A Review of the Psychological Aspects of Space Flight

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Instances of overt, serious functional impairment of space crews caused by adverse psychologic responses have not been scientifically documented. However, transient disorientation, spatial illusions, and visual disturbances as well as anomalous myopias, sleep disturbances, and instances of substandard performance have been described. Moreover, anecdotal information describes significant psychologic aberrations in space flight. Adequate scientific data are lacking for optimal psychological and psychophysiological methods for crew selection, training, and performance evaluation, for identifying key psychosocial factors for crew compatibility, cohesiveness, and productivity, and for determining the effects of space flight on perceptual, intellectual, and motor skills. The ad hoc Working Group, convened to review psychological aspects of space flight, favored establishment of a comprehensive research and development program to address the deficiencies identified in the study.

CREW MOTIVATION and effectiveness have been high in United States and Soviet manned missions, and overt functional impairment caused by adverse psychological responses has not been reported (26,43,44,57). However, some experts believe that longer, increasingly complex, and relatively routine space missions involving larger, heterogeneous crews may generate psychologic and psychosocial problems for which solutions are not currently available. In the planned space station, potentially stressful factors include physical and social isolation, confinement, boredom, threat of potential hazards, and discomfort associated with crowding, lack of privacy, artificial life support, and microgravity.

Documented untoward psychological and psychophysiological responses to space flight include transient disorientation and spatial illusions (8,49,90), temporary alterations of visual function (8,49), anomalous myopias (50,51,65,85), as well as degradation of performance and sleep disturbances associated with undue shifts in work, rest, and sleep schedules (9,48,49,78). Space sickness, which compromises crew effectiveness, may have a significant psychological component in some people (41,42).

Anecdotal information from space missions of the United States and Soviet Union includes other examples of adverse psychological effects such as hostility between space- and groundcrews, friction between members of spacecrews, and episodes of mental depression (11,34).

Past activities of an operational or research nature that are analogous to space missions in terms of such factors as confinement, physical and social isolation, crowding, lack of privacy, and perceived danger, include long submarine missions, undersea habitats, and polar stations. Research and operational monitoring have shown that adverse psychological effects in these endeavors have ranged from listlessness and depression through anxiety with psychosomatic symptoms, sleep disturbance, and fatigue, to irritability and frank hostility (30,32,83).

The NASA Biomedical Research Program* includes a focus on human behavior and performance. The

This manuscript was received for review in June 1985. The revised manuscript was accepted for publication in August 1985.

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*The NASA Biomedical Research Program is conducted intramurally by NASA Research Centers and by means of extramural grants and contracts. Qualified scientists interested in learning more about the program and in submitting research proposals should write to Chief, Space Medicine Branch/EBM, Life Sciences Division, NASA Headquarters, Washington, DC 20546.
research objectives are to acquire knowledge and develop methodology that promote crew safety, effective performance, and well-being in space missions. The research program includes investigations on behavior and performance as they are affected by perception, cognition, motivation, psychological stability, small group dynamics, and psychological and mental performance.

An ad hoc Working Group convened by the Life Sciences Research Office, Federation of American Societies for Experimental Biology has reviewed aspects of human behavior and performance related to the contemplated United States Space Station, to the Shuttle Program, and to both near- and long-term, space-related problems of a generic nature. A report of the deliberations and recommendations of this Working Group has been published (19). The report includes a review of pertinent scientific literature and opinions of knowledgeable experts.

In broad terms, the report (19) focused on: 1) human performance requirements for the long-term (90 d) manned mission; 2) human perceptual, cognitive, and motor capabilities and limitations in space; 3) crew composition, individual competencies, crew competencies, selection criteria, and special training; 4) environmental factors influencing behavior; 5) psychosocial aspects of multi-person spacecrews in long-term missions; 6) career determinants in NASA; 7) investigational methodology and equipment; and 8) psychological support.

This article summarizes the major observations and conclusions of the ad hoc Working Group’s report (19) and identifies opportunities for future research emphasis.

