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Finding the team for Mars: a psychological and human factors analysis of a Mars Desert Research Station crew

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Abstract. A two-week mission in March and April of 2011 sent six team members to the Mars Desert Research Station (MDRS). MDRS, a research facility in the high Utah desert, provides an analogue for the harsh and unusual working conditions that will be faced by men and women who one day explore Mars. During the mission a selection of quantitative and qualitative psychological tests were administered to the international, multidisciplinary team. A selection of the results are presented along with discussion.

Keywords: extreme environments, expeditionary teams, nextgen astronauts , human factors psychology, mars exploration

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1. Introduction

In the history of the exploration, numerous expeditions have set out on voyages and faced all of the accompanying dangers and discomfort. Many of the individuals involved paid the ultimate price for their daring. Often such disasters derived from the collective inability to anticipate the up-coming perils and therefore to select the optimal crew, give it the appropriate training, plan the best route, and provide the necessary equipment to circumvent what would prove to be fatal stumbling blocks. The space age gave birth to a new approach to exploration. Since human spaceflight has been, from its inception, a scientific enterprise, it has been based on the recognition that safety required extensive a priori research. At first, such efforts were focused on the engineering problems. These included the reliability of propulsion systems, spacecraft that could survive launch and re-entry, and technology that could keep the crew alive during their journey. Although the age of engineering concerns is nowhere near over, we are now entering a time where the primary challenge for extended, manned spaceflight is a human one. In the past, the primary check on astronaut readiness was based on their medical condition. This level of assessment was based on the implicit assumption of "*physiological adequacy*." That is, while the astronaut was able to physiologically survive the conditions, the mission could proceed. Modern exploration however, must be based on "*psychological adequacy*." That is, the mission can only proceed while the performance capacity of the crew remains in a stable state (and see Hancock & Warm, 1989). To understand the stresses, pressures and cognitive loads which will inevitably be placed upon long-duration space exploration teams, we have to begin now to explore and exploit the various environmental analogs that we possess in order to work toward principled, quantitative selection criteria for optimal crew composition. There has been significant work which has founded this necessary exploration (e.g., Harrison, Clearwater, & McKay, 1991: Suedfeld, 1991; 2010), and the purpose of the present paper is to report on one such experience with a limited size, mixed gender and mixed nationality/culture crew and a selection of the quantitative and qualitative tests conducted on its members during a two-week duration mission.

2. The Mars Analogue

As hopes grow for the mission to Mars, various analogues and simulations have emerged through which we are able to begin to solicit important foundational information. One of these facilities has been created and maintained by the Mars Society. Raising the funds from a number of space-oriented donors (with eventual participation by NASA), in 2000 the Society established one station on Devon Island in the Canadian High Arctic (the Flashline Mars Arctic Research Station, FMARS). In 2002 a second facility was added in the desert of Utah (the Mars Desert Research Station, MDRS). The present research was conducted in the latter facility, an illustration of which is shown in Figure 1.

Figure 1: The MDRS: Mars Desert Research Station in Utah, U.S.A., in which the present experimental procedures were conducted.

We are, of course, the first to acknowledge that, like all analog environments (and even near-Earth orbit facilities), the present testing environment has severe restrictions of transfer validity of information accumulated. The present experience lasted only 14 days compared to the several months and even years of the actual mission. Most of the dangers of space travel (e.g., bone and muscle deterioration, radiation, penetration by space debris or other objects, etc.) are not duplicated in the present environment. While the analog does provide a good representation of Mars surface, our crew can be rescued in an emergency, and sick, injured, or troublesome crew members can be readily removed from station (cf. Zubrin, 2003). In this sense, there are inevitable constraints on the information developed from such experiences. However, perfect transfer is never to be had in field analogs and like

many such experiences the present report looks only to provide indicative and not determinative data.

Despite these differences, there are sufficient similarities that a psychological study of the crew is relevant. The crew is confined and isolated in an uncomfortable environment which itself is within a remote, isolated, harsh location. Furthermore, how similar the psychological effects of the MDRS environment are to what we know about the effects of other long-duration isolated, confined environments can act as a test of how effective a simulation of Mars exploration (not including the round trip) it provides: analogues and simulations needing to be evaluated by the similarity between the experiences of their crews, not necessarily by the similarity between physical environments (Suedfeld, 1991).

