PSYCHOSOCIAL ISSUES IN SPACE: FUTURE CHALLENGES

Gro M. Sandal*

Department of Psychosocial Science, University Bergen, Bergen, Norway

ABSTRACT

As the duration of space flights increases and crews become more heterogeneous, psychosocial factors are likely to play an increasingly important role in determining mission success. The operations of the International Space Station and planning of interplanetary missions represent important future challenges for how to select, train and monitor crews. So far, empirical evidence about psychological factors in space is based on simulations and personnel in analog environments (i.e. polar expeditions, submarines). It is apparent that attempts to transfer from these environments to space requires a thorough analysis of the human behavior specific to the fields. Recommendations for research include the effects of multi-nationality on crew interaction, development of tension within crews and between Mission Control, and prediction of critical phases in adaptation over time. Selection of interpersonally compatible crews, pre-mission team training and implementation of tools for self-monitoring of psychological parameters ensure that changes in mission requirements maximize crew performance.

INTRODUCTION

Psychological factors have been pointed out as a limitation for the success of long duration missions in space (Collet et al. 1991). Upcoming challenges include the operations of the International Space Station (ISS) as well as interplanetary missions. On the ISS, the scenario of rotating crews staying aboard the station for different time periods raises important questions on how to optimize performance and interaction between people from diverse cultural backgrounds, many of whom might not get much opportunity to know each other before the mission. As the severity of the environmental, work and personal factors increases, or as the importance of goal attainment increases, it becomes increasingly critical that psychological issues are dealt with in a proactive manner.

A possible mission to Mars, for example would present obvious technical problems; no less challenging, however, would be the complex issues raised by crew design. Considerable effort will be required to determine requirements for crew size and composition. Distant missions there will require increased crew autonomy and reliance on automation. Crew self sufficiency is critical to such long-duration missions because the distance from Earth either impedes or makes impossible the traditional level of communication and support by controllers on Earth.

So far, there have been few opportunities to collect behavioral data that might assist mission planners in the development of strategies for selection, training and support of astronauts during long-duration missions. Much of our present understanding about psychology in space is based on studies of groups operating in so-called analog environments (research stations in Antarctica, submarines and hyperbaric chambers) where personnel are exposed to many of the same stresses as those experienced by astronauts in space We need to determine how to connect behavioral data collected in these environments to the space program, and learn how such studies should be designed to provide the most valuable and relevant data. This paper discusses how future operations in space might benefit from data collected from analogue environments, and outlines several behavioral issues and changes in operations that need to be addressed to optimize crew member's safety, health and efficiency, as well as mission success.

Correspondence to: Gro M. Sandal: e-mail: Gro. Sandal@ psych.uib.no; Fax: 47 55589879

ANALOG ENVIRONMENTS

Analog environments might supply larger sample sizes than are typically available either from the US or Russian space programs, and studies conducted in these settings might be less expensive than collecting similar data in space due to logistic reasons. Space simulation studies in hyperbaric chambers experimentally control external events that influence the interaction and coping strategies of crew members, and allow us to better predict the crew performance of scheduled space missions. The European Space Agency has sponsored four psychosocial simulation studies in hyperbaric chambers where groups have been confined for periods lasting from 28 days to 240 days. Before the studies, a Mission Protocol was developed specifying all medical, technical and operational requirements to approximate the living conditions of astronauts on a space station. The studies have provided the opportunity to evaluate the efficiency of methods for monitoring psychological and interpersonal parameters for subsequent application during real flights (Kanas et al., 2000). The studies have also provided empirical evidence for behavioral issues anecdotally reported from space, such as the tendency of crews to direct aggression towards personnel at Mission Control (Sandal et al., 1995, Gushin et al., 1996,1997). The study also identifies issues that might cause psychological and interpersonal problems in space. For example, a simulation study [called SFINCS]) modeled the living conditions on the International Space Station, and documented how tension developed between multinational crews staying in different modules. This adverse situation resulted in closing the door between the two chambers and one subject's leaving the experiment. Designing countermeasures for dealing with interpersonal and psychological problems might be one of the most important future objectives of simulation studies (Holland and Curtis, 1998). Similarly, these studies could provide insight optimizing the extent that crewmember autonomy or control over workload influences health and performance.