**Determinants of Behavior, Performance, and Psychological Well-Being**

The space programs of the U.S. and U.S.S.R. include efforts to achieve a permanent manned presence in space. NASA currently has two major manned space flight programs: the fully operational Space Transportation-Shuttle Program (STS-Shuttle), and the Space Station Program, which is in the planning stages. Among the unresolved problems that will impact the contemplated space station system are questions of optimal psychological and psychophysiological criteria and methods for crew selection, psychological and psychosocial factors in crew compatibility and productivity, and the effects of the space station environment on perceptual, intellectual, and motor skills. Numerous other pertinent questions are suggested by the list of topics in Table I. A considerable amount of basic research is needed to provide an adequate data base for solving problems in such applicable areas as perceptual, cognitive and psychomotor processes, capabilities, and limitations in relation to spacecraft and space systems.

**State of Knowledge in Applicable Areas**

**Perception:** The small infight alterations of visual performance parameters reported by Soviet investigators (8,49) tend toward preflight values as missions proceed, and Soviet space medical scientists have concluded that infight visual function is as reliable as on Earth (57). Nevertheless, Soviet scientists continue to investigate infight visual function, and, with the aid of a new, portable device (27), NASA is conducting more sophisticated infight vision tests than have been feasible in the past.

Illusory sensations that have been noted upon entering weightlessness, such as overturning or inversion of the body and movement of objects in the visual fields, usually have lasted only a few minutes or, rarely, up to a day (49). The genesis of such sensations is not fully understood. There is no persuasive evidence of untoward effects of space flight on audition, olfaction, and gustation; however, these functions have not been extensively tested infight. Vestibular system effects and space sickness have been reviewed recently (79).

**Cognition and Perceptual-Motor Function:** One perceptual-cognitive phenomenon that, reportedly, causes some space flyers to perceive a slippage between performance and scheduled time-lines has been called “time compression.” It probably contains elements of excessive mental workload, information overload, and cognitive processing involving inferences, judgment, and decision-making, for which the data bases are insufficient. Elucidating the mental processes involved in the overloaded operator will require substantial additional research in such areas as cognitive systems (47,55,61,62), mental workload, inferencing, reasoning, and decision-making, and the interaction of stress, emotions, attention and cognitive processes (14,63). Other manifestations of altered time sense in space missions have been reported (8).

Experience with manned space flight and extra-vehicular activity suggests that, for the tasks performed to date, no serious impairments of perceptual-motor functions have occurred. On the other hand, impaired motor function has been common after long missions, and vigorous infight exercises have failed to prevent it. Atrophy of skeletal muscle accompanied by a decrease in muscle strength has been documented in the Skylab Program and other long-term flights (26,40,81). Whether degradation in neuromuscular control of fine movements of the hands and fingers may occur in these circumstances is not known.

**Psychological Stability:** Psychological stability, a mandatory characteristic of candidates for spacecrews (46,52), is generally considered a part of the makeup of a normal individual. Personality traits considered desirable in members of spacecrews have been identified and are taken into account in the selection process (17,24,49,66,82). Available knowledge is adequate for optimal psychological selection of individuals for space- and groundcrews. On the other hand, despite some progress in identifying favorable personality characteristics and procedural influences (16,22,33,36,37), currently available information is insufficient on how to select persons who will be the most compatible in dyads, triads, or larger groups. For the space station, as an example, crew selection and high technical proficiency will not guarantee a cohesive, smoothly functioning group.

In addition to the customary intensive training programs for each space system and careful organization
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of the crew in terms of leadership, functional structure, and allocation of responsibilities, plans should include social sensitivity training and sufficient cross-training in specialized technical skills to permit some rotation of members in and out of the more interesting mission activities. Such role sharing has been shown to improve group cohesion and productivity (31,35).

Fatigue has proved to be a particularly important negative influence on psychological stability, human reliability, and productivity. Means for its prevention have been identified from cumulative space flight experience, adequate sleep being the most significant element (52).

Motivation will be a keystone of productivity in the space station as well as in future Shuttle missions. Expert opinion suggests that developing and maintaining good motivation may prove difficult for long, relatively routine missions that may lack the glamour and pioneering interest and stimulation of earlier manned space programs. If this supposition is correct, the need for identifying and implementing methods of assuring proper motivation appears essential. Involved are such issues as space system organization, command and control, space station autonomy, role sharing, psychological support, career development, growth potential, and incentives.
Performance: Two aspects of the subject of crew performance were especially emphasized by the ad hoc Working Group: lack of expert assessment by behavioral scientists during preflight training, simulations, and inflight; and the inadequate state of knowledge of group performance under conditions of emotional stress such as in emergencies.

