate the challenges of this project.

I would also like to express my sincere gratitude to Jason Kring, for helping elevate these ideas into a higher level and into something concrete, for believing in this project, and for inspiring me and nurturing further interest in potential career fields.

To my professors, thank you for sharing your knowledge with me and helping me discover new interests and passions, for challenging me and helping me achieve a higher level of excellence.

To my friends, thank you for becoming part of the story of my life. Many of us left home to live away from our families for the first time, and, as I navigate life away from home, you have become my new family and support system.

Most of all, I would like to thank my family for their prayers, love, unconditional support and sacrifices for educating me. Thank you for raising me to be independent and for providing me with all of the experiences that have given me everything I know and stand for today.

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Abstract

Considering that a new era for space exploration has begun, space scientists and engineers have devoted their time to develop the capabilities needed to send humans abroad into extended forays in space. Individuals who are subjected to these hostile environments experience various aspects of social isolation and confinement. The stress induced by living under these environmental conditions has been shown to cause changes in brain structures that negatively impact mood cognitive performance. However, it has been found that musical training can positively impact the structural and functional organization of the human brain, thus improving the mood and cognitive performance of individuals. The present study proposes to investigate the effects of musical training on 12 individuals who will spend 9-months in a space analog facility in Antarctica. Mood questionnaires and cognitive tests will be used to assess distinct changes as a response to the environment. The findings of this study will presumably support the idea that musical training prevents cognitive decline and improves psychological health under conditions of isolation and confinement. What researchers learn from this study will potentially help astronauts prepare for longer, farther exploration missions, and will also contribute insight with regard to mitigating the effects of prolonged social isolation and confinement on other members of our population.

Keywords: Isolation, Confinement, Long-duration Missions, Musical Training, Mood, Cognitive Functioning

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Humans spend most of their lives living in groups. Because of this, people's thoughts, feelings, and actions are greatly influenced, shaped and affected by one another. Moreover, evolutionary benefits of group living and sociality have shown to be key for survival. As stated by Forsyth (2014), "In groups we solve problems, create products, create standards, communicate knowledge, have fun, perform arts, create institutions, and even ensure our safety from attacks by other groups" (p. 7). Nevertheless, living in groups is not always possible. Due to the nature of specific jobs, many people have worked under conditions of isolation and confinement for prolonged periods of time. Unlike any other profession, astronauts face one of the most challenging and hostile environments ever. Since great investment in space exploration at greater distances from Earth has increased dramatically over the past century, scientific interest in the problems associated with human adjustment to those conditions has emerged within the last four decades (Stuster, Bachelard and Suedfeld, 1999).

Anecdotal Comparisons

Oftentimes, anecdotal comparisons are made between expeditions of the past and modern-day space expeditions. Although it is true that the world of exploration has changed, from a psychological perspective, the challenges faced by both explorers of the 17th century and of space today are very much alike. These difficulties range from setting in unfamiliar territory to confinement in a small wooden ship locked in the polar ice cap vs confinement in a small but complex spacecraft making repeated journeys between Earth and space. Therefore, as stated by Stuster (2000), "some of the behavioral lessons learned from previous expeditions can be applied to the present generation of explorers in order to facilitate human adjustment and performance during future space expeditions of long duration (p. 49).

Back in the 19th century, the international race to claim the Earth's pole captured the attention of many. According to Potemra (1991), "These ventures involved severe isolation and exploration with self-contained and specially designed craft" (p. 275). The desire to venture to previously inaccessible locations led polar expeditioners to conceive, plan and promote scientific endeavors. From 1893 to 1896, the Norwegian scientist Fridtjof Nansen and his crew planned, developed and constructed their ships to embark on an expedition to the North Pole in order to conduct scientific observations. After noticing the failures of the many expeditions which had approached the North Pole from the west, the Norwegian explorer and crew members attempted to reach the North Pole through the east, returning home in triumph. Over time, humans have been able to venture, access, and explore previous inaccessible locations on the Earth's most extreme environments. In order to extrapolate meaningful information from these expeditions that closely resemble space missions today, space scientists and researchers have become increasingly interested in understanding how the human mind is affected by these extreme environmental conditions in order to advance the limits of human survival in these places.

Risks of Space Exploration

Due to the fact that our nation's space program is preparing for an ambitious new era of space exploration and interplanetary missions, new risks to human spaceflight need to be studied and addressed. During this time, researchers have been able to identify isolation and confinement as one of the five challenges of human spaceflight (Manzey, 2004). As described by Slack et al., 2016:

> Exploration missions will be marked with greater uncertainty as we move away from the

> known (the International Space Station) toward the unknown (e.g., deeper space, new destinations, new spacecraft). Isolation and confinement will be characterized by confinement in decreased habitable volume, decreased privacy, an inability to see Earth, a lack of resupply and care packages, anticipated periods of increased monotony and routine, limited medical care, no evacuation options, less social, physical, and sensory stimulation, and a delay in communication of up to 20 minutes one-way for up to 30 months. These specific conditions are anticipated to affect both mission operations and crew members' perceptions of isolation and their limited ability to stay in touch with mission control and family and friends on the ground. (p.12)

Although humans have the ability to successfully resist or adapt to variations in the environment, interaction between humans and their environment is crucial to provide humans with effective functioning in everyday life. As discussed by NASA Scientist, Tom Williams, being in isolation in space means being in a monotonous area, in an environment that doesn't give any kind of challenge and feedback on how things are different every day and how people are adapting to those changes (Stafford, 2018). Considering the present risks, the astronaut selection committee at NASA has to conduct stringent screening for astronaut candidates and training programs should constantly work on the development of skills for dealing with unpredictability such as requiring astronauts to perform effectively should an adverse cognitive or behavioral condition arise during spaceflight.

Since 1959, the National Aeronautics and Space Administration (NASA) has included screening for mental illness during the selection process for astronauts. As reported by Tania Lewis (2014),

> The psychological selection process consists of two parts, one of which includes the process of psychiatrically qualifying or disqualifying astronaut applicants. Currently, the selection system seeks both to screen out those applicants with a pre-existing illness and to identify those applicants best suited to life as an astronaut (Cox et al. 2013). After this rigorous process, a panel of experts reviews the results to make recommendations to the astronaut selection board. The former reduces the likelihood of psychiatric conditions and the latter reduces the incidence of psychiatric conditions as well as adverse cognitive or behavioral symptoms. (p. 1)

The Behavioral Health and Performance (BHP) Element at NASA defines an adverse behavioral condition as “any decrement in mood, cognition, morale or interpersonal interaction that adversely affects operational readiness or performance”. As defined by the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), a mental disorder is “a syndrome characterized by clinically significant disturbance in an individual’s cognition, emotion regulation, or behavior that reflects a dysfunction in the psychological, biological, or developmental processes underlying mental functioning” (APA, 2013, p. 20). When taking this into context, adverse cognitive or behavioral health outcomes can result in a mental disorder for astronauts and can occur as a result of two factors. First, there is the possibility that mental disorders can occur during spaceflight as a result of factors associated with human space exploration. Second, it is also plausible that these adverse conditions are not detected or mitigated early on in the process and, therefore, result in a mental health disorder (Slack et al., 2016). To further address these hazards and ensure a safe and productive space travel, NASA’s Human Research Program scientists and engineers have devoted their time to develop research studies in their analog facilities.