The weakness of simulation studies lies in the simple fact: simulations are never completely realistic. Collection of useful data depends on whether test participants consider the simulation similar to actual work conditions that they might encounter. In the confinement studies for ESA, the crew members performed personally and professionally relevant work aimed at increasing their perception of themselves as true participants rather than as "research subjects" (Collet et al., 1991, Vaernes et al., 1995, Vaernes, 1996). Nevertheless, one must still question whether the dynamics among people cognizant that they are psychological subjects in a simulation study is comparable to the psychological reactions of crews during space missions.

Another issue we need to address concerns how long a simulation needs to be maintained to demonstrate the interpersonal and psychological dynamics that take place during long-duration missions. Findings from the space simulation studies indicated that psychological reactions and coping patterns were linked to the relative passage of time (Gushin et al., 1996, Sandal et al. 1996, Sandal in press), but potential long term costs of adaptation still need to be better explored. Volunteers, even from the astronaut corps, might not be willing to endure an earth-based simulation of the same duration as a mission to Mars.

During its operational life, the International Space Station will represent an ideal laboratory to investigate human performance in preparation for long-duration flights. Data from Shuttle missions and future lunar expeditions should extend our knowledge of factors that are unique to the space environment, such as the effects of microgravity on communication. Ethical and practical considerations might prohibit the creation of some inherent stresses encountered during long-duration space missions, such as the presence of life-threatening dangers and the knowledge that immediate evacuation might not be possible. Polar expeditions might serve as models for examining these situations. A previous study found that coping strategies during polar expeditions were different from reactions associated with confinement in hyperbaric chambers (Sandal et al., 1996). Polar expedition members indicated a noticeable drop in aggression after the first quarter but homesickness increased with time. In contrast, crews in hyperbaric chambers indicated a gradual improvement in coping skills over the course of their confinement. These findings demonstrate that direct comparison and generalization of psychological data across environments might be difficult to evaluate. However, different terrestrial settings might capture different aspects of life in space. Polar expeditions might serve as a good model for examining group interaction and performance of circumstances predicted of future exploration and colonization of the moon and more distant planets, where danger and novelty will be important psychological stressors. In contrast, many stresses on a space station appear due to monotony and enforced confinement with people not of one's choosing. These confinement stresses might be better approximated by simulation studies in hyperbaric chambers.

Comparison of data collected from space with those from simulation studies will be essential to assess the value of the information with respect to different aspects of space missions beyond the characteristics of the physical environment. Any attempt to transfer experiences across settings requires a thorough evaluation of the variables of crewmember characteristics, crew size, crew tasks and overall mission objectives. Numerous studies of groups in organizational settings have documented that variations in group size and composition might differentially affect outcome variables, such as satisfaction and performance (Furnham, 1997). Earlier studies found that most individuals participating in polar crossings had personality characteristics associated with superior coping strategies in isolated and extreme environments (Sandal et al., 1996, Sandal 2000). Personnel in Antarctic research stations and crews confined in hyperbaric chambers (similar to astronaut populations) were more heterogeneous. Submariners differed from the other samples, and had lower scores on scales measuring aspects of achievement motivation. Personality differences, together with the fact that submarine crews are normally larger in size than astronaut crews, suggest that data collected from submarine missions might have a limited value when applied to space missions. The appropriateness of subjects might also be determined by such factors as whether they are representative of the professionals and nations involved in the International Space Station or other long duration missions. Although these kinds of requirements might be difficult to fulfill in many naturally occurring environments where the psychological research is secondary, the design of future simulation studies has the possibility to emphasize the criticality of crew subject selection.

Over the past 20 years, a large number of studies have been performed in different confined and isolated environments. Comparisons of results across studies have sometimes been difficult because different sets of measures and definitions of constructs have been applied. Another limitation has been the small sample sizes normally involved in the studies. Meta-analyses used to identify overall statistical effects that are beyond the scope of any single study might be helpful to define the state of the art. In future studies, a common set of measures to facilitate comparison of results from different studies could be achieved (Palinkas, 2000). Based on experiences from previous simulation studies, efforts should be made to develop methods that are nonintrusive and less sensitive to potential attempts by subjects to present themselves in the best light possible (Vaernes et al., 1995). To gain access to relevant subjects and to prevent the bias of ethnocentrism, multinational endeavors in space will benefit from collaborative projects between researchers of different nationalities and cultural backgrounds. Such large-scale projects might also contribute to the definition of common operational requirements for such missions.

