Psychological Effects of Space Flight

GEORGE E. RUFF, M.D.

PSYCHOLOGICAL EFFECTS of space flight may arise from central nervous system changes produced by physiological stress or from emotional reactions to various aspects of the flight. Since either of these may disrupt crew performance or impair the health of crew members, potential sources of adverse psychological change must be identified and steps to control it must be taken.

Man's behavior in space may be affected by any stressor which alters the functions of his central nervous system. The effects of acceleration, heat, noise, and vibration, problems with food and oxygen supply or waste disposal, radiation, and toxic fuels should all be studied psychologically as well as physiologically. It is apparent, however, that changes induced by these conditions are minimized by planning the vehicle and mission to keep stress levels as low as possible, by careful selection of crew members, and by training and conditioning to improve tolerance. Responsibility for this lies with physiologists and others who are primarily concerned with these areas. At the same time, it must be remembered that psychological variables may be sensitive measures of the intensity of physiological stress. It is consequently helpful for psychologists and psychiatrists to be involved in planning, monitoring, and follow-up studies of space missions and related on-the-ground experiments.

The other effects of space flight are produced by its symbolic implications—the aspects of a mission which alter behavior because of their meaning to the traveler. These cannot be studied as directly and precisely as the effects of objectively describable environmental changes. Perhaps they can best be dealt with by thinking of man's needs, then considering ways in which space flight may either permit or interfere with gratification of these needs, and finally attempting to predict the effects of non-gratification. To do this we must know something both about human behavior and about space flight.

It is obviously impossible to begin by listing everything we know about human behavior. But most would agree that some needs are fundamental—such as food, water, and exchange of certain gases. Furthermore, man requires protection against too much or too little of various environmental stimuli. Because of painful past experiences with excesses or lacks of supplies and stimuli, he has learned to respond to the threat of pain before he actually begins to suffer. Avoidance of pain and death are thus secondary needs which are almost universal.

Other secondary needs concern the presence of other people to whom the individual can relate and on whom he can depend to act in a more or less predictable manner. These needs probably exist because at one time they were associated with primary needs for food and escape from pain, but that is another story.

At present, knowledge of the psychological implications of a space environment is speculative. It is based upon consideration of behavior on earth under conditions comparable in some respects to those expected in space. Such data are derived both from accounts of natural stress experiences—such as polar expeditions or shipwrecks—and from laboratory experiments. Particularly useful are studies combining the controlled environment of the laboratory with the impact of an actual mission—the Manhigh balloon flights, for example.

These sources of information suggest that the

From the Department of Psychiatry, School of Medicine, University of Pennsylvania.

chief psychological problems will be isolation and prolonged exposure to danger. Beginning with isolation, it is apparent that we are dealing with a many-sided problem. One aspect is "aloneness," or the feeling of separation from other people. Another is separation by physical distance. A third is "cultural" isolation, where the individual feels cut off from his society. Still another aspect is removal from familiar surroundings. Most people must maintain meaningful relationships with other individuals and with the society in which they live. If taken too far from this accustomed matrix of customs and experiences, severe disorders may develop.

Closely associated with this is the problem of sensory deprivation. If the quantity and variety of sensory input are too low, disturbances in perception and thought will occur. Proprioceptive feedback from muscles and joints seems particularly important. Lilly's work suggests that prolonged immobility, coupled with zero gravity, may lead to a state of restlessness which might produce severe discomfort for a space traveler.[1]

It is also apparent that altering sensory input involves more than a change in the physical characteristics of stimuli. By depriving a man of the information usually carried by these stimuli, his environment becomes meaningless—an unbearable state of affairs for most people. Furthermore, patterns of information input adequate to support efficient functioning for short periods may become indequate in time. Since even the most carefully planned capsule cannot supply all the variety of life on earth, mild levels of sensory deprivation may eventually become a problem for space crew members.