In view of the current planning emphasis on productivity of the future space station crews, and in the Shuttle Program, a need for performance assessment appears clear, the main objective being to improve operator performance. Reliable predictive data based on actual space flights are not available on the likelihood of significant performance degradation from possible adverse behavioral effects of long-term occupancy of a multi-crew space station. Moreover, insufficient information is available accurately to predict whether crews will take effective, coordinated action during inflight emergencies or situations requiring improvisation. For example, whether well-trained crews may be expected to react as decisively and effectively to an inflight emergency as did the crew of Apollo 13 is problematical (44).

A major potential contributor to successful spacecrew composition and productivity is psychological, as distinguished from psychiatric, appraisal. Refinements in the potential of psychological selection may be expected because of recent advances in understanding relationships between individual and group performance, certain personality traits, and real-life situations that influence behavior (34,75).

Small Group Dynamics: An opinion that has often been expressed by authorities in astronautics and the space life sciences holds that the feasibility of future long-duration space missions will depend upon solution of the associated psychosocial problems of heterogeneous crews living and working in isolation and confinement (6,10,15,58,84). According to Novikov (58), development of fundamental data on psychological compatibility and criteria for the selection of groups such as those contemplated for the space station are outstanding examples of unsolved problems of group psychology. He emphasized the importance of studying the social psychological mobility of personality, that is, the ability to adapt to group isolation, the role of self-regulation, and the need to develop methods of group psychological training and skills of joint action. He stressed as well the essentiality of clear assignments of responsibilities and duties in order to avoid conflict tension (58). The importance of avoiding role ambiguity and conflict was amply demonstrated in the Spacelab Mission Development Tests III (SMD III) simulation of the Spacelab mission (38). For instance, a potential for conflict was identified between spacecrew members and ground controllers and between ground-based scientists in charge of in-flight experiments and their spaceborne scientific collaborators (12,38).

Progress has occurred in recent years in identifying factors that influence group cohesion, cooperation, and productivity in settings applicable to aeronautics and astronautics (1,16,18,22,23,31,33–37,76).

While some useful information is available about human needs for contact, privacy, and personal space and about crowding (2,5,88), the data base is limited in terms of privacy needs and methods of meeting them in confined environments. Moreover, data are lacking on some of the more subtle psychological aspects of habitability. The need for privacy of space-ground radio communication for crew members with their families, flight surgeons, fellow astronauts in mission control, and others has been repeatedly emphasized by American and Soviet space medical authorities as essential for maintaining morale, solving personal problems, and reducing emotional stress.

Methodology: The most serious lack of data pertains to the performance of astronauts and other crew members during training, simulations, and actual space flight. To acquire the means of improving inflight performance of operators as individuals or members of crews, data from the "real world" of training and space flight derived from expert observations and measurements of actual crew members are essential.

A technique that has proved valuable in assessing workload in United States Air Force (USAF) aircrewmembers is the embedded secondary task method. The basic concept of this technique is to use as the measuring instrument a function which the crew member must perform as part of the mission. In this way, the well-recognized advantages of secondary task methodology in assessing workload are obtained without the intrusiveness or artificiality typically experienced with that method. For example, the USAF has quantified communication tasks in the A-10 aircraft, and has shown good reliability for the technique (74).

The extremely limited information available on details of spacecrew performance inflight was regarded as a pivotal gap in essential knowledge for identifying clues for improving design, operational procedures, training, and formulation of research plans. The Working Group advocated crew performance assessment in all space flights as well as in ground training and simulations including participation by expert behavioral scientists.

Techniques for identifying reactions to stress in United States Navy (USN) divers have been developed and refined for research and operational use. These include observation by video or sequential photography, voice analysis, measurement of intention tremor, and pencil and paper devices for examining types and characteristics of personality and attitudes in divers. It is considered feasible to embed the intention tremor device so that its use is unobtrusive. In addition, changes in rate and pattern of respiration are useful and virtually universal indicators of impending stress in all situations and should be considered as another practical means of monitoring psychophysiological status and assessing reactions to the environmental and situational influences of space flight.