COUNTERMEASURES

Although research on behavior and performance in space might also provide advancement in fundamental knowledge of more general principles guiding human behavior, the main priority and legitimacy of space psychology lies in its operational significance Performance of astronauts in space is determined by the interplay between a complexity of factors related to environmental, individual, group and organizational factors, and these should be considered as part of mission planning. Strategies to optimize crew member performance during manned space missions need to address not only the individual crew member, but the member's family, and key external personnel of the wider organizational system. In multinational flights, questions at the organizational level might be most sensitive to study because they touch upon issues of national sovereignty and pride. These issues might include how decision-making functions are made in a decentralized multicultural endeavor, as well as shed light on the resolution of disagreements between the multi-national agencies involved.

Implementation of psychological countermeasures needs to be based on operational analyses of behavioral issues likely to impact on performance. One of the neglected areas in aerospace research concerns the effect of cultural variability within the astronaut corps and the complex environment of multinational space missions (Helmreich, 2000). Culture refers to widely shared beliefs, expectancies and behavior of members of a group on an organizational, professional or national level. Survey data from pilots in 26 countries collected by researchers at the University of Texas found significant national differences in attitudes, such as acceptance of hierarchical leadership, the necessity of adhering to rules, and procedures and interaction with computers (Helmreich and Merritt, 1998). Helmreich and Merritt emphasized that such differences have the potential to cause problems in safety, performance reliability and interaction between crewmembers. Indeed, accident investigations in aviation have implicated culture as a factor, particularly with regard to communication (Helmreich, 2000). General organizational research shows that existence of communication barriers and differences in personal values increase the likelihood of conflicts and tension. During the SFINCSS simulation study, differences in coping strategies and views of appropriate gender behavior, such as whether kissing should be interpreted as sexual or not, were identified as sources of tension between the crews. This study involved three different crews. With the exception of one German participant, two of the crews were Russian. The third crew was multinational with members from Russia, Austria, Canada and Japan. Compared to the two former crews, more tension was detected between members of the multinational group. The small sample size in this study makes it difficult to isolate the effects of culture from other factors (i.e.the personalities and the professional training backgrounds of crewmembers). Understanding how culture might impact on team performance and interaction during multinational space missions needs to be further examined in both its frustrating and satisfying aspects. Data from the first space simulation studies sponsored by ESA indicated that cultural diversity may also minimize social monotony and lead to rewarding interpersonal experiences (Sandal et al., 1995). Helmreich (2000) identified a number of positive effects in individuals working in cross-cultural aircrews. Decisions were verbalized more fully and stricter adherence to Standard Operation Procedures (SOPs) was followed. Palinkas (1998) has argued that on a national level, cross-cultural issues might indeed have a minimal impact on crew behavior and performance since astronauts and cosmonauts are all part of a common professional "microculture". In short, the interplay between national, organizational and professional cultures is conceptually complex and needs to be further explored.

Conducting cross-cultural research raises a number of methodological difficulties. Cross-cultural variations in socially valued characteristics might have important implications for how respondents prefer to present themselves. Data collected at the University of Texas (Helmreich & Merritt, 1998) has shown that Japanese respondents tend to avoid Likert scale extremes. Italian and Philippine respondents, in contrast, show an opposite tendency that led them to avoid the middle and neutral responses of the scale. Research designed and conducted within a single culture risks being ethnocentric, and conclusions may be drawn that do not pertain to the actual cultural blending that will be involved in future space operations. Therefore, the utility and acceptance of countermeasures that stem from such research might be limited.

Development of countermeasures to minimize performance decrements and enhance optimal crew interaction requires a better understanding of other factors that impact on the development of interpersonal tension and cohesion. Since living and working with the same people in a restricted area pose strain on the relationships between crew members, heightened friction and social conflicts are expected correlates of isolation and confinement (Harrison et al., 1990). Crewmembers are part of a group that must satisfy both work and social needs, and people in conflict may be the only ones available for support. Even though high levels of interpersonal tension might adversely impact on health and performance, too much harmony might result in a phenomenon known as "groupthink" which, because its members are reluctant to express disagreement, is associated with lower quality performance. Both ground personnel and crews need to be trained to carefully monitor group dynamics and strategies to deal with dysfunctional patterns resulting from too high or too low tension levels.

