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Preliminary Report

# Issues in Selection and Training for Long Duration Space Flight

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# ISSUES IN THE SELECTION AND TRAINING OF FUTURE SPACEFLIGHT CREWS

In the forefront of those porblems yet to be adequately addressed in preparation for future long-term space missions are the many issues surrounding who and how to select and train crew members for such flights. Given the important point that the human element is often the most variable and least reliable in any human-machine complex, the demands of selecting and training crews for space missions of considerably longer duration and greater complexity than previously achéived must be considered paramount in future space flight programming. Indeed, the solution to many of the psychosocial demands of spaceflight can be ultimately reduced to our ability to anticipate the consequences of long-term spaceflight for the human organism and to compensate for these conditions through the selection and training of individuals most capable of dealing with these consequences either through their own innate personalities and abilities or through specific and generalized training. In effect, the topic of crew selection and training encompasses all the other topics covered in this volume. Beyond the technical engineergin requirements of spaceflights and those human factor elements which can be resolved or minimized through engineering design considerations the remainder of the problems will probably be either minimized or enlarged depending upon our ability to select and train a superiorcrew. This particular chapter will detail some of the factors relevant to this selection and training process and outline those areas where our current knowledge is weakest.

## SELECTION CRITERION CATEGORIES

Based on our previous experiences with crew selection, we can assume that there will be three important broad avenues of consideration for future missions (1): 1) technical qualifications and expertise, 2) medical fitness and ability to tolerate the various conditions of space, and 3) psychosocial considerations including personality structure, motivation, intelligence, leadership potential, group compatibility, etc. While the primary emphasis here will be on this third category, several important points can be noted with respect to the first two.

### TECHNICAL QUALIFICATION CRITERIA

In the early phases of the manned space program the main criteria for selection of astronauts centered around recruiting individuals already best qualified professionally and physically (2). NASA and the Space Task Group jointly explored professions most likely to furnish the technical skill and adaptability necessary to produce astronauts. These included: aurcraft pilots (3), balloonists, submariners, deep sea divers, mountain climbers (4), Arctic and Antarctic explorers, flight surgeons, and scientists that included physicists, astronomers, and meteorologists. In 1959, however, the President issued instructions that only active military test pilots were to be used as astronauts in Project Mercery. While individuals from other professions, who doubtless could have become astronauts given time and training, were bypassed there were several distinct advantages to restricting the selection group to military test pilots. For example, these individuals already had extensive medical records, officer effec-

tiveness ratings, records summarizing combat experience, educational history, awards and decorations received, and had already been through numerous selection processes in order to become test pilots (5-10). Technically, there were certainly specific advantages. Each candidate had a college degree in one of the engineering or physical sciences and at least 1500 hours of flying time-much of it in jet aircraft (11). Thus, these individuals had already experienced many of the psychological stresses of flight under unusual conditions and had proven themselves outstanding. In addition, they were very experienced with the military system of leadership and presumably felt more comfortable with the NASA command structure than would have non-military personnel. There seems to be some very sound justifications for selecting future spaceflight pilots from among the ranks of those laready experienced with flight control systems, engineering, and the dangers of experimental flight crafts. However, there was no readily analogous pool from which to draw the scientist-astronauts of the late 1960's or those to serve during the Space Shuttle era. Instead, a general public announcement was issued by NASA inviting interested scientists to apply with the National Research Council designated to determine scientific professional competence and qualifications. At this point the selection process became more complicated and illustrates some of the difficulties which may pose problems for future successful selection and training.

There were several striking differences in the personalities, behavior, and attitudes of this new group. These will be covered in the later section of Psychological Determinants of Selection. While it is difficult to make gross generalizations between ca-

reer profession and personality structure, it is safe to say that on the whole individuals from such widely divergent technical backgrounds as those of pilot-astronauts and scientist-astronauts do have major differences in orientation, interest, attitudes, and behavior. This has some important implications for selecting and maintaining groups in space. As we look toward future spaceflights where the number and type of individuals will be even more diverse the possiblities of intra- and inter-group friction increases. Originally, crew members came from similar backgrounds (the majority were first born children from the Midwest), had similar professional aspirations, and indeed were selected so as to include those with certain personality similarities. This was ideal for the original missions which included only a few crew members at any one time involved in flights of relatively short duration. However, as the size of crew and length of missions increases the importance of knowing what similarities and/or differences yield the most effective and efficient crews becomes quite critical. The important point here is that there is probably some strong interactions between professional orientation and personality structure which will make selection processes for professionally heterogenous crews considerably more complicated. Is it the case for example, that we wish to have the scientist-astronaut psychological criteria be the same or different from those of astronaut-pilots? Previous research in the Antarctic suggests that considerably different demographic and personality characteristics predict success in year long missions among different professional categories (12). These findings suggest that for future space crew selections our approach may have to be considerably more di-

verse and that perhaps even separate selection criteria may be necessary for different catogories of technical and professional expertise.

MEDICAL QUALIFICATIONS

Over the past 25 years an extensive battery of medical tests has been developed and included as part of the astonaut selection program. While this was most important during earlier flights, the necessity of stringent medical qualifications will probably continue to diminish as spaceflight becomes more routinue (although the liklihood of reducing the qualifications to those required for regular commercial aircraft flight is unlikely in the near future). As we anticipate those potential problems involved in long term space travel there may be a need to shift the focus of medical selection to other factors rather than sheer endurance. For instance, as we begin to better understand the mechanisms underlying space motion sickness it may prove useful to include tests which will select for those less susceptible to the temporrarily debilitating effects of this phenomenon. Certainly this is an area that deserves more investigation given the long history of problems we have had with this difficulty.

A second area where medical selection may prove useful is in the selection of individuals possessing specific diurnal rhythm patterns. It may prove useful to select, when possible, for those inidividuals with flexible circadian rhythm patterns. Given the stressful nature of desynchronosis, there may be some advantages to selecting individuals less susceptible to the effects of time zone travel or extended periods of disrupted sleep-wake schedules

(such as those discussed in much of the shift work literature (13)). While it is in the best interest of the crew to technically ensure that earth-like sleep-wake patterns can be maintained in space, previous experience has shown that the all too often hectic schedules of the astronauts, the occurrence of unexpected emergencies, and the problems of temperature, noise, and vibration have all added to the difficulties of altered sleep-wake cycles to which crews have had to adapt. Furthermore, we know from research in the Antarctic (14-16) and other naturally occurring situations of long-term isolation and confinement that inadequate and abnormal sleep patterns are more the norm than the exception. Still there appears to be a differential effect with some individuals more susceptible to sleep problems than others. It would be a significant advancement if variables predictive of sleep abnormalities could be determined such that those individuals less susceptible to difficulties could be included on future long-term space missions. Those individuals best able to adapt to such altered time schedules may have an important advantage in their overall ability to successfully complete a mission.

One new area of investigation which may eventually become the backbone of psychosocial-medical selection instruments is the work being accomplished in the area of brain lateralization. Researchers have long sought a methodology which would permit rapid and accurate assessment of stress and fatigue and its effects on the psychophysiological organism. Activation and arousal level have frequently been tied to this, but no single measure has yet emerged to measure these effects and processes. Work described by Teichner (17-19) and Natani (20) may provide this tool. Teichner

has developed a working model of the brain based on various levels of activation and information processing bandwidth. An attentional state of narrow bandwidth is presumed to reflect an activated state while a wide bandwidth is associated with lower levels of activation, i.e. bandwidth in inversely related to activation level. These attentional states have been previously demonstrated to relate to performance according to an inverted U-shaped function. That is, activation as measured by heart rate, skin conductance, pupil size, etc. is optimal at intermediate levels. But when activation levels are too high or too low they interfere with optimal performance (21). Bandwidth, and therefore activation level, has been related to the lateralized functions of the brain. For example, the lateralization concept assigns a serial information processing role to the left hemisphere. This by definition is a narrowband process. The right brain has been hypothesized to function in a parallel processing model (a wideband phenomenon). From this, it can be hypothesized that the type and quality of information processing in the two brain hemispheres (and thus performance) should be correlated and predictable given the individual's activation level. There is some evidence to support this conclusion (22). Exploratory efforts suggest that there are at least three discrete patterns of cerebral organization related to optimal activation/performance levels. The most adaptive appears to be one in which both hemispheres are highly differentiated and permit swift and flexible alternation between response sets requiring the abilities of the right or left hemisphere. The other two organizations demonstrate less differentiated patterns and more mixing of right and left functions across the right

and left hemispheres. Under conditions of high information load, more interhemispheric conflicts would be generated by the mixed specializations than the differentiated pattern. This would increase activation levels and could produce response blocking and occasion ally inappropriate behavior for individuals with mixing of specializations. In addition, individuals with less differentiation may be required to make some type of compensation for this lack of differentiation. They may have to mobilize their neural resources to a greater extent and work harder to attain levels of performance comparable to the individual with more highly differentiated functions. Thus, inappropriate strategies due to functional dispositions for a particular mode of information processing could interfere with adaptive flexibility and also impose greater cortical workloads. As Natani points out, one would expect to see marked individual differences in response resulting from these three differences in neural organization that may eventually be subject to controlled selection and testing procedures. Recent developments in psychometrics and particularly neuropsychology (23), coupled with advances in the application of computer technology in the behavioral sciences has increased the probability of the establishment of such a procedure in the not to distant future. At this point, considerably more research is needed in the field of neurometric procedures and is certainly warranted. The establishment of an effective procedure for assessing brain lateralization functioning could revolutionize selection programs for long-term spaceflight. It is a truly exciting possibility.

Another direction for continued research involving the psy-

chophysiological approach to differential responses to stress comes from work on the characteristics of individuals best able to adapt to sensory and perceptual deprivation. There is evidence to suggest that some of the effects of extreme, short-term sensory/perceptual deprivation may be similar to those observed in field settings of long term reduced sensory input (usually also involving isolation and confinement). It may prove useful to better understand what factors improve adaptability to extreme sensory-perceptual deprivation and how this may improve our predictions of who can survive best in long term isolation conditions (such as those which might be encountered in space). One characteristic which seems to have been validated in the sensory/perceptual deprivation literature as a differential predictor of adaptability is perceptual mode. This work began with a series of studies at Duke University (24-26) and utilizes the work of Witkin et al (27, 28) who classified subjects as field-dependent or field-independent depending upon their perception of the vertical position of a luminous rod surrounded by a luminous frame. When the body position of subjects was shifted in such a way that they could either rely upon the external stimuli of the rod and frame or their own internal kinesthetic sensations in making judgements about the true gravitational vertical of the rod those influenced more by external cues were labelled field-dependent, while those more influenced by bodily cues were labelled field-independent.

Generally, field dependent subjects do not fair well in sensory deprivation experiments. After two hours, they show more suspiciousness, more disorganization of thought, more visual and

auditory imagery, more discomfort with body sensations, more inner feelings and fantasies, and more movement than field independent subjects (24-26). Witkins (27,28) has further delineated these categories of individuals on the basis of differential personality characteristics. He noted that field dependent persons show more passivity in dealing with the environment, more submissiveness to authority, lower self-esteem, and a less distinct body image. They can be characterized as outer-directed, extroverted, more likely to use projection and denial as defense mechanisms, and more susceptible to hypochondriacal complaints. Interestingly, they tend to view their mothers as the major source of affection, the major source of punishment, and the main role model. On the other hand, field-independent subjects show more aggressive personality characteristics, more active coping, and greater comfort with internal values and drives. They can be described as more inner-directed, more introverted, possess greater ego strength, and have distinct body boundaries. They perceive their mothers as the major source of affection, but their fathers provided the major source of punishment and were the main role model.

The prospect of using the ord and frame test as part of a test battery of predictors of differential success under isolation and confinement conditions is exciting. Unfortunately, no one to date has explored such a possibility either in the laboratory or the field. Given the usefulness of distinguishing perceptual modes in sensory/perceptual deprivation experiments the logical extension would be to test its usefulness under other conditions. While this remains to be done, it is encouraging to note that many of the personality characteristics associated with

field-dependent perceivers are also those which have shown to be nonadaptive in Antarctic research settings. This lends some credence to the notion that perceptual mode may be a valuable aid in predicting differential outcomes under extreme environmental alterations. Furthermore, the growing amount of physiological research related to style of perceptual mode (29, 30) provides a satisfying marriage between psychological and physiological approaches which could prove to be quite helpful in better understanding human characteristics which predict adaptability. This certainly fits the style of investigation NASA has preferred in the past. It is suggested that more expanded research with perceptual mode, central nervous system functioning, and personality characteristics should be consideredin determining our best approach to the selection of astronaut criteria.

As the direction of the space program changes to more routinue flights of longer duration there may be yet other medical factors to be included in the selection process. For example, during long-term missions it may prove helpful to consider those individuals already adapted to the rigors of a somewhat sedentary lifestyle. Those individuals confined to wheelchairs on earth may prove to be valuable crewmembers in space due to their adaptability (both physiologically and psychologically) to hypodynamic conditions. Indeed, some studies of isolation and confinement have found such individuals superior in their abilities to cope with the stresses of these conditions (Dr. Charles Winget, personal communcation).

PSYCHOSOCIAL DETERMINANTS

While technical and medical qualifications have previously

been the most heavily emphasized criteria for selection, the advent of long-term missions will necessitate a much greater emphasis on the psychosocial determinants of crew selection. As with the original Mercury Selection Program we are faced with knowing that personality and social factors are important, but not having any real experiential data in space to determine what specific variables must be emphasized. Certainly one place to begin is to consider what psychosocial factors have been considered in previous NASA selection procedures. Many of the traits which were considered critical for short-term flights will also be important for long-term missions.

