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Stress and Coping During Simulated EVAs and Habitat Living

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Abstract

Planning for long duration exploration missions (LDEM) involves both the effectiveness of the extravehicular operations, in particular as it is related to the functioning and comfort of the space suits, and how the crew functions together in accomplishing the objectives of the mission. The University of North Dakota Department of Space Studies has developed a multi-modular Inflatable Lunar/Mars Analog Habitat (ILMAH) and is testing iterations of their NDX-2AT space suit. Five 12-14 day missions, each consisting of 3-4 individuals (Total 13; 11 men, two women) were carried out. Team members independently completed a Daily Rating Form (DRF) each day of the mission; the measure assessed space suit functioning during a simulated exploration EVA, psychological factors of mood, positive events and stressful situations experienced, and strategy/decision making processes. The EVAs proceeded in a smooth manner and ratings indicated that the space suit performed well in enabling the team members to carry out the simulated exploration tasks effectively. There were few incidents of tension or arguments with a teammate; ratings of mood state indicated that positive mood predominated over negative mood throughout the mission. Adaptive coping methods were reported as appropriate for the particular stressor experienced; problem-focused coping, for example, discussing task concerns with a teammate, emotion-focused coping methods, relaxation, meditation, humor; meaning-focused coping, keeping the goal in sight. The specific behavioral and cognitive coping methods participants used to deal with the stressors experienced were highly effective in promoting optimal personal and team performance. Training in the use of particular coping strategies and the flexibility to use different coping methods depending on the specific stressors experienced appears helpful in preparing astronauts for the many demands and challenges of living and working together on LDEM. This training should also be helpful for dealing with the psychological recovery period following an EVA.

I. Introduction

A three-year mission to Mars presents significant psychological challenges, including confinement of a small group of individuals in close quarters in the space vehicle and habitat, coordination of multiple teams to safely complete extravehicular activity (EVA) and other critical tasks. In planning for Mars and other long duration exploration missions (LDEM), it is important to evaluate individual and team performance in different types of analog situations to identify the components of optimal functioning.[1,2] The manner in which crew members work together and cope with the many and varied demands of the mission is critical to the success of the mission and key to their wellbeing during and after the mission is completed.

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A number of LDEM simulation studies have been carried out over the years in different types of habitats and environments. While of course no analog entirely replicates the experiences of a space mission, different kinds of analogs have been used to evaluate particular features of a mission that are of interest. The focus of research within these analogs has included the evaluation of space suit designs, rovers and other equipment and technologies; other analogs have evaluated a range of psychological and human performance factors. Studies of crew performance have been carried out in enclosed chambers within a laboratory complex, for example, the ESA SFINCSS'99 study evaluating team interactions,[3] NASA HERA team interaction research[4] and the Russian Mars120 and Mars500 studies.[5] Other analogs consist of habitats located in an outdoor environment simulating aspects of a planetary environment, for example, the NASA Desert Rats analog in the Arizona desert,[6] Houghton Mars Project on Devon Island, Canada,[7] HI-SEAS project in Hawaii,[8] NEEMO underwater laboratory environment.[9] Polar expedition teams and work groups also have been studied as a space analog (discussed in greater detail below).

In planning for future LDEM missions, in addition to all of the equipment and technology aspects, the success of the mission critically depends on the psychological status of the crew members and the effectiveness of their working together. Human performance research in different analog settings has been focused primarily on team interactions and the evaluation of team conflicts. However, findings from the Mars 500 study demonstrate the effects of the psychological status of the individual on team processes; crewmembers with the highest self-ratings of stress and physical exhaustion also reported the greatest number of conflicts with either mission control or team members.[5]

An analysis of five HERA missions identified four types of team conflicts: noted discords (attributing the conflict to external causes, such as fatigue), work disagreements (disagreements over mission tasks or procedures), interpersonal tensions (tense, blaming interactions), interpersonal breakdowns (high emotion, relationship toxicity).[4] The type of conflict type and the timing when conflicts occurred varied across teams. These findings clearly demonstrate that conflicts inevitably arise in isolated, confined and challenging environments, and there are individual differences in how team members cope with the stressors they experience. The coping strategies an individual uses to deal with a stressful situation in turn has an impact on team cohesion or further team conflict.[1]