Resistance and mistrust of outsiders, often referred to as the "us versus them" phenomenon, seems to serve as one mechanism that unites isolated group members. Several studies of real and simulated space missions have identified tension between the crew and Mission Control (Sandal et al., 1996, Gushin et al., 1996, 1997, Kanas et al., 2000). This has been interpreted as tension displacement by the crew to maintain harmony within the group. High cohesion resulting from isolation and shared experience in a highly unique environment is likely to make the distinction between the crew in space and outsiders salient. A concern is that this might inhibit communication, and interfere with the capacity of the group to accurately receive and process information from the ground thereby resulting in errors in judgment and performance decrement. In the context of prolonged space missions, the existence of this problem also reveals the potential danger of relying too heavily on Earth-based command and support mechanisms (Nicholas & Foushee, 1990). Disagreements between the crew and Mission Control over task overloads, or regulations of crew activities imposed by Mission Control have been reported from several missions (Gushin et al., 1996, 1997). The level of autonomy that should be given to space crews to ensure optimal performance represents one of the important issues for the planning and execution of long-duration missions.

The tendency of confined crews to displace aggression and hostility might also represent a risk factor for tension between established and new crews arriving onboard the space stations or between crews staying in separate modules. Inter-group conflicts might be resistant to change because members of one group tend to support each other in negative evaluations of another group, and due to deteriorated communication between groups. Such conflicts need to be better understood in terms of precipitating factors if effective countermeasures are to be developed and deployed for operations on the International Space Station. During the SFINCSS simulation study, several crewmembers reported that the arrival of an international visiting crew, staying in the chamber for a period of five days, contributed helped to neutralize tension between the crews. In the past, issues that caused tension between crewmembers and outside monitoring personnel have been ameliorated through "bull sessions" both in simulations and during actual space missions. Future crews and their ground control personnel should be trained together preflight to use interactive techniques. Finally, experts in group dynamics who work with, and are trusted by the crews should be available on the ground to assist in conducting such sessions during the mission if the need occurs (Palinkas et al., 1998).

Prediction of when psychological and interpersonal problems are most likely to occur might enable crew members and outside personnel to better prepare for them and to intervene before these problems result in operational degradation or health problems. Several studies have suggested that psychological reactions in time-limited stress situations occur in stages regardless of the actual time duration, although other studies have failed to identify such systematic patterns (Gushin et al., 1993, Kanas et al., 1996, Palinkas et al., 2000, Sandal et al., 1995, Sandal, 2000). Given the potential operational relevance of the findings, more research is required to identify potential critical phases of space missions in terms of psychological parameters. If ground personnel and crewmembers are aware that incidents are to be expected, then problems might be handled with greater tact because they will not be personalized. Such knowledge might also have design consequences. Habitat design, work tasks and schedules might be planned to minimize social and psychological problems during these periods. Experience from Russian missions shows that different strategies such as lighting schedules, celebrations, or distracting tasks, might reduce the negative effects of foreseen crises (Kanas, 1991).

During the missions, it might be difficult to get access to vital information regarding the emotional stress and interrelations of crewmembers. In daily communication between crewmembers and flight surgeons, astronauts might be reluctant to address sensitive issues. Russian space missions have shown that a reliable, and often sole, source of data is through the communication sessions between the crew and Mission Control. To monitor crews throughout missions, aspects of speech have been analyzed that include intonational and time characteristics (duration of communication sessions, talking speed and silences), and themes discussed (Gushin et al., 1997). Analysis of communication sessions has provided empirical evidence to support several features assumed to reflect the psychological climate within the crew and that also affect the interaction between the confined crew and the ground control. Such features, which have been documented during both space missions and simulation studies, include psychological closing (i.e. a tendency of crewmembers to avoid sharing feelings with others) and information filtration in crew communication (Gushin, 1993, 1996, 1997). The Russian approach of analysis has not been fully explored by Western space agencies, and the development and evaluation of tools to recognize psychological and interpersonal problems during missions represent important areas for future research.