ORIGINAL ASTRONAUT SELECTION PROGRAM

Kubis and McLaughlin (31, p. 321) have summarized the emphasis of Wilson (32) and others involved in previous NASA astronaut selection programs by outlining the following psychological requirements of potential candidates:

> The search was for an individual with a high degree of intelligence, preferably characterized by mathematical and spatial aptitude. He was to be sufficiently creative to contribute not only to the development of test and space hardward, but also to the planning necessary for the success of the space program. With an ability to work closely with others, he was expected to tolerate extreme isolation without anxiety. Though reliable and consistent in his behavior, he was to possess the necessary flexibility and adaptability to meet any emergency without psychological disintegration. Deliberate rather than impulsive, and with outstanding capacity to tolerate stress, his motivation for volunteering in the space program was to be mission-oriented rather than based on personal need for achievement.

Certainly the characteristics of the individual as outlined here are important for future missions. However, there are important differences between the above description and the focus necessary for long-term flights. The most important is that the

is that the early focus of the selection program used criteria almost solely framed around individuals. This has been the traditional approach where it is often assumed that by selecting effective individuals it is possible to form effective work teams. However, for future missions composed of groups of individuals the focus needs to be shifted. Given that the interactions and interdependencies of groups in space requires cooperative functioning and team orientation, selection criteria need to be directed toward identifying effective groups rather effective individuals. The latter may or may not be effective team members.

Our future selection program may need to assess at least two different levels of astronaut abilities: 1) those individual traits such as intelligence, motivation, skill, creativity, etc. and 2) those traits which contribute to the overall performance, stability, and effectivenss of groups. This second level would include traditional measures of personality and psychosocial effectiveness might also include new indices as will be discussed later on. First, let us consider how the analysis of candidates has proceeded thus far.

Psychological testing has always been embedded in a larger medical evaluation program. Table 1 presents the psychological tests administered during the Mercury and later flight selection programs. The tests are generally intended to measure intellectual abilities, motivation, personality, etc. But, again from within an individualistic orientation. From the data generated from these tests, we can address the issue of what test variables appear to distinguish selected from non-selected candidates given the current selection criteria orientation. Such information

TABLE 1

PSYCH. TESTS CONDUCTED

SEE HARTMAN & McNEE

has been slow in forthcoming, but a recent analysis by Hartman and McNeil (33) has finally addressed the issue. Unfortunately, the original pool of potential candidates were apparently so homogeneous with respect to psychological characteristics that only a few statistically significant differences appeared. This was also probably due to the fact that many other selection factors were considered besides the psychological evaluations. The data from their analyses are presented in Tables 2-4. Separate univariate analyses were made between the selected and not selected groups for the Mercury and the Apollo candidates. The only difference in means detected at the .05 level of significance was for the overall Rating for the Mercury candidates (those selected had significantly higher ratings than those not selected). Disappointingly no other differences in means between those selected and not selected for the Mercury Program or those selected and not selected for Gemini-Apollo Programs appeared. Also, there was very little difference in the variances across the selected and non-selected groups (pointing up the fact that the many previous selection rpocedures these individuals had gone through produced a pool of relatively homogeneous candidates). Only the variances in Rorschach F% were significantly different between Mercury selected and not selected candidates (more heterogeneous for those not selected) while variances for Rorschach F%, P, and M and Edwards Deference were significantly different between Gemini/Apollo selected and non-selected candidates (more heterogeneous for non-selectees on Rorschach F%, less heterogeneous on Rorschach P, M, and Edwards Deference).

A stepwise multivariate approach was also used with the Ge-

Table 2

Table 3

Table 4

mini/Apollo data alone. The best set of discriminant variables found by this technique was Wechsler Verbal I.Q. (VIQ) and the total number of Rorschach Responses (R). Using the best discriminating linear combination of VIQ and R resulted in a 19% error rate in classification.

While none of this data is particularly impressive with respect to how well psychological tests can distinguish candidates who were and were not selected it must be remembered that these instruments were not the primary source of overall selection. Indeed, given that there was little a priori data with which to determine the construct validity of these instruments for selection of effective astronauts it would be unduly harsh to say that these tests were not useful. They were intended to be more of a screening battery to select out potential failures rather than to discriminate within a highly homogeneous group to select in those who could be effective astronauts (indeed how could there be any predictive validity when no astronauts had yet completed a mission to serve as comparative criterion data). Nevertheless, this batery was useful and will continue to be so, particularly as we now have more experienced astronauts whose test data can be used for predictive comparisons to new, more heterogeneous applicants.

Even the original test battery does give us some insights into the dynamics of individuals originally considered appropriate for testing as an astronaut candidate. Those who did become candidates (whether selected or not) when compared with a group of non-candidate pilots were significantly higher in intellectual resources, were more homogeneous in test performance, had more of an ability to deal with complexity in a matter-of-fact, creative, and

emotive way and were more indipendent types of individuals.

SELECTION CRITERION ISSUES FOR FUTURE MISSIONS

With regard to future selection of crews the level of analysis previously used by NASA will continue to be important. High levels of intelligence, tolerance to complexity (loosely taken as a rough index of stress level), as well as strong motivational drives, creativity, etc. will still be qualifities we will wish candidates to possess. However, are there any individual personality characteristics of those we will wish to include on long-term missions which may be different from those considered important for personnel of short duration flights? It appears that there are given the opinions of some researchers in this field (34, 35) who feel that our current astronauts would probably not do well in a long-term group mission. We know for example that the original astronauts possessed action-oriented or aggressive acting out impulses (36), tended toward extroversion, did not have particularly rich fantasy lifes or inner-directed tendencies, and tended to be concrete rather than fluid and abstract in their thinking (34). All of these characteristics have been demonstrated to be of negative value to those who have experienced Antarctic confinement (37-39) and at least on some dimension resemble subjects with field-dependent perceptual modes who do poorly in sensory/perceptual deprivation experiments as discussed earlier. What then is the picture of the individual most suited to long-duration isolation confinement? Specifying those particular traits which are most predictive of success in other extreme environments with similarities to space is an extremely difficult task: It is dependent upon not only traits important to any individual, but may vary as a function of (1) pro-

underwater research laboratories. Performance studies indicated that those high in social contact (presumably a quality of extroverts) showed higher levels of work productivity. On the other hand, studies of laboratory isolation and confinement have reported that those with a high need for social contact do not do well under the constraints of reduced social variety (42). Also, field-dependent subjects who tend toward extroversion have been shown to be poor adaptors in studies of sensory/perceptual isolation. Furthermore, in at least some professional categories, those who are extroverts do not fare well under the conditions of long-term confinement in the Antarctic (39). If we assume that individuals high in extroversion rely more strongly upon social c contact, and interactions with others to maintain self-esteem it is not difficult to see how the constriction of such processes under confined, socially monotonous conditions could have more of an adverse impact on those tending toward extraversion than introversion. From this we get both the picture of contradictory results and evidence that even the most straight forward of personality characteristics may have both advantages and disadvantages for the individual under extreme conditions. These results also strongly indicate the probelsm of trying to isolate individual factors from those which interact with group size, degree of heterogeneity, and other factors of the individual (such as professional orientation) which may influence the nature of a given characteristic and its influence under socially restricted, isolated conditions.

While some factors have been listed which will be of importance to all crew members, we may find it more fruitful to look

at what types of characteristics seems to be predictive of success in confined, isolated environments for different professional categories of our crew.

As alluded to earlier, there do appear to be some rather distinct differences in personalities of individuals as a function of their professional orientation, training, and background. Even during NASA's original selection program, such factors became apparent (though of little concern given the short missions such personnel were to fly). For example, during the course of the selection process it was noted that astronaut pilot candidates showed considerably less general acceptance of psychological testing. On the other hand, the role of psychologic testing and psychiatric evaluation in nonpilot astronaut selection was generally recognized by these candidates as mingingful, necessary, and therefore acceptable (43).

On three specialized tests measuring abilities in verbal, and engineering areas, scientist-astronauts scored consistently higher, while pilot-astronauts showed significant differences in greater self-confidence and increased maturity (43).

Scientist candidates manifested greater variability in the Rorschach protocol, had more responses, with greater numbers of whole responses and content categories. They tended to be impatient with routine procedures and challenged by projective tests. Some differences between pilots and scientists did appear in the overall pattern of projective results.

On tests of personality (Rorschach) engineer types tended toward more concrete perceptions, tending to emphasize form characteristics of the blots. Their movement responses were the popu-

lar ones along with a controlled use of color. Their percepts suggested a somewhat distant affective and emotional tone, tending to handle sensitive interpersonal relationships rather distantly.

The other category of candidate was more creative, introspective and cognitively oriented. They responded with greater opennes to Rorschach stimuli. There was greater latitude in their response processes due to greater harmony of emotional and perceptual processes (43).

While there were few major differences on the Thematic Apperception Test between military and civilian groups, the scientists did tend to express their aggressive feelings more openly than did the military group.

There are some potential conflicts here. It is not unrealistic to assume that the creative, ingenious, self-actualized individual could pose a problem for an action-oriented, engineer type, and vice versa. Indeed as O'Leary (44) has reported there were some rather striking conflicts between the engineering, operation orientation of the military pilots and the strong pro-science emphasis of the scientist-astronauts. Even to the degree that two of our astronaut-scientists resigned from the corp. More on the issue of potential crew incompatabilities will be discussed in a latter section.

Personality and occupation differences have been discussed as important factors in predicting performance in other situations similar to long-term space flight. For example, Doll, Gunderson, and Ryman (45) assessed 240 wintering-over personnel of three occupational groups (Navy Seabees, Technical-Administrative, and

Scientists) in the Antarctic using fiver performance measures (Emotion, Task, Social, Leader, and overall). Distinctive predictors were found to vary across groups. A more thorough analysis reported by Gunderson (39) combined a large number of screening information items into five predictor sources: Personal History and Hobbies, an Opinion Survey, the FIRO-B Inventory, a Friend Description, and psychiatric evaluations. These results are shown in Table 5. The numbers in the table represent the numbers of items that were significantly correlated with each criterion for each group. Further details of this data can be obtained for Gunderson's report. For our purposes, these data dramatically point out the complexity of performance prediction in natural, isolated groups. They demonstrate that such specificity in predicting success in group space missions will be a difficult and challenging task. We may do well to rely more upon data from other analogous settings (such as the Antarctic) in formulating our own selection criteria. If we assume that many of the qualities necessary to survive and maintain performance in space are similar to those required in the Antarctic, we can make great use of this type of assessment. There is some support for this from the taxonomic approach used by Sells (46).

Similar assessment studies have been conducted for personnel involved in submarine missions. Although usually of shorter duration than the year long wintering-over periods necessary in the Antarctic, much of this data could also be useful in formaulating our criteria of the individual best adapted to long-term space travel.

As all of these data point out, one issue at the individual

Table 5 from Gunderson in Rainwater

level may be selection criteria based on differential occupa-occupational categories. Beyond this there is still the issue of how to select individuals to form effective groups. If our emphasis is going to be shifted from individuals to groups we have to determine what qualities best determine group actions and how to best select and compose these groups. This is certainly a task much different from the individualistic orientation of the current NASA selection program. What approaches can we point to that may lead the direction in this new group irentation. If we assume, based on much of the social psychology literature, that similarities between individuals is a strong, attracting force in forming interpersonal relationships, our conclusion might be that we should select individuals as homogenous as possible. However, the support for this is not encouraging. Based on Antarctic research, it does appear that commonalities in interests and backgrounds do lead to pairings of individuals early in the wintering-over period, there is much stronger support for the notion that individuals similar at least in some traits such as dominance (42) or introversion (47) do not form satisfying and cohesive relationships and are associated with decreased levels of performance and increased problems of adaptability. It would appear that similarity per se is not an effective measure with which to form our crews. However, the related concept of compatibility demonstrates considerably more promise. Individuals said to be compatible may be either homogenous or heterogeneous depending upon the dimension being scaled. Thus, both the notion of similarity and complementarity can be brought into play depending on what factors are being assessed. While the importance of form-

ing compatible groups is emphasized time and time again in many areas of research related to long term space travel, disappointingly few studies have actually been conducted to measure such groups. In one experiment, Dunlap (48) confined a 4-man crew deliberately selected for compatibility for 12 days and later for 30 days in a space cabin simulator. No serious personal problems or conflicts were reported, but unfortunately no control groups data was available either.

Cowan and Strickland (49) reported data on two groups of six men isolated in a university penthouse building. One group was specifically selected for compatibility (loosely defined) and confined for six weeks. The other group underwent a 12-week confinement interval. The experiment was performed primarily to obtain nutritional data, but some psychological collaboration was involved. These researchers report that the compatible group had a demonstrably easier time during confinement than did the other group constituted without regard for compatibility. While these results are encouraging, the research design and assessment methodology leave much to be desired.

Certainly the most detailed and well executed studies on the topic of compatibility in isolation are those which have been conducted by Altman and Haythorn (50-54). Subjects were deliberately paired to form dyads varying in degrees of compatibility along dimensions for dogmatism, dominance, and needs for achievement and affiliation. Four of nine isolated dyads experienced difficulties during 10 days of observation, which in the case of two groups led to early termination. All four of these dyads were those composed to be incompatible. Of further interest to

our discussion is that none of the control dyads (pairs not experiencing isolation) even in the incompatible groups showed similar problems. These results clearly demonstrate that the necessity of interpersonal compatibility is dramatically increased under confined, isolated settings.

Despite the importance of these findings no new research in this area has been generated for the past fifteen years. The Russians (55) have reported on the success of a year long study of a compatible group in isolation, but no control group was involved and the exact measures and data unreported. It would seem that there is a strong need for further research of this kind. While Altman and Haythorn based their compatibility dimensions on studies and literature reviews of marital relationships, it should be possible to use factor analytic approaches to more precisely detail what dimensions of compatibility may be important in forming groups in isolation.

