

PSYCHOSOCIAL ISSUES IN LONG-TERM SPACE FLIGHT: OVERVIEW

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ABSTRACT

Anecdotal evidence of the individual and interpersonal problems that occurred during the Shuttle-Mir Space Program (SMSP) and other long-duration Russian/Soviet missions, and studies of personnel in other isolated and confined extreme (ICE) environments suggest that psychosocial elements of behavior and performance are likely to have a significant impact on the outcome of long-duration missions in space. This impact may range from individual decrements in performance, health and well being, to catastrophic mission failure. This paper reviews our current understanding of the psychosocial issues related to long duration space missions according to three different domains of behavior: the individual domain, the interpersonal domain and the organizational domain. Individual issues include: personality characteristics that predict successful performance, stress due to isolation and confinement and its effect on emotions and cognitive performance, adaptive and maladaptive coping styles and strategies, and requirements for the psychological support of astronauts and their families during the mission. Interpersonal issues include: impact of crew diversity and leadership styles on small group dynamics, adaptive and maladaptive features of ground-crew interactions, and processes of crew cohesion, tension and conflict. Organizational issues include: the influence of organizational culture and mission duration on individual and group performance, and managerial requirements for long duration missions. Improved screening and selection of astronaut candidates, leadership, coping and interpersonal skills training of personnel, and organizational change are key elements in the prevention of performance decrements on long-duration missions.

Apart from the medical and psychological screening conducted on astronaut candidates, psychosocial issues have traditionally received very little attention in NASA's manned-space program. Reasons include the perspective of an institution dominated largely by engineers that psychology and psychiatry are "soft" (Harrison, 1986) a belief in "the right stuff" of astronauts (Santy, 1994), and the relatively short duration of past space flights where the occurrence and severity of psychosocial problems are viewed as minimal at best (Helmreich, 1983). Nevertheless, there has been an increased awareness in recent years that psychosocial issues are equally, if not more, important to the success of long-term missions in space than other dynamics related to crew health and safety. This recognition has occurred in response to anecdotal evidence of the individual and interpersonal problems that occurred during the Shuttle-Mir Space Program (SMSP) (Burrough, 1998; Linenger, 2000) and other long-duration Russian/Soviet missions (Lebedev, 1988; Oberg, 1981), and studies of personnel in similar

isolated and confined extreme (ICE) environments (Gunderson, 1974; Sandal et al., 1995). Accounts of prolonged depression, social withdrawal upon news of the death of a loved one, interpersonal tension and hostility, poor leadership, miscommunication, and human error have precipitated a re-examination of the ability of astronauts possessing the "Right Stuff" to live and work alone and in groups, in an isolated, confined, extreme environment for prolonged periods of time.

Numerous reviews illustrate the breadth and scope of psychosocial issues relating to long-term space flight (Christensen and Talbot, 1986; Connors et al., 1985; Harrison et al., 1991; Kanas, 1985, 1987; Nicholas, 1987; Palinkas, 1991). The objective of this article is to examine in depth a limited set of issues, highlighted in the 1998 report issued by the National Research Council's Committee on Space Biology and Medicine, that reflect three hierarchical domains of behavior: the individual, the interpersonal and the organizational. This examination is based largely on recent studies conducted both in space and in analog settings.

INDIVIDUAL DOMAIN ISSUES

Stress and Coping

For many individuals, the prospects of living and working in an isolated, confining and hostile environment for prolonged periods of time can be quite stressful. Crewmembers of long-term space missions must endure lengthy separation from family and friends, limits on communication with earth caused by delays in transmission, distortion of audio and visual signals, and the inability to detect nonverbal, face-to-face cues important in the communication and interaction between individuals. Space vehicles offer little in the way of privacy and personal space. In addition, territoriality is more likely to become important in such settings. Likewise, social monotony develops in response to the constant interaction with the same group of fellow crewmembers. Finally, advances in technology may do little to alter the perceived risk of living in a hostile environment characterized by microgravity, exposure to high doses of radiation, collisions with micrometeorites and supply vehicles, fires, and other environmental hazards.