Monitoring from the ground, and implementing interventions when dysfunctions are detected, might be all but impossible during future interplanetary missions. The time delay in communication from Mission Control poses a problem in terms of confronting real-time situations. A unique characteristic will be that during most parts of the mission, there will be no possibility of help from Earth during emergencies. During such missions, it will be critical that the crew members are provided with sufficient training with regard to the occurrence of any deviation that may be dangerous to themselves and the mission, as well as tools for monitoring and resolving their own problems. It will be necessary to pay attention to more than the traditional indicators of wakefulness and awareness (i.e. overt behavior, electroencephalographic recordings, neuropsychological tests). It is also important to register any deviations or indicators of a breakdown in the organization and coherence in the group for crew member safety, well-being and productivity, as well as overall mission success (Ursin et al., 1995). Voice analysis, sociometric ratings, and group sessions all represent possible tools that should be evaluated. The emotional state, the motivational state, and coping skills of individuals affect medical and biological samples probably more than often is realized among medical and biological scientists (Ursin et al. 1995). The understanding that biological variables are regulated by the psychological state of the individual is an essential element in contemporary psychophysiology, psychoendocrinology, and psychoimmunology. Biological indicators therefore represent tools of potential value for monitoring psychological parameters during long-duration missions.

Selection and training of crewmembers might represent efficient countermeasures to prevent or reduce the likelihood of performance decrements due to psychological and interpersonal dysfunctions. To optimize crew performance, guidelines for assignments could balance technical qualifications with individual stress resistance and interpersonal compatibility. At the individual level, the objective of selection strategies is two-fold: to eliminate unfit or potentially unfit applicants, and to select from otherwise qualified candidates those who will perform optimally. A distinction is therefore made between "*select-out"* and "*select-in"* criteria. With the prospect of multinational crews aboard the International Space Station, there is a need to identify cultural/national differences in policies and procedure and to develop a common approach to eliminate unsuitable candidates (Palinkas, 2000). In contrast to select-out, select-in criteria need to be developed in relation to specific aspects of the mission, and these criteria need to be based on systematic work-analysis of such aspects as objectives, duration and crew composition. Data on select-in characteristics, although promising, require validation against in-flight performance measures, and need to be explored in a mission-specific manner. So far, many studies have aimed to identify a more general "right stuff" personality for team-operations, typically defined by attributes such as interpersonal sensitivity and high levels of achievement motivation (Chidester et al., 1991, McFadden et al., 1994, Sandal et al., 1996).

To date, the absence of formal criteria for astronaut performance, and the limited research opportunities have made it very difficult to evaluate the efficiency of crew selection strategies. Such evaluation also requires that select-in criteria must not be used in the initial selection until they have been found to predict astronaut performance. One potential bias in validating selection criteria on astronauts and cosmonauts who have already gone through a formal selection process is related to restriction of range in personality scores. A study on psychological determinants for astronaut effectiveness at NASA (McFadden et al., 1994) showed that expressive traits were significantly associated with astronaut effectiveness in tasks involving teamwork (called "group-living"), whereas instrumental traits had low predictive validity due to low variability in scores. The investigators attributed the latter finding to the highly screened nature of the astronaut corps relating to excellence in prior job performance and education and commented that astronauts are currently not as highly screened for interpersonal flexibility.

Research that assumes homogeneous controlled crew composition for long duration space missions might be of limited application (Kuroda et al. 2000). As for the International Space Station, each partner agency will nominate its candidates for a certain mission, and social, political and cultural forces will always be contributing factors. Furthermore, even though the different space agencies might agree on criteria, a common selection procedure might be difficult to establish due to differences in preferred methodology. In the context of multinational missions, one of the more important challenges will be to ensure that crewmembers are compatible on an interpersonal level. Crewmembers may be considered compatible in that each member demonstrates qualities and behaviors that other crewmembers consider desirable and appropriate. Evaluation of compatibility might be based on the results from psychological performance tests and personality questionnaires. Another more behavior-oriented approach, which has been developed in the context of industrial applications, includes the combination of a variety of behavioral exercises (e.g., role-plays, group discussions, group exercises). This approach, called assessment center, has been found to be a potent tool for predicting job performance in normal organizations (Hunter & Hunter, 1984). Up to now, assessments of interpersonal compatibility for long-duration missions have only been implemented in the Russian approach to crew selection. The Russian space program has spent considerable effort developing methods to examine the extent to which crewmembers synchronize their activities (Gazenko, 1980). The assessment methods used by Russian psychologists include attitude assessments, psychophysiological tests, and specific group exercises. In the future, the efficiency of these methods should be subjected to objective evaluation along with sociometric tests used within the broader field of organizational psychology.