At least one other notable effort has been made to dimensions of personality best suited to group composition and work performance. Helmreich (56-59) and his associates have concentrated on the concepts of masculine/feminine traits and achievement motivation. His approach is decidedly different from that of Altman and Haythorn. While the latter have experimented with the formation of compatible groups based on the homogeneity/heterogeneity of individual personalities within the group, Helmreich has attempted to obtain a single cluster of personality factors advantageous to each individual and the group. There is certainly an advantage to any method which will allow us to assess each potential crew member according to the same set of norms or

criteria rather than selecting some individuals for certain traits that will be compatible (sometimes heterogeneous, sometimes homogeneous) with other group members. It substantially eases our task if all individuals can be selected on the basis of a common set of positive criteria. However, Helmreich is quick to note that other factors aside from androgyny will be important so we are still faced with the other issues of how compatible groups can be composed. Nevertheless, Helmreich's work is exciting and valuable and deserves further consideration.

Androgyny. Androgynous individuals can be defined as those that possess both masculine and feminine traits. Psychological masculinity being defined as that cluster of characteristics denoting instrumental, goal seeking orientation; femininity being defined by attributes reflecting psychological expressivity and sensitivity to the feelings and needs of others. Individuals of each sex possessing both instrumental and expressive traits appear to have more positive self-concepts, to be more interpersonally effective, and to establish more rewarding social interactions. Given our need to focus more extensively on the social needs and problems of mankind in space there appears to be considerable merit to Helmreich's approach. Further study of the Personal Attributes Questionnair constructed by Spence and Helmreich might prove valuable in the design of our selection procedures. Also work done by Sandra Bem (Bem Sex Role Inventory, 60) and others in the general area of sex role development may contribute to a better understanding of what individual traits can be useful in considering group formation.

Motivation. Hemreich has taken the concept of androgyny one

step further and investigated its relationship to achievement motivation. Using the Work and Family Orientation Questionnaire (WOFO, 57) Gelmreich isolated three motivational factors: Work Orientation, characterized by positive orientation toward work as a rewarding endeavor; Mastery, representing the desire to solve difficult problems and to better previous performance (a type of intrapersonal competitiveness); and Competitiveness, defined as a concern with bettering others performance and winning in interpersonal situations. In several populations studied, Helmreich found a positive correlation between productivity/success and high scores for Work and Mastery along with a negative correlation between productivity/success and Competitiveness. This was true for college students with high grades, businessmen with large annual incomes, and Ph.D.-holding scientists with frequently cited research publications (61).

The finding of a negative correlation between performance and Competitiveness brings up some important points. As Helmreich points out, highly competitive individuals may be overly concerned with the prospect of failure based on evaluation of themselves primarily in comparison to others rather than in terms of their own objective standards. It is easy to conclude that such an approach could be quite deterimental to the performance of groups. Such an orientation could interfere with optimal individual performance, substantially reduce group efforts, and most probably result in increased interpersonal stress and hostilities. This characteristic seems to predominate in the attitudes of many of the astonauts selected to date. We know for example that many of the astronauts appeared to fear failure almost more than death (62) and that com-

petition within the astronaut corp has been intense at times (44). While this has posed no problems during short term missions, the chances for difficulties during longer duration flights seem probable.

It appears then that the most successful individuals with respect to performance output are those with high Work and Mastery characteristics, but low Competitiveness. Interestingly, Helmreich's data suggest that androgynous individuals may be more likely to manifest this pattern of motives than those individuals high either in masculinity or femininity alone (they are more apt to be relatively high on all three dimensions). This adds another positive feature to the use of androgyny as an important concept in the selection of long duration space crews.

Compatibility research and the factors considered by Helmreich and associates deserve further attention. It is hoped that research on motivation and andronyny will be expanded to include populations in naturally occurring isolated environments. Should these factors prove to be predictive of success in these settings they could add substantially to our ability to select effective crews for long term space missions.

Selection for Women in Space

In discussing the complex issues of successfully composing effective groups for space travel the factors of heterogeneity and compatibility appear repeatedly. Certainly the advent of woment astronauts will add to the problems of group composition and heterogeneity. Almost no research exists in this area to allow us to formulated hypotheses as to the types of problems, if any, sexually mixed crews might generate. Certainly no data exists

which would lead us to assume that women cannot effectively adapt to the conditions of space. Indeed, there is some limited data to suggest that they may have some advantages over men. For example, the Russians report that women appear to adapt to weightlessness faster than men (63). Also, Helmreich found that in studies of the sexually mixed crews of Project Tektite II, a team of female aquanauts performed at superior levels to teams of male peers on some tasks (64). Women appear to be equal, or superior to, men on most dimensions thus far measured with respect to spaceflight. Studies of hypodynamia at Ames Research Center (65, 66) have indicated no problems among women in adapting to the simulated conditions of altered physiological processes in space. The Russians report similar findings with regard to sensory deprivation conditions, and other training regimes (63).

There do appear to be some data which raise the question of individual differences in the adaptability of women to the demanding tasks and schedules of spaceflight. These issues revolve around the influence of the menstrual cycle on female behavior and performance. While the extent and direction of bodily activity is not entirely agreed upon by investigators there is considerable evidence that significant changes do occur beyong those which produce the menstrual cycle. These include blood pressure, metabolic rate, pulse rate, body temperature, and body weight (67). It is unclear at present whether any of these changes pose potential difficulties to women in space. The probability is that they do not, but given our relative lack of understanding about the long term effects of weightlessness (see Biomedical Chapter) on human physiology there is room for at least a cautious note of

concern.

Psychologically there appear to be changes in the psychosomatic condition of at least some women. For example, Altmann, Knowles, and Bull (68) found that the premenstrual phase was accompanied by irritability and tension among women studied. It has has been observed that anti-social activity occurs more frequently during the menstruum and pre-menstruum. For example, several investigators have shown that suicide frequency increases (69), the incidence of crime rises (70), and the number of individual cases of kleptomania goes up (71, 72). In one study Schwarz (73) found poorer overall adjustment, greater emotional lability and egocentricity, loss of consideration for others and a decrease in the capacity for planning, organization, and integration among 100 young women.

In terms of performance output the results are somewhat contradictory. Some investigators have found decreases in industrial performance (74), reduced proficiency on academic examinations (75), lowered athletic prowess (76, 77), and declines in simple motor coordination tasks (78) concomittant with the menstruum and/or pre-menstruum. Also increases in the incidence of accident during these phases has been reported (79). Other investigators have observed no difference or actual increases in performance (80, 81) during these periods, so the results remain contradictory. This appears to be tied to the demands of the task and the degree to which motivation can compensate for the tendency toward decline. The overall conclusion to be drawn from this literature is that if significant decrements in performance occur they are most likely to happen when subjects are working at or

close to the limits of their capacity.

At least some of the difficulties associated with the menstrual cycle are linked with the concept of pre-menstrual tension (PMT). It is difficult to estimate the incidence of PMT because of variance in definitions and questions regarding the point where simple physiological responses evolve into pathologic processes. However, Fluhman (82) suggests that 60% of all normally menstruating women experience mild to severe symptoms. Limb (83) observed symptoms in 73% of 127 student nurses tested while Rees (84) found symptoms in 40% of those tested (with 15.6% considered severe). These figures are high enough to warrant some concern about what behavioral effects the menstrual cycle may have upon women in space.

Overall, there is evidence to suggest that the menstrual cycle may pose a problem to some women under spaceflight conditions particularly during periods where high task demand and intragroup cohesion and interaction are critical factors. However, there is considerable variability in the influence of the menstrual cycle across the female population. In all liklihood those women who are significantly debilitated before or during menstruation would selectively choose not to apply for space duty in any event. Among those who do apply it may be important to assess the degree to which personality and performance may be affected by menstruation. In such cases where the potential for problems exists, the use of chemical agents to alter the course of the cycle may be desirable. For example, many women report fewer problems with menstrual symptoms when regularly using birth control pills. However, it should be noted that many women suffer un-

pleasant side effects when using the pill and recent evidence indicates there is a potential health hazard to long term users. This also again brings up the issue of what effect drug-long term weightlessness interactions may produce.

The point of this discussion is not to suggest that the activity of women in space should in any way be restricted, but rather to point out that consideration for the health and safety of all crew members is a necessity. Any factor which might be a potential deterrant to the optimal performance of individuals and crews as a group should and must be subject to research and planning. It is conceivable that within the overall conglomerate of selection criteria the influence of menstruation upon behavior may be important to consider.

Most likely the issue of women in space will not revolve around their individual adaptation to the demands of flight, but rather will be one point in the complex of factors involved in group interaction. For example, one could conceive of problems occurring due to the presence of crew members of either sex who possess strong prejudices about the appropriate roles and/or capacities of the sexes. There are unfortunate reports recently within the military that sexually mixed groups have been subject to abuses of power. Experiments with mixed sex groups in the military academias and at duty sites have found some incidence of conflict, particularly around male officers attempting to manipulate more junior female personnel into sexual favors. The current incidence of court hearings regarding these problems involving employers and employees in the business world give evidence that this is not a problem restricted to the military. Since little,

if any, research exists on sexually mixed crews under long term, potentially hazardous conditions it is difficult to predict the extent to which similar problems might occur in space. However, there is no question but what it would be advantageous to select crew members of both sexes who are flexible and tolerant in their attitudes and responses toward members of the opposite sex.

There are certainly a host of important research questions that remain unanswered in this area: What are the effects of a female leadership command upon male compliance? Do American stereotyped images of men and women become more predominant during emergencies (for example, will men take unnecessarily dangerous action to save female personnel in times of crises)? Do social cliches involving separate sexes result during long term confinement? Few, if any, of these questions have been adequately addressed, but all could certainly be important to the successful completion of space missions. It is hoped that data useful to these and other questions will be generated by the forthcoming Space Shuttle flights although they are of considerably shorter duration than the mission lengths generally being addressed in this volume.

Mixed Nationality Crews

Another factor adding to the complexity of selecting compatible, heterogeneous groups for long term space flight is the issue of multi-nationality selection. As we move toward an era of international cooperation in space the need to select and form crews using individuals from different countries will become an issue.

Certainly we can predict some problems in this process. One of these is the issue of language. This appeared to be the single

most constraining problem for the members of the joint American-Soviet flights of the 1970's. While no serious problems were reported, it is conceivable that in times of emergency there would be a tendency to revert to using one's native language thus enhancing communication problems under already stressful conditions. Also, despite the use of a common language or the inter-mixing of languages by bilingual crews there could be problems due to accents and/or regional dialects. Certainly within the English language there are subtleties of intonation, inflection, context, meaining, and interpretation which can influence the degree of communication and understanding among its users. As we increase the number of personnel with varying language backgrounds the possibility of communication difficulties may increase as well. It will be important in the design of the craft for multi-nationality crews to ensure superior communication systems, both formal and informal. It may also prove useful to code much of the instrumentation and equipment with international symbols or at least with symbols whose meaning have previously been agreed upon by all crew.

With regard to social interactions there may be important differences to consider. For example, are the leisure time activity preferences of individuals from different cultural backgrounds significantly different? Will diet and food preferences be a problem (snails may be a welcome delicacy for French crew members, but a dietary liability for Americans!) and if so what kind of menu acceptable to all crew members will need to be designed? These questions might entail researching the normal cultural patterns of countries represented as well as the individual preferences of crew members on board (not all French personnel may like snails

and certainly some Americans do find them tasty). The question of social cliches again emerges along with the possible questions of inter-nationality disputes and alliances. Also, to what degree will agency politics and secrecy be an issue? Such questions as attitudes toward female crew members, acceptance of command structure, role of scientists versus pilots of differing nationalities, and the entire area of legal structures and questions have yet to be addressed.

We are also faced with the question of cultural differences in the type of individual that might be considered appropriate for space missions. Americans have relied upon the image of assertive, competitive, pioneer types as appropriate for the early conquest of space. Would we be as likely to specify these features in selecting individuals from Japan, for example, where at least Westerners have the stereotype that great emphasis is placed on decorum, mild manneredness, and emotional control within the population? Indeed, will we even want to try to specify a common set of characteristics desirable and mandatory across all cultures involved? If so, one problem we will certainly face is the issue of measurement instruments. Those test procedures routinely used for American astronaut screening and selection may be (and probably are) totally inappropriate and invalid when used in different cultures (even when translated into the appropriate language). The issue of culture fair tests will be discussed further in an upcoming section.

We are agin faced with an enormously complex issue for which little if any research is available. There do seem to be some interesting prospects however. The mixed-nationality crews of the

large oil supertankers which service so many world ports could provide useful sociometric data on crew interactions and problems as a function of cultural background. Also, the increasing influence of the European Space Agency and the possibility of mixed nationality crews on-board the Space Shuttle is an exciting idea and a postentially profitable source of data on this issue. It is hoped that international space efforts will be established and that persuant with this goal research will be launched to address the many issues involved in such a multi-nation effort.

Comments on Components of Crew Composition

It is clear from the preceding discussion that the question of how to select effective crews for long-term missions is complex and riddled with uncertainties. Issues of compatibility, sex, and nationality appear to be among the greatest questions to be considered. Now that we have established some of the dimensions important in the selection of individuals and groups it is important to consider what selection procedures are currently available to us and what the abilities and limitations of these techniques may be for the purposes of selecting and composing effective groups in space. That is the intent of the following sections.

## ASSESSMENT TECHNIQUES FOR CREW SELECTION

As discussed in a previous section, our approach to the psychosocial selection of astronauts to date has revolved around the use of extensive psychological test batteries. Psychiatric interviews have also been included in the screening procedure with interviewers rating each candidate on 17 dimensions including "drive", "dependency", "social relationships", "identity", etc.

Referring back to Table 1, a listing is shown of those tests included in the screening battery. The tests can be roughly divided into those measuring cognitive abilities (e.g., Wechsler, Doppelt, etc.) and those measuring various dimensions of personality and psychosocial effectiveness (MMPI, Rorschach, TAT, etc.). Several important points can be made regarding the intents and usefulness of these measures.

