

## Stress and Coping in Extreme Environments: Implications for a Mars Mission

El estrés y su enfrentamiento en entornos extremos: implicaciones para una misión a Marte

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### ABSTRACT

**Introduction:** There are very few studies of all-women teams performing in highly challenging isolated, confined, and extreme environments.

**Objective:** To evaluate individual stressors, coping methods, and team functioning over an extended highly challenging trek.

**Methods:** Subjects in this study were six British military officers who successfully traversed the Antarctic continent on skis over a 61-day 1700 km trek. The measures administered and their timing were as follows: Pre-expedition - Multidimensional Personality Questionnaire-Brief Form (MPQ-BF); Triarchic Psychopathy Measure (TriPM); Portrait Values Questionnaire (PVQ); Expedition - weekly rating form (WRF) assessing stress, coping, and team decision making; Post-expedition - debriefing interview and PVQ.

**Results:** The group had high scores on personality scales indicating traits of Achievement, Social Closeness, Absorption (imagination), and Boldness, although individual differences were evident. Subjects gave high ratings to PVQ Hedonism (pleasure), Stimulation, and Self-direction values; the Tradition value was rated low. Subjects reported primarily positive experiences on the ice, and used both cognitive and

behavioral coping methods to deal with stress. A salient issue was resolving individual goals among team members vs. team goals in the pace and distance covered each day. Other themes related to the importance of honesty in communication for team success, dealing with friction between two dominant individuals, and proving oneself through the physical challenge.

**Discussion:** The implications of these findings for a Mars mission include the importance of enhancing the effectiveness of both pre-flight training and the countermeasures developed for use during flight to deal with interpersonal and work performance stressors. The effective use of ground-based analogs such as expedition teams operating in challenging and extreme environments is discussed.

**Key words:** Mars Analog; Stress; Coping; Womens Expedition.

## RESUMEN

**Introducción:** Existen muy pocos estudios sobre el desempeño de equipos exclusivamente femeninos en entornos muy hostiles, aislados, confinados o extremos.

**Objetivo:** Evaluar los factores estresantes individuales, los métodos de afrontamiento y el funcionamiento del equipo durante una caminata prolongada y altamente desafiante.

**Métodos:** Los sujetos del presente estudio fueron seis oficiales militares británicas que atravesaron exitosamente el continente antártico en un fatigoso recorrido en esquís de 1 700 km y 61 días. Las mediciones administradas y su duración fueron las siguientes: Pre-expedición - Cuestionario multidimensional de personalidad - formulario breve (MPQ-BF); Medida psicopática triárquica (TriPM); Cuestionario de valores (PVQ); Expedición - formulario de evaluación semanal (WRF), que evalúa el estrés, el enfrentamiento y la toma de decisiones colectivas; Post-expedición - entrevista sobre incidentes y PVQ.

**Resultados:** El grupo obtuvo altas calificaciones en las escalas de personalidad relacionadas con los siguientes rasgos: Logros, Cercanía Social, Abstracción (imaginación) e Intrepidez, aunque con evidentes diferencias individuales. Los sujetos otorgaron altas calificaciones a los valores PVQ de Hedonismo (placer), Estimulación y Autodirección, mientras que el valor Tradición obtuvo una baja calificación. Los sujetos reportaron sobre todo experiencias positivas en el hielo, y aplicaron métodos de enfrentamiento tanto cognitivos como conductuales para manejar el estrés. Un problema recurrente fue la conciliación entre los objetivos individuales y los colectivos en cuanto a la velocidad de avance y la distancia que debían cubrir cada día. Otros temas fueron la importancia de la honestidad en la comunicación para lograr éxitos colectivos, el manejo

de las fricciones entre dos individuos dominantes, y el probarse a uno mismo mediante el enfrentamiento a retos físicos.

**Discusión:** Las implicaciones de estos resultados para una misión a Marte incluyen la importancia de elevar la efectividad tanto del entrenamiento anterior al vuelo como de las contramedidas elaboradas para su aplicación durante el mismo, con vistas a manejar los factores estresantes en el trabajo y las relaciones interpersonales. Se analiza el uso efectivo de condiciones análogas en tierra, como pueden ser las expediciones que se desenvuelven en entornos hostiles y extremos.

**Palabras clave:** Análogo de Marte; estrés; enfrentamiento; expedición femenina.

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## INTRODUCTION

There are very few studies of all-women teams performing in highly challenging isolated, confined, and extreme environments.

The objective of this paper is to evaluate individual stressors, coping methods, and team functioning over an extended highly challenging trek.