Optimally, selection and training of crews should be a continuous process where performance during training would result in a reevaluation of crew composition. The prospect of crew heterogeneity in terms of cultural background, vocation and gender is likely to increase the psychosocial demands of missions and consequently the need for joint crew training prior to the mission (Manzey et al., 1995). Getting training time allocated to such activities depends on the perceived need and the motivation of astronauts and managerial staff, as well as a supportive organizational climate. Some Western astronauts might see psychology as a possible enemy because they fear being grounded or removed from a mission.

One critical question is how training programs should be designed to provide adequate preparation for personnel during long duration missions. Existing forms of training used in other contexts (such as Cockpit Resource Management Training for aircrews) might potentially be adapted to multinational space missions (Helmreich, 2000). Manzey (1998) has suggested that crew training for the International Space Station should involve two main parts: first, basic training in the beginning of an astronaut's career (as part of basic medical training), and, second, crew-oriented mission preparation addressing a specific crew that has been assigned for a certain mission. This crew-oriented training should focus on the following issues: (1) Support of a team-building process within the crew (e.g., establishment of a stable crew structure, development of common behavioral norms, identification of common mission goals), and, (2) "anticipatory problem-solving" (i.e. making the crew members aware of how to deal with specific psychological problems most likely to arise in the course of a mission). While the efficiency of this training strategy needs to be explored empirically in the environment of space operations, Manzey (1998) suggests that results from two space simulation studies conducted for the European Space Agency, support the value of the approach. These studies involved two groups that were confined in hyperbaric chambers for periods of 28 and 60 days. Communication analysis performed at regular intervals during the confinement was classified according to content, to speaker and to whom the speech-act was addressed. Figures 1 and 2 illustrate patterns of communication at different days of the studies (Sandal et al., 1995). The thickness of the arrows indicates the amount of communication, and subject C represents the Commander in both groups. For the 26-day "ISEMSI" study (Figure 1), all subjects participated in communication in a relatively balanced manner at the beginning of the confinement. At the end, subject D (the most dominant subject beside the commander) was totally isolated, and the communication of all other crewmembers remained limited to two-way communications with the commander. For the 60-day "EXEMSI" study (Figure 2), no struggle between dominant crewmembers was found and communication was maintained between all of them during the whole period. Manzey highlights two reasons for the differences among the two crews. In contrast to ISEMSI, the EXEMSI crew was based on a group-assessment of interpersonal compatibility (see Manzey, 1998). Furthermore, the crew participated in team training prior to the isolation. Astronauts who have flown on multinational missions have endorsed the importance of receiving cultural and language training prior to their mission (Palinkas, et al. 1998). Furthermore, training programs in countries others than one's own, and the requirement to function socially and operationally for extended periods in a second language have been emphasized. At this time, very little is known about the requirements and demands that will be placed upon crewmembers during future inter-planetary missions and how crews should be designed and trained. The International Space Station and Earth facilities represent important training platforms to highlight interpersonal issues that might lead to group dysfunctions during these missions. On the other hand, it will be difficult to establish a thorough understanding of the cumulative effects of living in space for such a long period of time as a mission to Mars requires.

CONCLUSIONS

Whereas almost any mechanical inconvenience, awkward habitation, or uncomfortable crew mix can be tolerated for a few days in space, inadequate attention to psychological and interpersonal factors can be dangerous and threaten mission success as space flight mission durations increase beyond those of Shuttle flights (Kuroda et al, 2000). Practical value for long duration space missions requires in-depth investigation of determinants for optimal crew interaction and performance in space. Even though many areas need further exploration, current data suggest that mission planning to a larger extent should emphasize the interpersonal compatibility of crew members, pre-mission

