

Final Report

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PROJECT SUMMARY

The primary aim of this project was to examine group dynamics and individual performance in extreme, isolated environments and identify human factors requirements for long-duration space missions using data collected in an analog environment. Specifically, we wished to determine: 1) the characteristics of social relations in small groups of individuals living and working together in extreme, isolated environments, and 2) the environmental, social and psychological determinants of performance effectiveness in such groups. These two issues were examined in six interrelated studies using data collected in small, isolated research stations in Antarctica from 1963 to the present. Results from these six studies indicated that behavior and performance on long-duration space flights is likely to be seasonal or cyclical, situational, social, and salutogenic in nature. The project responded to two NASA program emphases for FY 1997 as described in the NRA: 1) the primary emphasis of the Behavior and Performance

Program on determining long-term individual and group performance responses to space, identifying critical factors affecting those responses and understanding underlying mechanisms involved in behavior and performance, and developing and using ground-based models and analogs for studying space-related behavior and performance; and 2) the emphasis of the Data Analysis Program on extended data analysis. Results from the study were used to develop recommendations for the design and development of pre-flight crew training and in-flight psychological countermeasures for long-duration manned space missions.

TASK PROGRESS

Project objectives were to use data collected from 1963 to the present in Antarctica to determine the following:

- The extent to which crew size, severity of station environment, and the social and psychological characteristics of crew members are significantly and independently associated with the structure of social relations, conflict and cohesion in a small group in an isolated, extreme environment.
- The extent to which these variables are also associated with changes in the structure of social relations over time.
- The extent to which consensus of group members as to group structure is associated with group size, and the social/demographic characteristics of crew members.
- The extent to which individual performance measures of ability, stability, and compatibility are associated with social structure, severity of station environment, crew size, and individual psychosocial characteristics.

Analyses of data collected in Antarctica since 1963 were conducted to identify features of behavior and performance likely to occur during long-duration missions in space. The influence of mission duration and station latitude on POMS mood scores was examined in 450 American men and women who overwintered in Antarctica between 1991 and 1998. The influence of crewmember social characteristics, personality traits, interpersonal needs, and station environments on measures of behavior and performance at the end of the austral winter was examined in 657 American men who overwintered between 1963 and 1974. Both data sets were used to examine the influence of crew social structure and consensus as to social roles on individual performance.

Results from these six studies indicated that behavior and performance on long-duration space flights is likely to be seasonal or cyclical, situational, social, and salutogenic in nature. These results are described in further detail below.

Seasonal Characteristics of Behavior and Performance

Seasonal variations in sleep characteristics and their association with changes in mood were examined in 91 American men and women who spent the 1991 austral winter at three different research stations in Antarctica. Measures of total hours of sleep over a 24-hr period, duration of longest (i.e., “nighttime”) sleep event, number of sleep events, time of sleep onset, and quality of sleep remained unchanged over the course of the austral winter (March through October). However, exposure to total darkness based on station latitude was significantly associated with total hours of sleep, duration of longest sleep event, time of sleep onset, and quality of sleep. Reported vigor the previous month was a significant independent predictor of changes in all five sleep measures; previous month’s measures of all six POMS subscales were significant independent predictors of sleep quality. Sleep characteristics were significant independent predictors of vigor and confusion the following month; total sleep, longest sleep event, sleep onset and sleep quality were significant independent predictors of tension-anxiety and depression. Changes in mood during the austral winter are preceded by changes in sleep characteristics. In turn, mood changes appear to affect certain sleep characteristics, especially sleep quality.