Polar expedition teams performing in isolated, confined, and extreme (ICE) environments provide another analog for some aspects of a Mars mission, enabling comprehensive study of individual personality factors and team processes in a highly challenging environment.[2,10] A study of an ultimately unsuccessful two-men polar expedition team clearly indicated that attention to compatibility in personality and personal values prior to the expedition might have mitigated some of the difficulties experienced that resulted in the ultimate decision to abort the expedition.[11]

To gain further information on performance in ICE environments, a number of expedition studies were carried out that included a measure similar to the Daily Rating Form used in the current study.[12] Six two-person Danish military Sirius Patrol teams deployed over a 26-month period in Greenland were assessed over 7-week Fall and 23-week Spring dogsledge journeys. A second longitudinal study evaluated Danish military personnel stationed at Station Nord in Greenland who remained confined at the station for a 26-month deployment, rather than on patrol.[13] The findings indicated that there were no differences in patterns of stress and coping when comparing the two groups, irrespective of the differences in environmental conditions and activity levels they experienced. Both groups used problem-focused coping and positive reappraisal strategies to deal with the stressors encountered. The importance of extended training in strategies for conflict resolution was noted.

A subsequent study of a six-person all-women British military team that successfully traversed the Antarctic continent in 61 days assessed factors related to expedition progress and goals.[14] A theme evident in the debriefing interviews was honesty in communication as crucial to team effectiveness; congruence in personal vs. team goals also was mentioned as an important factor. As noted in other studies of analog groups, the presence of two highly dominant individuals had a negative effect on team dynamics.[15,16]

The current study was designed to simulate some aspects of a Mars mission: simulated exploration activities in a prototype space suit; crew coordination with support crew members remaining within the habitat during EVA; communication with external mission ground controllers/support; work and interpersonal interactions within the habitat. Because the group must work together to deal with the EVA and other task demands of the mission, it was possible to examine the stressors experienced, methods of coping with these stressors and effects on team performance. The assessment measures used in this study, repeated every evening throughout the mission, enabled a fine-grained immediate report of the specific stressful events experienced, along with the specific coping mechanisms used to deal with these stressors. The daily report procedure mitigated possible changes over time in recall of events that happened, for example, over the past week or other duration. The rationale was that the information obtained in this study on stress and coping processes in a space analog environment could be applied to enhance psychological support of personnel in other types of ICE conditions, such as LDEM.

II. Method

1. Participants.

Participants for this study were recruited by means of an online national solicitation, flyers and other written formats, followed by a down selection process to select a qualified group in terms of age, educational background and physical and psychological status. As part of the application process, applicants completed a comprehensive questionnaire that included items on physical and mental health, and possible issues related to being confined in close spaces or claustrophobia. This was followed by an interview with the principal investigator of the overall project. Those selected for further consideration were observed in a space suit to further evaluate comfort within confinement. Finally, the last down selected group was required to pass a Class 3 FAA medical certification. Eleven men and two women took part in this research; three of the men participated in two different missions. Four missions consisted of three team members; one mission had four members. Demographic details were as follows: mean age-28.22 years; standard deviation-6.76; education-four team members had B.S. degrees in engineering or biology, nine were working towards a M.S. in Space Studies; one had a M.D. in family medicine. Five participants were born in the United States, eight were born in other countries. The study was approved by the University of North Dakota Institutional Review Board; informed consent by all crew participants was obtained.

2. Procedure.

One mission was 12 days in duration; two missions 13 days; three missions 14 days. The simulated missions were designed so that most aspects of the surface operations of a Mars expedition were as realistic as a 1-G analog on Earth can allow. All participants had a chance to care of plants within the habitat Plant Production Module. This included tasks such as seed germination, transplanting, watering, and various testing (soil, water and air). They were able to communicate with mission control via two-way radio, and with friends and family via email and occasional phone calls for STEM education outreach. The only aspect of communications that was not realistic for LDEM was the time delay; all communications were performed in real time.

Crew members maintained an 8-10 hour working day with appropriate mealtimes and exercise similar to that of current NASA Standards aboard the International Space Station. The types of daily work completed within the habitat included system checks, plant maintenance, suit maintenance, communication with mission control, surveys, geology characterization and biological laboratory experiments. Crew EVA durations were limited to a maximum of 2 hours per person for each event outside of the habitat. Every evening after completion of tasks for the day, participants completed a Daily Rating Form (DRF) downloaded on their laptops.[13]

3. Measures

The DRF is a measure developed by the first author that has been used in numerous previous studies;[17] some of the items on the basic form were modified for the specific circumstances and focus of the current study. The individual sections are: Feelings and Emotions (Positive and Negative Affect Schedule [PANAS]),[18] EVA Experiences, Plant Experiences; Positive and Negative Event Checklist; Coping Methods Checklist, Strategy/Decision Processes. The PANAS is rated on a scale from 1 (very slightly, not at all) to 5 (extremely). The Coping Methods Checklist was derived from reported daily coping strategies monitored over a 7-day period by a group of Army recruits undergoing basic training. The DRF is included in the Appendix.