Exactly how much stress is experienced by volunteers for missions in such environments remains controversial. Anecdotal reports of previous space flights and studies conducted in space simulators and polar research stations have documented increases in the prevalence and severity of symptoms of depression, insomnia, irritability/anger, anxiety, fatigue, and decrements in cognitive performance (Christensen and

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Talbot, 1986; Gunderson, 1974; Kanas, 1985). A recent study by Palinkas and colleagues (2001) reported that 5.2% of a team of men and women who spent an austral winter in the Antarctic over a four-year period met the criteria for a DSM-IV disorder. Mood and adjustment disorders were the most common diagnoses, accounting for 31.6% of all disorders, followed by sleep-related disorders (21%), substance-related disorders (10.5%), and personality disorders (7.9%). Significantly, each of these individuals had undergone successful psychiatric and psychological screening prior to their deployment to the Antarctic. Even larger percentages of Antarctic winter-over personnel experience symptoms of stress, although these symptoms may fail to meet DSM criteria for a psychiatric disorder. In 1989, for instance, 64.1% of the winter-over crew interviewed at McMurdo reported some problem with sleep; 62.1% reported feeling depressed; 47.6% reported feeling more irritable than usual; and 51.5% reported difficulty with concentration or memory (Palinkas, 1992). While such symptoms may be considered minor in most other environments, their significance to the health and well being particularly becomes magnified by the conditions of isolation and confinement.

However, other studies have either found no evidence of these symptoms or suggested that they pose little threat to the health and well being of crew or to the success of the mission (Leon et al., 1989). Such studies suggest one of three possibilities: a) isolated and confined extreme environments are no more stressful than other environments (Suedfeld and Steel, 2000); b) highly motivated, self-selected individuals who volunteer for such long-term missions are capable of maintaining high levels of performance in such environments over long periods of time (Palinkas et al., 1995); or c) some highly motivated individuals simply do better than others (Palinkas et al., 2000a).

Screening and selection

It is this third possibility (that some highly motivated individuals do better than others) which leads us to explore the potential of psychological screening as a means of identifying individuals who do better than others in isolation and confinement. To minimize the likelihood that such psychosocial disturbances will develop, NASA and other agencies (e.g., the U.S. Navy, the United States Antarctic Program) routinely subject their crewmembers to a program of psychiatric screening and selection. The screening and selection of astronaut personnel in the U.S. space program has traditionally been based on a “select-out” philosophy that excludes those with any diagnosable psychiatric disorder or high likelihood of developing such a disorder (Santy, 1994). Although this approach has been generally successful in minimizing decrements in behavior and performance during short-duration missions (1-14 d), the advent of missions of longer duration, ranging from a three-month assignment aboard the Mir Space Station to a three-year mission to Mars, has generated greater interest in screening and selection based

on a “select-in” philosophy. Such an approach would seek to identify candidates whose character traits predict the ability to perform under stress and interact productively as a member of a crew (Santy, 1994).

Previous research has identified several characteristics that predict astronaut effectiveness. Among the better known are a set of personality traits based on the work of Spence and Helmreich (1978) and identified on the basis of responses to the Personality Characteristics Inventory (PCI) (Chidester et al., 1991). These traits are grouped into three clusters, labeled the “Right Stuff,” the “Wrong Stuff,” and “No Stuff.” Individuals characterized as having the “Right Stuff” exhibit high levels of positive instrumentality (attributes reflecting goal-orientation and independence), positive expressivity (attributes reflecting interpersonal warmth and sensitivity), mastery (a preference for challenging tasks and striving for excellence), and work (a desire to work hard and do a good job) and by low levels of negative instrumentality (negative characteristics reflecting arrogance, hostility and interpersonal invulnerability) and verbal aggressiveness (complaining, nagging and fussy verbal behavior). Individuals exhibiting “Wrong Stuff” exhibit high levels of competitiveness (preference for tasks with clear winners and losers and a desire to outperform others), negative instrumentality, and impatience/irritability, and low levels of positive expressivity. Individuals characterized as having “No Stuff” exhibit low levels of positive instrumentality, positive expressivity, mastery, work, and competitiveness, and high levels of negative communion (self-subordinating, subservient, or unassertive) and verbal aggressiveness. These traits have been found to be significant predictors of performance among astronauts (McFadden et al., 1994; Rose et al., 1994), aircrews (Chidester et al., 1991), submariners (Sandal et al., 1999), and military recruits (Sandal et al., 1998).