First, all of the personality indicators used are most frequently employed in the clinical setting to detect and quantify psychopathology. The emphasis is away from the measurement of "normalcy" and strongly concentrated on psychological deficiencies. Indded, the interpretative usefulness of data from "normals" is questionnable (85). In effect, these tests are not desinged to generate maximally useful data among psychologically healthy individuals as is the case with most of the astronauts applicants to date. While they may be useful in selecting "out" those candidates who are truly inappropriate, their merit in distinguishing among the remaining non-psychopathological applicants may be poor. Unfortunately, even the heavy loading toward identifying and classifying those who should not be selected has not been impressively effective. For example, in Hartman and McNee's (33) multivariate analysis of candidates selected and not selected for the Mercury and Gemini/Apollo Programs the best linear discriminant classification of loading factors yielded a 19% error rate. While this is not a terribly porr misclassification rate, the direction of the errors is significant. While only 1 of the 23 not selected Apollo candidates was misclassified, 5 of the 9 selected applicants (or over 50%) were misclassified. This does not necessarily mean that those candidates inappropriately se-

lected according to the linear discriminate analysis possessed pathological behaviors and should not have been included. Rather it points to the limitations in using these various measures of abnormal behavior to make quantitative distinctions among otherwise normal, healthy individuals. One must also consider that so many other factors were considered in selection besides the psychological ratings that the actual ability of the tests to reliably pick the most qualified candidates (psychologically) was not completely optimal.

These findings should not be taken to mean that the tests employed are not important and should not be included. It does indicate that these tests are maximally effective when dealing with unhealthy individuals and much less so with the superior type of candidate with which we usually deal. Thus, the tests can be very helpful in screening out obviously inappropriate candidates from among the total pool, but give us less help in selecting "in" those candidates from within a superior group who are indeed the best suited for long term group crew duty.

We also must be aware of the limitations of these tests even under the best of conditions when considering their overall reliability and validity (86). The projective tests have been demonstrated to be particularly suspect in this respect and must be used with caution by only the most extensively trained interpreters.

We are faced with other problems in the use of these tests. Certainly in the case of the Wechsler (if not others) the question of cultural bias can be raised as an issue (87). As we begin to recruit minority members for space duty will we face the kind of

interpretive difficulties which have plagued school boards and affirmative action employers who routinely use I.Q. tests with non-white, middle class populations?

On a larger scale the problem of cultural bias in testing will pose immense problems when international cooperative space missions become a reality. It will not be possible to apply the same psychological test system to all the applicants from all the nations participating. Instead new indices will have to be developed and employed on a country by country basis. This is already being instigated for the Space Shuttle Program. For example, the German translation of Cattell's 16-PF Test failed to be helpful in the selection of pilot applications for a civil aviation company. So a new multidimensional personality test was constructed by Kirsch (88) which has proved to be highly reliable over the past several years.

What this indicates is that we are faced with the task of developing a catalogue of psychological requirements which can be employed cross-culturally in candidate selection. We will have to specify a broad range of factors to be used for selecting in candidates and allow each country to develop their own instruments to accomplish this end. This will not be an easy task given our own relative lack of ability to select in, rather than selecting out, candidates.

Given that we must make use of those instruments available to us (and to develop and employ new measures such as Helmreich's Life History Questionnaire to predict work productivity, his Personal Attributes Questionnaire to measure androgyny, and his Work and Family Orientation Questionnaire to measure motivational

characteristics) what other methods might we use for selecting in candidates? One technique which has been used in other circumstances is peer nomination.

Peer Nomination

One method for making final selections and group composition might involve peer nominations. This technique has proven to be very reliable for obtaining performance criterion information in the Antarctic and might prove useful for personnel selection in space.

Table 6 gives a listing of peer nomination items used by Gunderson (38). Item 10 of this instrument proved to be particularly useful and had a very high multiple correlation with three other components measured independently (task, emotion, and social effectiveness). This item seems to represent general effectiveness quite well. This particular test procedure has been used for over 10 years now and has proven to be a useful source of performance measurement.

The peer nomination procedure has also been used in selection and group composition procedures for submarine missions involving small crews. Weybrew (89) used such a method as part of a larger procedure to match officer and enlisted study groups for two- to four-man crews. The procedure proved to work rather well in producing optimally functioning, cohesive groups.

There are several criticisms, however, which have been levelled at this procedure. One possibility is that it merely represents a "popularity contest". The influence of friendships in swaying the judgements of individuals could be a problem in ensuring that the truly most effective persons are selected. How-

ever, at least Gunderson's data suggest this is not the case. His analysis of peer nomination data specifically excludes choices given to friends (based on answers to item 5). Also, because of differences in station size and therefore the maximum number of nominations that could be received, the choices an individual received were expressed as percentage of total nominations received by station members. Interestingly, when the anslysis was also done by including choices given to friends there was no significant differences in the data anyhow. This suggests that individuals, at least in this particular population, were able to make objective judgements relatively uninfluenced by personal alliances.

A principal problem Gunderson addresses in the use of peer nominations is that of acceptability to group members. Siple (90) has criticized the use of "buddy ratings" as disruptive of morale at the South Pole. Other observers also have felt that the peer nomination method is too personal and too threatening to personnel. Gunderson found few problems with its use in his studies. Relatively few station members have refused to provide nominations. While these findings are encouraging, this problem has been reported within our own astronaut corp where peer nominations have been used in the past (91, 92). It has been reported that peer nominations are looked upon as meaningless and have been conducted with complaints (62). It may be difficult to fully use such a procedure within a group of highly trained, highly dedicated individuals without the procedure being too threatening.

Another difficulty with the procedure is its questionnable use with newly formed pools of applicants. As Haythorn (93) points out, if the individuals know each other very well the pro-

cedure works better than any other we have now have available to compose effective groups. But its use in situations (such as our initial astronaut selection screening phases) where individuals who do not know each other well are brought together for brief periods and then asked to mutually choose each other seems unreliable.

On the other hand, Weybrew (89) has reported successful outcomes from unpublished data involving an unusual variation of the peer nomination procedure with totally unacquainted crewmen. Prior to launching of the Nautilus, 23 men volunteering for the mission, were asked to rank order passport-size, face-on photographs of the remaining 22 men to be onboard prior to becoming acquainted. They were to rate the liklihood that they would become friendly during the two months of confinement in the sealed submarine. Weybrew reports that there was a strong and surprising corresponsdence between the rand ordering of the photos and the peer preferences measured at the end of the mission.

Despite these results the use of peer nominations during the initial screening phases probably will not be useful in astronaut selection. It does appear that such a procedure could prove helpful though in making the final selections and actually composing the groups which will enter space for long term group missions. Even then there is the problem of transitivity. As Haythorn (93) points out, if you find that person A chooses B and B chooses C, there is always the possibility and problem that C will reject A.

Some of those problems may be minimized however if the members of the available pool have considerable knowledge of and interaction with the other members of the pool prior to group as-

signment (as has been the case with the astronaut corp in the past). This technique certainly warrants consideration and deserves further research to validate more completely what exactly are the advantages and limitations.

Training as Selection

The potential use of the peer nomination technique brings up and important point regarding the various phases of the selection program. Traditionally, distinct phases of selection and subsequent training have been conducted rather independently. In the case of long term mission selection procedures it may prove useful to formulate a more interactive approach to these areas of mission preparation. That is, training could be used as a more direct approach to the question of selection at least on a mission by mission basis. The selection of an astronaut should not be complete once training begins, but rather viewed as an initial step with the actual training considered to be an ongoing selection process in depth. By continuing to assess performance throughout the training period we could generate a considerably more comprehensive picture of each individual than that afforded by the several hours of testing employed in the initial screening tests. Despite the competence of those who passed high on the initial psychological screening tests, everyone has a breaking point. We are much more likely to gain an accurate estimate of this point by assessing the individual throughout the rigors of a strenous training program. What better way, for example, to observe and measure the social abilities, intra-team conflicts and cohesiveness, as well as the range of the individual to handle mergency problems than by assessing these factors during the actual training for

flight. Under these conditions it would seem that peer nominations would be a very valuable tool in the formation of groups, plus we would have a strong baseline of sociometric data with which to assess the later effects of extended spaceflight conditions upon the finally selected group and its individuals. By observing different combinations of individuals attempting to solve problems and maintain performance under the stresses of training we would have a ready made laboratory for making judgements as to which individuals seem to work best together and which have the potential to remain effective during long term flight.

If behavioral scientists could be included in this process it would also establish a desirable link between crew and ground control during training that could prove helpful should any problems of a spychological nature occur during the mission. As discussed in the Crisis Chapter, there will be a need for an on-call therapist to be available for telecommunication contact with crew members in the event that any psychosocial problems do occur in flight. What better way to establish the necessary rapport than to involve the behavioral scientists/clinicians with the crew during the course of training. The approach has been strongly advocated by many psychologists and psychiatrists involved in the early stages of the Manned Space Program (85).

Situational Testing

One technique which could be used both during the initial screening period and during later training pases is situational testing. This procedure could serve as a valuable link between the concept of training as selection and the more traditional approach of pencil and paper test battery assessment. Actually,

situational testing encompasses a wide range of possible techniques which could be a welcome addition to our current selection procedures. Some of these possiblities are outlined below.

The advent of situational testing is usually traced to the development of the Office of Strategic Services (OSS, 94, 95) which was responsible for the selection of intelligence agents during the 1940's. While the exact content of the program varied slightly across a several year period the core program involved a several day intensive psychological assessment of individuals in groups of 18. Included in the program were a number of standard psychological tests, and extensive life history questionnaire and interview, and a number of ingenious tasks employed to permit observation and quantification of the person's overall capabilities from a more holistic, practical perspective htan otherwise permitted by the other previously mentioned instruments. One of the better known of the situational tests was the Brook Test.

Brook test. In this situation a group os six candidates was taken to a shallow brook (explained to be a raging, deep river) whose bands were eight feet apart. On one bank was a heavy rock (assigned to be a box of percussion caps), on the other a log (assigned to be a delicate range finder). There were trees along both bands and a number of short boards, three lengths of rope, a pulley, and a barrel with both ends knocked out on the side of the river where the candidates began. Their task in this situation was to transport the range finder (log) to the far bank and to bring the caps (rock) back to the starting side along with all personnel and any material used.

This particular situational test provides a good example of

the conditions important to these type of tests in general. First, it is a leaderless group. It would be particularly easy to determine how the group could quickly form who would be the leader(s), and to distinguish between asserted and effective leadership. It vertainly provides plenty of opporunity to gather sociometric data regarding the interactions and coordination of the various individuals within the group. Also, it would provide the opportunity to rate candidates on such variables as energy and initiative, effective intelligence, social relations, and physical ability.

Another point about this particular situation was the time constraint. Given that everyone felt pressured to complete the task as rapidly as possible how would different individuals perform under stress? What effect would the time parameter have on the group's performance and that of individuals?

Several of these leaderless conditions were employed by the OSS. Even something as simple as a leaderless group discussion proved to be useful in assessing leadership, effective intelligence, energy and initiative, social relations, etc.

Construction test. To further measure resistance to stress and frustration tolerance an innovative test known as the Construction Test was devised. Here the candidate was required to direct the work of two helpers (role playing assessment staff members) in constructing a five- foot cube structure from a huge "tinker-toy" set of materials within a 10 minute interval. All of the work had to be done by Kippy (passive, sluggish, and something of a stuvblebum) and Buster (aggressive, critical, constantly making impractical suggestions) the role playing assessment team members

under the supervision of the candidate. In the history of the program, no one ever completed the task in the alloted time. Most applicants became so involved and so frustrated they had difficulty handling the situation and their anger. A few physically attacked their helpers, and some asked to be relieved from the program after this exercise.

Many of the characteristics measured in these situations are certainly ones we would consider necessary to assess for long term spaceflight crew members. Indeed it is not difficult to imagine that these situations could be altered to more closely simulate events which might occur in-flight and thereby provide some dynamic observations as to how potential crew members might deal with certain emergenices, problem solving dilemas, or delicate social matters. Some of this idea was even partially employed during our original astronaut selection program. There were certain psychological tasks (such as the mechanical reaction time box or the requirement that each candidate immerse his hand in ice water) and physiological procedures (load tests, etc) which served the purpose of giving investigators first hand information on the stress and frustration tolerance of the candidates (43). This approach could be significantly expanded to provide more extensive observation of how candidates respond under conditions simulating those perhaps likely to occur in space.

There was one other task employed in the original astronaut selection procedure that deserves mention at this point. It could serve the as the foundation for a type of situational test. This was the snesory deprivation experiment (34). Originally there was some concern by scientists that weightlessness might produce

a type of reduce sensory input leading to the types of symptoms well validated in laboratory experiments of extreme sensory and perceptual deprivation. Astronaut candidates were therefore exposed to a sensory deprivation condition to assess their tolerance to such a condition if it did occur in space. While basically a very good idea they were only exposed for three hours. Most studies (96) indicate that a critical period is more like three or four days. Not only was the period used far too brief to observe any crucial adaptation problems but most of the men were so worn down from a hectic week of day night testing that this three hours came as a welcomed relief.

Given that many of the symptoms which occur during long wintering-over periods in the Antarctic (perhaps analogous to many of the conditions expected for long term space travel) have proved to be similar in some ways to those seen in subjects exposed to laboratory sensory deprivation conditions it seems fruitful (if not essentail) to include a test of sensory deprivation tolerance in our selection procedure. Perhaps it could be worked into a group procedure further permitting the assessment of social relations like those permitted by other situational tests.