When more than one person is isolated, problems of interpersonal relationships arise. Because of limitations on the size of crew compartments, space vehicles will involve closer associations between individuals than during operations of other kinds. Submarine crews, for example, include many small groups whose composition and location constantly shift as individuals alternate between duty and leisure periods. Members of a space crew may have no opportunity to withdraw from each other when friction arises.

Just as different cultures develop forms of social organization adapted to their particular needs, it can be expected that space crews will devise methods to make the stress of prolonged confinement more tolerable. Preliminary experiments indicate that techniques for handling the pressure of enforced interaction over long periods differ from group to group. Future studies will be directed toward identifying patterns of organization and customs which can be emphasized in selecting and training crews.[3]

No one can be sure whether prolonged exposure to danger will be any different for the space traveler than for the person who faces risks on earth. Perhaps the earth represents a source of support to man which cannot be left behind without consequence. The apprehensiveness felt by some people on water or in the air could be intensified by lacking even something to float on. A man adrift on the sea at least has oxygen and the possibility of food and water.

It must be remembered that when talking about this kind of problem, its reality may be less important than how a man feels about it. Consider, for example, a space vehicle well stocked with food and oxygen, and given a substantial margin of safety against mechanical failure of the system. Chances of starvation or anoxia may be no greater than in many situations on earth. But if leaving earth carries the implication of starvation, a man will react to it regardless of the actual state of affairs.

Next, let us consider what happens when the needs we have referred to are not gratified or if the space traveler feels as if they will not be gratified. The initial psychological reaction is one of anxiety. This indicates an attempt to adjust to a stressful situation. Although often considered a subjective sensation of discomfort, anxiety includes autonomic nervous system discharge, followed by feedback from the viscera to the central nervous system (CNS); skeletal motor discharge, followed by proprioceptive feedback; neuroendocrine discharge, followed by chemical feedback to the central nervous system; and higher CNS activity involved in both the afferent and efferent processes. The total reaction must thus be studied by measuring neurophysiological variables, endocrine excretion, affect changes, and psychological performance.

Rioch has described the net result of these processes, first, as permitting a shift from previous ongoing activity to a pattern of behavior appropriate to the new situation; and, second, as making possible continued metabolic support of this new pattern.[2]

While anxiety has the adaptive function of facilitating alertness and making possible high energy output for fight or flight, the behavior of the organism may become disorganized if the process goes too far. It is necessary, therefore, to conserve the mechanism—at least to eliminate all possible sources of psychological stress. This will give a space traveler the best chance of adapting to events which cannot be foreseen.

Assuming that we have begun with a man who has adapted successfully to new situations in the past, what can be done to minimize chances of adverse psychological effects? In the case of isolation, we know what the sense of separation by distance is more bearable when cultural isolation is minimized. A strong sense of identification with one's society—plus communication with others on whom one can depend—will be essential. The necessity of providing meaningful, varied sensory input has already been discussed. Our studies also make it clear that spatial and temporal orientation is important during isolation.[4] Our traveler must thus know where he is and when—and preferably be able to see where he is going.

With regard to danger, we shall have to assume that even when the engineers have done their best, some risk will remain. One lesson well learned is that when faced with danger—real or fancied—the worst thing is to be helpless—not to be able to do anything but accept passively whatever comes next. Associated with this is the inability to understand the nature of the problem. Under these conditions, non-adaptive mechanisms come into play. A man may deny his plight, or rely on the fantasy that he is invulnerable. He may become fatalistic, and assume that control over the outcome of his situation is in the hands of a third party. He may tell himself, for example, that if a meteorite has your name on it, you've had it. If not, don't worry. Or he may propitiate those who write the names by supersition or magic. Finally, he may become apathetic and eventually lose all capacity to solve his problems.

To avoid this, everything possible must be done to train a man to respond to all foreseeable situations and give him the background necessary to help solve unforeseeable problems. To accomplish this, it is desirable to structure the mission—to schedule activities in order to make most reactions automatic. But it must be remembered that once behavior becomes routine, something must be added so that long flights won't become too monotonous.