Analog Facilities

Analog facilities offer a controlled environment that shares physical similarities to the extreme environment astronauts will encounter in space. Studying these issues on Earth is important so that researchers can anticipate and develop the right strategies to mitigate the adverse effects that may arise from living and working under isolation and confinement. While living under these circumstances, it has been demonstrated that conflict and displacement of negative emotions rise up among crewmembers (Pagel & Chouckèr, 2016). For a long time, many explorers have been aware of the effects of isolation and confinement on crew adjustment and behavior. An example of this is Biosphere 2. In 1994, eight biospherians closed themselves into a closed ecological system in Arizona to conduct scientific observations and demonstrate the viability of closed ecological systems to support and maintain human life in outer space. Although crewmembers were carefully selected with the best tests for conformity, inhabitants of Biosphere 2 experienced severe psychological stress that was enough to interfere with their ability to complete daily tasks (Poynter, 2006). Fights and bitter arguments arose and everyday social interactions became extremely difficult to manage. Although these were carefully chosen and ideal conditions, by all accounts, humans didn't do well. Consequently, efforts have been gathered to identify countermeasures that will help astronauts cope with the strong emotions that emerge as a result of isolation and confinement.

Psychological Effects of Isolation and Confinement

Both Antarctic expeditions and space exploration are characterized by isolation and confinement. Because of the significant commonalities that exist between the two, the psychological experiences perceived by individuals living in Antarctic stations over extended periods can be translated to astronauts. In a study examining the reports of Australian Antarctic winter personnel, scientists found variations in everyone's mood from time to time ranging from either positive or negative (Watson & Tellegen, 1985). Interestingly, positive moods have been shown to predict many types of helping behavior, including increased helping behavior toward others (Fisher 2002). Further, positive affect has been associated with greater cognitive flexibility and greater problem solving skills, making employees perform better (Isen, 1999; Tsai et al. 2007). Thus, enhancing positive moods in astronauts could be a powerful tool to improve people's well-being and, subsequently, produce desired positive outcomes in the workplace. Interestingly, variability in mood, difficulties attending to tasks, complaints of cognitive slowing, and memory problems while on orbit are often observed in anecdotal reports (Slack et al,. 2016). Taking this into consideration, NASA can anticipate for similar patterns on astronauts who are adapting to similar environmental conditions during prolonged periods of time. This evidence will allow researchers to address this issue and thus, prevent alterations in mood and degrade in cognitive performance that could potentially compromise a future space mission.

Palinkas and Houseal (2000), examined mood changes of men and women who wintered over in three research stations in Antarctica during the austral winter. Researchers found different patterns of tension and other stress-related negative moods among people in the three stations. A significant decrease in negative mood was shown for people in the most remote continental stations as the winter began and isolation became profound. However, an upturn was shown as the end of the winter approached. By contrast, the personnel located in the least harsh and most accessible peninsular part of the circumpolar area, showed no significant changes in mood at any time. What researchers found for personnel in the most remote station is specifically important because the conditions in which they were living better approximates the isolation and hardships astronauts will face in long-duration space missions. In addition to these findings, Chepenik, Cornew, and Farah (2007), stated that “studies of depressed individuals have shown changes in perception, attention, memory, and executive functions, suggesting that mood has a pervasive effect on cognition” (p. 802). More specifically, cognitive control, which is defined by researchers as the process by which the needed amount of attention is allocated to avoid errors, is also impaired in depression, as measured by tasks such as the Stroop Color and Word Test (Rogers et al., 2004). Therefore, all of these risks should be addressed and evaluated in conjunction with one another so that proper steps can be taken towards reducing the risk of adverse cognitive and behavioral conditions in astronauts who spend extended periods of time in space.

In a study concerning the effects of environmental deprivation and social isolation on the human brain, Stahn, Gunga, Kohlberg, Gallinat, Dinges and Kühn, (2019), found that variations in physical and social environments influence the hippocampus, brain structure that contributes to cognitive functions. This study was conducted on nine polar expeditioners who lived in Antarctica for 14 months. High-resolution T1- and T2- weighted magnetic resonance imaging (MRI) data were obtained and cognitive performance was analyzed before, during, and after the expedition. In addition, to control for possible variations and changes in the brain, longitudinal data was obtained from a control group that matched the polar expeditioners’ age, sex and initial hippocampal volume. Upon the expeditioners’ return, researchers found reductions in regions within the hippocampus. Individuals who had experienced isolation were also found to have lower cognitive performance in tests of spatial processing and selective attention.

As found by the researchers, restrictions to a single living and work space and limited social interactions have detrimental effects on the brain. Furthermore, the association between the reductions in volume of regions within the hippocampus, variabilities in mood and lower cognitive performance in the tasks mentioned above are important factors to highlight when considering long-duration space missions. Supporting these findings, Cinini, Barnabe, Galvão-Coelho, Medeiros, Perez-Mendes, Sousa, ... & Mello (2014) have found in studies with animals that exposure to environmental monotony and social isolation is associated with harmful effects on the brain, particularly in decreasing the generation of new neurons in regions of the hippocampus (p. 1). Another reason why this issue is particularly relevant is that there is increasing evidence showing that the generation of new neurons in regions of the hippocampus could also be important for emotion regulation (Sahay & Hen, 2007; Anacker & Hen 2007). There is substantial evidence supporting the idea that isolation and confinement not only impact brain regions within the hippocampus but cognitive performance and mood regulation. Therefore, it is important to address these issues as they will directly impact astronauts' behavioral health and cognitive performance in prolonged periods of time under these forms of deprivation.

Although more knowledge on the prolonged effects of isolation and confinement on brain functions should be acquired, the present evidence provides a good insight into how the human body and mind might respond during extended forays into space. As it has been shown, isolation and confinement causes changes in the brain, and such changes could lead to more serious consequences such as cognitive and mood disorders (Barlow & Targum, 2007). For this reason, the psychological impact extreme environments have on humans have become a relevant issue in space medicine because such circumstances can impact human performance and well-being, overwhelm the body's psychological resources and become a great safety hazard.

Pharmacological and Nonpharmacological Approaches

As stated by Sproule (2020), “space medicine is integral to the success of an exploration-class mission because space medicine has the potential to largely reduce the risk of an onboard medical event” (p. 45). Researchers in this field are currently developing pharmaceutical solutions for astronauts to support preparations for deep space missions. At the present moment, medications are available at the International Space Station (ISS) in case a behavioral emergency arises. Although replenishing these medical kits is a complex task, these resupply missions are still possible given the fact that the ISS sits only 400 kilometers from Earth. However, the opportunity for supply replenishment won't be as easy when talking about long-duration space missions. In addition, there are two important factors when considering the use of either psychostimulant or antidepressant medications in spaceflight. First, there is very little scientific data on the pharmacodynamics of these drugs and how they affect the human body in a microgravity environment. Second, very little is known with regards to the pharmacokinetics related to the absorption, distribution, and metabolism of the medication within the body and then the excretion from the body in space (Wotring, 2015). For this reason, NASA has developed several non-pharmacological tools to monitor behavioral issues on spacecraft.

The most common tool being used for crewmembers at the ISS is the private psychological conference, which is held biweekly with a psychologist or psychiatrist from Earth (Slack et al., 2016). Private psychological conferences provide individualized behavioral health and psychological support that are useful both as a monitoring tool and a psychological intervention should the need arise. However, assisting astronauts in this manner won't be as simple for longer missions at greater distances from Earth because there can be huge communication delays between ground personnel and crew members. Therefore, there is an increasing need to develop self-directed tools to sustain and improve psychological health during these missions. Interestingly, exercise, eating healthy, keeping a strict sleep and work schedule and making time for leisure activities have shown to be effective in maintaining astronauts' overall physiological, emotional and psychological health in isolation and confinement. While in orbit, crew members have the opportunity to relax, watch movies, talk to their families and even pursue their love for music.

Russian space psychologists have noticed that playing music in-orbit improves the welfare of cosmonauts on long-duration missions (Mars, 2020). In addition to these strategies, writing in journals and using mindfulness techniques are coping mechanisms that are key to help astronauts regulate their emotions, ease isolation stress and psychologically reframe a negative situation into a positive one (Williams, 2020). Considering missions aboard the International Space Station, longer periods of monotony and too much free time will arise (Kanas, 2015). In addition, back-and-forth real-time communication with the ground will become extremely hard as the crew gets further out into space. Therefore, investigating potential ways to counteract isolation and confinement stress without the constant interplay between the crew and ground needs to be explored, in addition to evaluating and developing non-pharmacological strategies that could assist astronauts and stand in for a therapist during longer missions.