4. Habitat and space suits.

The habitat and facilities were funded by two NASA EPSCoR Grants and are part of the University of North Dakota Department of Space Studies.[19] The Inflatable Lunar/Mars Analog Habitat (ILMAH) utilized for the 12-14 day missions was designed to simulate some characteristics of a Mars habitat, including capabilities for EVA and habitat system inspections. The multi-modular ILMAH consists of a Core Module where the living quarters are located, and four additionally connected research modules. The core module has living and private quarters for 4 crew members, containing six chairs, three desks, two sinks, a toilet and a shower. The remaining 4 modules contain 6 additional desks and 8 additional chairs. These modules are as follows: EVA module where the pressure suits are stored and maintained, independent airlock and repair shop facilities; Edible Plants Production Module to grow different crops to supplement thermostabilized and frozen food; Exercise and Human Performance Module equipped with fitness equipment and a basic medical facility; Geology and Biology Module with instrumentation for the analysis of samples. Two full pressure space suits are available that are a representation of a planetary EVA suit (model NDX-2 AT (North Dakota eXperimental 2 Advanced Trainer), pressurized to 2 psi.[20] A pressurized electrical rover vehicle equipped with two suit ports is used to traverse the 11 acre field during EVAs. Rock sample collection, area mapping and other EVA operations are prepared by the external mission support personnel so teams can perform a variety of scenarios based on NASA reference operations on Mars.[21]

Image 1a and 1b. University of North Dakota Integrated Lunar/Mars Analog Habitat; Exterior and Interior Views.

III. Results

1. EVA.

Participants who performed EVAs reported that the space walks proceeded in a smooth manner and the activity was well coordinated with the support team, based on ratings averaged over the mission days when an EVA was conducted. Support team members also rated the EVAs as proceeding in a smooth manner and well-coordinated with both the EVA member and mission control. Ratings of space suit performance were on a scale from 1(low)-10(high): "Overall physical comfort of the space suit" – mean=7.72, standard deviation=1.02; "Ability to see the surface you were walking on during the EVA" – mean=7.81, standard deviation=0.60; "How easily you were able to pick up objects while working on the planetary surface" – mean=7.0, standard deviation=0.60. Complete details are presented in Table 1.

Table 1. EVA and support team ratings.

EVA Team		
	Mean	**SD**
EVA proceeded in a smooth manner+	0.87	0.03
EVA well-coordinated with support team+	0.95	0.66
Overall physical comfort of suit++	7.22	1.02
Ability to see surface walking on++	7.81	0.60
Easily pick up objects++	7.0	0.60
EVA Support Team (crew remaining in habitat and mission controllers)		
EVA proceeded in a smooth manner+	0.79	0.10
Well-coordinated with EVA team+	0.93	0.09
Well-coordinated with mission control+	0.94	0.09

+1=yes; 0=no
++ Scale 1(low) to10 (high) rating

2. Plants.

Participants varied in the number of days they took care of the plants grown in the habitat, based on overall assignments for a particular day; they rated the experience as follows on a scale from 1(not at all pleasant or interesting) to 10 (extremely pleasant or interesting): mean=7.79, standard deviation= 0.75, demonstrating the positive nature of the experience.

3. Psychological processes.

Overall, the findings demonstrated that participants had a positive experience during the mission period based on their mood ratings. A two-tailed paired comparison t-test of the PANAS mood measure with items rated on a scale of 1(very slightly, not at all) to 5(extremely) and averaged over the mission period indicated that positive affect was significantly higher than negative affect throughout; PA mean=3.62, standard deviation=0.51; NA mean=1.19, standard deviation=0.15, $P<0.0001$.

Table 2. Daily Rating Form (DRF) mood, events, and coping methods endorsed over a 12-14-day confinement period averaged across participants.