However, a person-environment fit model of behavior suggests that the ability of traits such as instrumentality and expressivity to predict performance is mediated by the characteristics of the environment itself. Personality traits that predict behavior and performance pre-flight may be of little value in predicting behavior and performance in-flight because the actual characteristics of the environment in which the behavior occurs is so dramatically different. For instance, a previous study of 119 men and women who spent the 1989 austral winter in Antarctica found that while several features of personality characteristics, coping methods and resources, and social resources were associated with concurrent measures of depressive symptoms, pre-deployment levels of depressive symptoms was the only significant independent predictor of late-winter depressive symptoms (Palinkas and Browner, 1995). These results suggested that baseline measures of personality, stress and coping characteristics are weak predictors of behavior and performance during the winter because performance is influenced more by the conditions of environmental isolation and confinement than by stable traits of individuals (Carver and Scheier, 1994). These conditions

include the stressors (e.g., isolation, confinement), and the limited availability of resources necessary to cope with these stressors. Likewise, methods and resources used to cope with stressful situations prior to deployment in Antarctica may not be effective in coping with isolation and confinement in Antarctica because they are situation-specific and not transferable from one social environmental context to another, particularly when that context is an ICE environment (Palinkas et al., 2000a).

A similar prospective screening study of the 657 men who overwintered at 8 different stations in Antarctica between 1963 and 1974 found that a high level of boredom was inversely associated with task ability, emotional stability, social compatibility, and overall performance (Palinkas et al., 2000b). The desire for optimistic behavior in crew was a significant independent predictor of emotional stability and social compatibility. Peer-supervisor assessments of crewmember leadership were positively associated with the need to control others and inversely associated with self-reports of absentmindedness. On the other hand, the need for order was inversely associated with emotional stability and leadership, while the need for achievement was inversely associated with social compatibility. A desire for efficiency in friends was inversely associated with emotional stability. High levels of motivation were inversely associated with evaluations of leadership, and a desire for affection from others was inversely associated with task ability, emotional stability, social compatibility, and overall performance.

The needs for achievement and orderliness, affection from others, and efficiency in friends may reflect personality characteristics uniquely suited to ICE environments. Under conditions of isolation and confinement, satisfying a need for achievement and order is often restricted by the environment itself. Individuals wishing to complete projects on schedule become frustrated at delays in communication with the outside, constant equipment failure, or absence of necessary supplies (Palinkas, 1992). Crewmembers who adapt best to such situations are those who revise their expectations to fit the reality of the situation (Palinkas, 1991). Adjustment of expectations to meet the reality of the situation may also account for the inverse association between a desire for efficiency in friends and emotional stability. Similarly, the ability to satisfy a desire for affection or affirmation from others is limited by a perceived need among all crewmembers to create their own personal space in a confined setting. The willingness to display friendship and offer emotional support to other crewmembers is often counterbalanced by a perceived inability to offer effective support and a fear of being burdened by the others' problems that are similar to one's own (Palinkas, 1992).

Psychological Support and Countermeasures

Psychiatric and psychological screening and selection procedures represent just one of the existing and proposed countermeasures designed to reduce the likelihood of psychiatric morbidity and impaired performance during

long-term missions. At the pre-flight stage, training in strategies for coping with isolation and confinement at both the individual and interpersonal levels is also important. In-flight countermeasures include monitoring of individual behavior, intervening directly or through the flight surgeon when necessary and appropriate, and facilitating crewmember contact with clinical and social support systems. Post-flight countermeasures include debriefing assessments of health and well being, and intervention when necessary and appropriate (Committee on Space Biology and Medicine, 1998).