Seinfeld, Figueroa, Ortiz-Gil, and Sanchez-Vives (2013) sought to investigate the impact of musical training vs other leisure activities in older adults. Although existing literature presents evidence in support of the positive effects of music on different aspects of people's lives, this study wanted to specifically investigate the impact of reading music and playing the piano on mood, cognitive performance and quality of life. 29 participants between 60-84 years old were assigned to either the piano training program or to other types of leisure activities. Before and after the 4-month period, the two groups were given neuropsychological tests as well as mood and Quality of Life (QOL) questionnaires. Significant improvement was seen for people in the experimental condition on the Stroop test. In addition, an enhancement of visual scanning and motor ability was found and positive mood states increased. The findings of this study support the idea that reading music and playing the piano prevents cognitive decline and improves psychological health on a greater level than other leisure activities.

As seen, research has shown that the act of making music can greatly influence and impact brain functions as well as human behavior. Moreover, intensive training, such as musical training, has shown to positively affect the structural and functional organization of the human brain (Wan & Schlaug, 2010). Because it has been found that music can elicit strong emotions and affect the mood and cognitive performance of individuals, more researchers in the realm of neuroscience have sought to investigate the neural networks underlying these processes. Interestingly, functional neuroimaging and lesion studies have shown activation of limbic areas of the brain, structures known to deal with emotions and cognition, for both musicians and non-musicians when making music (Koelsch, 2010). Therefore, individuals engaging in these types of activities are likely to sustain a positive mood while feeling motivation to engage in an intensive training program that involves music.

A large amount of research has shown the effects of intensive training on the aging adult brain. For example, it has been noted that participants who undergo musical training appear to be less susceptible to age-related degenerations in the brain, which can otherwise result in emotional and cognitive disruptions. This positive effect is seen presumably as a result of their daily musical activities (Sluming et al., 2002). This evidence highlights the potential of rehabilitation treatments, such as musical training, to induce continual modifications to the adult brain while at the same time becoming an extraordinary tool that allows the mature brain to adapt to environmental changes (Wan & Schlaug, 2010; La Rosa, Parolisi & Bonfanti, 2020). For this purpose, music may be a suitable medium to serve during mood regulation and cognitive functioning. Although developing a more sophisticated understanding of the neural mechanisms underlying music, cognition and mood needs to be achieved, such findings are crucial steps towards developing, in this case, feasible countermeasures that will help support space travelers during future missions.

Music in Space

Making music in microgravity is not new. Astronauts who play musical instruments on Earth take them into space. For some, bringing their instruments onboard serves as sentimental items that remind them of their connection with Earth. For others, having their instruments serves as a diversion during the long days and nights in orbit (Dunbar, 2003). In 2011, NASA Astronaut Cady Coleman brought her personal flute to the ISS where she collaborated for the first space-Earth performance with British musician Ian Anderson. Coleman, an amateur flutist, played a portion of the song "Bourree" 220 miles above the Earth and Anderson played his part in Russia. The two parts were later joined. What they played was an arrangement of which Anderson and Jethro Tull, a British rock band, performed during their 1969 U.S. tour as Neil Armstrong and Buzz Aldrin stepped on the moon (Dunbar, 2015). What is interesting about this is that, according to the astronauts, there is no difference between the sounds of the musical instruments on Earth and their sounds in space. However, astronauts have had to deal with the challenges of gravity. To overcome the lack of gravity, astronauts have created novel ways to stay in place using foot restraints and attaching bungee cords to their instruments to keep them from floating away. In addition, prior to the mission, tests are performed on the instruments before they're approved for flight. This aspect is highly crucial in order to protect the astronauts and spacecraft from any potential hazard. As shown, music is noninvasive, and its existence is universal. Thus, if music can help people perform better in high-pressure situations and aid in the process of emotion regulation, the application of such a safe and inexpensive option is limitless for both mission preparation and space missions in isolation and confinement. But, in order to develop safeguards and collect data, human volunteers will be required.

The Study

Considering the above, the present study proposes to specifically investigate the impact of reading music and playing a musical instrument on mood and cognitive performance as participants work to successfully complete their simulated space mission in isolation and confinement in Concordia Station, Antarctica. Researchers will specifically address the question, Does reading music and playing musical instruments prevent cognitive decline and enhance positive mood in conditions of isolation and confinement? To study these effects in Antarctica, researchers will submit the human research proposal to the European Space Agency (ESA). In order to qualify for such an opportunity, the research study proposal will address human research questions that are relevant to long-duration missions to the Moon, Mars or beyond.

Concordia Station in Antarctica is a research facility owned and operated by the French Polar Institute (IPEV) and the Italian Antarctic Programme (PNRA). This research station is considered to be one of the best real-life Earth-based analogs for long-duration deep space missions (European Polar Board, 2021). In addition, Concordia Station has been considered by many researchers as the perfect environment to study these risks because “you can’t walk off the ice. That goes for whether you’re having a health, behavioral health or a personal issue, you’re not going anywhere,” said Lisa Spence (2017), project manager for NASA flight analogs in the

Human Research Program. "That is very similar to spaceflight. It changes your mindset about how you are going to respond when you know you can't leave." (Edwards, 2017). Since 2005 the French and Italian National Antarctic Programmes have worked together to make use of the most remote station on Earth for the implementation of biomedical and psychological research experiments that cannot be done as well elsewhere. The research being conducted at this station not only provides a unique opportunity for investigating the consequences of spaceflight but also serves to benefit the people who choose to undertake the adventurous challenge of working in polar regions by improving their work and living environment. But, in order to develop safeguards and collect data, human volunteers will be required. Advertisement will be done through the European Space Agency and volunteers will respond to a call for analog research participants. For the purpose of this study, researchers will observe 12 volunteers, age 23 to 59 who will participate in an isolation analog in Antarctica. In order to ensure the safety of study participants and research staff, this research proposal will be reviewed and approved by the local Institutional Review Board (IRB). Following candidates approval and selection, the proposed study will be implemented over the winter season in Antarctica. Although the experiment will be conducted by the Research Medical Doctor selected and appointed by the ESA, the Principal Investigator of the study will have the opportunity to train the Research MD in advance before the departure to Concordia.

Upon arrival at Concordia Station, participants will be divided into two groups: musical training and a control group. Alicia Ann Clair (2014) states that, "the piano demands an attention and focus that does not allow interfering thoughts that might be distracting or distressful, and in that way relieves the pressures and the stresses of the day" (paras. 4). Therefore, the piano will be selected as the instrument for the musical training group. Through the course of the investigation participants' selective attention and mood will be specifically assessed before starting the intervention, at month 3, month 5, month 7, and immediately after the end of the intervention. The choice of this cognitive and mood evaluation is based on previous literature showing an effect of isolation and confinement on these specific functions (Pagel & Choukèr, 2016; Palinkas, Johnson and Boster, 2004; Abeln et al., 2015). Participants in the musical training group will participate in a 4-month online piano training program that includes learning musical theory, sight-reading and playing a keyboard. Participants in the musical training group (n = 6) will be compared to a control group (n = 6) that will participate in other types of leisure activities (physical exercise, reading books, painting, among others). In comparison to the control group, I expect to observe significant improvement for people in the musical training condition on cognitive function and mood based on evidence that music improves psychological health in a greater level than other leisure activities (Seinfeld, Figueroa, Ortiz-Gil, & Sanchez-Vives, 2013). The findings of this study will presumably support the idea that reading music and playing musical instruments prevents cognitive decline and enhances positive mood in conditions of isolation and confinement.