PANAS+	**Mean**	**SD**
Positive Affect (PA)	3.62	0.51
Negative Affect (NA)	1.19	0.15
Events++	**Percent**	**Range**
Enjoyment of the analog space situation.	95.67	86-100
Equipment problems inside the habitat.	29.14	10-49
Technical problems communicating with mission controller.	19.06	4-46
Interpersonal problems communicating with mission controller.	8.47	0-21
Concern about how effective my teammates and I are working together.	33.12	10-47
Pleased about how effective my teammates and I are working together.	86.71	56-100
Tension or argument with a teammate.	3.67	0-10
Concerns about the effectiveness or safety of decisions I made today.	26.26	5-47
Discomfort because of lack of privacy.	0.70	0-4
Fear of being injured.	0.50	0-3
Physical problems.	7.65	0-21
Coping Methods++		
Kept my feelings to myself.	21.86	7-41
Discussed task concerns with a teammate.	61.74	38-79
Discussed task concerns with mission control	40.9	39-45
Saw the situation in a very positive way, what I'm learning and getting out of it.	72.93	36-100
Kept a positive attitude. Humor, joking around, having fun.	93.93	89-100
Relaxed, meditated, listened to music, daydreamed.	82.73	50-100
Kept the goal in sight. Thought about finishing the mission and why here.	74.28	64-82
Tried to figure out how to solve the situation that's bothering me.	53.55	21-90
Yelled, stomped, threw things around.	16.34	0-67

+Mean score; 1=very slightly, not at all to 5=extremely.

++Percentage of times a particular item was endorsed over the 12-14 daily rating periods.

The DRF Events and Coping Methods binary data were calculated as the proportion of times an item was endorsed (Yes/No) by a participant over the course of the mission period; item scores were averaged across all participants on that particular mission, and then across the five missions. The findings were consistent with the mood data indicating generally positive experiences within the habitat. The percentage of time items were endorsed over the period of the mission were as follows: "Enjoyment of the analog space situation." – 95.67%; "Pleased about how effective my teammates and I are working together." – 86.71%. Endorsements were low for "Tension or argument with a teammate." – 3.67%; "Discomfort because of lack of privacy." – 0.7%; "Fear of being injured." – 0.5%. Items reflecting negative experiences were: "Concern about how effective my teammates and I are working together." – 33.12%; "Equipment problems inside the habitat." – 29.14%; "Concerns about the effectiveness or safety of decisions I made today." – 26.26%. However, there were individual differences in endorsement ratings as reflected in the range of scores on each item. The complete list of items and scores are presented in Table 2.

The coping methods endorsed by participants were highly adaptive for living and working in the habitat. Highest rated problem focused coping strategies were: "Discussed task concerns with a teammate." – 61.74%; "Discussed task concerns with mission control." – 40.9%; "Tried to figure out how to solve the situation that's bothering me" – 53.55%. Cognitive and emotion-focused methods included: "Kept a positive attitude. Humor, joking around, having fun." – 93.93%; "Relaxed, meditated, listened to music, daydreamed." – 82.73%; "Kept the goal in sight. Thought about finishing the mission and why I'm here." – 74.28%; "Saw the situation in a very positive way, what I'm learning and getting out of it." – 72.93%. Negative coping in terms of "Yelled, stomped, threw things around" was endorsed by only one participant who indicated some overt frustration (yelling, stomping) on several days specifically related to technical and equipment problems. Individual differences in coping styles are reflected in the range of endorsements on each item.

IV. Discussion

The systematic examination of stress and coping in challenging situations proceeded from the seminal writings of Lazarus and Folkman.[22,23] They delineated two major methods of coping when a person appraises a situation as stressful, problem-focused and emotion-focused coping. Problem-focused coping involves planning and acting on the situation that is causing distress; emotion-focused coping involves minimizing the stressful situation by distraction or seeking emotional support from others. The addition of the concept of meaning-focused coping refers to cognitive strategies to deal with the challenge, such as thinking about one's values and goals.[24] Because space and other ICE environments are by their nature challenging, it is important for effective performance that team members use appropriate, effective coping methods to deal with the stressors they inevitably will be confronted with.