The Behavioral Health and Performance Program at Johnson Space Center is responsible for several psychological countermeasures in four specific domains: sleep and circadian rhythms, human factors, psychological adaptation, and behavioral health (Committee on Space Biology and Medicine, 2000). Existing countermeasures related to psychological adaptation include: pre-flight select-in screening procedures for Astronaut Corps that include the Helmreich Personality Characteristics Inventory (described above); the Family Support Office which is responsible for counseling and support services to family members of crews at all phases of a mission; a preflight training program devoted to long-duration missions and cross-cultural issues that include self-care and self-management; leadership, teamwork and group living; in-flight psychological support in the form of leisure activities, arrangement of communication with family members, development of family photo albums and videos; and care packages that serve as reminders of loved ones on the ground; and post-flight debriefings to address any unresolved emotions or problems that occur in-flight. Proposed countermeasures include the implementation of "select-in" screening procedures for Expedition Astronaut Corps, field training and assessments for individual crewmembers as well as for the crew as a whole, individual training support and consultation, the development of crew performance plans, and confined operations training that might take place in a remote, high-latitude environment or in an environment simulator (Committee on Space Biology and Medicine, 2000).

Existing countermeasures related to behavioral health include: pre-flight "select-out" procedures for the Astronaut Corps, behavioral medicine care for astronauts and their families during pre-flight training, and pre-flight training in behavioral medicine for the Crew Medical Officer; in-flight monitoring and care, use of the Space flight Cognitive Assessment Tool (S-CAT) to monitor cognitive performance and neuropsychological status, a private medical conference (weekly when on orbit) with the crew Flight Surgeon, and consultation on the use of psychotropic medications when appropriate. Proposed countermeasures include an annual behavioral health examination, adoption and implementation of "select-out" screening procedures for the Expedition Astronaut Corps, development of individual performance plans, conducting of preflight assessments of mood and stress, preflight and post-flight Behavioral Medicine Meetings with crew and family members, and use of the Space flight Behavioral Assessment Tool (S-BAT) to

monitor mood and stress in-flight (Committee on Space Biology and Medicine, 2000).

INTERPERSONAL DOMAIN ISSUES

Interpersonal Tension, Conflict and Cohesion

As with individual issues of behavior, there is general agreement that interpersonal issues will become increasingly important in the training and performance evaluation of astronaut personnel (Christensen and Talbot, 1986; Connors et al., 1985; Kanas 1987; Nicholas, 1987). Anecdotal evidence collected from astronaut personnel in the U.S. and Soviet/Russian space programs as well as studies of small groups in other isolated environments suggest that prolonged isolation and confinement leads to increased social tension. This tension is reflected in open antagonism directed towards fellow crew members or Mission Control, or more commonly through social withdrawal and isolation, and, ultimately, decreased cohesiveness.

A number of Russian cosmonauts who participated in extended space missions have reported that conflicts among crew members were a common feature of these missions. Reports and records from the Soviet missions described decreased crew cohesiveness over time (Christensen and Talbot, 1986; Connors et al., 1985; Kanas, 1985). Russian cosmonaut Valentine Lebedev, who spent 211 days aboard the Mir Space Station in 1982, estimated that 30 percent of the time spent in space involved crew conflict. Citing his own as well as the experience of other Russian cosmonauts, Lebedev argued that misunderstandings among crew members and misunderstandings between crew and Mission Control were the most difficult problems experienced during prolonged missions in space.