Methods

Setting

The 13-person winter-over crew will spend nine months at Concordia Research Station, a French-Italian research facility in Antarctica that has been permanently manned since November 2004. The time from mid-November to mid-February is considered the summer period and from mid-February, mid-November is the winter period. More specifically, the winter-over starts in February and will end in November. Because of Concordia's location at the southernmost point on land, during winter, the Southern Hemisphere is tilted away from the sun. This causes the continent to be in complete darkness following a 24-hour cycle. Therefore, the crew must live without sunlight for four months of the nine months. Concordia Station was built at a location called Dome C on the Antarctic Plateau, Antarctica. This area is considered to be one of the most hostile places on Earth and the environmental characteristics include an altitude of 3233m above the sea level, equal to an equivalent altitude of almost 4000m on the equator, air pressure of 645 hPa (chronic hypobaric hypoxia) and less than 4 inches (10cm) of rain per year and a completely flat landscape. The overall mean temperature is -59.8°F. During the summer, the mean temperature is -22 °F, -76 °F during the winter (lowest record in 2002 -121 °F) and the average wind speed is 2.8m/s (5.4 knots). The precipitation range at Dome C is low. Usually, 2-10 cm of snow is received per year. In addition to the hostile environmental conditions, the winter-over crew members will encounter many challenges like prolonged isolation and confinement, life in a multicultural setting, limited resources, and high levels of autonomy (Mekarnia & Frenot, 2013).

Participants

The winterers' team of the polar mission will be composed of four Italians, two Swiss, two English, and five French, three of whom are women (one Italian and two French) and ten of whom are men. The multicultural crew will be made up of five technicians for station maintenance, five scientists for the research programs, a cook, and two medical doctors. One of the medical doctors will be responsible for the clinical assistance and treatment of the crew. The other medical doctor will be responsible for the medical research at the station. He will be in charge of coordinating the biomedical research experiments at Concordia to assess the prolonged effects of isolation on the human body and mind. He will also execute, oversee and amend, if necessary, the present study and will be in frequent contact with the principal investigators. Overall, the personnel is in charge of the realization of scientific programs and the maintenance and operation of the station during the winter period. Proficiency in the English language is required and participants will be aged between 23 years and 59 years for an average of 37 years.

Ethics & Safety

The study will be compliant with European laws and guidelines for human biomedical research. This research will be approved by the local Institutional Review Board (IRB) **(See Appendix A)**. In addition, safety hazards and assessments, including a description of possible hazardous situations for the test subjects, will be provided and informed consent will be obtained from participants **(See Appendix B)**. As in any human research effort, crewmembers have the right not to continue to serve as test subjects if they so wish and participation in psychological research at the Concordia Research Station is completely voluntary.

Materials & Procedures

The winter-over teams are selected through extensive screening for physical and psychological wellness. Prior to departure, every crew member must pass a series of medical tests to prove that they are healthy enough to handle the unique challenges posed by the Antarctic environment. Because of the less reliable access of MEDEVAC resources to Antarctic stations during the winter months, many of these tests are designed for the early detection of any potential medical problems that can be especially life-threatening. This medical evaluation includes cardio checks, a full dental exam, chest X-rays, and blood tests. In addition to analyzing the blood samples to assess participants' physical health, blood tests are done to identify participants' blood type should the need to serve as a blood donor arise among the limited number of people in Antarctica. Moreover, participants will receive Human Performance Behaviour training at the European Astronaut Center in Cologne, organized by the European Space Administration. The crew will further train to prepare for Antarctica with IPEV (French

Polar Association) and PNRA (Italian Polar Association). For the medical doctor/expedition chief, additional expedition medical training in Chamonix will be organized by IPEV (European Space Agency, 2020).

Planning and designing the experiential study will be done well in advance and the implementation of the study will be flexible due to the fact that exact times of travel to or from Concordia Research Station are often known relatively close to the actual dates of departure. Crewmembers will be transported by plane from Christchurch, New Zealand, to Mario Zucchelli Station, an Italian seasonal research station, and then further to Concordia as well as selected light cargo. The total trip will take approximately 3-5 hours. Heavy equipment will be brought to the station using maritime transportation coming from Hobart, Australia, by ship to Dumont d'Urville, a French scientific station in Antarctica. Depending on water currents and other factors, the cargo ship sailing from Australia will typically take 12 days and deliver approximately 500 tons of payload. Transportation of the musical instruments will be organized well in advance since the weight and size of equipment should be minimized (Mekarnia & Frenot, 2013). Upon their arrival, the crew will be completely isolated and confined for 9 months during the winter period. Participants will be randomly assigned into two conditions; music training (n=6) and control group (n=6). Individuals in the music training group will participate in an online piano training program and individuals in the control group will participate in their regular leisure activities at the station which includes exercising, watching movies, reading books, among others. In addition, a computerized self-administered mood questionnaire **(See Appendix C)** and a neuropsychological test will be given to both groups at 5-time points. Since questionnaire translations may not have undergone a full linguistic validation process and may require further work to be suitable for use in a study, the questionnaire will be in the English language.

Piano Training Program

An online piano training program recorded by a professional music teacher and pianist will be designed and implemented for participants at Concordia. 10 participants will be randomly assigned to two groups; musical training (experimental group) and non-musical training (control group). Participants in the musical training condition will receive online piano lessons for a period of 4 months. The level of difficulty of the piano program will increase gradually. The piano learning phases and their increase in difficulty are specified in **Table 2**. Each session will last an hour and a half and will be taken individually on a daily basis. Each participant will have a computer assigned and a keyboard that they can use for their online lessons and individual practice. Classes combine essential theoretical knowledge about music notation and theory with the actual practice of piano playing. Three homework exercises requiring the playing of a piano sequence will be given in each lesson, and participants will be committed to practice independently at least 5 days per week for 45 mins, for an average of 4 hours of practice per week. A calendar will be given so that participants can register on a daily basis their devoted time. Each day participants have to practice playing a piano sequence 10 times with their dominant hand, and 10 more times with their non-dominant hand. Free access to practice the piano during the week will be possible. Each participant will be given a portable piano keyboard so practice can happen at any time.

In addition to the weekly online lessons, participants will meet once a week to play the piano sequence that they had practiced during the week with the other participants. This methodology will be used to motivate participants with a weekly goal, in addition to making it a supportive space for effective feedback from other “classmates”. Finally, at the end of every group meeting, participants will have to solve doubts about the new exercises proposed for that week. After the training face is over, participants will be required to maintain the same practice schedule and will be provided with sheets of music for them to learn and perform once a month for all the crewmembers in a low-stress, supportive environment. This will serve as motivation and will give participants something to look forward to for the remainder of their time at the station.

Table 2 | Piano learning phases and their gradual increase in difficulty.

Piano learning phases	Piano exercises
1st Phase	Participants practiced ascendant and descendent progressions of consecutive musical notes with the five fingers of the hand. Each exercise was repeated with the right hand in the treble clef, and with the left hand in bass clef. Finally, subjects had to practice with both hands together.
2nd Phase	Alternating musical notes were practiced with the five fingers of both hands. Ascendant and descendent chord triads were practiced increasing the distance between musical intervals.
3rd Phase	Practice of "thumb under" exercise in the piano, with both hands.
4th Phase	Playing different melodies with each hand and alternating.
5th Phase	Playing a melody with the right hand, while playing long musical notes with the left hand.
6th Phase	Playing a melody with the left hand, while playing long musical notes with the right hand.
7th Phase	Playing two different melodies at the same time by alternating learned movements with the hands.
8th Phase	Adding articulation, staccato, and legato.
9th Phase	Adding indications of expression.