When we have done all we can to minimize undesirable psychological effects before the mission starts, we must consider briefly what we can do on the ground to observe our traveler and further assist in the success of his journey. First of all, it is important to know what his reactions to stress will be and to recognize his own characteristic signs of decompensation. A doubling of the pulse rate, for example, may be serious in one man and not in another. By knowing as much about our subject's characteristic psychological methods of adaptation as possible, we can hope to tell whether certain changes in thought and affect indicate that he is coming close to his tolerance limits. Since available communication channels will usually be occupied with information essential to progress of the mission, it will be best to have a skilled clinician monitoring the flight. Armed in advance with foreknowledge of what to look for in this particular individual, and able to observe how functions of different degrees of complexity are carried out, he may be able to see trouble before it reaches serious proportions.

Finally, decisions must be made beforehand regarding what to investigate when the traveler returns. It is not enough to know that he survived and was not psychotic. Was he near the point of decompensation when he returned? And if not, how much did it cost him to function under the stress of the mission? Furthermore, even if effects seem mild at the time of landing, we may not have all the answers. Strange psychological reactions have appeared in men who have apparently mastered stressful situations with ease. Again, careful psychological and physiological follow-up studies will be essential.

In conclusion, now that some of the problems have been pointed out, a more positive opinion can be stated. It seems that no matter how stressful experiences have been in the past, some men have adapted successfully and thrived on them. Consider, for example, the voyagers of the fifteenth century. Not only were crews not carefully selected, but they were usually the dregs of society. Not only didn't they have reason to anticipate a safe return, but many fully expected to meet sea monsters, have the ocean boil, or sail off the edge. Although they might be told that all this was untrue, not even the *leaders* had the faith in what was then known that members in our culture have in our technology, today. If *they* could do it, it is hard to see why potential psychological problems should prevent man from exploring space.

REFERENCES

1. LILLY, J. C.: Mental effects of reduction of ordinary levels of physical stimuli on intact, healthy persons. *Psychiat. Res. Rep., Amer. Psychiat. Ass.*, 5:1, 1956.
2. RIOCH, D. McK.: Experimental aspects of anxiety. *Amer. J. Psychiat.*, 113:435, 1956.
3. RUFF, G. E., LEVY, E. Z. and THALER, V. H.: Studies of isolation and confinement. *Aerospace Med.*, 30:599, 1959.
4. RUFF, G. E., LEVY, E. Z. and THALER, V. H.: Factors influencing reactions to reduced sensory input. *In* P. Solomon, et al.: *Sensory Deprivation*. Cambridge: Harvard Press, 1961.

Pulmonary Circulation During Exercise

ROBERT J. MARSHALL, M.D., YANG WANG, M.D., HERBERT J. SEMLER, M.D., and JOHN T. SHEPHERD, M.D., Mayo Clinic and Foundation, Rochester, Minn.
Circulation Res., 9:53-59, 1961

The pulmonary vascular bed in dogs can easily accommodate any probable blood flow with only a modest increase in pressure difference across the pulmonary vessels. During exercise, pulmonary blood volume probably rises slightly.

After running on a horizontal treadmill at the highest speeds maintainable for two-minute periods, cardiac output increased about threefold in 6 intact dogs. An increase of only 12 to 50% occurred in the pressure of the main pulmonary artery (PA) minus a pulmonary-artery wedge (PAW) position, thus evidencing a continued fall in pulmonary vascular resistance. In 2 of 3 dogs in which blood volume of lungs and left heart was measured, changes did not occur; in the third dog, volume rose 18% with intense exercise.

In 4 dogs with ligation and division of the left pulmonary artery, rapid running also increased cardiac output threefold. Since the entire output passed through one lung, effect on the pulmonary vessels was comparable to a sixfold increase in output for an intact dog. Despite such large flows, the difference between PA and PAW pressure in 3 dogs rose only 37 to 50%. Volume of blood in the lungs and left heart did not change from rest to speeds of 8 km. per hour but increased up to 20% at higher speeds.—From *Modern Medicine*, May, 1961.