3. Methods

Six international crew members, all graduate educated, English speaking, and of various ethnicity and descent, were selected by application from a pool of candidates to spend two weeks living and doing research at the MDRS facility in Utah. One of the present authors (J.D.) administered psychological assessments including the Post Expeditionary Growth Scale, , the Perceived Stress Questionnaire, used to assess stress in extreme environments, and the Positive and Negative Affect Scale Extended or PANAS-X (Watson & Clark, 2004). Each assessment was administered by hand three times; at the outset of the expedition, at the midpoint, and near to the mission termination. Results were coded and analyzed at the University of Central Florida (UCF) using SPSS analysis package.

4. Results

Given the wide range of results, only selected elements are explored here. In regard to the PEGS, we compared the team means to population means with 926 participants from 14 studies who had experienced various forms of trauma (Taku, Cann, Calhoun & Tedeschi, 2008). The present sample size is too small for statistical significance testing using specified tests such as independent t-tests. This being said, some differences are noteworthy since, with a bigger sample sizes they may prove to be significant sources of variation.

Overall, the present team's mean was 63.67, while the population comparator was 53.04. This difference is not significant; however, a difference between a sample of 20 retired cosmonauts (M=63.95) and the population had previously proved to be significant. Therefore, the present group appears much more to resemble the cosmonaut group.

Using the same logic as above for change in Personal Strength, the difference between group mean and population norm is 4 points. This is also very similar to the cosmonaut sample. Therefore, this group may have experienced greater growth in Personal Strength as a result of the mission.

In addition, one of the team members (M=26.00) reported much lower positive changes/effects than the team mean (M=63.67) and than other individual team members. This may be a sign of poor adjustment to the environment, the group, or potential other problems. When looking into the PANAS-X data, a main effect of gender was seen, such that female participants reported higher levels of Negative Affect on the PANAS-X ($F(1,17) = 6.8, p < .05$, $R^2=.31$)(Fig. 2), and also reported higher levels of stress on the PSQ ($F(1,17) = 21.4$, $p < .05$,$R^2=.51$). Indeed, the PSQ and PANAS-X were highly correlated for both the positive ($r = .79$, $p=.05$) and negative ($r=-.59$, $p=.05$) aspects of the PANAS.

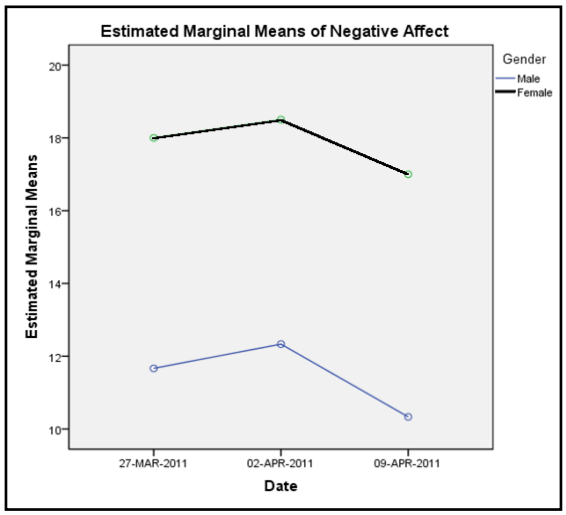

Figure 2: Example of the main effect of gender seen in the negative affect component of the PANAS-X.

5. Discussion

The present sets of results are more suggestive than they are definitive. This in itself highlights one of the central problems of both this genre of research and the eventual question of crew selection. While our results are indicative, they lack sufficient power to provide normal standards of evidence for significance testing. However, this, in some sense is precisely the point. In constructing an optimal crew for Mars we are not looking at norms and averages. We are examining response capacities of highly selected small groups. We should therefore ask whether our normal parametric approaches, or even non-parametric procedures, are relevant to this particular task. It is clear from both objective and subjective reflections of the present crew response that the experience of analog mission conditions is somewhat aversive, even in the relatively benign conditions of the MDRS.

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