Assessment Center Methodology

Since the use of situational testing by the OSS, this procedure, combined with more traditional approaches to assessment, has formed the core of an ever growing global methodology generically known as assessment center methodology. First adapted for use in American industry as an aid to the line organization in the selection of high-potential employees by American Telephone and Telegraph Company in the 1950's, it has expanded to nearly all situa-

tions in which assessment procedures are necessary to identify an individual's strengths and development needs. While it is heavily employed by business to aid in the evaluation of potential candidates for various types and levels of supervisory and management positions it has also been used in many other contexts. For example, by 1976 five colleges and universities, including the Graduate School of Business at Stanford University, were using the assessment center method as part of their regular curriculum. Within government, the Federal Aeronautics Adminstration, the United States Air Force and Army, the Internal Revenue Service, and the Civil Service Administration for the Office of Management and the Budget have all used this approach to assess various level of personnel. Seferal reports have been issued which indicate that the data generated from this approach has solid validity (97-99) and can be conducted with good reliability. Let us briefly discuss some of the defining features of the assessment center approach.

The first, and certainly a crucial factor, in the use of this method is a clear and concise analysis of the relevant job behaviors to be analyzed. This may be accomplished through specific preparatory research (perhaps using factor analysis techniques) or through collaborative negotiations between assessment center staff and the administration of the organization employing the services.

Next, there is a heavy emphasis on multiple assessment of the candidates. At least one (but usually more) of the techniques used must involve a simulation. Situation tests may include group exercies, in-basket exercies, and fact-finding exercies (to be discussed in a following section). Other techniques may

include pencil-and-paper test batteries, interviews, questionnaires, etc.

One important point is the use of multiple assessors. Throughout the test period, particularly during situational testing, several trained assessors observe and rate according to objective behavioral categories the dimensions of behavior considered important based on the job analysis previously determined. Also, judgements resulting in an evaluative outcome at the conclusion of testing is based on pooling information from assessors and techniques. An overall evaluation of behavior is made by assessors at a separate time from observation of behavior and one single report is generated which represents an agreement among assessors on the relevant findings and their interpretation. This is an important feature. The most reliable and valid index of performance offered by assessment center methodology is this overall evaluative score.

Finally, the center also provides feedback to the candidates (where desirable and appropriate) and management as to the data generated. These sessions can be used for generating new personnel approaches to compensate and enhance employee performance and to give the applicant direct feedback regarding their strengths and areas of needed improvement.

Overall, there are some positive analogies between this approach and that used in our astronaut selection to date. There has always been an emphasis on using multiple assessment techniques (e.g., test batteries, interviews, stress testing, etc.). Here it would seem that the inclusion of more situational testing would strengthen the approach, particularly given the increasing

need to measure social factors. We have made use of multiple assessors and single overall evaulation reports and ratings (indeed, our most valide measure of performance proved to be the overall evaluation score (33)). It would seem that the current approach is a solid one if we expand the selection rpocedure to include more simulation tests and more emphasis on social factors. It might prove useful to model our own selection procedure after that of the assessment center methodology. Few changes would need to be made and we would be able to directly tap into the data available from other selections to increase our own validity and reliability. Since the assessment center methodology makes heavy use of situational testing, let us return to this topic once more and detail some of the techniques which have developed since the days of OSS.

In-basket exercises. This task involves providing the candidate with selected background material and references and a package of problems which have built-in priorities, relationships, and required decision making. A specified amount of time is allowed for the assessee to work on the problems during which they are observed and rated. The actual written material produced can be later analyzed on a number of dimensions such as organization and planning, decisiveness, use of delegation, etc. to yield measures of performance (100). Such a test could easily be modified for use in astronaut selection where important command decisions must be dealt with effectively.

Group exercises. These tasks often involve a leaderless situation (similar to those used by the OSS). Two tasks in particular seem relevant to the assessment of astronauts. In one si-

tuation a group of candidates are given an ambiguous situation and asked to discuss its ramifications. They they must generate specific solutions and approaches to coping with the problem. This test can be a good measure of group problem solving ability. It also permits assessors to examine creativity, social tact, cooperativeness, etc. A similar situational task can be arranged to examine behavior in a competitive situation. A group can be formed where the task requires the individuals to compete against each other toward some perspective goal. The use of the cooperative and the competitive conditions could be especially enlightening for astronaut selection as it would permit assessment of individual motivation and drive for achievement as well as the person's ability to subordinate to the needs and goals of the group.

Comments on Selection Procedures

The preceding sections have outlined some of the strengths and weaknesses of the assessment procedure and the assessment instruments currently used for astronaut selection. Those points discussed with regard to assessment center methodology provide an ideal outline for future assessment of crews destined for long term missions: 1) define job related dimensions of behavior to be assessed (this might proceed from a consideration of traits necessary to the individual and traits necessary to the group), 2) employ multiple assessment (this would include pencil-and-paper test batteries, stress tests, exposure to sensory deprivation, training as selection, situational testing, etc.), 3) employ multiple assessors using objective behavioral rating scales, and 4) issue an overall report and rating which represents the input of all testing personnel involved. We have a solid assessment pro-

cedure established from previous astronaut selection programs. Now our task appears to be one of expanding and modifying that procedure to more thoroughly investigate individuals from a group perspective and with an emphasis on the necessary traits compatible with long term missions.

## Training Procedures

One purpose of careful candidate selection is to minimize the training requirements. However, the tremendous complexities involved in space flight and the continuing improvements in engineering hardware and scientific procedures make the task of training even the highly selected astronaut a formidable one. One way to approach the task of developing any training program i. to first determine what job related behaviors and abilities will be required. Voas (101) has outlined these requirements for the astronaut program as demanded by Project Mercury (although this analysis seems equally appropriate for the later U. S. missions flown): 1) "programming" or monitorying the sequence of vehicle operations during launch, orbit, and reentry; 2) systems mangaement, the monitoring and operation of the onboard systems such as the environmental control, the electrical system, the communications systems, and so forth; 3) the vehicle attitude control, 4) navigation; 5) communications; 6) research and evaluation. Based on these requirment astronaut training programs have revolved around the following areas of learning and skill maintenance: 1) vehicle operation; 2) knowledge of space sciences; 3) familiarization with space flight conditions; 4) ground activities; and 5) maintenance of flights skills and athletic condi-

tion.

While these areas of training will probably continue to be important for future long term flights, it is also important that we reexamine and expand our analysis of the job requirements and necessary training procedures involved in longer duration missions. None of the above descriptions outlined by Voas include any mention of the psychological demands of long term isolation and confinement or the problems of constrained social interactions. The missions demands and training requirements which evolve from this aspect of space are the point of this section of the chapter.

Some of the other important issues related to training needs can be found in several other chapters (e.g., countermeasures related to biomedical factors are discussed in the Biomedical Chapter, stress and fear training issues in the Performance and Crisis Management sections, rotational leadership and need for leadership training in the Organization and Management Chapter). Here we deal with some of the advantages and disadvantages of the current astronaut training program and the areas needing expansion to help crews to effectively deal with the psychosocial dimension of space travel.

Group Social Awareness Training

As pointed out learlier in this chapter, the need for group compatibility may prove to be critical issue in the survival and operation of crews in space. One suggestion which has been offered by investigators (102, 103) to help illuminate various dimensions of incompatibility prior to flight is the use of sensitivity training. Such a technique was used by Dunlap (48) prior to an investigation of a four-man crew of college students to be

confined in the Douglas Space Cabin Simulator. Dunlap states that sensitivity training "accelerated the acquaintanceship process, exposed potential sources of interpersonal friction, provided understanding of interpersonal problems, and imparted techniques for controlling frictions that do arise." While there does appear to be a need for some type of vehicle by which to help crews deal with group interactional processes in space we must question whether sensitivity training is the best of mechanisms available and what exactly would be the role of sensitivity training. There seem to be at least two potential directions one might take in using sensitivity training. One would be to expose the potential problems of incompatibility within a group for use as important information in the selection of group members. Another would be its use in ironing out antagonisms prior to flight, sensitizing individuals to potentially hazardous areas of interaction, and otherwise accelerating the familiarization process prior to the mission. While each of these intents seem reasonable there are several potential problems in using sensitivity training to accomplish these goals. First, we know from previous laboratory research that one of the phenomena which occur during confined isolation is a greatly increased acquaintanceship process (50, 104). The overexposure of individuals clearly leads to the revelation of more personal information and greater depth of intimate communication. Even in as short a time as 10 days, isolated dyad members have revealed personal information at an intimacy level approximating what they had revealed to their best friends. This rapid acquaintanceship leads to the telling of favority stories, displays of personal idiosyncracies, and the

revelation of personal information to the point of boredom and irritation. There, we must question whether speeding up this process even further prior to an actual mission is desirable. Perhaps within the constraints of a safe, therapeudic atmosphere coping with this process before hand will decrease irritations during missions. On the other hand, would such a process merely add to the otherwise complicated and annoying problems of overexposure and boredom during the actual mission? Dunlap found the technique to be helpful prior to mission lengths of 3, 12, 18, and 30 days, but these are relatively short periods and the findings may not be entirely relevant to missions of much greater length. On the other hand, these confinement periods are comparable to those used in laboratory studies of isolation in which the acquaintanceship process has been shown to rapidly increase. There is simply not sufficient data to fully answer the question at this time. Further research should be directed at this issue.

At least one other question regarding the use of sensitivity training has been raised. Back (105) points out that the current astronauts place very heavy emphasis on being professional and upon the work requirements of missions. We also know from studies of groups under isolated conditions that meaningful work is a primary factor in mitigating some of the stresses of the situation (105). Back feels that sensitivity training might actually be detrimental because it would detract from an emphasis on the work roles of crew members. As he points out, astronauts currently do not volunteer to find friends or to have a group experience, and emphasizing this aspect may make them less able to structure relationships in terms of their work.

While the role of work has certainly been (and will be) a fundamental aspect of space flight missions, future astronauts may need to be selected for prowess in social abilities. While work is important, disruption and antagonism within the group could certainly be detrimental to performance. Rohrer (106) has observed that social ostracism in the Antarctic sometimes results in the "long eye" characterized by long periods of inactivity or aimless repetition of simple tasks. It appears that in these conditions unfavorable group rapport has more of a demoralizing effect on work than the ability of work to compensate for strained social relations. Still, Back's point is an interesting one that deserves research and consideration.

The issue of sensitivity training for space crews seems to be in need of further research before its role and usefulness can be fully detailed. It does seem that it could be a useful selection technique to aid in composing groups, but whether it is also of value in increasing group compatibility and cohesiveness, decreasing individual hostilities, and enhancing the group process in-flight remains to be seen.

It is our position that some sort of group social awareness training would be a useful feature of future training programs. However, the emphasis would be placed on better learning to deal with the personalities of individuals, coping with group discension, and otherwise becoming a more socially aware and tolerant team member. This would not necessarily involve an increased acquaintanceship process or the need for individuals to drudge up personal deficits and painful experiences as a means for other group members to better understand the personal needs and desires

of the individual.

One other possibility that deserves attention is the potential use of Gestalt therapy as part of training. One of the most requently reported dings in the study of silated groups in the Antarctic is the rise in psychosomatid disorders which occur (107). Chief among these seems to be migraine headaches, and muscular soreness. Weybrew (108) reported similar problems for men aboard the 83-day USS Triton moyage. An average of about 25 percent of the men on any given day had headaches of an undetermined origin. These findings are probably related to the increased constraints of social interactions. Because the members of most groups quickly learn not to alienate one another, it is common for irritation, hostility, and anger to be internalized rather than overtly expressed. Gestalt therapy L109) has proved to be a particularly effective psychotherapeudic approach for dealing with anger and its expression. Perhaps exposure to this type of technique during training would be helpful for crew members when later problems of internalized antagonism may occur. It is clear that some type of outlet is needed to permit the ventilation of accumulated annoyances. This and other vehicles (access to psychotherapist via communications sytems, training in stress reduction, etc.) should be explored further.

Group Training

One large issue yet to be dealt with is the degree of group socialization optimal prior to long term missions. How well and how closely should crews know each other prior to flying together during a long duration flight? This harkens back to the question addressed in the previous section on the possible advantages and

disadvantages of sensitivity and/or group social awareness training. Clearly, there are advantages to having crews be very familiar with each other and able to function as a cohesive group prior to the mission. Such an approach would permit us to observe the group and better determine whether individual conflicts might occur and to deal with these prior to the mission. Hopefully, it would also promote a group espirit de corp helpful in sustaining motivation. We might also expect that greater familarization might enhance greater tolerance.

On the other hand, overexposure of individuals prior to flight may add to in-flight monotony and potentially reduced social interaction. There are few, if any, instances in the literature where groups have been formed and working closely together for long periods before being exposed to long term isolation. What effect does prior group formation and cohesion have upon behavior in isolation and how in turn does isolation affect the behavior of laready well familarized individuals? Does the positive effect of previously achieved group cohesion minimize the problems of the greatly increased acquaintanceship process ordinarily observed in isolation or does it contribute to the problems of boredom and monotony? Such questions are important with respect to the training of crews for long term missions. In the past, a considerable amount of astronaut training has not occurred as a group. The astronaut's individual schedules have often been so diverse that the only point of regular contact during the week is a special astronaut corp meeting (44). Even then, many astronauts have been unable to attend because of otherwise pressing demands. Looking toward longer flights should a greater emphasis be placed on group

training throughout the program or should training proceed as in the past except for a very intense period of group training just prior to the mission? Such fundamental questions will have to be addressed before the exact nature and scheduling of training can be defined.

Problem Solving

One characteristic of astronauts which is and will continue to be an important is a well developed problem solving skill. One feature we have discussed as being an important facet to identify duirng selection is this ability. Individual problem soling can take place on several levels, some easier to acquire or train than others. For exmple, mechanical solutions can be achieved by trial and error or by a rolte set of rules. Solutions can also be ottained by understanding principles involving a higher level of thinking. Here two phases are employed: 1) discovering general properties of a correct solution; and 2) generating functional solutions (110). A third type of problem solving ability has been referred to as insight. This is said to occur when an answer suddenly appears after a period of unsuccessful thought. Each of these three approaches to problem solving may involve various types of thinking: 1) inductive (going from specific facts or observations to general principles); 2) deductive (going from general principles to specific situations); 3) logical (proceeding from given information to new conclusions on the basis of explicit rules); or 4) illogical (intuitive, associative, or personal). The one area that ties together all of these concepts is the study of creative thinking (111). Creativity involves all these styles of thought (in varying combinations) plus fluency (the to-

tal range of thought), flexibility (the degree of ability to shift solution sets), and originality (the ability to generate novel or unusal ideas).