Note. Reprinted from "Effects of music learning and piano practice on cognitive function, mood and quality of life in older adults", by Seinfeld, S., Figueroa, H., Ortiz-Gil, J., & Sanchez-Vives, M. V. (2013, November 01). Retrieved from https://www.frontiersin.org/articles/10.3389/fpsyg.2013.00810/full

Mood assessment

Positive, and Negative Affect Schedule (PANAS)

The PANAS scale is one of the most widely and frequently used scales to measure mood or emotion. This brief scale comprises two mood scales, one that measures positive affect (PA) and the other which measures negative affect (NA). The questionnaire contains 20 items, with 10 items measuring positive affect (e.g., excited, attentive) and 10 items measuring negative affect (e.g., nervous, afraid). Each item is rated on a five-point Likert Scale, ranging from 1 = *Very Slightly or Not at all* to 5 = *Extremely*, to measure the extent to which the affect has been experienced in a specified time frame (Tran, 2013) **(See Appendix C).**

Cognitive Control Task

Stroop Color-Word Interference

The Stroop Color and Word Interference Test is a neuropsychological test extensively used to assess the ability to inhibit cognitive interference that occurs when the processing of a specific stimulus feature impedes the simultaneous processing of a second stimulus attribute, well-known as the Stroop Effect. This test will requires participants to identify the name of a color (e.g., “blue,” “green,” or “red”) that is printed in a color that matches (e.g. the word “red” printed in red ink) or mismatches (e.g., the word “red” printed in blue ink instead of red ink) (Hamer, 2013). Words will be presented one at a time in the center port of a computer screen in a standard color Stroop experiment. Names of colors (e.g., red) or sizes (e.g., small) will appear in a 24-point Chicago font in one of five colors on a black screen, and participants will be instructed to name aloud the color in which each word appeared. One hundred words will be presented in each of two blocks of trials. Reaction times (RTs) will be recorded and the measure of interest, the congruency effect, will be calculated by subtracting each participant's mean RT on congruent trials from that on incongruent trials.

Data Analysis

JASP statistical software package (Version 0.14.1, 2020) will be used for data analysis. To test for the impact of training and time, The three dependent measures (Positive Affect, Negative Affect and Stroop) will be analyzed separately with a 5 (Time: time 1, time 2, time 3, time 4, time 5) X 2 (Condition: Music, Non-music) repeated measures Analysis of Variance (ANOVA). With time as a within-subjects factor and condition as a between-subjects factor.. Preliminary analyses will presumably identify condition differences for all of the dependent measures over time. Therefore, this analysis will be followed up with Independent Sample T-tests for the two independent groups of observations (Musical Training, Control). Significance will be evaluated at a P-value of < 0.05.

Predicted Results

In total, twelve individuals will complete the PANAS questionnaire and the Stroop Color-Word Interference Test at 5-time points. The final sample will include 5 technicians, 5 scientists, 1 cook, and 1medical doctor.

Mood assessment

Positive Affect (PANAS)

A Two-way repeated measures Analysis of Variance (ANOVA) with Condition as a between-subjects factor and Time as a within-subjects factor revealed that there was a significant main effect of Condition, $F(1,10) = 98.63$, $p = <.001$, indicating that the music group ($M = 40.07$, $SD = 5.09$) had higher levels of positive affect compared to the non-music group ($M = 26.53$, $SD = 6.22$). There was also a main effect of Time, $F(4,40) = 3.61$, $p = 0.01$, indicating a significant difference in positive affect as a function of Time. No significant interaction was found. To follow-up on the main effect of Time, a series of independent samples t-tests were conducted in order to compare the positive affect for the music and non-music group at each time point. A significant difference was observed at each time point, Time 1, $t(10)$, = 2.38. $p = 0.04$, Time 2, $t(10)=2.96$, $p = 0.01$, Time 3, $t(10)=5.49$, $p = .001$, Time 4 $t(10)=4.71$, $p = .001$, Time 5 $t(10)=4.22$, $p = .002$. Overall, this indicates a higher positive affect for participants in the music than for those in the non-music group **(See Figure 1)**.

Negative Affect (PANAS)

A two-way repeated measure ANOVA with Condition as a between-subjects factor and Time as a within-subjects factor revealed that there was a significant main effect of Condition, $F(1,10) = 16.71$, $p = .002$, indicating that the non-music group ($M = 20.4$, $SD = 5.05$) had higher levels of negative affect compared to the music group ($M = 13.90$, $SD = 4.75$). There was also a main effect of Time, $F(4,40) = 4.96$, $p = .002$ indicating a significant difference in negative affect as a function of Time. The interaction between Condition and Time was significant $F(4,40) = 4.24$, $p = .006$ indicating that the impact of Condition depended on Time. To follow-up on this interaction of Condition, a series of independent samples t-tests were conducted in order to compare the negative affect for the non-music and music group at each time point. A significant difference was observed at three time points, Time 3 $t(10)=-5.77$, $p = .001$, Time 4 $t(10)=-3.93$, $p = 0.003$, Time 5, $t(10)=-3.29$, $p = 0.008$, indicating that participants in the non-music group scored higher on negative affect later in the intervention than participants in the music group **(See Figure 2)**.

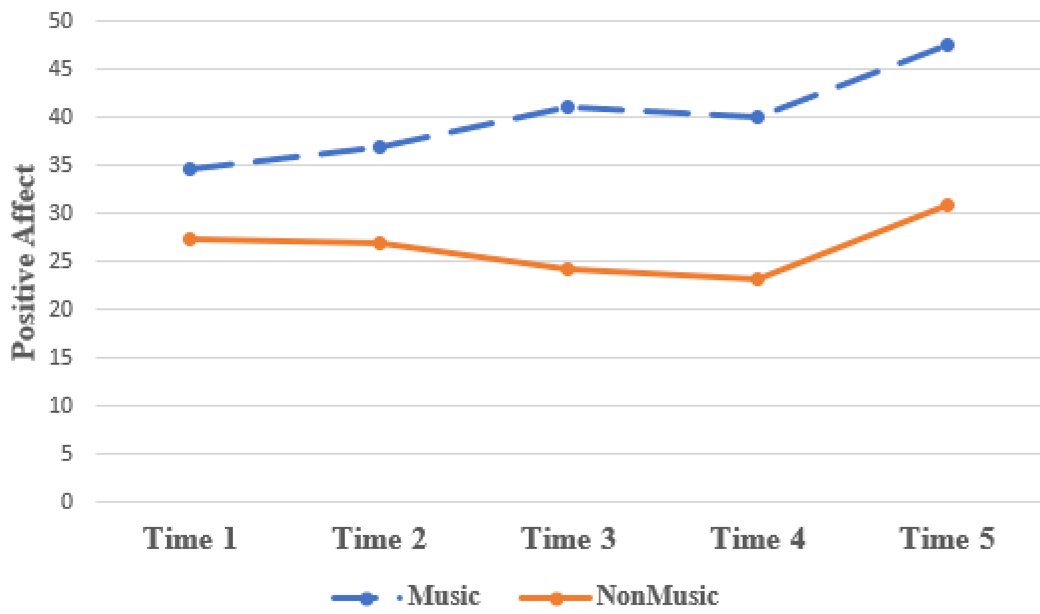
Cognitive Control

Stroop Color-Word Interference

A two way repeated measure ANOVA with Condition as a between-subjects factor and Time as a within-subjects factor revealed that there was a significant main effect of Condition, $F(1,10) = 31.30$, $p = <.001$, indicating that the music group($M = 76.73$, $SD = 28.35$) had a smaller congruency effect compared to the non-music group($M = 108.90$, $SD = 28.48$). The main effect of Time was also significant, $F(4,40) = 2.52$, $p = .05$, indicating a significant difference between Stroop performance as a function of time. No significant interaction was found. To follow-up on the main effect of Time, a series of independent samples t-tests were conducted in order to compare the congruency effect for the music and non-music group at each time point. A significant difference was observed for three time points, Time 3, $t(10)$, -5.54, $p = <.001$, Time 4, $t(10)$, -2.71, $p = 0.022$, Time 5, $t(10)$, -1.69, $p = 0.122$, showing reduction in cognitive control performance for participants in the non-music group **(See Figure 3)**.