Situational Characteristics of Behavior and Performance

We examined the influence of crew member social/demographic characteristics, personality traits, interpersonal needs, and characteristics of station physical environments on measures of behavior and performance in 657 American men who spent an austral winter in Antarctica between 1963 and 1974. During screening, subjects completed a Personal History Questionnaire, which obtained information on social and demographic characteristics, The Deep Freeze Opinion Survey which assessed 5 different personality traits, and the FIRO-B Scale which measured 6 dimensions of interpersonal needs. Station environment included measures of crew size and severity of physical environment. Performance was assessed on the basis of combined peer-supervisor evaluations of task ability, emotional stability, social compatibility, leadership, and overall performance; peer nominations of fellow crew members who made ideal winter-over candidates; and self-reported depressive symptoms at the beginning and end of winter. Military service, low levels of neuroticism, extraversion and conscientiousness, and a low desire for affection from others were significant independent predictors of more than one performance measure. Ideal candidates for long-duration missions appear to have the following characteristics: low levels of depression at the beginning of winter, boredom, and a desire for affection from others; a low need for achievement and orderliness; a high need for optimism but a low need for efficiency in others; and military service. Leaders of such missions should be married, highly motivated, and express a need for control over others. Social/ demographic characteristics associated with peer-based performance evaluations are dependent upon their proportional representation in isolated and confined groups. Personality traits and interpersonal needs associated with successful performance in extreme environments or during long-duration missions may not be associated with similar performance elsewhere or during short-duration missions. In particular, the low need for personal achievement and orderliness, affection from

others and efficiency in friends may reflect characteristics that are uniquely suited to the prolonged isolation, confinement, and unique environmental characteristics of Antarctic research stations. Highly motivated personnel in small stations may also experience depressive symptoms at various points during an extended mission in an isolated, confined environment due to the absence of opportunities and resources to meet social and psychological needs. Select-in criteria for these environments must take into consideration the characteristics of the environment and the limitations they place on performance, as well as the characteristics of the individual and group.

Social Characteristics of Behavior and Performance

The evolution of network structure as it relates to the formal and informal aspects of social roles in well bounded, isolated groups was examined with data collected at the Amundsen-Scott South Pole Station over a 3-year period. Information was obtained on crewmembers' networks of social interaction and personal advice over each of the 8.5-month winters during a time of complete isolation. In addition, data was collected on informal social role structure (e.g., instrumental leadership, expressive leadership). It was hypothesized that development and maintenance of a cohesive group structure was related to the presence of and group consensus on various informal social roles. Core-periphery structures (i.e., reflecting cohesion) in winter-over groups were associated with the presence of critically important informal social roles (e.g., expressive leadership) and high group consensus on such informal roles. On the other hand, the evolution of clique structures (i.e., lack of cohesion) were associated with the absence of critical roles and a lack of consensus on these roles, particularly the critically important role of instrumental leader.

We also conducted a longitudinal assessment of social support and mood using this data to address three important questions: 1) to what extent do conditions of isolation and confinement affect the association between social support and mood; 2) what is the direction of causality in this association; and 3) is this association affected by the structure of the group? Specifically we wished to determine whether an increase in negative affect over the course of a winter in isolation and confinement was associated with a decrease in requests for advice from others and an increase in requests for advice to others, and whether these associations are mediated by the structure of the group. Both mood and the seeking and providing of advice were significantly associated with the group structure. The core/periphery structure group reported significantly less tension-anxiety and anger than the other two groups, but also less seeking and providing of advice, suggesting that crewmembers seek advice from others when they perceive a need to do so. There was a significant decline in both forms of support over the course of the winter. In turn, these forms of social support were associated with a subsequent increase in each of these measures of mood. Furthermore, low levels of depressive symptoms and total mood disturbance were associated a subsequent decline in seeking advice from others while low levels of seeking advice was a significant independent predictor of a subsequent decline in depressive symptoms. High levels of tension-anxiety, depression, anger, confusion and total mood disturbance and low levels of vigor appear to have contributed to a subsequent increase in the seeking and giving of advice in the core/periphery crew. High levels of fatigue preceded an increase in seeking

advice from others in the clique and core/periphery structure crews. However, in the core/periphery structure crew, seeking advice from others appears to have also contributed to a subsequent increase in tension-anxiety, depression, anger, fatigue and confusion and a further decline in vigor. In contrast, seeking advice from others was associated with a subsequent decline in tension-anxiety, anger and fatigue in the hybrid structure crew. The patterns observed in the core/periphery structure crew suggest that the giving and seeking of advice to and from fellow crewmembers was motivated by high levels of negative mood and a low level of vigor, but that it also contributed to a further increase in negative mood and a further decline in positive mood. Because everyone is in the same situation, crewmembers often experience difficulty in obtaining emotional support from their fellow crewmembers. Similarly, those called upon to give advice are similarly frustrated and irritated with fellow crewmembers seeking advice from them because there is very little in the way of support they can provide that their fellow crewmembers do not already possess.