Several tests have been devised to measure creativity including the Unusual Uses Test (where a person must describe as many possible uses for an object as possible), the Consequences Test (where a hypothetical condition is stated and the individual must list as many reactions as possible), and the Anagrams Test (where subjects are given a word and asked to make as many new words as possible by rearrnaging the letters). These tests vary in their validity and reliability but do offer so objective inference as to the degree of creative thinking a person possesses. It might prove useful to include some combination of these tests in the astronaut eandidate test battery. A strong problem solving ability will certainly be an asset to those involved in long duration missions where the probability of problems occurring is much greater.

Specific training the techniques of individual problem solving could be useful too. Attention could be focused on some of the more common reasons for thinking errors: 1) inadequate information; 2) rigid mental set; 3) difficulties with logical reasoning; and 4) oversimplification.

There will undoubtedly be occassions during which group members will be faced with problems that must be dealt with at a group level. The Organization Management Chapter reviews some of the research dealing with when problems are best dealt with by individuals and when by groups. When the group process is ininvoked prior training in different group problem solving techni-

ques could prove useful. One such technique is known as brainstorming (112).

The four basic rules of brainstorming are listed below:

1. Criticism of an idea is absolutely barred. All evaluation is to be deferred until after the session.

2. Modification or combination with other ideas is encouraged. Credit for ideas or keeping them neat is deemphasized.

3. Quantity of ideas is sought. In the early stages of brainstorming quatity is more important than quality.

4. Unusual, remote, or wild ideas are sought.

Participants are encouraged to produce as many ideas as possible by removing the threat of eavluation. Only after a brainstorming session is complete are ideas reconsidered and evaluated.

To this approach we may add the suggestions of Parnes (113) helpful in encouraging original thought:

1. Consider other uses for all elements of the problem.

2. Adapt. Consider how other objects, ideas, procedures, or solutions could be adapted to the present problem.

3. Modify. Consider changing anything and everything that could be changed.

4. Magnify. Exaggerate everything you can think of. Think on a grand scale.

5. Minify. Shrink the problem down to size by considering the problem as if there were no differences between element of the problem.

6. Substitute. Examine how one object, idea, or procedure could be substituted for another.

7. Rearrange. Break the problem into pieces and try shuffling them.

8. Reverse. Consider reverse orders, opposites, and turn things inside out.

9. Combine. Consider all possible combinations of the elements of the problem.

Familarity and capacity to use these principles and the brain-

storming technique (among others) could be an advantage for crews in space (particularly the barring of evaluation during discussion given the group pressures to narrow thinking and conform to group norms as discussed in the Small Groups Dynamics Chapter).

Overtraining

The issue of how to evaluate and facilitate problem solving ability brings up the approach our current program has used in helping candidates prepare for and cope with various types of problems, particularly emergencies or changes in flight plans. As Kubis and McLaughlin (31) summarize, overlearning of the mission tasks to be performed, extensive training in the diagnosis of and means to deal with simulated system failures, and comprehensive training in egress, escape, and survival techniques have all been emphasized as ways of building confidence, reducing and controlling anxiety, and minimizing potential problems which might occur in-flight. There is no question but what this has been a valuable facet of astronaut training given the many emergencies that have occurred in-flight and the expertise with which the astronauts have dealt with them. However, in anticipation of future longer duration missions there are some potential problems with such a comprehensive overtraining approach that deserve attention.

One of the greatest problems which occurs in confined, isolated settings is monotony and boredome. Levine (114), in a review of submarine and Antarctic studies, comments that the boredom so often felt exists in spite of the fact that numerous facilities are available to alleviate such a condition. Aerospace studies have reported similar findings (115, 116). This problem seems to be particularly prevalent when meaningful work

has been learned well enough for it to become routine. Given the extreme importance that isolated individuals place on stimulating, challenging, meaninful work, we must at least question whether a rigorous overtraining program might reduce the interest value of mission responsibilities during a long duration flight. Great caution must be taken not to add to the laready great prospects for monotony and boredom which exists for a long term mission. This has not been a problem for short term flights, but even here there has been occassional signs that even some previous astronauts have found flight preparations and pre-flight count down (a period we might normally assume to be highly arousing) to be less than stimulating. For example, prior to the departure of the last Mercury Project flight, Gordon Cooper fell asleep inside the capsule during a long hold before lift-off (62).

As the novelty and excitement of space flight decreases and flight operations become more routine the possibility that overtraining might erode the positive effects of meaninful work in space should be considered. At least one unique compromise can be suggested for how to deal with this possibility. Perhaps the approach of overtraining those tasks considered absolutely crucial for mission success could be continued while the learning of less important procedures could be scheduled in-flight. If it were possible to actually schedule some of the training exercises and academic material learning during the flight itself, the additional challenge and stimulation of meaningful work would still be available. This possibility would seem particularly plausible during cruise phases of missions, where only routine duty tasks are required and little in the way of important mis-

sion goals are involved. It would appear that some combination of pre-flight overtraining and in-flight scheduled training would ensure mission integrity and yet provide more of that all important factor for individuals in isolation: meaningful work.

One issue here that would have to be researched further is the degree to which motivational declines in isolation might reduce the degree and efficiency of learning/training scheduled in-flight. Levine (114) has observed that among isolated individuals few, if any, complete correspondence projects brought with them for the expressed purpose of filling long duty free periods with meaningful work. On the other hand, laboratory investigators such as Rogers (117) who have specifically assigned learning materials to be completed during isolation have found them to be useful as meaningful work and have observed no reduction in quality during relatively brief periods of confinement. The key here may be to ensure that a requirement to complete certain learning tasks or training procedures be built into the program so that it is considered an integral and necessary phase of the in-flight mission. Such external structure may be what is lacking among other isolated crews and could be a partial explanation for why so few projects are completed by otherwise ambitious and achievement oriented individuals.

Cross Training vs. Specific Training

The approach which has been taken in astronaut training to date emphasizes cross training each individual crew member on a variety of tasks. That is, all team members are trained to be proficient with the majority of flight requirements. On the other hand, a speciality area is assigned to each astronaut requiring

additional personalized training and information (101). The advantages of this approach are clear. Each team member has certain responsibilities for which they are primarily responsible, but other crew members are also knowledable in these areas and could serve as back ups in the event that one or more individuals were unable to perform their duties.

This approach has strong meir particularly as we approach the Space Shuttle era in which individual crew member responsibilities will become even more specialized. There is one potential difficulty we should be aware of that could generate friction among crew members. Rohrer (106) has observed that among Antarctic community members "the occupational role becomes highly valued by the man, and he guards very jealously the work activities attendant to that role". It would seem that specialized duties are very important to individuals in isolation. This brings up the question of how much cross-training and/or specialized training should be employed. On the one hand specialized training and duties seem to be important for crews, and yet in the event that an individual cannot adequately perform their duties a well trained back up team member would also seem to be critical. These issues also pose problems for the notion of rotational crew duties. A not implausible notion can be drawn from the isolation literature that rotating crew duties might help alleviate boredom and satiation of interest in any particular duty requirement. However, the issue of possessiveness around work duties clouds this idea and suggests an important planning and research topic. The literature is clear that when the work roles of each member are unique and relatively indispensable, each individual is valued and ac-

capted, social interactions become positively oriented, and group cohesiveness is increased (105, 118). However, when work roles are not clearly delineated group productivity may suffer (119), anxiety may develop (120) and a low opinion of one's effectiveness may occur (121). The implication of these findings for cross-training vs. specialized training, and for rotational crew duties deserves further consideration and research.

Comments on Training Issues

From this and other chapters it is clear that the degree and additional types of training needed for long term space crews is significantly different than that used in the past. Also, the scheduling and emphases of training may be changed based on issues specific to the isolation confinement of long term missions. How we proceed with this will certainly depend upon research yet to be conducted.

One concept we might consider is the idea of a life-time astronaut program. Its members could be slected for a long term committment with the space program with actual missions entailing only a small portion of the actual time in the program. Such an approach would provide us with the flexibility to conduct the type of awesome selection and training phases which may be necessary for the success of flights. Given the enormous expense of a long term mission we cannot afford to leave any stone unturned in researching and resolving the many issues inherent in such a program.

A life time astronaut corp might involve many phases beyond initial selection specific mission training. For example, crew members without prior experience in isolated settings might be

given a year long assignment in the Antarctic. What better way to simulate the problems of social life in space than to experience such difficulties first hand.

Another feature might be the involvement of previously flown long term mission crews in the selection and training of future crews. We in fact have already instigated this approach in our current space program. Selection of Apollo, Gemini, and Skylab crews included the involvement of astronauts previously selected and acquainted with the conditions of NASA training and spaceflight itself. (43, 44).

One final point regarding astronaut selection and training needs to be made. When considering the many issues of spaceflight already known and yet to be addressed one ultimate note seems to continually resound throughout the literature: select and train a superior crew and all other factors will be minimized. Indeed as we pointed out at the beginning of this chapter a great number of potential problems in space can be reduced to the issue of how good is the crew and how well can we select and train a mission team. This focus places considerable pressure on researchers to address the many questions of how to select and train astronauts for space. There are sufficient uncertainties at present regarding our ability anticipate all the problems of space and to deal with them effectively. For this reason we must be able to select and equip the best possible group with the knowledge and training necessary to deal with the expected and the unexpected as is humanly possible. Selection and training must become a primary focus of future research if we are to accomplish this goal.

## SUMMARY OF PRINCIPAL PLANNING AND RESEARCH ISSUES

The adequacy of our current astronaut selection and training program has been repeatedly born out by the success of U. S. missions to date. Reliance upon action oriented, extroverted, emotionally distant individuals exposed to extensive overtraining procedures has proved to be of significant value to the success rate of the relatively brief missions of the Manned Space Program. However, there is considerable uncertainty as to how well the features of this situation can be effectively generalized to future long term missions of greater complexity and greater crew heterogeneity. Several key issues demand further research and planning as discussed below.

As the size and heterogeneity of crews increases the focus of our attention must be shifted away from an individual orientation to an emphasis on groups. So far we have concentrated primarily on identifying and training individual for missions. For future flights the ability of the group to function as a compatible, cohesive whole will be a major requirement thus the need for a group orientation. This radical sift from the individual to the group level poses many questions regarding how to best select and train candidates for group missions. For example, we have almost no data regarding mixed gender groups in isolation. With women entering the astronaut corp we have an immediate need to understand what effects this may have on group formation and functioning, leadership roles and effectiveness, social, work, and morale levels. Further research is also need to investigate physiologically determined changes

in space and how these may affect psychophysiologic functioning among female crew members.

We also have only sparse data on the functioning of international communities in isolation. As we look forward future international efforts in space we can anticipate problems with language and cultural differences and how they may impact group functioning in isolation. We have only begun to even consider these questions and will have many issues around how to select and train individuals from widely divergent backgrounds for future flights. This is an area we will have to make an important one for future research and planning.

For the present, we are more directly faced with the issues of determining what types of characteristics will be most important for group members in space. There appear to be some significant differences between those individuals best suited to the rigors of isolation and confinement and the types of astronaut proven to be so effective for short term missions. Several approaches have been proposed in categorizing the traits of the adaptive group member. One approach focuses on factor analytic studies of traits endigeneous to those who have scored well on supervisor, self-, and peer-ratings in naturally isolated settings such as the Antarctic. While these studies give us important data on what individual charcteristics are important post hoc the list of variables is long and complicated and does not lend itself easily to our own practical needs for space crew selection. It does, however, point out that a number of demographic, attitudinal, and experential factors interact as an aggregate in permitting the well adapted individual the flexibi-

lity, ego strength, tolerance, etc. to survive the problems of isolated group confinement. One important point from this research area stems from the finding that different characteristics are predictive of success as a function of different occupational/professional orientations/backgrounds. The fact that some traits appear to be an asset at some levels of professional expertise, but a liability at others suggests that we may have to reassess our ability to develop a common set of selection criteria for all professional classification crew members. For example, the characteristics which define an adaptable astronaut pilot may or may not be the same as those predictive of success among scientist astronauts. Our own space related data in this area does suggest that there are important differences between the personnel within these categories that could lead to conflict and/or differential indicators of success in long term missions. While it does not appear that the post hoc factor analytic approach can provide all the answers of whom to select it does provide us with an important database with which to formulate our own selection program. While it is implicit in the interpretation of this data that somehow those individuals who adapt best must by nature be adequate group members this approach still appears to focus too heavily on the individual rather than the group level.

A second approach to the definition of adaptability of crews comes from laboratory research on group compatibility. Pitifully little has really been done with this notion. While many investigators recognize the need to compose groups with compatible individuals relatively few studies have actually investi-

gated what dimensions might be most important and what similarities and/or differences between individuals along these dimensions might define compatibility. The most technically specific series of studies in this area has defined dogmatism, dominance, and needs for affiliation and achievement as four such important dimensions. There is considerable evidence to indicate that incompatibility along these lines does result in poor group functioning in isolation. There are probably other dimensions we should explore as well. This line of research certainly deserves considerably greater expansion, but our first efforts must be focused on better determining what dimensions may be most important. This might be addressed via the factor analytic method previously discussed. If we could combine these two approaches it might permit us to first assess what group compatibility factors might theoretically be most important and then to actually investigate whether these dimensions of compatibility do lead to differential success of groups in isolation. Such information would certainly be valuable in formulating future approaches to crew selection.