The effective use of ground-based analogs such as expedition teams operating in challenging and extreme environments could be important for a Mars Mission

## METHODS

Six British military women successfully traversed the Antarctic continent in 61 days on skis, hauling sledges with all of their gear (See Blackadder-Weinstein et al.<sup>(1)</sup> for the full report) They skied for 10 hours/day with interspersed rest stops; each team member led a 75-minute leg. The team covered 1700 km over the course of the trek with temperatures that ranged from -14°C to -56°C. During the expedition, nightly meetings were held in the leader's tent to discuss daily progress and any team member concerns. While listening to differences of opinion, the leader had final decision authority.

Prior to the expedition, psychological training included team and individual meetings with military psychologists to examine their typical coping strategies for dealing with stressful situations, followed by instruction as needed on more adaptive methods for coping with stress. Subjects completed a battery of psychological measures assessing personality characteristics (Multidimensional Personality Questionnaire-Brief Form [MPQ-BF], Triarchic Psychopathy Measure [TriPM]); and personal and social values (Portrait Values Questionnaire [PVQ]). Each week on the trek team members completed the Weekly Rating Form (WRF), assessing feelings and emotions, a positive and negative event checklist, methods of coping with stressors experienced, and environmental and physical health factors. The WRF also included items on strategy/team decision processes regarding the progress of the expedition across the ice. The WRF was programmed on each subject's mobile phone, set up to save data and provide a blank form for subsequent weekly ratings. Individual semi-structured debriefing interviews were carried out nine days after the team returned to England. Subjects also completed the PVQ post-expedition.

## **RESULTS**

The MPQ-BF findings are presented as T-scores and standard deviations. Team members scored relatively high on the following personality characteristics: Achievement; Social Closeness (enjoys close interpersonal relationships); and Absorption (imagination, emotionally responsive to sensory stimuli). The lowest scale score was on Harm Avoidance, indicating a risk taking propensity. The Stress Reaction scale findings indicated a group close to the norm on this characteristic. However, notable individual differences in personality among team members were evident in the large range of standard deviations on the MPQ-BF scales, although generally within the normal range of functioning. The exception was the consistently low scores across subjects on the Harm Avoidance scale. The complete MPQ-BF data are presented in table 1.

**Table 1.** Personality Characteristics of Team Members Assessed by Measures Evaluating Different Aspects of Personality

SCALE	M <sup>+</sup>	SD
<b>MPQ-BF Lower-Order Scales</b>		
Wellbeing	53	4.0
Social Potency	52	6.12
Achievement	56	8.02
Social Closeness	55	8.43
Stress Reaction	48	11.41
Alienation	53	5.05
Aggression	45	5.87
Control	45	9.56
Harm Avoidance	40	1.64
Traditionalism	41	5.14
Absorption	55	7.37
<b>MPQ-BF Higher-Order Factors</b>		
Positive Emotionality	56	7.74
Negative Emotionality	47	5.27
Constraint	39	4.46
<b>TriPM<sup>++</sup></b>		
Disinhibition	0.26	0.05
Boldness	0.64	0.08
Meanness	0.15	0.03

MPQ-BF - Multidimensional Personality Questionnaire-Brief Form; TriPM - Triarchic Psychopathy Measure  
<sup>+</sup>T-scores; standardized score with mean 50, SD 10  
<sup>++</sup>Scores range from 0 (low) to 1 (high)

The TriPM personality findings showed high scores on the Boldness scale and low scores on the Disinhibition and Meanness (callousness) scales. This profile reflects individuals who are high on adventure-seeking characteristics, yet low on impulsive-irresponsible traits, negative emotional arousal and callous/aggressive interactions with others (table 1).

The PVQ hierarchy of values indicated that the group as a whole self-identified with the following values: Hedonism (pleasure-seeking), Stimulation, and Self-Direction. The Tradition value was rated lowest. The post-expedition assessment was consistent in indicating this same hierarchy of values.

The PANAS mood scale is imbedded in the WRF; ratings of positive affect were significantly higher than negative affect throughout the expedition ( $t(4) = 7.84$ ,  $P < 0.001$ ), with little variation among individuals. WRF items assessing positive/negative events and coping methods were scored according to the percentage of

the nine weekly rating periods in which a particular item was endorsed, averaged across the six team members. The range for each item provides an assessment of individual differences in the experience of each event/coping method engaged in. Table 2 presents the significant events endorsed over the course of the expedition. Highest endorsements occurred for “Satisfaction I am able to cope with the challenges;” “Feelings of camaraderie/closeness with teammates;” “Satisfaction that the equipment is working properly;” “Enjoyment of the Antarctic Environment;” “Satisfaction in making good progress today.” Negative events generally were infrequently endorsed. However, the item “Tension or argument with a teammate” showed a range of differences.