There is a need for a more coherent, comprehensive, performance assessment battery. One such battery, which is nearing completion of its developmental phase for the military services was regarded by members of the ad hoc Working Group as superior to any other available system for its intended uses. This type of system is discussed in Thorn et al. (80). It would be
an excellent means of assessing some of the behavioral effects of space flight on a before-and-after basis, and it appears to have potential for modification for onboard use.

An excellent opportunity apparently exists for acquiring abundant data unobtrusively on spacecrew behavior and performance via the video and audio systems on the Shuttle Orbiter. Similar opportunities should exist on the space station. For example, one could video- and audio-tape the spacecrew during representative segments of a mission, not merely brief transient recordings. Very good, sophisticated techniques are available for analyzing unobtrusive data in such areas as performance parameters, social interactions, and nonverbal behavior.

From such information could come a series of descriptive analyses of doing ordinary things such as brushing teeth, washing, and other basic tasks of living onboard as well as the more complex tasks of operating and maintaining the space vehicle, communicating, and functioning in the scientific and technical spheres. Moreover, experience with unobtrusive behavioral observations of this sort should lead to improved means of monitoring spacecrews for psychophysiological stability and detection of maladaptive trends or events requiring intervention.

Another area of great practical interest involving a need for progress in methodology concerns identification and classification of stress-tolerant people and means of preparing individuals and groups for coping with the stresses of space flights. Examples include methods for self-control such as relaxation techniques, control of autonomic responses using biofeedback, and psychological self-defense. Pertinent references include Benson (7), Henry and Stephens (39), Mason (53), McGuire (54), Orne (59), Schultz and Luthe (67), Selby (71), and Wolpe (87). In this general area belong, as well, methods for teaching elements of group dynamics such as social sensitivity, awareness of each other's needs, and how to interact with other members of the space- and groundcrews to achieve the mission objectives cooperatively and efficiently.

Models: It might prove beneficial to organize the factors identified in Table 1, and other potentially important variables, into a preliminary conceptual model of spacecrew performance. Such a model could provide: 1) a coherent blueprint of the research arena and principal variables under investigation; 2) a framework or foundation for classifying important variables, reflecting known or hypothesized relationships, developing research propositions, identifying variables for multivariate experimental investigations, and prioritizing research; and 3) a taxonomy for cataloging research findings, incorporating new knowledge, refining theory, and identifying knowledge gaps.

Development of another potentially useful conceptual model, based on the notion of generic human effectiveness concerns the influence of personal, organizational, and environmental variables on performance. For example, the total spectrum generic model of human effectiveness identifies certain dimensions of the organizational and physical environments that also apply to spacecrews. The dimensions (68) and efforts to develop measures of those with satisfactory psychometric characteristics (69) have been described.

Other models that have been useful in the behavioral sciences include physical models for workplace design such as described by Roebuck et al. (64), and manual control models such as those of Askenas and McReur (3). However, adequate models for handling such matters as cognitive workload, decision making, and supervisory control are yet to be developed, although considerable promising work is being conducted. Sheridan et al. (72) summarized some of the research needs in the area of supervisory control systems.

NASA's Research in Behavior and Performance

Currently, the NASA research program in the psychological aspects of manned space flight includes four tasks:

Cognitive Performance and Stress: The objectives are to explore the nature of cognitive performance in fearful situations, to determine relationships of fear-modified performance to other indicators of fear as assessed in both actual stress situations and in imagination or anticipation of expected stress. Attempts are being made to develop predictors to discriminate between those persons whose performance may decline and those whose performance will be maintained or even enhanced.

Determinants of Performance: The objective of this task is the development of techniques for the selection and training of spacecrews and the composition and management of crews in future space missions such as the space station. The focus is on techniques of maximizing performance and adjustment. Some of the tests are directly applicable to crew selection as they decompose such dimensions as masculinity-femininity, self-esteem, and need achievement into components which, in a proper pattern, appear capable of predicting high levels of performance and adjustment under conditions of prolonged social intimacy within a continuously isolated group.