The third appeoach to group coordination which has been offered seeks to identify certain core traits at the individual level which are most adaptive to the conditions of group interaction. The concepts of androgyny and non-competitive work motivation have been discussed as possible features of the individual which may be adaptive at the group level. There is evidence to indicate that androgynous, non-competitive work oriented individuals do fare well in groups. Unfortunately, this approach has not been extended to groups in isolation and it remains to

be seen whether these concepts have equally high validity under these conditions.

It is our contention that the use of personality dimensions is quite useful. However, there are many other dimensions along which to assess the individual aside from sex role orientation. It may prove useful to explore the introversion/extroversion dimension to discover if an "ambivert" personality exists who could have greater abilities to deal with the simultaneous demands of isolation and group interaction. Our point is that other dimensions should also be explored to determine if a group of core traits can be identified which will allow us to select group members highly adapted to the unusual demands of long term space flight.

While there are at least three broad approaches which have been taken in determining what type of group member is best adapted to the demands of isolated group living our ability to use this data is only as good as our assessment instruments. We may well be able to define the various traits or dimensions important for selection, but if we do not have adequate assessment tools to measure these characteristics across group candidates this data becomes rather meaningless. To date we have relied primarily on psychological test batteries involving various pencil-and-paper tests designed to measure cognitive, motivational, and psychosocial personality characteristics. Several points can be raised regarding future implementation of these tools. First, their assets usually lie in "selecting out" inappropriate candidates rather than giving us solid positive, "selecting in" capabilities. Their main prowess rests in quantifying pathology

rather than normalcy. Furthermore, they do not give us any first hand observable data on group processes. For this reason we argue that other types of tests be included to better illuminate the social faculties of the candidates. These might include any of the various situational tasks described in this chapter as well as the simulation exercises normally associated with the assessment center methodological approach. Our greatest concern centers around how the individual functions as a group member. Effective individuals may or may not be effective group members and our task is to view the individual from within the structure of the group. For this reason, our assessment tools must be expanded and modified to reflect this greater emphasis on the group rather than the individual level.

One avenue of investigation which deserves further attention is the use of psychophysiological tests as measures of isolation adaptability and problem solving capacity under stress. Recent work in the field of lateralized brain functioning should be explored to determine if any relevant concepts can be applied to the selection of astronaut groups. If indeed hemispheric separation of functions does lead to enhanced cognitive functioning, the ability to assess this characteristic could be a useful tool for our selection procedure.

Also, further attention should be directed toward the use of perceptual modes-CNS functioning as a possible predictor of sensory deprivation tolerance. The application of field dependency tests should be examined to determine their usefulness for our purposes in selecting those most adapted to the rigors of isolation and whether there is a general link between adaptabi-

lity to sensory deprivation and the more molecular stimulus constraints of isolation and confinement.

In considering a neuropsychological approach to selection there is considerable need for further information regarding differential physical sensitivity to the stresses of space flight. For example, research is needed to increase our understanding of what factors contribute to space motion sickness. Identification of the physical and psychological correlates of this phenomenon would enhance our ability to more accurately select those individuals with minimal sensitivity.

Along these same lines, we need a greater understanding of the relationship between circadian rhythm flexibility and the ability of the individual to work and sleep under stressful, desynchronis conditions. Those individuals least susceptible to the adverse effects of desynchronosis may prove to be more reliable during extended conditions influenced by changes in diurnal cycling both with respect to their work performance and as a social element of the group.

As we begin to focus more on group processes in long term flight, and therefore more on the selection of groups rather than individuals, several important issues with respect to training procedures will demand greater research and planning. One prospect to be explored is the possibility of integrating more fully the selection and training phases of the astronaut program. While a candidate pool will have to be drawn initially, from there it may prove wise to consider mission training as an extension of final selection. By continuing to evaluate candidates throughout training a more extensive (and hopefully useful) as-

sessment of the individual within the group could be made. It might prove useful to implement peer nomination procedures during final selection stages also to help in forming the most readily acceptable group composition from among candidates. Situational testing could also be employed during the training period both as a useful training technique for candidates, but also as a further evaluative check of social capabilities among the applicants. One type of situational test which might be most relevant would be a group exposure to isolation.

In terms of the actual training to be conducted, it may prove useful to employ some type of social awareness technique. Some researchers have suggested sensitivity training. Others have objected to this on the grounds that it diminishes the importance of work orientation. It is important that we determine whether any type of group process training is desirable and if so what the exact nature of this training should be.

Another type of training which we can suggest in preparation for long term missions entails proficiency with problem solving techniques. First, there should be some clear guidelines established pre-flight as to when individuals are to address specific problems and when a problem is to be approached by the group as a whole. There are certain types of problems which have been shown to be most advantageously approached by each of these orientations and it is important that the crew be aware of this breakdown (see Organization and Management Chapter for details). At the individual level it may prove useful to acquaint team members with the types of problem solving errors most commonly encountered, to familiarize individuals as to how

to identify and rectify these varriers, and to introduce training methods to aid in generating new and creative solutions to problems. At the group level, training could be instigated using brainstorming procedures as an example, to enhance the effectiveness of crew problem solving capabilities. This procedure would seem to be especially productive given that evaluation of ideas is postponed until all ideas have been generated. In theory this should help reduce group bias, pressure toward conformity, and reliancy upon the ideas of specific individuals (all difficulties normally enhanced by the narrowed social flexibilities of group confinement).

The way in which we approach training will also be important. For example, in the past we have relied on overtraining and overfamiliarization as a means of building crew confidence and as a technique for anticipating as many potential problems as possible. Now we must determine whether the use of overtraining may lead to such a reduction of interest in mission tasks on-board that work will actually become boring, monotonous, and add to the already reduced stimulation. We may wish to consider scheduling some types of training in-flight. Those tasks most crucial to mission success could still continue to be overtrained pre-flight, but some learning would be required in-flight be provide a source of challenging, stimulating, meaningful work.

Our approach to training must also consider the several issues of specific versus cross training. Will we wish to continue the current procedure of training all crew members on the majority of mission tasks, but with each member responsible for a different area of specialization? Research has shown that clear

delineation of work roles is a necessity for productivity and morale in isolation. Individuals experiencing isolation become highly possessive of their work roles and cling to their duties as a source of solidarity and stimulation in an otherwise monotonous environment. This poses some important research questions regarding the degree of specialization and cross training we will wish to persue for long term missions. For example, will we wish to focus more heavily on specialization so that work roles can be more clearly demarcated? If so, what effect will the absense or work slow down of a particular crewperson have on the overall performance of the group or their ability to take up the slack? Will we want to explore rotational duties as a means of providing stimulating and differing work on a periodic basis so the individual does not "burn out" on any one particular set of tasks or assignments? If so, will such a rotational procedure tend to decrease the ability of the individual to cling to their own particular work as a source of individualized satisfaction and prestige? Given the overwhelming importance of work and work roles as demonstrated in the isolation literature it is clear that we must address these questions first before we can most effectively define what the mission responsibilities of individuals will be. In more abstract terms, our problem is to aid the individual in establishing individualized ways of satisfying needs for prestige, work satisfaction, and group acceptance while maintaining an emphasis on the overall work productivity of the group and its ability to cohesively handle the tasks of a mission at the molecular level. We must be careful that emphasizing group performance (through cross training for

example) does not detract from the accomplishments of the individual or their ability to gain satisfaction with the duties to be performed. At least with respect to work our emphasis will need to be proportioned appropriately to reinforce the group as a whole as well as the individual within the group. Lose of individual identity at this level could jeopardize individual esteem and satisfaction and therefore productivity. This is a planning and research area that certainly demands further consideration.

Another question about how we train our crews concerns the degree of group training time to be used pre-flight. It can be argued that crews which will need to work and relate with each for long term missions should receive much of their training together. Pre-flight time could be spent developing group morale, team coordination, and a sense of group orientation. Such an emphasis might also serve to illuminate any potential group social and/or working problems before they surface in-flight. On the other hand, we know relatively little about how the development of a strong group pre-flight will affect the crew once in flight. Will the already well developed acquaintanceship process aggrvate or ameliorate problems of social boredom in isolation? Will the types of alliances, friendships, and informal communication lines developed pre-flight continue or breakdown under the constancies of interaction in confinement? These issues harken back to our lack of information regarding the effects of isolation on already well formed groups. Since we have almost no data available to us on this subject it seems imperative that one focus of future group isolation research be to in-

vestigate the differences between previously formed groups versus newly formed groups under conditions of isolation and confinement. This data is badly needed if we are going to effectively address the questions of how and why to schedule group time and training pre-flight.

While not a final solution to all of our problems, one suggestion we can present is the consideration of a life time astronaut corp. By selecting individuals for life sevice we could employ them in research to answer many of our unresolved issues. Experiments with group processes could be a phase of their duty. They could also be stationed in naturally isolated settings for training and for observation. Later they could be involved in the selection process of future astronauts. It is clear that we need some kind of structured, coherent research program within which to explore the many unanswered research questions of long term flight addressed in this and other chapters. Perhaps the creation of a life time astronaut program would provide the foundation for this venture.

REFERENCES


1. Klein, K. E. and Hordinsky, J. R. Medical and Psychological Selection and Training Criteria for European SL-Payload Specialists. Paper presented at the 1978 Goddard Memorial Symposium: An International Forum on Shuttle/Spacelab Utilization. March, 1978. Washington, D. C.

2. Lovelace, W. R., II, Schwichtenberg, A. H., Luft, U. C., and Secrest, R. R. Selection and maintenance program for the National Aeronautcs and Space Administration. Aerospace Medicine, 1962, 33(6), 667-684.

3. Von Dolbeln, W., Engstrom, C. G., Malstrom, G., and Strom, G, Physical Working Capacity of Pilots in Relation to Age. Paper presented at 2nd World Congress and 4th European Congress of Aerospace Medicine. October, 1959. Rome.

4. Simons, D. G. The manhigh sealed cabin atmosphere. Journal of Aviation Medicine, 1959, 30, 314-325.

5. Balke, B. Corrleation of static and physical endurance. Randolph AFB, Texas, School of Aviation Medicine, 1952 (Project 21-32-004, Report 1)

6. Balke, B. and Ware, R. W. An experimental study of physical fitness of Air Force personnel. United States Armed Forces Medical Journal, 1959, 10(6), 675-688.

7. Carp, A. (Ed.), Report of the Working Group on Personnel Selection for Man in Space. Washington, D. C., National Academy of Science, 1959.

8. Clarke, N. P., Hyde, A. S. Preliminary Report of Human Response to Rearward Facing Re-entry Accelerations. Wright-Patterson AFB, Ohio, Wright Air Development Center, 1959, (WADC-TN-59-109).

9. Darling, R. C. The significance of physical fitness. Archives of Physiology and Medicine, 1947, 28(3), 140-145.

10. Haber, H. The Physical Environment of the Flyer. Randolph AFB, Texas, School of Aviation Mecicine, 1954. (USAF Aerospace Medicine Center Library, Brooks AFB, Texas)

11. Sharpe, M. R. Living in Space. Garden City, New York: Double Day & Co. Inc., 1969.

12. Gunderson, E. K. E. Individual behavior in confined or isolated groups. In J. E. Rasmussen (Ed.), Man in Isolation and Confinement. Chicago: Aldine Publishing Co., 1973, 145-166.

13. Colquhoun, P., Folkard, S., Knauth, P., and Rutenfranz, J. (Eds.), Experimental Studies of Shiftwork. Opladen: Westdeutscher Verlag, 1975.

14. Natani, K., Shurley, J. T., Pierce, C. M., and Brooks, R. E. Long-term changes in sleep pattern sin men on the South Polar Plateau. Archives of Internal Medicine, 1970, 125, 655-659.

15. Shurley, J. T. Physiological research at United States stations in Antarctica. In E. K. E. Gunderson (Ed.), Human Adaptability to Antarctic Conditions. Washington, D. C.: American Geophysical Union, Antarctic Research Series, Vol. 22, 1974, 71-88.

16. Shurley, J. T., Pierce, C. M., Natani, K., and Brooks, R. E. Sleep and activity patterns at South Pole station. Archives of General Psychiatry, 1970, 22, 385-389.

17. Teichner, W. H. Interaction of behavioral and physiological stress reactions. Psychological Review, 1968, 75, 271-291

18. Teichner, W. H. and Olson, D. E. Predicting human performance in space environments. NASA CR-1370. Springfield, Va.: National Technical Information Service, 1969.

19. Teichner, W. H. and Olson, D. E. A preliminary thoery of the effects of task and environmental factors on human performance. Human Factors, 1971, 13, 295-344.

20. Natani, K. Future directions for selecting personnel. In S. Cheston and D. Winter (Eds.), Human Factors in Outer Space Production. Wasington, D. C.: American Association for the Advancement of Science, 1980 (in press).

21. Duffy, E. Activation. In N. S. Greenfield and R. A. Sternback (Eds.), Handbook of Psychophysiology. New York: Holt, Rinehart and Winston, 1972, 577-622.

22. Natani, K. Letters: the split and whole brain. A comment on body position and thinking. Human Nature, 1978, 1, 9 & 96.

23. Tworek, M. W., Green, J. L., and Lancaster, M. C. Design of an automated Hasted-Reitan neuropsychological test system. Proceedings of the 30th ACEMB meeting, Los Angeles, November, 1977.

24. Cohen, S. I., Silverman, A. J., Bressler, B., and Shmavonian, B. M. Problems in isolation studies. In P. Solomon (Eds.), Sensory Deprivation. Cambridge, Massachussetts: Harvard, 1961, 114-129.

25. Cohen, S. I., Silverman, A. J., and Shmavonian, B. M. Neurophysiological, humoral and personality factors in the response to sensory deprivation. Proceedings of the 3rd World Congress of Psychiatry. Toronto: University of Toronto, 1962a, 1004-1009.

26. Cohen, S. I., Silverman, A. J., and Shmavonian, B. M. Psycho-

physiological studies in altered sensory environments. Journal of Psychosomatic Research, 1962b, 6, 259-281.