Increased social conflict and decreased crew cohesiveness have also been reported in studies of prolonged isolation of small groups in analog environments. Several studies of crews aboard nuclear submarines, other undersea submersibles, and land-based space simulators found decreased group cohesiveness and social interaction, and increased interpersonal conflict and anger displacement to outside observers over time (Haythorn, 1970). Similar results have been reported in studies of military and civilian personnel who have wintered-over at small research stations in Antarctica (Gunderson, 1974; Palinkas, 1992). In all of these settings, individuals perceived to be deviant by other crew members have frequently been ostracized or socially isolated (Miller et al., 1971; Palinkas, 1992). Despite the development and utilization of psychological countermeasures in the Soviet/Russian space program, some cosmonauts have reported these countermeasures to have little effect on preventing crew conflicts after 30 days (Kanas, 1985). Similarly, the experience of the United States Antarctic Program indicates that psychological screening has had little impact on the problem (Palinkas, 1990).

However, not all isolated crews have experienced such conflict. Group cohesiveness was found to be high among participants of three Sealab missions in 1964 and 1965

(Radloff and Helmreich, 1968) and the Tektite missions in 1969-1970 (Miller et al., 1971). Two of three studies of 4-person crews in McDonnell Douglas space cabin simulators, lasting 30-d and 60-d in duration, found no significant level of interpersonal conflict among crew members, although a tendency to displace irritation and anger to outside observers was reported in each study (Dunlap, 1965; McDonnell Douglas, 1968). In the third and longest duration (90-d) study, crew morale began to suffer two-thirds of the way through the mission, resulting in decreased cohesiveness and increased hostility (Jackson et al., 1972). Studies of Antarctic winter-over crews have found that group cohesion varies from one year to the next (Palinkas, 1992).

The social dynamics of small groups in isolated and confined environments is characterized by three stages (Palinkas, 1992). The first is characterized by open interaction and identification of common interests between and among crewmembers. The process of social comparison establishes the basis for social interaction, yet also leads to the identification of differences and dislikes. In the second stage, subgroups begin to form as individuals organize on the basis of common characteristics, occupational demands, leisure interests, political and ideological allegiances, and so on. In some instances these subgroups become exclusive in membership leading to the formation of cliques. In the third stage, the entire group begins to coalesce around a social core. The extent of interaction between any one crewmember and the remainder of the crew may differ with respect to the individual and the dyads and subgroups formed in Stages I and II. Nevertheless, a distinct core and attendant social identity emerge from this process. However, this core may emerge at the expense of certain individuals who refuse to adhere to group norms and standards of behavior. These individuals become ostracized and isolated from the group itself. Thus, at each stage, the group may lean toward tension and conflict or toward cooperation and cohesion.

In turn, the extent to which the crew social dynamics are characterized by tension, conflict or cohesion can influence both the crew's structure and the behavior and performance of its individual members. Use of multidimensional scaling of data collected from pile sorts of the structure of the winter-over crews at the South Pole during a three-year period revealed three distinct patterns (Palinkas et al., 2000b). The first pattern was a clique structure in which crew members identified three distinct subgroups based on areas of the station where each subgroup usually spent most of its leisure time. In addition, there was a small number of "isolates" who were not a part of any group. The second pattern was a core-periphery structure in which most crewmembers strongly identified themselves as members of the same group (the core); this was followed by a smaller group of individuals who maintained close ties with the core but were somewhat more independent (semiperiphery), and another group of individuals who were more independent in their social interactions (periphery). The third pattern was a clique-core/periphery hybrid in which a relatively unified group contains identifiable subgroups. The crew characterized by a clique structure exhibited significantly higher levels of

tension-anxiety, depression and anger than the crew characterized by the core-periphery structure throughout the entire winter. The mood scores of the hybrid-structure crew fell in between those of the other two crews. The three crews also differed significantly with respect to the amount of support given to fellow crewmembers over the course of the winter (Palinkas et al., 2000b).