Figure 1

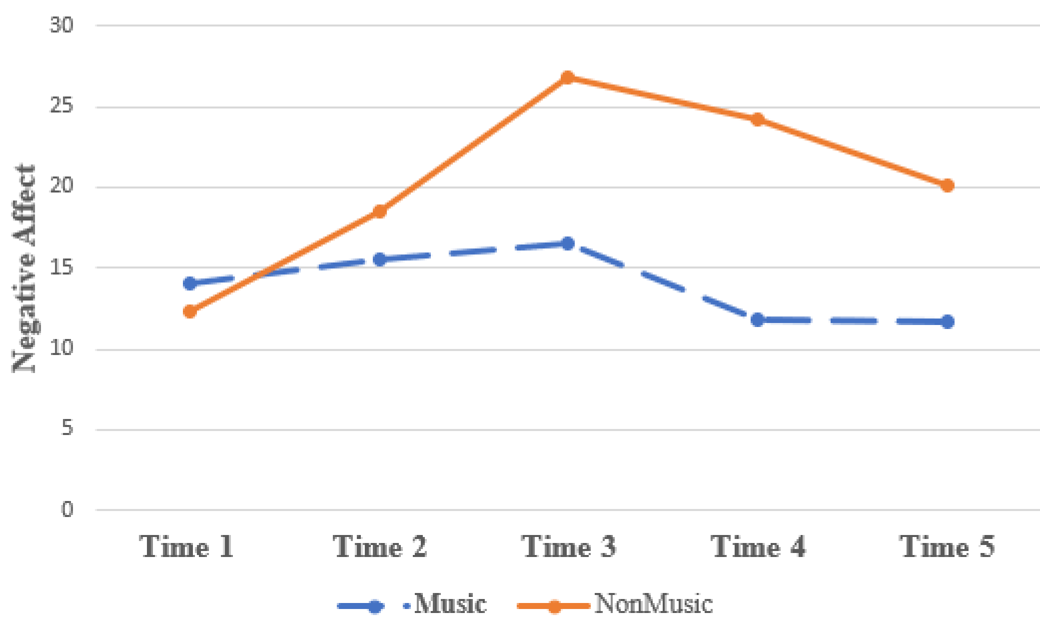
Positive Affect as a Function of Time and Condition



Note. This figure shows the mean scores for Positive Affect for participants in the music condition and participants in the non-music condition. Participants were assessed at baseline, time 2, which was the 3rd month after the intervention started, time 3, which was the 5th month, Time 4, which was the 7th month and Time 5, after the intervention ended.

Figure 2

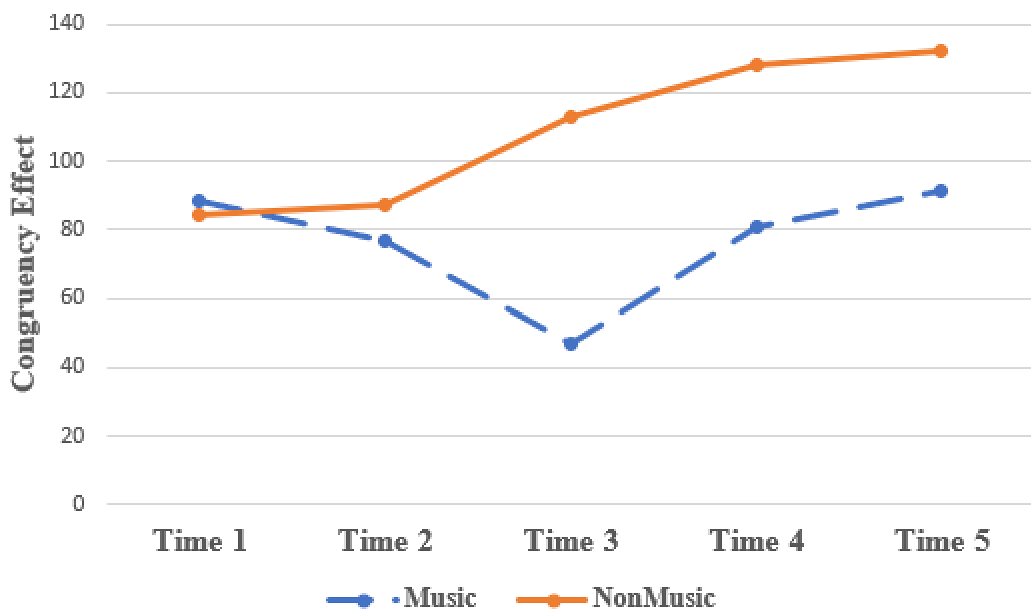
Negative Affect as a Function of Time and Condition



Note. This figure shows the mean scores for Negative Affect for participants in the music condition and participants in the non-music condition. Participants were assessed at baseline, time 2, which was the 3rd month after the intervention started, time 3, which was the 5th month, Time 4, which was the 7th month and Time 5, after the intervention ended.

Figure 3

Congruency Effect as a Function of Time and Condition



Note. This figure shows the mean scores for the congruency effect for participants in the music condition and participants in the non-music condition. Participants were assessed at baseline, time 2, which was the 3rd month after the intervention started, time 3, which was the 5th month, Time 4, which was the 7th month and Time 5, after the intervention ended.

Discussion

Summary of predicted results

Given the potentially negative spaceflight associated behavioral experiences of stressors during long-duration missions, the present study seeks to assess the effects of a 4-month online piano training program on affective states and cognitive function on individuals in isolated and confined environments that are analogous to spaceflight. The results of the present study support the hypothesis that reading music and playing musical instruments prevents cognitive decline and improves mood in conditions of isolation and confinement. These results were supported by the improved performance in both affective and cognitive tests. Overall, the results of this study demonstrate the feasibility of music as a tool and countermeasure to mitigate the effects of isolation and confinement on mood and cognition. Two key findings were observed. First, significant effects in cognitive abilities related to attention and executive function were shown for the Stroop. Second, a significant improvement in positive affective states (PANAS) for participants in the musical-training group was observed. Since the control group participated in other types of leisure activities like physical exercise, painting, reading, writing and language lessons, the changes identified in different parameters are specific to musical training and not just to the fact of being involved in some stimulating activity with social interactions.

Linking findings to previous research

This pattern of results is consistent with previous literature that suggests that individualized piano instruction enhances executive functioning in older adults (Bugos et al., 2007) while at the same time offering a rapid and sustained improvement in mood (Manalai, Manalai, Dutta, Fegan, and Scrofani, 2012). These results are consistent with the claim that music is, arguably, among the most powerful and diverse cognitive and emotional experiences for the human brain (Särkämö, 2017). Whereas past researchers have found that leisure activities such as reading, playing board games and dancing are associated with cognitive well being (Verghese et al., 2003), and positive mood states (Han & Patterson, 2007), the present study supports the idea that reading music and playing a musical instrument, when compared to other leisure activities, reduces cognitive decline and enhances positive mood on a greater level. These results will represent the first direct demonstration of music as a non-pharmacological solution to mitigate the effects of isolation and confinement on mood and cognition on a terrestrial space analog.

Discussing research results

The online piano training program resulted in higher positive affect, lower levels of negative affect and improvement in the Stroop test for people in the musical training group. This idea is further supported by the findings from Wan and Schlaug (2010), that suggest the potential value of plasticity-based training, like musical training, in preserving brain functions like cognitive and emotional function. Therefore, improvement for participants in the music training group seems to be specifically caused by the musical training since the control group did not show such a pattern change through time. Interestingly, a previous study showed that professional musicians had significantly smaller color-word interference effects in the Stroop task (Travis et al., 2011). Participants in the non-music group showed lower levels of positive affect, higher levels of negative affect and larger congruency effect on the Stroop Task.