A third study conducted in 657 American men who spent an austral winter in Antarctica between 1963 and 1974 found that self-reports of depressive symptoms at the end of winter were inversely related to crew centrality and cultural consensus. Specifically, crews with high centrality (i.e., a core-periphery structure) and high cultural consensus as to ideal crewmembers reported significantly fewer depressive symptoms among its members than crews with low centrality (clique structure) and low cultural consensus. Measures of centrality and consensus were also directly associated with station size. However, these measures were unrelated to average personality traits of station crewmembers, suggesting that situational factors relating to the combination of crewmembers, leadership skills, and crew mission were more important predictors of social dynamics than the presence or absence of any one particular set of individual traits.

Salutogenic Characteristics of Behavior and Performance

Finally, analysis of data collected from 657 American men who spent an austral winter in Antarctica between 1963 and 1974 found that depressed mood was inversely associated with severity of station physical environment, supporting the existence of a positive or “salutogenic” effect for individuals seeking challenging experiences in extreme environments. Performance is directly associated with measures of ability and compatibility, but inversely associated with measures of stability, perhaps because severity of station environment was also related to group size, as noted above.

APPLICATIONS AND EARTH BENEFITS

This research seeks to understand fundamental processes of social interaction and social dynamics in small groups in isolated and confined environments (ICEs). These include both long-duration missions in space and such ground-based environments as polar research stations, nuclear submarines, isolated military outposts and mining communities, and offshore oil rigs. The results of this research will assist in the development of “select-in” methods for screening and selection of personnel to live and work in space and other isolated and confined environments for prolonged periods. The results will also assist in the development of training programs and psychosocial countermeasures

designed to enhance group performance and cooperation and to minimize the risk of interpersonal conflict during long-duration missions in space and other isolated and confined environments. Research results will also help to elucidate the relationship between patterns of social organization and interaction and individual behavior and performance in small groups.

Results from these studies have led to the development of three types of countermeasures to potential decrement in behavior and performance during long-duration space missions. The first type of countermeasure includes pharmacologic, nutritional, and phototherapeutic interventions designed to attenuate circannual variations in behavior and performance. These interventions include the daily administration of thyroxine supplements or tyrosine (a amino acid precursor to central catecholamines), and periodic administration of bright light (10,000 lux for 30 min per day). Efforts are underway to evaluate these interventions with winter-over crewmembers in the Antarctic.

The second type of countermeasure involves improved screening and selection of personnel for long-duration space missions and other assignments in isolated and confined environments. The results from the studies conducted served as the basis for the development of recommendations on standardized procedures for personnel psychological screening and selection in extreme, isolated environments, made by the Human Biology and Medicine Working Group to the Scientific Committee on Antarctic Research in Concepcion, Chile. These recommendations call for a "select-in" approach that identifies candidates based on the person-environment fit between characteristics such as low neuroticism and extraversion and the conditions of prolonged isolation and confinement. A framework for developing, testing and validation of a similar approach for screening and selection of astronaut personnel for long duration space missions was also developed.

The third type of countermeasure involves the development and implementation of training programs designed to facilitate and promote effective teamwork and group living during long duration space missions. A set of strategies and recommendations was prepared for the Expedition Astronaut Training Program (EATP), and included in a resource guide for astronauts prepared by the Behavioral Health and Performance Group at NASA's Johnson Space Center under the direction of Dr. Holland. This material was also summarized in a seminar to a group of expedition class astronaut trainees at JSC in December, 1999. An ongoing series of training seminars for astronauts assigned to the International Space Station and other long duration space missions is planned.

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