Inevitably, evidence of both conflict and cohesion appears in small groups in isolated and confined extreme environments. However, the extent to which a group experiences one or the other depends on a number of factors, including the style of leadership exercised by the commander, social, cultural and personality characteristics of crew members, and size and structure of occupational subgroups. For example, in space simulation environments, crewmates who are both high on psychological dominance do not work well together (Kanas, 1985), whereas people who are compatible and sensitive to each other in a complementary manner do much better. Socially adept introverts with little need for affection from others are viewed as more socially compatible than socially inept extraverts with high needs for affection or interaction (Palinkas et al., 2000a).

The presence of men and women on long-term space missions may also contribute to tension and conflict. Instances of overt and implicit sexual stereotyping, both in space and in earth analogs (Lebedev, 1988), are common. While it is usual for such behavior to take place in the general population, it often takes on added significance in isolated and confined environments, and results in misunderstandings and increased tension between men and women who must live and work together for a long time with little opportunity to establish and maintain the personal space or social distance that is necessary for social harmony and individual identity.

Differences in career orientation among crew members may also lead to increased interpersonal tension and conflict. Studies conducted in space analog environments have identified tensions between individuals or groups of individuals representing different occupations or possessing different career objectives (Palinkas, 1992; Sandal et al., 1996). In some cases, conflicts developed between individuals or groups who have compromised mission goals (Harrison et al., 1991). In space, pilots and engineers and scientific payload specialists or "guests" with no operational responsibilities may differ in their perception of mission objectives and the importance of specific tasks. Tensions may also occur when some crew members value their roles as being more important than those of other crew members (Committee on Space Biology and Medicine, 1998).

Finally, cultural and language differences may lead to miscommunication, misunderstanding, embarrassment, irritation, tension, and ineffective responses to danger, all of which can negatively impact the success of the mission. Reports from long-duration Russian space missions involving people from other nations have highlighted conflicts among crew members based on differences in language competency and culturally-determined expectations, values, attitudes, and patterns of

behavior (Oberg, 1981; Lebedev, 1988). On the other hand, cultural differences may have a minimal impact on crew behavior and performance, since, as members of a common profession, astronauts share a body of knowledge, set of expectations, and common skills which comprise the "microculture" of the space crew (Connors et al., 1985). Such microcultures emerge as crews make explicit the values and norms of behavior, often at the expense of deviant members who are ostracized for failing to adhere to such norms (Palinkas, 1992). Inherent in such microcultures are the shared experience and excitement of space flight that significantly contributes to enhancing communication between and among crewmembers (Kelly and Kanas, 1992). However, as crews become larger and include individuals with diverse backgrounds, skills, and responsibilities, the development of such a microculture may become more problematic (Committee on Space Biology and Medicine, 1998).

Leadership

One of the key differences in the three winter-over crews described previously was in the leadership style exercised by the station manager and the degree of crewmember consensus on informal leadership roles (Johnson et al., in press). The leader of the clique structure crew remained fairly isolated from the remainder of the crew and made few attempts to exercise authoritarian or participatory styles of leadership. The crew exhibited low consensus on whether anyone within the crew was capable of acting as an informal leader. In contrast, consensus on informal leaders in the core-periphery crew was high, and the formal leader (the station manager), was lauded for his ability to vary his leadership style to suit the demands of the crew and the situation.

Poor or ineffective leadership can lead to task disruptions and decreased morale (Nelson, 1964; Sandal et al., 1995). During short-term space flights, the identified leader is the mission commander, the lines of authority are clear, and activities are task-oriented. On long-term missions, however, periods of unstructured time and the stress of isolation and confinement call for supportive leadership. The ideal commander should possess both task-oriented and supportive-oriented leadership traits. In the 135-day Mir simulator study, crew cohesion was significantly associated with high crewmember evaluations of the leaders' task-oriented, instrumental characteristics, and his supportive, expressive qualities (Kanas et al., 1996). However, the mission commander may be unable or unwilling to provide social or emotional support to his or her fellow crewmembers, either because he or she lacks the capacity to exercise supportive leadership, or because such a leadership style would be inappropriate under the circumstances. When such supportive leadership is exercised informally by another member of the crew, lines of authority may alter, and the mission commander may experience status leveling (Committee on Space Biology and Medicine, 1998).

