No. of pages 8
No. of words 2097

Summary of Research Issues in Behavior and Performance in Isolated and Confined Extreme (ICE) Environments

RUNNING HEAD: Behavior and Performance in ICE Environments

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Current Status of Research

The papers presented in this section describe changes in behavior and performance in various isolated and confined extreme (ICE) environments, including Antarctic expeditions and research stations, space simulators and isolation chambers, and submarines. Each of these environments possesses characteristics that are in some way analogous to those found on long-duration space missions. Despite differences in length of mission, characteristics of mission personnel or crew, and characteristics in the physical environment, the various ICE environments described in this collection of papers appear to produce similar changes in behavior and performance. These changes include increased disturbances of mood, increased rates of psychiatric disorder, increased interpersonal tension, and a disruption of circadian rhythms. However, these environments do not inherently produce decrements in performance. Palinkas and colleagues suggest that prolonged exposure to the isolation and confinement in the Antarctic can actually have positive or "salutogenic" effects as well, evidenced by a decrease in mood disturbances and increase in performance measures.

Furthermore, the changes in behavior and performance themselves exhibit certain consistent patterns. Some of these patterns are tied to alteration of circadian rhythms with prolonged exposure to cold, darkness, isolation, and monotony. Other patterns are tied to discrete phases of mission. The papers by Palinkas et al and Sandal, for instance, provide evidence of a biphasic or "third quarter" model of behavior in which decrements in performance are most likely to be observed during the second half or third quarter of a mission, regardless of mission length or severity of the physical environment. The paper by Sandal also documents changes in behavior that correspond to stages of interpersonal tension.

A third set of patterns of change in behavior and performance reflected in these papers is tied to certain characteristics of small groups in ICE environments. For instance, Palinkas and colleagues report that levels of tension and anxiety, depression and anger assume a dose-response relationship with the structure of interpersonal relations within Antarctic winter-over crews. Thus, crewmembers of groups that exhibit a clique structure report significantly higher levels of these moods than crewmembers of groups that exhibit a core-periphery structure.

Finally, patterns of change in behavior and performance in ICE environments are tied to the characteristics of individual crewmembers. Kitamura found low self- directedness to be associated with the prevalence of psychiatric disorder and expressions of anger to be associated with the prevalence of mood disorders among Japanese Antarctic expeditioners. Wood and colleagues report that individual differences account for significantly more variance than gender differences in social identification, perceived social support, and perceived change in relationships with those at home in a study of Australian winter expeditioners in the Antarctic.

Another common theme of the papers in this session is the situational character of both individual and interpersonal behavior in ICE environments. For instance, the personality traits of ideal candidates for long-duration missions in ICE environments appear to be different from those considered ideal in other, less extreme environments. Evidence presented in the paper by Palinkas and colleagues suggest that state (i.e., situational) characteristics are better predictors of behavior and performance than trait (i.e., stable) characteristics. Wood and colleagues found individual characteristics to be more important in predicting measures of social compatibility than social or demographic characteristics such as gender. Sandal concludes that the `right stuff' may vary according to the demands and resources of the situation, such as interpersonal compatibility. The importance of interpersonal sensitivity as a predictor of individual and interpersonal behavior on a long-duration mission in an ICE setting is an example of this situational feature of behavior and performance. Palinkas and colleagues present data that suggest a low need for social interaction is associated with decrease in depressive symptoms in Antarctica.

Critical Questions of Human Factors in Space

One of the most important issues raised by the papers in this session concerns the usefulness of analogues in determining the requirements for optimal behavior and performance during long-duration missions in space. Given the obvious inability of analogues such as polar expeditions, isolation chambers and submarines to duplicate conditions of microgravity, as well as differences in other features of the physical environment, crewmember personality traits, crew size, and mission demands, the usefulness of analogue studies for an understanding of human factors in space remains an open question. However, the consistency of the findings across different analogues represented in these papers suggests the presence of common underlying principles, which transcend the obvious differences between these analogue environments as well as the differences between these environments and space. Given this consistency, analogues such as those described in these papers provide opportunities for the development of hypotheses to be tested in space. Analogue studies also allow us to differentiate between effects of specific features of environment, (e.g., isolation, confinement, cold, darkness, monotony, living space, danger, etc.) on specific features of behavior and performance (e.g., cognition and task ability, stress and emotional compatibility, social compatibility). Analogue settings also provide opportunities for countermeasures development, testing, and validation. These opportunities are likely to occur with greater frequency and be more cost-effective for logistic reasons than similar efforts conducted aboard the International Space Station or on other long-duration space missions. Moreover, they offer the potential for working with larger sample sizes than is currently available from working with astronaut personnel alone.

A second critical question raised by the papers in this session is whether decrements in performance in ICE environments are inevitable. If the answer is yes, then research is required to identify the specific features of the environment, the mission, or the individuals participating in the mission that is responsible for these decrements. If the answer is no, then research is required to identify the environmental, individual, interpersonal and organizational factors that promote successful adaptation and adjustment on long-duration missions in these environments. For instance, the papers by Sandal and Palinkas and colleagues both suggest that highly compatible crews might reduce the risk of individual performance decrements. However, it is unclear as to what makes for a highly compatible crew. Are such crews the result of a certain style of leadership exercised by the commander, or are they a function of the psychosocial characteristics of individual members? Do they develop naturally, or can they be "designed" through programs of screening, selection, and training?