It is interesting that for positive affect, a significant difference between the groups was observed at time 1. The most compelling explanation for this unexpected finding is that playing the piano is a motivating activity that might be more exciting to begin with (Seinfeld et al., 2013). Two other results from this study merit comment. First, a significant difference was observed at three time points for scores in negative affect, indicating that participants in the non-music group scored significantly higher on negative affect later in the intervention than participants in the music group. These significant differences were shown during the 5th month, the 7th month, and the 9th month (right after the intervention was finalized). Second, the same pattern of results was observed for cognitive control performance. Participants in the non-music group showed significant reductions in cognitive control performance during the 5th month, the

7th month, and the 9th month (right after the intervention was finalized). Interestingly, these results were observed from the middle of the mission to the end. This might be explained by the winter-over syndrome. As described by Palinkas and Suedfeld (2008),

> The winter-over syndrome consists of an accumulation of symptoms typical of Antarctic expeditions. Symptoms include interpersonal tension and conflict, cognitive impairment, and negative affect, among others. The symptoms peak shortly after the midpoint of an expedition, which is independent of the length of the expedition. This is believed to occur as a result of individuals realizing that their expedition is only half over and seems to be an inevitable consequence of the living circumstances. (p. 157)

Study limitations

There are at least three potential limitations concerning the results of this study. The first limitation concerns sample size. Only 12 people were involved in the study analysis. Because a small sample size is usually unavoidable for NASA or analog studies, traditional (i.e., “big” N) assumptions about how sample sizes are calculated are often not realistic in this context (NASA Human Research Studies). Therefore, the data of these analog studies should be interpreted with caution. A second potential limitation is that there is no real-time communication via one-to-one or video conferencing with participants on the online piano training group. This means that the piano lessons are not tailored to participants' individual music needs. In addition, there is no instant feedback on their progress, coaching to correct bad habits, or the possibility to give guidance. Although an issue like this will be encountered when astronauts travel long distances, communications engineers are developing ways for astronauts to stay connected with Earth. However, it is possible that musical training can be implemented for astronauts before departure and, in addition to these benefits, other advantages can potentially be obtained from musical training.

Directions for future research

The most important contribution of this research may be that it raises a variety of intriguing questions to further examine. In terms of future research, it would be useful to extend the current findings by specifically exploring Särkämö's (2018) call of "examining music intervention studies in conjunction with behavioral outcome measures, neurophysiologic and endocrinologic markers as well as structural and functional neuroimaging methods that can better elucidate the neural mechanisms underlying the efficacy of music interventions (p. 417). This could, eventually, help target the interventions at the individual level. Moreover, because of what researchers expect to find in this study, examining the implementation of musical training for astronauts for the period of their training before going to space can be crucial for a later mission. Through qualitative analysis, it has been discovered that the effective acquisition of musical skills can lead to a successful transfer of knowledge and skills into new domains. A research study by Kim (2018) sought to identify the skills that musicians can carry over into new professions (p.2). The findings of this study found suggest building a solid musical foundation is crucial in order to develop the correct and desirable skill set that can be transferable to new domains in the long run. Therefore, as a recommendation from the author, musical training and performance programs should be evaluated in order to improve the curricula and facilitate a greater chance of success for those considering fields of work outside of music (Kim, 2018). Although much work remains to be done before an official implementation of musical training for astronauts before their space missions, examining this possibility could potentially support the idea that trained musicians do possess numerous skills that are widely transferable to many other career fields.

Conclusion

The Arctic environment and its extreme conditions of isolation help researchers understand and solve the unique challenges that will face astronauts on their missions. The importance of studying the effects of isolation and confinement on humans relies on the fact that, among many behavioral issues, mood and cognition are significantly altered under these conditions. As it has been noticed, “The history of space exploration has seen many instances of reduced energy levels, mood changes, poor interpersonal relations, faulty decision-making, and lapses in memory and attention” (Douglas, 2011, p. 26). Therefore, a decline in mood and cognition can not only have serious implications on the human body itself but on a mission's overall success.

Despite the limitations, the present study will enhance the current understanding of the relationship between music, mood, and cognition under conditions of isolation and confinement on a terrestrial space analog. Researchers hope that the current research will stimulate further investigation of this important area and further previous findings that indicate that music activates extremely complex and widespread bilateral networks of cortical and subcortical areas that control many cognitive and emotional functions. The present research will contribute to a growing body of evidence suggesting that music has, in fact, greater benefits compared to other leisure activities. In summary, this research intends to further the study and findings from Seinfeld, Figueroa, Ortiz-Gil, and Sanchez-Vives, (2013), which found that musical training promotes brain plasticity, prevents cognitive decline, and improves mood and quality of life at a greater level than other leisure activities. The present study will provide clear support for musical training as a coping and resource strategy that can be applied to improve human adaptability to extreme environments and missions. These results can be used to inform selection and training programs in order to enhance astronaut adaptive task performance under conditions of isolation and confinement.

NASA's journey abroad orbit includes preparing and training astronauts to cope with several months of isolation and confinement in an extreme environment. Due to the increasing evidence supporting the idea that musical training activates many psychological functions like emotion, memory and attention, implementing music lessons during astronaut training can increase the resiliency of the brain and serve as a countermeasure to mitigate the adverse effects of isolation and confinement. In addition, these musical skills are potentially transferable into other aspects of the mission, such as motor demands. What researchers learn from this study will help astronauts prepare for longer, farther exploration missions, and will also contribute insight with regard to mitigating the effects of prolonged social isolation on other members of our population, like the elderly community.

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Appendix A

Template for New IRB Submission – Bard College

Section 1

Please enter the following information about yourself:

Name:

- Gabriela M. Rosado Torres

Email:

- gr5747@bard.edu

Your Academic Program/Department/Office:

- Psychology

Your status (faculty, staff, graduate, or undergraduate student):

- Undergraduate student

Adviser or Faculty Sponsor (if applicable):

- Thomas Hutcheon

If you are a graduate or undergraduate student, has your Adviser or Faculty Sponsor seen and approved your application?

- Yes

Your Adviser's or Faculty Sponsor's email address (if applicable):

- thutcheon@bard.edu

Please list all individuals (full name and status, i.e. faculty, staff, student) involved in this project that will be working with human subjects. Note: Everyone listed must have completed Human Subject Research Training within the past three years.

- Gabriela M. Rosado Torres, student

Do you have external funding for this research?

- No

Section 2

Please enter the following information about your project.

What is the title of your project?

- Music as Medicine: Supporting NASA's Advancement into Long-Duration Space Missions

Describe the population(s) you plan to recruit and how you plan to recruit participants. Please submit all recruitment material, emails, and scripts to IRB@bard.edu

- Healthy, non-smoking volunteers, ages 23 to 59 will respond to the European Space Agency open call for analog research participants. A physical and psychological assessment needs to be done successfully in order to qualify. After the selection process and prior to the beginning of the study, participants will receive preparatory courses and training. All of this will be done through the European Space Agency.

Will your participants include individuals from vulnerable or protected populations (e.g., children, pregnant women, prisoners, or the cognitively impaired)?

- No

If your participants will include individuals from the above populations, please specify the population(s) and describe any special precautions you will use to recruit and consent.

- Not applicable

Approximately how many individuals do you expect to participate in your study?

- 10

Describe the procedures you will be using to conduct your research. Include descriptions of what tasks your participants will be asked to do, and about how much time will be expected of each individual. NOTE: If you have supporting materials (printed surveys, questionnaires, interview questions, etc.), email these documents separately as attachments to IRB@bard.edu. Name your attachments with your last name and a brief description (e.g., "WatsonSurvey.doc").

- Participants will be randomly assigned to two groups; treatment or control. Participants in the treatment group will participate in a 4-month online piano training on a weekly basis for an hour and a half. In addition, participants will be required to practice independently for 45 min for at least 5 days per week. After the training period, participants will be required to maintain the same practice schedule for the 5 months and will be encouraged to perform monthly in a low-stress, friendly and supportive environment. A computerized self-administered mood questionnaire will be administered and completed at 4-time points as well as a cognitive task.

Describe any risks and/or benefits your research may have for your participants.

- There is minimal risk for participation in the study. There is a very small probability that the research may produce harm or discomfort.