The findings from this investigation indicated that the participants on each of the missions were psychologically adaptable and able to cooperate with each other both interpersonally and on the tasks of the mission. There were few incidents of tension or arguments with a teammate and high levels of positive mood throughout their mission. The EVAs proceeded in a smooth manner and ratings indicated that the space suit performed well in enabling the team members to carry out the simulated exploration tasks effectively. Participants enjoyed taking care of plants in the habitat. They also demonstrated flexibility in the coping methods used, depending on the situation; problem-focused coping - discussing task concerns with a teammate, trying to figure out the problem; emotion-focused coping - relaxation, meditation, humor; meaning-focused cognitive strategies - keeping the goal in sight, seeing the situation in a positive way. The evidence of the large array and types of coping methods used attests to the flexibility of the participants in dealing with the exigencies of the mission in a highly positive manner.

Overall, the effectiveness and psychological adaptiveness of different types of coping methods depends in part on whether the situation one is dealing with is controllable or noncontrollable, and importantly, for people to recognize this difference and act accordingly. In controllable situations, problem-focused coping is the key, and certainly these are methods an astronaut is highly trained on, in terms of the performance of operational tasks. However, training in applying effective coping methods to deal with potentially nonchangeable interpersonal or task situations also is needed. The flexibility to use a variety of coping methods to deal with noncontrollable situations is important for mission success, including accepting the lack of control and distracting oneself by enjoyable activities or focusing on an important meaning in the specific situation/challenge one is confronted with.

Psychological adaptation and optimal individual and crew performance on LDEM remains an area of considerable importance. The first step in this process is crew composition.[1] Based on extensive research on personnel living and working in the Antarctic, Gunderson concluded that the components of effective performance were emotional stability, task motivation, and social compatibility.[25] An extensive review of recent research concluded that adaptability to ICE environments consists in part of emotional stability, self-control, hardiness, and task-oriented coping.[26] Hardiness was particularly emphasized, defined as the person's belief that they have the ability to accomplish challenging tasks or situations, that is, a sense of self-efficacy.

The analog and space research literature clearly indicates that over time conflicts inevitably occur.[4,10] Therefore, for crew members to live and work together effectively for an extended period of time, greater consideration of the psychological aspects of LDEM is required; The challenge is for the individual and the group to learn to deal with these conflicts in an adaptive way.

V. Conclusions

A limitation of this study is the short duration of each mission; however, by aggregating the findings from this particular mission with the findings from other missions that used the same measures, it is possible to draw more general conclusions. The data from this short-term analog study extend the findings from previous expedition research highlighting the flexibility of team members to effectively use a range of coping methods to deal with the challenges of the mission.[12-14] To ensure psychological adaptability and optimal work performance on future LDEM, we recommend systematic training focused on dealing with stressors and the flexible use of effective coping methods for different types of challenging situations. Furthermore, in reference to the range of individual differences in specific events that a participant endorsed as being stressful or a challenge, we recommend more individually focused psychological training for optimal performance during EVAs and within the habitat.

Appendix

Daily Rating Form

Code No._____ Mission Day: ________

1. **This section consists of a number of words that describe different feelings and emotions.** Type the number indicating to what extent you felt that way today:

1 = very slightly, not at all; 2 = a little; 3 = moderately; 4 = quite a bit; 5 = extremely

interested ___ guilty ___ irritable ___ determined ___
distressed ___ scared ___ alert ___ attentive ___
excited ___ hostile ___ ashamed ___ jittery ___
upset ___ enthusiastic ___ inspired ___ active ___
strong ___ proud___ nervous ___ afraid ___

2. **This section deals with your experiences today during the EVA (Check correct line)**

___ I did an EVA. Proceed to Section 2.a
___ I remained in the habitat as one of the support team. Proceed to Section 2.b

2.a. EVA Experience. Type either 1 for "Yes" or 2 for "No" to these items.
___ The space walk proceeded in a smooth manner
___ The activity was well coordinated with the support team
___ Rate the overall physical comfort of the space suit on a scale from
1 (Not at all comfortable) to 10 (Extremely comfortable)
___ Rate how well you were able to see the surface you were walking on during the EVA on a scale from
1 (I could only see what was directly in front of me) to 10 (I had full visibility both in front and at the periphery of my visual field
___ Rate how easily you were able to pick up objects while working on the "planetary surface"
1 (Not at all easy) to 10 (Extremely easy)
What was the most difficult issue to deal with during the EVA?

2.b. Support Team Experience. Type either 1 for "Yes" or 2 for "No" to these items.
___ The space walk proceeded in a smooth manner
___ The activity was well coordinated with the team member doing the EVA
___ The activity was well coordinated with the mission controller
___What was the most difficult issue to deal with during the EVA?