Small Group Behavioral Interactions: This task explores the performance capabilities of dyads and triads studied in a programmed environment under aversive or appetitive procedural rules. Observed variables include "pacing", social interactions, change of social structure, positive and negative motivation, and group cohesion-ness. The experimental facility provides quantitative data on such parameters as stimulus input, behavioral output, location in the facility, activity, interactions, and the effects of cooperative or noncooperative social contingencies.

Human Performance Analysis Methodology: The long-term objective is to develop noninvasive methods of measuring the effects of weightlessness, mental workloads, and environmental hazards of space flight on human cognitive and perceptual processes. Near-term objectives are to determine the physiological basis for evoked magnetic field and evoked electric potential responses and to develop instrumentation and methods for using evoked responses for assessment of human performance in the space program.
The NASA Biomedical Research Program also includes several tasks with implications for human behavior and performance as parts of other programs such as studies of the space adaptation syndrome, the effects of certain foods and nutrients on behavior, and the behavioral effects of altering normal circadian rhythms.

The psychology research program may be expected to grow moderately under the current system of unsolicited proposals. Nevertheless, the current level of effort is too restricted to produce the research needed to meet the stated objectives of the program. In addition, the scope of the stated program objectives, while broad, appears too restricted to include such essential considerations as the psychological aspects of groundcrew organization, operation, and interaction with spacecrews, and development of improved psychological selection and training criteria and techniques.

Suggestions for Research and Planning

There is a need for a high-priority program directed toward the needs of the STS-Shuttle Program and the Space Station Program in the near term, using available data, and short-term research to obtain best estimate solutions for the initial missions, and a supporting, longer-term program seeking more optimal solutions and addressing longer-term problems. A near-term program should be directed at the design of, or at least the requirements for, a space station interior, crew systems, crew operational procedures and tasks, and the specification of crew skills, characteristics, composition, and training requirements. A longer-term program should explore topics in psychology and psychophysiology which require a substantial time commitment (19).

As reported by Christensen and Talbot (19), the Working Group, in formulating its research suggestions, considered the research implications of the fundamental changes in size, functions, responsibilities, and composition of spacecrews and ground support staffs that have occurred in the STS-Shuttle Program and that are contemplated in the Space Station Program, the nominal 90-d missions with possible extensions, the emphasis on system productivity which permeates space station planning, and the changing character of careers for the associated space and ground personnel.

A common theme in the recommendations of expert groups on research needs in behavior and performance in space flight has been the overriding importance of establishing a firm commitment to a well integrated, comprehensive, long-range research and development program. One recognized method of planning large research programs in the psychological and social sciences is the ecological systems approach (4,70,86). Such an approach favors a methodology for descriptive analysis of natural settings and social interactions observed unobtrusively.

The suggestions are divided into two main groups: 1) near- and long-term research and development, and 2) technical and other considerations. Because this is a synopsis, the suggestions are condensed to tabular form; however, a selected few are expanded to serve as examples of their presentation in the Working Group’s report (19).

Near- and Long-term Needs

a. Near-term

- Develop a new generation performance assessment battery for use in training, mission simulations, and flight. A suggested model is the Tri-Service Performance Assessment Battery.
- Develop appropriate embedded secondary tasks as means of monitoring and assessing workloads and performance in space missions.
- Plan the use of Shuttle onboard video and audio resources for behavioral observation of crews.
- Provide near- and long-term support for basic laboratory studies to improve theory of performance and its measurement.
- Plan studies of behavior and performance to take advantage of the space station mockups that will probably be developed by NASA. Include perceptual, cognitive, and psychomotor parameters and group dynamics.
- Plan near- and long-term approaches to investigating and solving crew problems such as conflict management, integration of new members, crisis intervention, psychological support, authority structure, and distribution of responsibilities and work.
- Plan near- and long-term expert behavioral observation of space- and groundcrews during training, simulations, and space flight.
- Investigate interactions of personality factors and group performance.
- Develop methods of noninvasive tracking of neurohumoral markers of responses to stress. Investigate means of determining indices of impending failure of the adaptation response to sustained or intermittent stress.
- Acquire and evaluate inflight data on space-related perceptual phenomena with potential for demonstrated operational or psychophysiological significance.
- Study the effects of space flight on the precision of psychomotor functions and control.
- Plan special training for flight- and groundcrews of the space station program including social sensitivity, cohesiveness, interpersonal communication, and strategies for coping with operational stresses.