Describe how you plan to mitigate (if possible) any risks the participants may encounter.

- Adequate safeguards will be incorporated into the research design such as the presence of a medical doctor who can respond to emergencies if needed and procedures to protect the confidentiality of the data using password-protected folders.

Describe the consent process (i.e., how you will explain the consent form and the consent process to your participants):

- The purpose, procedures, risks, benefits and alternatives to participation will be verbally explained to the potential participant. Afterward, a written consent form will be given for participants to read. Time will be allowed for the researcher to address any additional questions or concerns the prospect may have while ensuring that the risks and benefits involved were fully understood. After explaining the research and assessing participant comprehension, the signature of the participant will be obtained if they have agreed to participate.

Have you prepared a consent form(s) and emailed it as an attachment to IRB@bard.edu? Note: You must submit all necessary consent forms before your proposal is considered complete.

- Yes

If you are collecting data via media capture (video, audio, photos), have you included a section requesting consent for this procedure(s) in your consent form(s)?

- Not applicable

If your project will require you to employ a verbal consent process (no written consent forms), please describe why this process is necessary and how verbal consent will be obtained and stored.

- Not applicable

What procedures will you use to ensure that the information your participants provide will remain confidential and safeguarded against improper access or dissemination?

- Participants' data will be automatically assigned a participant ID code. There will be no way to directly link participants' names with their data. In addition, study data will be kept on password-protected folders and only study personnel will have access to these files. No personally identifying information will be collected electronically or appear when the results of the study are presented or published.

Will it be necessary to use deception with your participants at any time during this research? Withholding details about the specifics of one's hypothesis does not constitute deception, this is called incomplete disclosure. Deception involves purposefully misleading participants about the nature of the research question or about the nature of the task they will be completing.

- No

If your project study includes deception, please describe here the process you will use, why the deception is necessary, and a full description of your debriefing procedures.

- Not applicable

For all projects, please include your debriefing statement. (This is information you provide to the participant at the end of your study to explain your research question more fully than you may have been able to do at the beginning of the study.) All studies must include a debriefing statement. Be sure to give participants the opportunity to ask any additional questions they may have about the study.

- Thank you for your participation in this research. The goal of this study is to assess and counteract the cognitive and psychological challenges that arise under conditions of isolation and confinement with the use of music. Your participation will provide meaningful insight with regard to mitigating the effects of prolonged social isolation on extreme environments and what we learn from this study could potentially be transferable to other members of our population, like the elderly community.

If you will be conducting interviews in a language other than English, will you conduct all of the interviews yourself, or will you have the assistance of a translator? If you will be using the assistance of a translator, that individual must also certify that he or she is familiar with the human subject protocol and has completed the online training course.

- Not applicable

If your recruitment materials or consent forms will be presented in languages other than English, please translate these documents and email copies to IRB@bard.edu. I have submitted all of my translated materials.

Appendix B

Informed Consent

Principal Investigator

Gabriela M. Rosado Torres

Psychology Program

Bard College

Faculty Adviser

Thomas Hutcheon

Project Title

Music as Medicine: Supporting NASA's Advancement into Long-Duration Space Missions

Introduction

You are being asked to be a volunteer in an experiment conducted by members of the Psychology Program at Bard College. Please read the following information carefully prior to proceeding to the experiment.

Purpose

Because the impact of social isolation and confinement has been felt on our bodies and minds, researchers have become increasingly interested in understanding this issue in order to extrapolate meaningful information to other scenarios, like space. Living under these environmental characteristics, which are specific to space missions, have shown to cause detrimental effects on mood and cognitive performance as well as causing difficulty when coping with the rigors of daily life. Therefore, the present study seeks to assess and counteract the cognitive and psychological challenges that arise under conditions of isolation and confinement with the use of music. This research will help identify countermeasures to mitigate the stressors that can overwhelm the body's psychological resources. In addition, what we learn from this study will potentially contribute insight with regard to mitigating the effects of prolonged social isolation on other members of our population, like the elderly community.

Study Procedure

If you decide to participate, you will be asked to participate in a 4-month online piano training The online piano lessons, lasting one hour and a half, will be taken individually on a weekly basis. You will have a computer assigned and a keyboard that you can use for your online lessons and individual practice. Three homework exercises requiring the playing of a piano sequence will be given in each lesson, and you will be committed to practice independently at least 45 min per day at least 5 days per week (~4 h per week). In addition to the weekly online lessons, you will meet once a week to play the piano sequence you had practiced during the week with the other participants. After the training face is over, you will be required to maintain the same practice schedule and will be encouraged to perform once a month for all the crewmembers in a low-stress, friendly and supportive environment. Moreover, a computerized self-administered mood questionnaire will be administered and completed at 4-time points as well as a cognitive task. These behavioral measures will be used to evaluate the extent to which playing a musical instrument affects mood and cognition. Following your participation, you will be provided with information about the specific hypothesis in this study. **Participation in this study is completely voluntary and you are free to stop at any time without penalty.**

Risks and Discomforts

There is minimal potential risk and discomfort from participating in this study. The risks are not greater than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.

Benefits

Music training could help improve participant's mood and cognitive performance by reducing the stress, anxiety, and depression symptoms that come along with isolation and confinement and by positively affecting the operational readiness and performance of individuals. In addition, what we learn from this study will potentially contribute insight with regard to mitigating the effects of prolonged social isolation on other members of our population, like the elderly community.

Compensation

Participants will not receive compensation for their participation in this research study.

Exclusion/Inclusion Criteria

Individuals must be between the age of 23 and 59 to participate in this study.

Confidentiality

Once you have completed the experiment, your data will be automatically assigned a participant ID code. There will be no way to directly link your name with your data. In addition, study data will be kept on password-protected folders and only study personnel will have access to these files. No personally identifying information will be collected electronically or appear when the results of the study are presented or published.

Questions

If you have any questions about your rights as a research participant, you may contact the Principal Investigator, Gabriela Rosado at gr5747@bard.edu or the chair of the Bard College IRB, irb@bard.edu

By clicking the box below, you affirm that you have read and understood the context of the consent form.

Appendix C

The Ohio State University

Positive and Negative Affect Schedule (PANAS-SF)

Indicate the extent you have felt this way over the past week.		Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
PANAS 1	Interested	1	2	3	4	5
PANAS 2	Distressed	1	2	3	4	5
PANAS 3	Excited	1	2	3	4	5
PANAS 4	Upset	1	2	3	4	5
PANAS 5	Strong	1	2	3	4	5
PANAS 6	Guilty	1	2	3	4	5
PANAS 7	Scared	1	2	3	4	5
PANAS 8	Hostile	1	2	3	4	5
PANAS 9	Enthusiastic	1	2	3	4	5
PANAS 10	Proud	1	2	3	4	5
PANAS 11	Irritable	1	2	3	4	5
PANAS 12	Alert	1	2	3	4	5
PANAS 13	Ashamed	1	2	3	4	5
PANAS 14	Inspired	1	2	3	4	5
PANAS 15	Nervous	1	2	3	4	5
PANAS 16	Determined	1	2	3	4	5
PANAS 17	Attentive	1	2	3	4	5
PANAS 18	Jittery	1	2	3	4	5

PANAS 19	Active	1	2	3	4	5
PANAS 20	Afraid	1	2	3	4	5

Scoring:

Positive Affect Score**:** Add the scores on items 1, 3, 5, 9, 10, 12, 14, 16, 17, and 19. Scores can range from 10 – 50, with higher scores representing higher levels of positive affect.
Mean Scores: 33.3 (SD±*7.2)*

Negative Affect Score**:** Add the scores on items 2, 4, 6, 7, 8, 11, 13, 15, 18, and 20. Scores can range from 10 – 50, with lower scores representing lower levels of negative affect.
Mean Score: 17.4 (SD ± 6.2)

Your scores on the PANAS: Positive: ____ Negative: ____

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of personality and social psychology*, *54*(6), 1063.