Successful leadership during long-term space missions must be flexible. For example, studies of polar expeditions have found task leadership to be more important during the initial stages (e.g., establishing camp), while supportive leadership becomes more important during the latter phases of an expedition (Gunderson and Nelson, 1963; Nelson, 1964). In addition, during emergencies, it is essential that the leader is decisive and directive. In other instances, shared decision making may be more appropriate. During the Salyut 6 mission, a younger commander shared decision making with an older crewmate who possessed the specific skills needed to accomplish the primary mission goals (Committee on Space Biology and Medicine, 1998).

A review of studies of four different types of groups (air crews, polar research stations, submarines and undersea habitats, and mountaineering expeditions) by Nicholas and Penwell (1995) identified several different leadership styles and traits that might be relevant to long-term space missions. These traits fall within four specific domains: personal traits, task management style, interpersonal style, and group maintenance style. Their review found that successful leaders of long-term missions are achievement-oriented; they possess a personal and a professional stake in mission outcome; they exhibit confidence, competence and experience; and they maintain a positive, optimistic outlook. The leader solicits subordinates' advice or judgement when necessary and appropriate, delegates responsibility but does not interfere with work, exercises a flexible leadership style (e.g., takes command in crisis, allows subordinates to exercise leadership at other times), participates with subordinates in routine work, emphasizes discipline, adopts a generally democratic leadership style, and clearly communicates with subordinates plans and subordinate's roles and responsibilities. The leader is sensitive to subordinates' personal problems and well-being, initiates frequent personal contact with subordinates, openly shows pride in subordinates, and gives frequent recognition and compliments to subordinates. Finally, the leader works to reduce clique rivalries and maintain group harmony, appears nonaligned and impartial in making decisions, and works to resolve subgroup conflicts.

Ground-Crew Interaction

Since it is easier to express anger and anxiety toward more remote individuals rather than toward people with whom one must frequently interact, tension involving a confined group of people may be displaced to outsiders who are monitoring their activities. Such displacement has been reported during both Russian and American space missions (Cooper, 1976; Lebedev, 1988), in the Antarctic (Palinkas, 1992), and during previous ground-based simulation studies (Kanas et al., 1996; Sandal et al., 1995). Astronaut's overt hostility toward excessive, unreasonable, or unclear demands placed upon them by ground-control personnel has led to expressions of anger and conflict in the past (Burrough, 1998; Lebedev, 1988).

For their part, ground-control personnel have complained of the failure of astronauts to adhere to schedules or follow directions, leading to increased risk of accidents and mission failure. More often, degradation in ground-crew interactions has led to instances of miscommunication. Both astronaut and ground-crew personnel have experienced difficulties in understanding messages sent (Committee on Space Biology and Medicine, 1998).

On the other hand, these apparent degradations in ground-crew interactions may actually have an adaptive function (Kanas, 1987; Committee on Space Biology and Medicine, 1998). Because ground-control personnel are physically remote from the crew, they may serve as an outlet for crew aggression and irritability that may be the result of factors external to ground-crew relations. The direction of anger and hostility towards external authorities and individuals may also serve to unite astronaut crews, thereby facilitating cooperation and enhancing performance.