3. This section deals with your experiences today with the plants growing in the habitat

___ I took care of the plants (Type 1 for "Yes,", 2 for "No")
___ If yes, rate this experience on a scale from 1 (Not at all pleasant or interesting) to 10 (Extremely pleasant or interesting)
___ I ate some of the plants that we grew in the habitat (Type 1 for "Yes,", 2 for "No")

___ If yes, rate this experience on a scale from 1 (Not at all a pleasant experience) to 10 (Extremely pleasant experience)

4. Enter "1" for each event/situation you experienced today. Enter "0" for events/situations you did not experience today.

___Enjoyment of the analog space situation
___Equipment problems inside the habitat
___Technical problems communicating with mission controller
___Interpersonal problems communicating with mission controller
___Concern about how effective my teammates and I are working together
___Pleased about how effective my teammates and I are working together
___Tension or argument with a teammate
___Concerns about the effectiveness or safety of decisions I made today
___Discomfort because of lack of privacy
___Fear of being injured
___Physical problems (please indicate)

Other significant events today

5. Enter "1" for each coping method you used <u>today</u>. Enter "0" for methods you did not use <u>today</u>.

___Kept my feelings to myself.
___Discussed task concerns with a teammate.
___Discussed task concerns with mission control.
___Saw the situation in a very positive way, what I'm learning and getting out of it.
___Kept a positive attitude. Humor, joking around, having fun.
___Relaxed, meditated, listened to music, daydreamed.
___Kept the goal in sight. Thought about finishing the mission and why I'm here.
___Tried to figure out how to solve the situation that's bothering me.
___Yelled, stomped, threw things around
___Other (explain)

6. Did you encounter a situation today in which you and a teammate had different opinions as to how it should be resolved?

___Yes ___No

If yes, describe the situation and how you resolved the difference of opinion.

References

[1]Bell, S.T., Brown, S.G., Abben, D.R., and Outland N.B., "Team Composition Issues for Future Space Exploration: A Review and Directions for Future Research," *Aerospace Medicine and Human Performance*, Vol. 86, No. 6, 2015, pp. 48-556.

[2]Leon, G. R., and Koscheyev, V.S., "Expedition Applications to Long Duration Space Missions," *Space V. Proceedings of the Fifth International Conference on Space '96.* Edited by Stewart W. Johnson, Vol 2. American Society of Civil Engineers, New York, 1996, pp. 997-1001.

[3]Sandal, G.M., "Culture and Crew Tension During an International Space Station Simulation: Results from SFINCSS'99," *Aviation, Space and Environmental Medicine*, Vol. 75, no. 7(Suppl), 2004, pp. 44-51.

[4]Marcinkowski, M.A., Bell, S.T., and Roma, P.G., "The Nature of Conflict for Teams in Isolated, Confined, and Extreme Environments," *Acta Astronautica,* Vol. 181, 2021, pp. 81-91.

[5]Basner, M., Dinges, D.F., Mollicone, D.J., Savelev, I., Ecker, A.J., Di Antonio, A. et al., "Psychological and Behavioral Changes During Confinement in a 520-Day Simulated Interplanetary Mission to Mars," *Plos One,* Vol. 9, No. 3, 2014, e93298. doi:10.1371/journal.pone.0093298

[6]Shull, S. A., and Peek, K.E. "Operational Lessons Learned Supporting NASA's Desert Research and Technology Studies (D-RATS)," *AIAA SPACE 2008 Conference & Exposition*, San Diego, California, 2008, AIAA 7788.

[7]Hodgson, E., Lee, P., Chase, T., Glazier, T., Overbeeke, A., Satienpoch, R. et al., "Evolutionary Development of Exploration EVA Systems Design and Operations Through Analog Field Tests: Lessons from the NASA Houghton-Mars Project, 2008-2010," *41st International Conference on Environmental Systems*, Portland, Oregon 2011, AIAA 5178.

[8]Anderson, A.P., Fellows, A.M., Binsted, K.A., Hegel, M.T., and Buckey, J.C., "Autonomous, Computer-Based Behavioral Health Countermeasure Evaluation at HI-SEAS Mars Analog," *Aerospace Medicine and Human Performance,* Vol. 87, 2016, pp. 912-920.