**Table 2.** Mean Percentage of Significant Events Endorsed Over the Course of the Expedition

ITEM	%*	Range
Problems with gear and equipment	25.5	0-75
Feeling of camaraderie/closeness with teammates	88.0	50-100
Concern about wellbeing of another teammate	71.3	50-100
Enjoyment of the Antarctic environment	79.2	66.7-100
Concern about how effective my teammates and I are working together	53.2	22.2-89
Feeling down/low because teammate feeling same way	26.2	0-77.8
Tension or argument with a teammate	40.7	0-88.9
Satisfaction in making good progress today	77.8	33.3-100
Satisfaction that equipment is working properly	88.0	55.6-100
Satisfaction I am able to cope with the challenges	89.0	66.7-100
Concerns about the effectiveness of or safety of decisions I made today	7.41	0-22.2
Fear of being injured	52.1	22.2-83.3
Worried about family, friends	5.6	0-22.2
Loneliness, homesickness	21.3	0-50.0
Personal hygiene (wanting to be cleaner)	50.0	0-100
Lack of privacy, personal time	18.5	0-55.6
Worried about encountering bad weather	35.2	0-77.8
Frostbite	1.8	0-11.1
Muscle or joint pain	63.2	33.3-88.9
Headache	9.3	0-33.3
Injury	15.1	0-44.4

\*Mean percentage of rating periods in which a particular item was endorsed.

The coping methods most frequently endorsed in dealing with stressors experienced reflected both cognitive and behavioral strategies. Cognitive strategies included: “Kept the goal in sight. Thought about finishing the expedition and why I’m here;” “Thought of something pleasant such as good times to come;” “Relaxed, meditated, listened to music, daydreamed; “Kept my feelings to myself.” Behavioral coping strategies were as follows: “Discussed task concerns with a teammate;” “Discussed personal/emotional concerns with a teammate;” “Tried harder, pushed myself to do my best, told myself I can do it;” “Tried to figure out how to solve the problem that’s bothering me” (table 3).

**Table 3.** Mean Percentage of Coping Methods Endorsed Over the Course of the Expedition

ITEM	%*	Range
Kept my feelings to myself	48.2	0-100
Discussed task concerns with a teammate	82.4	50-100
Discussed personal/emotional concerns with a teammate	64.8	33.3-100
Tried harder. Pushed myself to do my best, told myself I can do it	52.6	11.1-87
Prayer	34.3	0-100
Saw the situation in a positive way, what I’m learning and getting out of it	65.3	25.0-100
Kept a positive attitude. Humor, joking around, having fun.	74.5	50-100
Cried	14.8	0-44.44
Relaxed, meditated, listened to music, daydreamed	75.0	44.4-100
Kept the goal in sight. Thought about finishing the expedition and why I’m here.	92.6	66.7-100
Thought of something pleasant such as good times to come.	84.0	50-100
Tried to figure out how to solve the situation that’s bothering me	36.3	12.5-77.8
Yelled, stomped, threw things around	0.00	0-0

\*Mean percentage of rating periods in which a particular item was endorsed.

The debriefing interview thematic analyses resulted in four themes mentioned by all team members: resolving pace vs. distance in the daily ski plan; honesty in communication with teammates; tensions between the leader and a team member; the physical challenge, reflected in part by the motivation to prove oneself. These themes are illustrated by the following excerpts from individual interviews:

Individual vs. team goals in resolving whether to maintain a fast pace and either stop earlier or ski for a longer period each day, or maintain a slower pace to acknowledge individual differences in physical stamina.

*It's important to identify within the team what their team goals are and they agree to it...and accepting what each person can bring to the team....raised in team meetings....talked about what we wanted to achieve...and we actually managed to talk it through*

Team effectiveness was viewed primarily in terms of communication issues.

*Honesty in communication....openness and honesty and trust, not necessarily you have to always say what you think because that can be detrimental....communication is way up there, and self-awareness of others and a common goal that you all agree to*

*I think you don't need to be friends to make a good team, and actually it's probably better not to be friends*

Leadership tensions were related primarily to differences in opinion about the pace of the trek between the leader and another highly dominant team member. The effect on group morale was noted.

*The main frictions were between two other people and I was more external to it. Yeah, it affected me, I was aware of it, and the mood of the whole team brought me down.*

Personal motivation centered on proving oneself as successful and competent in a highly challenging situation.

*It was a challenge and I wanted something that would be the hardest challenge of my life. one of the select few ...to do something that no one had done before and I think a part of me didn't know whether I would be able to do it....It was a huge challenge, and that I'd never have that opportunity again.*

*To have the security to know you've done something really well once*

## DISCUSSION

In planning for a long-duration exploration mission to Mars or another planet, human factors are of highest priority. The NASA Human Research Roadmap; A Risk Reduction Strategy for Human Space Exploration lists risk of performance and behavioral health decrements due to inadequate cooperation, coordination, communication and psychosocial adaptation within a team as a specific risk factor.<sup>(2)</sup> The Team risk is rated at the High risk level for a three year planetary visit/habitation.