This observation leads to a third critical question for human factors research in space as well as on the ground in analogue settings: what can be done to minimize performance decrements and/or enhance performance? In the past, great emphasis has been placed on the use of screening and selection techniques and procedures to accomplish this objective. Most of these techniques and procedures are based on the concept of "screening out" or eliminating those candidates unsuitable for long-duration missions in space, other ICE environments, and probably any environment. With the prospect of multicultural crews aboard the International Space Station, however, there is a need to identify cultural/national differences in policies and procedures and develop common procedures and policies. For instance, Kitamura's paper reflects a philosophy, characteristic of the Japanese Antarctic Research Program, that allows for the selection of candidates with a history of mental disorders. This philosophy is at considerable variance with the policies of the United States Antarctic Program, as well as NASA, that specifically excludes such individuals. Whether such differences are likely to influence the screening and selection procedures used by different nations in identifying individual members of multicultural ISS crews is a critical question that should be addressed immediately.

The counterpart to the screening out philosophy implicit in all of these papers in a "screening in" approach that seeks to identify candidates for long-duration missions who are most likely to perform optimally in ICE environments. To do so, however, requires a better understanding of the demands placed on these individuals by the mission, specific features if ICE environments, and other aspects of the experience that are situational in character. It also requires a better understanding of the characteristics of successful individuals (i.e., emotionally stable, socially compatible, and productive) as well as the characteristics of successful (i.e., compatible, productive) groups.

Minimization of performance decrements and enhancement of optimal performance may also be accomplished by training programs that provide adequate preparation for personnel in long-duration spaceflight and other ICE environments. However, a critical question is how best to prepare space crews to cope with isolation and confinement, avoid interpersonal tension and promote cohesion within the crew, and interact/communicate efficiently with ground control. Are there existing forms of training used in other contexts that may be efficiently adopted for the training of multicultural crews of long-duration space missions? Do the special characteristics of these missions, crews and environments require the development of new protocols and new technology for training purposes? Should all training be conducted at the pre-flight or predeployment phase of a mission, or should some forms of training occur during the in-flight or deployment phase? Questions such as these are of critical importance for the planning and execution of long-duration missions in space. However, as evidenced by the papers in this session, the answers to these questions may lie elsewhere, in analogue settings. .

Recommendations for future research.

Four specific recommendations emerged from this session. First, it was agreed that a common set of measures was essential to further study of behavior and performance in space and in analogue settings. Future research should be directed to the identification of this common set. At a minimum, this set would be used to evaluate three specific domains of behavior and performance in ICE environments: task ability, emotional stability, and social compatibility. Such research would focus on issues of validity and reliability, technology required for data collection, and burden on study participants. The availability of a common set of measures would also facilitate comparison of results across studies. This research should be conducted in both space and in analogue settings. Research in space should begin with the screening and selection of the multicultural crews for long-duration assignments on the International Space Station.

Second, meta-analyses of analogue data should be conducted to identify environmental, individual, social and organizational factors that influence behavior and performance on long-duration missions in ICE environments. The large and varied data sets already available could be used to address issues, test hypotheses, and answer questions that are beyond the scope of any one data set. Such analyses offer a systematic means of describing what has been learned from the collective experience of analogue environments research to date about behavior and performance that is specifically relevant to long-duration spaceflight.

Third, additional research should be conducted in analogue environments to develop a better understanding of these environmental, individual, interpersonal, and organizational influences on behavior and performance. Research on environmental conditions should be conducted to develop a better understanding of the impact of monotony and lack of privacy on individual and group behavior in ICE environments. Research on physiological conditions should be conducted to develop a better understanding of the likelihood of performance decrements associated with the disruption of circadian rhythms, physiological manifestations of stress, changes in sleep architecture, and alterations of the hypothalamic-pituitary-adrenal (HPA) axis that occur in ICE environments. Research on individual factors should be conducted to develop a better understanding of the basis for individual variations in stress and coping, emotion, and cognition in ICE environments. Research on interpersonal factors should be conducted to develop a better understanding of the factors contributing to crew tension and cohesion (e.g., group structure and process, crew composition), and the dynamics of crew-ground interactions. Research on organizational factors should be conducted to develop a better understanding of the influence of organizational culture (values, attitudes, rituals, expectations, standards for performance) and mission characteristics (goals and objectives, duration, logistics) on individual and group behavior and performance.

Finally, analogue environments should be used to develop countermeasures to minimize performance decrements and enhance performance effectiveness. Prevention- focused countermeasures in need of further investigation include procedures and policies for screening-in ideal candidates and crews of long-duration missions, and training in interpersonal skills, individual coping skills, leadership skills, and alertness/sleep management. Treatment-focused countermeasures include crisis management, short-term psychotherapy, mediation and conflict resolution, and the use of psychoactive medications.