[9]Koutnik, A.P, Favre, M.E., Noboa, K., Sanchez-Gonzalez, M.A. Moss, S.E., Goubran, B. et al., "Human Adaptations to Multiday Saturation on NASA NEEMO," *Frontiers in Physiology,* 12 Jan, 2021. Doi: 10.3389/fphys.2020.610000

[10]Sandal, G.M., Leon, G.R., and Palinkas, L.A., "Human Challenges in Polar and Space Environments," *Reviews in Environmental Science and Bio/Technology*, No. 5, 2006, pp. 281-296.

[11]Leon G.R., and Venables N.C., "Fearless Temperament and Overconfidence in an Unsuccessful Special Forces Polar Expedition," *Aerospace Medicine & Human Performance*, Vol. 86, No. 6, 2015, pp. 567-570.

[12]Kjærgaard, A., Leon, G.R., and Fink, B.A., "Personal Challenges, Communication Processes, and Team Effectiveness in Military Special Patrol Teams Operating in a Polar Environment," *Environment and Behavior*, Vol. 47, No. 6, 2015, pp. 644-666.

[13]Corneliussen, J.G., Leon, G.R., Kjaergaard. A., Fink, B.A., and Venables, N.C., "Individual Traits, Personal Values, and Conflict Resolution in an Isolated, Confined, Extreme Environment," *Aerospace Medicine and Human Performance*, Vol. 88, No. 6, 2017, pp. 535–543.

[14]Blackadder-Weinstein, J., Leon, G.R., Norris, R.C., Venables, N.C., and Smith, M., "Individual Attributes, Values, and Goals of an All-Military Women Antarctic Expedition," *Aerospace Medicine and Human Performance*, Vol. 90, No. 1, 2019, pp. 18-25.

[15]Kanas, N., "Psychological, Psychiatric, and Interpersonal Aspects of Long-Duration Missions," *Journal of Spacecraft Rockets*, 1990; Vol. 27, No. 5, 1990, pp.457-463.

[16]Sandal G.M., Værnes, R., and Ursin, H., "Interpersonal Relations During Simulated Space Missions," *Aviation, Space, and Environmental Medicine,* Vol. 66, No. 7, 1995, pp. 617-624.

[17]Leon, G.R., Sandal, G.M., Fink, B., and Ciofani, P., "Positive Experiences and Personal Growth in a Two-Man North Pole Expedition Team," *Environment and Behavior,* Vol 43, No. 5, 2011, pp. 710-731.

[18]Watson, D., Clark, L.A., and Tellegen A., "Development and Validation of Brief Measures of Positive and Negative Affect: The PANAS Scales," *Journal of Personality Social Psychology*, Vol. 54, No. 6, 1988, pp. 1063-1070.

[19]de León, P., Daga, A., Schneider, I., and Van Broock, L., "Design and Construction of an Inflatable Lunar Base with Pressurized Rovers and Suitports," *61st International Astronautical Congress 2010,* Infrastructures and Systems to Enable International Future Exploration and Utilization of Space (3), Prague, Czech Republic, 2010, 8635.

[20]de León, P., and Harris, G.L., "NDX-2: Development of an Advanced Planetary Space Suit Demonstrator System for the Lunar Environment," *41st International Conference on Environmental Systems*, Portland Oregon, 2011. Paper ID: ICES 2011-5013.

[21]Stuster, J., Adolf, J., Byrne, V., and Greene, M., "Human Exploration of Mars: Preliminary Lists of Crew Tasks," Anacapa Sciences, KBR/Wyle Johnson Space Center Houston, Texas, 2018. Available in electric form at http://ston.jsc.nasa.gov/collections/TRS.

[22]Lazarus, R.S., and Folkman, S., *Stress Appraisal and Coping*, Springer, New York, 1984.

[23]Folkman, S., and Moskowitz, J.T., "Coping: Pitfalls and promise," *Annual Review of Psychology*, Vol. 55, 2004, pp. 745-774.

[24]Pearlin, L.I., and Schooler, C., "The Structure of Coping," *Journal of Health and Social Behavior,* Vol. 19, No. 1, 1978, pp. 3-21.

[25]Gunderson, E.K.E., "Psychological Studies in Antarctica," *Human adaptability in Antarctic conditions. Antarctic Research Series,* edited by E.K.E. Gunderson, Vol. 22, 1974, pp. 115-131, Washington, D.C.:AGU.

[26]Bartone, P.T., Krueger, G.P., and Bartone, J.V., "Individual Differences in Adaptability to Isolated, Confined, and Extreme Environments," *Aerospace Medicine and Human Performance*, Vol. 89, No. 6, 2018, pp. 536-546.