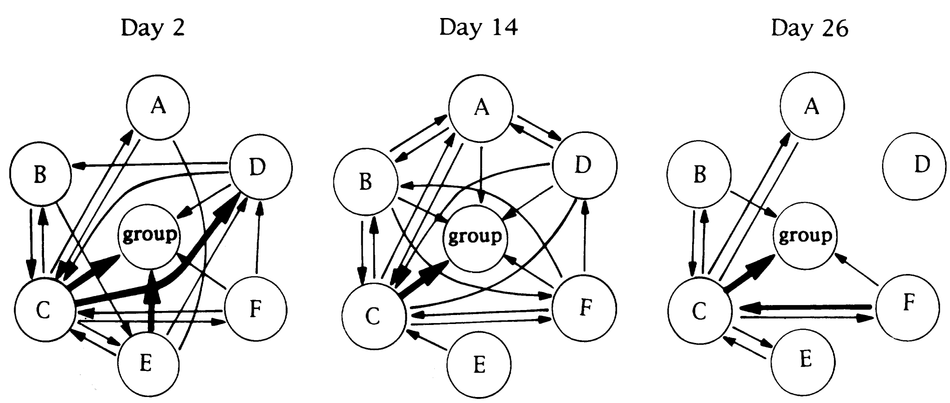

Figure 1. *Communication networks during ISEMSI. The thickness of the arrows indicates the frequency of occurrence.*

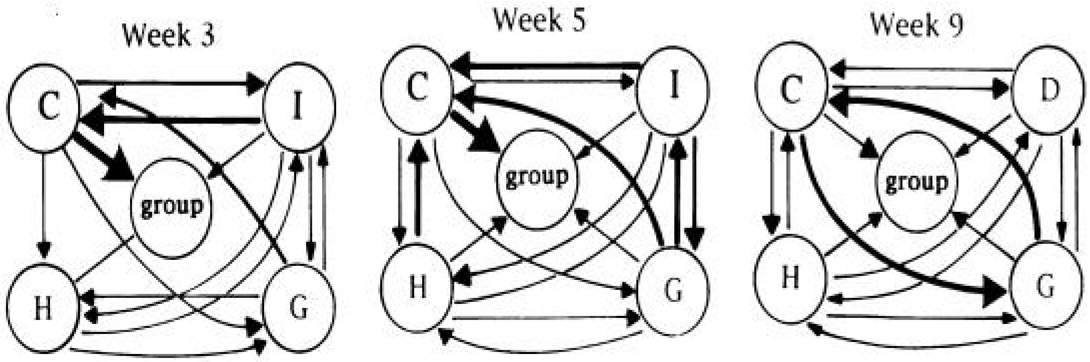

Figure 2. *Communication networks during EXEMSI. The thickness of the arrows indicates the frequency of occurrence.*

psychological training programs, and implementation of tools for self-monitoring of relevant psychological parameters. However, transforming psychological knowledge into action strongly depends on an organizational climate that gives priority to such human factor considerations.

ACKNOWLEDGEMENT

The author would like to thank M.D. Dave Musson for valuable comments

REFERENCES

Chidester, T.R., Helmreich, R.L., Gregorich, E., Geis, C.E. 1991. Pilot personality and crew coordination: Implications for training and selection. *International Journal of Aviation Psychology* 1:25-44.

Collet, J., Gharib, C.I., Vaernes, J. 1991. Scientific results from the ISEMSI experiment. *ESA Bull* 67:58-64

Furnham, A. 1997. *The psychology of behavior at work.* London: Psychology Press.

Gazenko, O. 1980. Psychological compatibility on Earth and in outer space. *Aviat Space Environ Med* 51: 622-23.
Gushin, V.I, Kholin, S.F., Ivanovsky, Y.R. 1993. Soviet psychophysiological investigations of simulated isolation. In: *Advances in Space Biology and Medicine.* (Bonting, S. Ed.) London: JAI Press Inc. 3: 5-14.

Gushin, V.I., Kolintchenko, V.A., Efimov, V.A. and Davies, C. 1996. Psychological evaluation and support during EXEMSI. In: *Advances in Space Biology and Medicine.* (Bonting, S., Ed.) London: JAI Press Inc. 5, pp. 283-296.

Gushin, V.I., Zaprisa, T.B., Kolintchenko,V.A., Efimov, A., Smirnova, T.M., Vinokhodova, A.G.and Kanas, N. 1997. Content analysis of the crew communication with external communicants under prolonged isolation. *Aviat Space Environ Med* 12: 1093-1098.

Harrison, A., Clearwater, Y.A. and McKay, C.P. 1990. The human experience in Antarctica: Applications to life in space. *Behavioral Science* 34: 253-271.

Helmreich, R.L. 2000. Culture and error in space: Implications from analog environments. *Aviat Space Environ Med* 71 (9,Suppl.)A133-9.

Helmreich, R.L. and Merritt, A.C. 1998. *Culture at work in aviation and medicine: national, organizational and professional influences*. Brookfield, VT: Ashgate.