ORGANIZATIONAL DOMAIN ISSUES

The third major component of the psychosocial system likely to influence the behavior and performance of multinational space crews is the organizations represented by their individual members. As noted previously, individual and group differences in values, motives for participating in long-duration missions, expectations, and the meanings attached to one's own behavior and the behavior of others may have a significant impact on interpersonal relations and group dynamics. However, these same individuals are also members of larger organizations represented in multinational space programs. Each space agency likely to participate in such ventures (NASA, RSA, ESA, CSA, NASDA) possesses different values, attitudes and behavior related to the principles and practices of management and organization that embody the cultural systems of their respective nations (Committee on Space Biology and Medicine, 1998). They also exhibit differences in experience with the application of these values, attitudes and behavior to the challenge of manned-space flight, which may account for differences in expectations and operational procedures during long-duration missions. NASA and RSA, for instance, have been involved in manned-space flight longer than the other space agencies, and are the only agencies who currently have the requisite technology (i.e., space vehicles). Furthermore, NASA and RSA are characterized by a number of operational features reflecting variations in their respective organizational cultures. These include differences in ground-crew interactions (e.g., Russian personnel have been reported to be more confrontational than their American counterparts in ground-crew interactions); extent of ground-crew communications (e.g., American ground control personnel remain in contact with space crews for longer periods of time); NASA emphasis on overtraining for missions versus RSAs emphasis of on "on-the-job" training; and

structure of rewards and restraints (e.g., Russian practice of docking the pay of cosmonauts who fail to perform prescribed tasks). These differences have been reported by astronaut and cosmonaut personnel as exerting a significant influence on crew dynamics (Burrough, 1998; Linenger, 2000).

Mission planning must also consider the variation in performance requirements imposed on the crew by the duration of the mission. Evidence from the U.S. space program has been of limited use in determining optimal periods of mission duration because the overwhelming majority of manned missions have been of two weeks or shorter in length. Despite the consensus that long- and short-duration missions evidence qualitatively different experiences in both behavior and performance, it is unclear whether mission duration significantly predicts performance and behavior. For instance, several studies of small groups in isolated undersea research labs and space simulation studies have reported significant increases in symptoms of depression, anxiety, and group hostility over time (Haythorn, 1970). These results have supported the hypothesis that ICE environments influence human behavior in a linear dose-response manner (i.e. the longer the exposure, the more significant the decrements). However, a recent study by Stuster and colleagues (2000) reported greater negativity in the diary entries of French polar expeditioners on short-duration missions than those on long-duration missions. Other studies support the hypothesis that decrements in performance under these environmental conditions occur in stages (Sandal et al., 1996). Bechtel and Berning (1991) described the "Third Quarter Phenomenon" in which performance is likely to decline during the third quarter of a mission in isolated and confined environments regardless of the total duration of the mission itself. Evidence of such a phenomenon has been observed in the Antarctic (Palinkas et al., 2000b; Stuster et al., 2000). Still other studies have reported no significant decrements in behavior and performance during long-duration missions in analog settings (Miller et al., 1971; Palinkas et al, 1995). Determining whether and when a decline in performance occurs is important for task scheduling, implementation of countermeasures, and rotation of crews.

One of the important management functions of the organizations involved in long-duration missions is the scheduling and monitoring of tasks performed in flight. Identifying the optimum amount of work that can and should be performed during long-duration missions is important for a number of reasons. Evidence from previous short-duration missions has pointed to the potentially adverse impacts of scheduling too many tasks within the time available (Cooper, 1976). These impacts have included conflicts between astronauts and ground-control personnel, refusal to perform assigned tasks, fatigue, sleep deprivation, a decline in cognitive performance, and an increase in negative affect (Committee on Space Biology and Medicine, 1998). On the other hand, evidence from long-duration missions and analog environments suggests that a lack of sufficient meaningful and productive tasks can result in boredom, and produces many of the same symptoms associated with

overwork (Stuster, 1996). Individual and group performance may also be affected when disparities in workload occur among crew members such that some are given too much while others are not given enough to do during a long-duration mission (Burrough, 1998).

CONCLUSION

To some degree, the past attitudes toward psychology have limited our ability to understand and respond to the psychosocial issues likely to affect the long-term, future space missions. Despite information suggested by anecdotal evidence in space and confirmed by studies in ground-based analogs, there is a clear need for additional research, especially systematic observational and experimental studies conducted in-flight as well as on the ground. Nevertheless, even this cursory review suggests that a number of psychosocial issues will become paramount as human beings begin to venture further from earth for longer periods of time. And the success of their efforts demands that we as scientists develop both a better understanding and a set of appropriate responses to the psychological issues they will face.

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