b. Long-term Research and Development

- Continue investigation and development of methodology and instrumentation for objective measurement of psychophysiological processes, status, and performance. Examples of approaches include:
  1. Improved performance assessment battery
  2. Embedded secondary tasks
  3. Central nervous system transmission times
  4. Intention tremor
  5. Evoked cortical electric potentials and magnetic field responses
  6. Voice analysis
7. Analysis of video recordings and sequential photographs

- Support basic studies of perceptual and cognitive processes to improve man-machine matching, man-system reliability, and human supervisory control of space systems.

- Continue to develop methodology and plans for expert, unobtrusive behavioral observation of the activities of space- and groundcrews.

- Improve methodology for qualitative and quantitative analysis of unobtrusively obtained behavioral data.

- Plan additional studies of factors that influence group dynamics such as motivation, heterogeneity of crews, organization for optimal productivity and psychological stability; and special training for social sensitivity, crew cohesiveness, and coping strategies.

- Investigate methods of enhancing intrinsic rewards for future spacecrew personnel including space station crews.

- Conduct studies to improve the database on spatial attachment, appropriation, territorial control, and privacy needs as may be related to space station crews.

- Develop optimal cognitive strategies to improve training methods. One useful approach involves extraction of performance strategies from expert operators by protocol analysis.

- Plan investigations of the effects of space flight on perceptual, cognitive, and motor capabilities and limitations. Include pertinent sensory systems.

- Plan long-term follow-up studies of behavioral and psychomotor changes that might result from the absence of normal perceptual-motor linkages in weightlessness.

- Include physiological and metabolic data in developing methods of evaluating behavior and performance.

Technical and Other Considerations

- Plan for monitoring and measurement of performance of operational personnel during training, mission simulations, and actual space missions.

- Select and implement procurement of expert concept and position papers.

- Define clearly the operational significance of psychophysiological phenomena occurring on STS missions.

- Add psychiatric evaluation to the periodic medical evaluations of spacecrew and mission groundcrew.

- Include management of inflight emotional crises and psychotic breaks with medical contingency plans.

In the basic report the research suggestions were treated in more detail. Examples follow:

Small Group Dynamics: Key areas needing additional work include: 1) definition of the components of individual and group motivation and their impact on behavior of space- and groundcrews; 2) the effects of heterogeneity of crews (astronaut/nonastronaut, mixed genders, different cultural backgrounds, different levels of responsibility, etc.) on behavioral and social interaction and productivity; 3) development of training methodology for social sensitivity, intracrew and space-ground communication, cooperation, and coordination in normal and emergency operational conditions; 4) organization for optimal productivity, including leadership, command and control, role sharing, crew participation in mission planning and decisions; and 5) best methods for crew rotation in the space station.

Basic studies of the interactions of individual personality factors and group performance should be accorded a high priority. Effort should focus on personality characteristics that favor compatibility and cohesiveness of small groups and should emphasize the real world of the physical and operational environment of the space station. In addition, the effects of group training in modulating individual personality characteristics toward improving group cohesiveness and productivity should be investigated.

Perceptual, Cognitive, and Motor Issues: Investigations of the effects of simulated space station missions on perception, cognition, and psychomotor performance should be planned for both the near- and long-terms. Planning should take advantage where possible of integrating studies with other planned experimental and training simulations. Where feasible, the studies should include observations and tests of skill maintenance, work-rest patterns, task allocation, group processes, and the behavioral effects of monotony of environmental stimulation.

The data base on complex perceptual and cognitive skills needs major augmentation in order to improve matching the human operator and the machine, man-system reliability, and capabilities for supervisory control of space systems. Basic research needs in these areas are identified in Pew (60). Examples of research that should be supported are: 1) theories of human inference and associated cognitive models (20,56); 2) theories and definition of the concept of human error (72); 3) refining the concept of mental workload (72); 4) determining operator capabilities and limitations for sustained, long-duration, mental workloads with fluctuating levels of demand (13); 5) defining psychophysiological correlates of mental workload (13); 6) the definition, separability, and coordination of cognitive systems and subsystems (45,55,61); 7) self-regulation of behavior in stressful situations (72); and 8) relations among cognitive processes, stress, and emotional responses (14,63).