The manner in which team members interact with each other both interpersonally and while performing operational tasks is paramount to mission success. Considering that the voyage to the Martian planet is projected as six months in duration, during which the crew will be confined in a small space vehicle during this time, mitigating personal and operational stressors by means of highly effective countermeasures is critical. Furthermore, once on the Mars surface, two member teams leaving the habitat to explore the planetary surface must coordinate with each other in a highly effective manner. Thus, specific training and countermeasures also need to be developed for this crucial and extended period of the mission.

The findings of the current investigation point to the importance of crew selection, which should include examining the motivations of individual crew members. The personality results indicated that team members can be quite different in terms of specific normal range personality characteristics and yet work well together. However, the negative impact on team cohesion and work performance by the presence of two highly dominant individuals has been documented in previous space simulation studies.<sup>(3,4,5,6)</sup> Further, given the greater autonomy from mission control that the crew will have during a Mars mission, if two crew members differ in their objectives while engaged in an exploration activity, such as the duration of the exploration or the distance traveled from the habitat, this could have a significant impact on their safety and mission success.

To mitigate potential problems, pre-flight training is crucial. This training needs to include examination of methods used by each team member to deal with stressful situations, and discussion of more effective coping strategies, as needed. Individual differences in personality among crew members also need to be addressed so that each member can anticipate and deal with particular behavior patterns of others in the group. Pre-training in strategies for conflict resolution is also critical; irrespective of the care in which a particular team is chosen, over an extended period of time conflicts will inevitably arise.<sup>(7)</sup> The importance for team effectiveness of honesty in communicating with others and sensitivity in how much to communicate and when has been noted in other expedition studies and is clearly relevant for any type of long-duration space mission (for example, Corneliussen et al;<sup>(7)</sup> Kjaergaard et al.<sup>(8)</sup> However, while greater pre-flight training is highly important, the application of effective and astronaut-friendly countermeasures to deal with personal and group problems during flight also is necessary. Clearly, not all potential issues that could negatively impact mission success can be dealt with and solved before the space flight takes place.

Empirical psychological studies of astronauts/cosmonauts during ongoing space missions are difficult to schedule; substantive conclusions also are hampered by the small number of space flyers available. The use of analogs that simulate certain aspects of space missions and the aggregation of data across different analogs are highly important in obtaining as much information as possible that can be applied to space missions. Comprehensive research on different types of polar expeditions is one analog paradigm in which individual and team processes can be examined. Expeditions have the advantage of occurring in a highly challenging and potentially dangerous environment, small team composition, striving for a specific goal, and the need for cooperation to ensure optimal work performance and safety. Individual differences in personality and behavior should also be assessed in relation to performance, thus obtaining information helpful for optimal crew composition.

## **REFERENCES**

1. Blackadder-Weinstein J, Leon GR, Norris RC, Venables NC, Smith M. Individual attributes, values, and goals of an all-military women Antarctic expedition. *Aerosp Med Hum Perform.* 2019;90(1):18-25.
2. NASA Human Research Program. Human Research Roadmap. Houston, Texas: NASA. 2004 [acceso 15/05/2019]. Disponible en: <https://humanresearchroadmap.nasa.gov>
3. Kanas N. Psychological, psychiatric, and interpersonal aspects of long-duration missions. *J Spacecraft Rockets.* 1990;27(5):457-63.
4. Leon GR, Scheib A. Personality influences on a two-man Arctic expedition, impact on spouse, and the return home. *Aviat Space Environ Med.* 2007;78(5):526-29.
5. Leon GR, Venables NC. Fearless temperament and overconfidence in an unsuccessful special forces polar expedition. *Aerosp Med Hum Perform.* 2015;86:567-70.
6. Sandal GM, Værnes R, Ursin H. Interpersonal relations during simulated space missions. *Aviat Space Environ Med.* 1995;66:617-24.
7. Corneliussen JG, Leon GR, Kjærgaard A, Fink BA, Venables NC. Individual traits, personal values, and conflict resolution in an isolated, confined, extreme environment. *Aero Med Hum Perf.* 2017;88(6):535-43.

8. Kjærgaard A, Leon GR, Fink BA. Personal challenges, communication processes, and team effectiveness in military special patrol teams operating in a polar environment. *Environ Behav.* 2015;47(6):644-66.

### **Conflict of interests**

There is no conflict of interest in relation to the research presented.