Holland, A.W. and Curtis, K. (1998) Operational psychology countermeasures during the Lunar-Mars life support test project. *Life Support Biosphere Sci* 5: .

Hunter, J.E. and Hunter, R.F. 1984. Validity and utility of alternative predictors of job performance. *Psychol Bull* 96: 72-98.

Kanas, N. 1991. Psychological support for cosmonauts. *Aviat Space Environ Med* 63: 353-5.

Kanas, N., Salnitsky, V., Grund, E., Gushin. V., Weiss, D.S., Kozerenko, O., Sled, A. and Marmar C.R. 2000. Interpersonal and cultural issues involving crews and ground personnel during shuttle/Mir space missions. *Aviat Space Environ Med* 71: (9,Suppl.)A11-6.

Kanas, N., Weiss, D.S. and Marmad, C.R. 1996. Crewmember interaction during a Mir space station simulation. *Aviat Space Environ Med* 67: (10): 969-975.

Kanas, N., Salnitsky, V., Grund, E., Gushin, V.,Weiss, D.S.,Kozerenko, O., Sled, A.and Marmar C. 2000. Interpersonal and cultural issues involving crews and ground personnel during shuttle/Mir Space Missions. *Aviat, Space Environ Med* 71: (9, Suppl.):A11-6.

Kuroda, I., Young, L.R. and Fitts, D.L. (2000). Summary of the international workshop on human factors in space. *Aviat Space Environ Med* 71: (9,Suppl.)A3-5.

Manzey, D.1998. Space Psychology. *Textbook for Basic Psychological Training of Astronauts*, AM-BMT-DLR-98-009, ESA/EAC, Cologne.

Manzey D, Schiewe, A. and Fassbender, C. 1995. Psychological countermeasures for extended manned spaceflights. *Acta Astronautica*: 35 (4/5): 339-361.
McFadden, T.J., Helmreich, R., Rose, R.M. and Fogg, L.F. 1994. Predicting Astronauts effectiveness: A multivariate approach. *Aviat Space Environ Med* 65: 904-909.

Nicholas, J.M. and Foushee, H.C. 1990. Organization, selection and training of crews for extended spaceflight: Findings from analogs and implications. *J Spacecraft* 27: 451-456.

Palinkas, L.A. 1998. *A strategy for research in space biology and medicine in the new century.* Committee on Space Biology and Medicine Space Studies Board. Commission on Physical Sciences, Mathematics, and Applications National Research Council. Washington, D.C.

Palinkas, L.A.2000. Summary of research issues in behavior and performance in isolated and confined extreme environments. *Aviat Space Environ Med* 71: (9,Suppl.)A48-50.

Palinkas, L.A., Gundersen, E.K.E., Johnson, J.C. and Holland A.W. 2000. Behavior and performance on long duration spaceflights: Evidence from Analogue Environments. *Aviat Space Environ Med 71*: (9,Suppl.)A29-36.

Sandal, G.M. 2000. Coping in Antarctica: Is it possible to generalize results across setting. *Aviat Space Environ Med* 71: (9,Suppl.)A37-43.

Sandal, G.M. Crew tension during a space station simulation. *Environ Behav*. In press.

Sandal, G.M., Bergan, T., Warncke, M., Vaernes, R.J. and Ursin, H. 1996. Psychological reactions during polar expeditions and isolation in hyperbaric chambers. *Aviat Space Environ Med* 67: 227-234.

Sandal G.M., Vaernes R. and Ursin H. 1995. Interpersonal relations during simulated space missions. *Aviat Space Environ Med* 66: 617-24.

Ursin, H., Bergan, T., Sandal, G.M. 1995. A biobehavioral monitoring system for space travelers. In :*Biobehavioral Self-Regulation. Eastern and Western Perspectives* (Kikuchi, T., Ed.) Tokyo, Springer, pp 46-51

Vaernes, R.J., Baranov, V.M., Demin, Y.P. and Stepanov, V.A. 1995. *HUBES - Main Report.* Bergen, Norway, Nutec report, pp. 10-95.

Vaernes, R.J. 1996. EXEMSI - Description of facilities, organization, crew selection, and operational aspects. In: *Advances in Space Biology and Medicine* (Bonting, S.L., Ed), Greenwich, JAI Press, 5, pp7.38.