Psychosocial Considerations: More work is needed in the near term on conflict management, crisis intervention, psychological support, absorption of new people into formed groups, and the question of optimal authority structure in spacecrews and ground control groups. The data base on person-environment linkages is adequate in a number of areas such as spatial attachment, appropriation, and territorial control (2,77), but more work is needed on privacy needs and methods of meeting them in confined environments (12).

Methodology: Performance assessment should include behavioral type performance measurement of complex perceptual motor activities and cognitive functions. Currently, the best, most comprehensive assembly for such use is the Tri-Service Performance Assessment
Battery whose development is nearing completion. It is designed to meet the requirements for laboratory and field use in the military departments, and represents an attempt to combine the best features of several existing devices including the United States Army Performance Assessment Battery (80), several USN batteries, and the USAF Criterion Task Set (73).

An emerging technology of potential value in assessing and monitoring perceptual processes is measurement of central nervous system transmission times. This can be done precisely in the visual and auditory systems via recording of steady state visual evoked responses and brainstem auditory responses. For example, variables such as perceived workload alter the temporal patterns of the responses. This methodology should be considered as another promising approach to the objective measurement of central nervous system processes (21,28).

Optimal cognitive strategies should be developed to improve training methods. Experience in the area of expert performance suggests that extraction of performance strategies from experts can provide useful data for improving training. Expert performance information may be obtained by protocol analysis or by experimental procedures (29).

Conclusion

The biomedical effects of exposures of up to 6 months of continuous space flight in the Salyut-6-Soyuz program have been reported (26,84). In addition, Garenko (25) summed up the 211-d mission of Salyut-7, flown in 1982, with the words, “In comparison with flights of shorter duration, space flights lasting up to 7 months do not lead to any qualitatively new biological changes in the human organism.” Except for space sickness and transient illusions of spatial disorientation, all of which disappeared after the first few days in orbit, no infight psychophysiological impairment was reported by the Soviet scientists. Behavioral disturbances in the long Soviet missions have apparently been infrequent and nondisruptive. Temporary postflight disturbances of vestibular function, posture, gastrointestinal stability, and locomotion have commonly occurred in cosmonauts and astronauts (41,89). Similarly, the manned space experience of the United States has apparently been free from adverse behavioral responses. The history of such robust success might well suggest little need for careful attention to problems of human behavior and performance.

However, review of the psychological aspects of space flight has revealed: 1) documented as well as anecdotal accounts of perceptual, cognitive, and emotional aberrations in spacecrew members; 2) markedly insufficient data bases in key areas that undergird optimal behavior and performance in settings such as space flight; and 3) important uncertainties on how best to select, train, and sustain for best productivity and psychological wellbeing, the relatively large, heterogeneous flight crews contemplated for the space station.

Therefore, in the interest of continuing success in manned space flight, a comprehensive program of research and development in human behavior and performance will be necessary. The research suggestions of the ad hoc Working Group on Behavior and Performance (19) outline major components of such a program.

ACKNOWLEDGMENTS

The authors wish to acknowledge the members of the Life Sciences Research Office, Federation of American Societies for Experimental Biology ad hoc Working Group and study participants:

I. Altman, Ph.D., Professor of Psychology and Vice President for Academic Affairs, University of Utah; A.J. Bachrach, Ph.D., Director, Environmental Stress Programs Center, Naval Medical Research Institute, Bethesda; J.M. Christensen, Ph.D., Chief Scientist, Universal Energy Systems, Dayton; G.E. Long, Ph.D., Senior Scientist, FAA Technical Center, Atlantic City; T.F. McGuire, M.D., NASA Consultant in Psychiatry, San Antonio; R.D. O'Donnell, Ph.D., Senior Program Scientist, Ergometrics Technology, Inc., Dayton; M.I. Posner, Ph.D., Professor of Psychology, University of Oregon; and, J.M. Talbot, M.D., Senior Medical Consultant, Life Sciences Research Office. G.E. SerCraft, Ph.D., of San Antonio, was a special contributing reviewer.

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