27. Witkin, H. A., Dyk, R. B., Faterson, H. F., Goodenough, D. R., and Karp, S. A. Psychological Differentiation. New York: Wiley, 1962.

28. Witkin, H. A., Lewis, H. B., Hartzman, M., Machover, K., Meissner, P. B., and Wapner, S. Personalith Through Perception. New York: Harper, 1954.

29. Lacey, J. I., and Lacey, B. C. Verfication and extesion of the principle of autonomic response stereotypy. American Journal of Psychology, 1958, 71, 50-73.

30. Lacey, J. I., Kagan, J., Lacey, B. C., and Moss, H. A. The visceral level: Situational determinants and behavioral correlates of autonomic response patterns. In P. H. Knapp (Ed.), Expression of the Emotions in Man. New York: International Universities, 1963, 161-196.

31. Kubis, J. F. and McLaughlin, E. J. Psychological aspects of space flight. Transactions of the New York Academy of Sciences, 1968, 30, 320-330.

32. Wilson, C. L. (Ed.), Project Mercury evaluation program. WAKDC Technical Report 59-505, Project No. 7164, Task No. 71832. Wright Air Development Center, ARDC, USAF, Wright-Patterson AFB, Ohio, 1959.

33. Hartman, B. O. and McKee, R. C. Psychometric Characteristics of Astronauts. In J. Collin (Ed.), Recent Advances in Space Medicine, AGARD Conference Proceedings No. 205, 1976, C10-1-C10-9.

34. Ruff, G. E. and Korchin, S. J. Adaptive stress behavior. In M. H. Appley and R. Trumbull (Eds.), Psychological Stress: Issues in Research. New York: Appleton-Century-Crofts, 1965, 297-306.

35. Haythorn, W. W. Discussion: Adaptive stress behavior. In M. H. Appley and R. Trumbull (Eds.), Psychological Stress: Issues in Research. New York: Appleton- Century-Crofts, 1965, 310-321.

36. Lester, D., Kendra, J. M., and Thisted, R. A. Prediction of homicide and Suicide: A test in a healthy risk-taking group. Perpetual and Motor Skills, 1977, 44, 222.

37. Gunderson, E. K. E. (Ed.), Human Adaptability to Antarctic Conditions. Washington, D. C.: American Geophysical Union, Antarctic Research Series, Vol. 22, 1974.

38. Edholm, O. G. and Gunderson, E. K. E. (Eds.), Polar Human Biology. London: William Heinemann Medical Books, Ltd., 1973.

39. Gunderson, E. K. E. and Nelson, P. D. Biographical predictors of performance in an extreme environment. Journal of Psychology, 1965, 61, 59-67.

40. Mann, R. D. A review of the relationship between personality and performance in small groups. Psychological Review, 1959, 56, 241-270.

41. Radloff, R. and Helmreich, R. Groups Under Stress: Psychological Research in Sealab II. New York: Appleton-Century-Crofts, 1968.

42. Altman, I. An ecological approach to the functioning of socially isolated groups. In J. E. Rasmussen (Ed.), Man in Isolation and Confinement. Chicago: Aldine Publishing Co., 1973, 241-270.

43. Link, M. W., Gurovskiy, N. N., and Bryanov, I. I. Selection of astronauts and cosmonauts. In M. Calvin and O. G. Gazenko (Eds.), Foundations of Space Biology and Medicine, Vol. 3. Washington, D. C.: Scientific and Technical Information Office, 1975, 438-452.

44. O'Leary, B. The Making of an Ex-Astronaut. Boston: Houghton & Mifflin, 1970.

45. Coll, R. E., Gunderson, E. K. E., and Ryman, D. H. Relative predictability of occupational groups and performance criteria in an extreme environment. Journal of Clinical Psychology, 1969, 25, 399-402.

46. Sells, S. B. The taxonomy of man in enclosed space. In J. E. Rasmussen (Ed.), Man in Isolation and Confinement. Chicago: Aldine Publishing Co., 1973, 281-304.

47. McLean, H. V. and Seeman, J. S. Crew selection. In NASA-Langley Research Center Preliminary Results for an Operational 90-Day Manned Test of a Regenerative Life Support System. Governement Printing Office, 1971.

48. Dunlap. R. D. The Selection and Training of Crewmen for an Isolation and Confinement Study in the Douglas Space Cabin Simulator. Douglas Paper No. 3446, Douglas Aircraft Co., Inc., Santa Monica, CA., 1968.

49. Cowan, T. A. and Strickland, D. A. The legal structure of a confined microsociety (A report on the cases of Penthouse II and III). Internal working paper No. 34, Space Sciences Laboratory, Social Sciences Project, University of California, Berkeley, August, 1965.

50. Altman, I. and Haythorn, W. W. Interpersonal exchange in isolation. Sociometry, 1965, 23(4), 411-426.

51. Altman, I. and Haythorn, W. W. The ecology of isolated groups. Behavioral Science, 1967a, 12(3), 169-182.

52. Altman, I. and Haythorn, W. W. The effects of social isolation and group composition on performance. Human Relations, 1967b, 20, 313-340.

53. Haythorn, W. W. and Altman, I. Together in isolation. Transaction, 1967, 4, 18-22.

54. Haythorn, W. W., Altman, I., and Myers, T. I. Emotional symptomatology and subjective stress in isolated pairs of men. Journal of Experimental Research in Personality, 1966, 1 (4), 290-306.

55. Burnazyan, A. I., Parin, V. V., Nefedov, Yu. G., Adomovich, B. A., Maksimov, S. B., Gol'dshvend, B. L., Samsonov, N. M., and Kirikov, G. N. Year-long bioengineering experiment in a ground complex of life-support systems. Environmental Space Sciences, 1969, 3(1), 6-14.

56. Spence, J. T. and Helmreich, R. L. Masculinity and Femininity: Their Psychological Dimensions, Correlates and Antecedents. Austin: University of Texas, 1978.

57. Helmreich, R. L. and Spence, J. T. The Work and Family Orientation Questionnaire: An objective instrument to assess achievement motivation and attitudes toward family and career. JSAS Catalog of Selected Documents in Psychology, 1978, 8, 35, MS #1677.

58. Spence, J. T., Helmreich, R., and Stapp, J. Ratings of self and peers on sex-role attributes and their relation to self-esteem and coceptions of masculinity and femininity. Journal of Personality and Social Psychology, 1975, 32, 29-39.

59. Helmreich, R. L., Wilhelm, J. A., and Runge, T. E. Psychological considerations in future space missions. In S. Cheston and D. Winter (Eds.), Human Factors in Outer Space Production. Washington, D. C.: American Association for the Advancement of Science, 1980 (in press).

60. Bem, S. L. The measurement of psychological androgyny. Journal of Consulting and Clinical Psychology, 1974, 42, 155-162.

61. Helmreich, R. L., Beane, W. E., Lucker, G. W., and Spence, J. T. Achievement motivation and scientific attainment. Personality and Social Psychology Bulletin, 1978, 4, 222-226.

62. Wolfe, T. The Right Stuff. New York: Farrar, Straus, Giroux, 1979.

63. Kanas, N. A. and Fedderson, W. E. Behavioral, Psychiatric,

and Sociological Problems of Long-duration Space Missions. NASA TM X-58067, 1971.

64. Helmreich, R. The Tektite II human behavior program. In J. W. Miller, J. G. VanDerWalker, and R. A. Waller (Eds.), Tektite II: Scicintists in the Sea. U. S. Government Printing Office, 1971, VIII-15-VIII-61.

65. Newsom, B. D., Goldenrath, W. L., Winger, W. R., and Sandler, H. Tolerance of females to $+G_z$ centrifugation before and after bedrest. Aviation, Space, Environment Medicine, 1977, 48(4), 327-331.

66. Pace, N., Kodama, A M., Grunbaum, B. W., Price, D. C., Rahlmann, D. F., and Newsom, B. D. Body composition changes in men and women after 2-3 weeks of bedrest. In P. H. A. Sneath (Ed.), COSPAR Life Science and Space Research, Vol. XIV. Berlin: Akademia Verlag, 1976, 269-274.

67. Redgrove, J. A. Menstrual cycles. In W. P. Colquhoun (Ed.), Biological Rhythms and Human Performance. New York: Academic Press, 1971, 211-240.

68. Altmann, M., Knowles, E., and Bull, H. D. A psychosomatic study of the sex cycle in women. Psychosomatic Medicine, 1941, 3, 199-225.

69. Rosenzweig, S. Psychology of the menstrual cycle. Journal of Clinical Endocrinology, 1943, 3, 296-300.

70. Dalton, K. Menstruation and crime. British Medical Journal, 1961, 2, 1752-1753.

71. Middleton, W. C. Is there a relation between kleptomania and female periodicity in neurotic individuals? Psychol. Clin., 1934, 22, 232-247.

72. Lederer, J. Kleptomanie pre'menstruene dans un cas d'hyperfolliculinie liee a une hypothyroidie. Annales D'Endocrinologie, 1963, 24, 460-465.

73. Schwarz, W. The relation of functional periodicity to changes in the characteristics of emotional reactions and personality. Dissertation Abstracts, 1959, 19, 3372-3373.

74. Gorkin, Z. D. and Brandis, S. Einfluss der menstruation auf einige psychophysiologische funktionen and auf arbeitsfahigkeit der frau. Arbeitsphysiologie, 1936, 9, 254-266.

75. Dalton, K. Menstruation and examinations. Lancet, 1968, 2, 1386-1388..

76. Brunelli, F. and Rottini, E. L' influenza del ciclo mestruale sul rendimental sportivo. Medicina dello Sport, 1965, 5, 822-831.

77. Fichera, C. and Romano, S. Sull' influenza delle regole

mestruali sulla capacita di lavoro fisico n giovani atlete. Medicina dello Sport, 1965, 5, 406-411.

78. Magelson, H. E. Periodic changes in blood pressure, muscular coordination and mental efficiency in women. Comparative Psychology Monograph, 1927, 20, 1-65.

79. Dalton, K. Effect of menstruation on schoolgirls' weekly work. British Medical Journal, 1960, 2, 326-328.

80. Vernon, P. E. and Parry, J. B. Personnel Selection in the British Forces. London: University of London, 1949,

81. Pickham, M. The effects of the menstrual cycle on test performance. British Journal of Psychology, 1958, 49, 34-41.

82. Fluhmann, F. The Management of Menstrual Disorders. Philadelphia: W. B. Saunders and Co., 1956.

83. Lamb, W. M. Premenstrual tension: EEG, Hormonal, and psychiatric evaluation. American Journal of Psychiatry, 1953, 109, 840-848.

84. Rees, L. Psychosomatic aspects of the premenstrual tension syndrome. Journal of Mental Science, 1953, 99, 62-73.

85. Perry, C. J. G. Psychiatric support for man in space. In C. J. G. Perry (Ed.), Psychiatry in Aerospace Medicine. Boston: Little, Brown and Co., 1967, 197-222.

86. Cronbach, L. Essentials of Psychological Testing. New York: Harper & Row, 1970.

87. Kagan, J. and Klein, R. E. Cross-cultural perspectives on early development. American Psychologist, 1973, 28, 947-961.

88. Kirsch, H. Faktorenanalyse eines neuen mehrdimensionalen Personlichkeits-Fragebogens. Deutsche Luft- und Raumfahrt FB 75, 1975, 20.

89. Weybrew, B. B. Discussion: Personality factors in isolated environments. In M. H. Appley and R. Trumbull (Ed.), Psychological Stress: Issues in Research. New York: Appleton-Century-Crofts, 1965, 389-397.

90. Siple, P. 90° South: The Story of the American South Pole Conquest. New York: Putnam, 1959.

91. Perry, C. F. G. Psychiatric selection of candidates for space missions. Journal of the American Medical Association, 1965, 194, 841.

92. Ruff, G. E. Psychological Tests. In C. L. Wilson (Ed.), Project Mercury Candidate Evaluation Program. WADD Technical Report 59-505, Project No. 7164, Task No. 71832.

Wright-Patterson AFB, Ohio, 1959, 81.

93. Haythorn, W. W. Discussion: Personality factors in isolated environments. In M. H. Appley and R. Trumbull (Ed.), Psychological Stress: Issues in Research. New York: Appleton-Century-Crofts, 1965, 389-397.

94. Office of Strategic Services (OSS) Assessment Staff. Assessment of Men. New York: Rinehart, 1948.

95. MacKinnon, D. W. From selecting spies to selecting managers-The OSS assessment program. In J. L. Moses and W. C. Byham (Eds.), Applying the Assessment Center Method. New York: Pergamon Press, 1977, 13-30.

96. Zubek, J. P. (Ed.). Sensory Deprivation: Fifteen Years of Research. New York: Appleton-Century-Crofts, 1969.

97. Bray, D. W. and Grant, D. L. The assessment center in the measurement of potential for business management. Psychological Monographs, 1966, 80 (17, Whole No. 625).

98. Dunnettee, M. D. Multiple assessment procedures in identifying and developing managerial talent. In P. McReynolds (Ed.), Advances in Psychological Assessment, Vol. II. Palo Alto: Science & Behavior Books, 1971.

99. Moses, J. L. The development of an assessment center for the early identification of supervisory potential. Personnel Psychology, 1974, 26(4), 569-580.

100. Hemphill, J. K., Griffiths, D. E., and Frederiksen, N. Administrative Performance and Personality: A Study of the Principal in a Simulated Elementary School. New York: Teachers College Bureau of Publications, Columbia University, 1962.

101. Voas, R. B. Project Mercury: Astronaut training program. In B. E. Flaherty (Ed.), Psychophysiological Aspects of Space Flight. New York: Columbia University Press, 1961, 96-116.

102. Kubis, J. F. Isolation, confinement, and group dynamics in long duration spaceflight. Astronautica Acta, 1972, 17, 45-72.

103. Adams, C. R., Dunlap, R. D., and Batterton, R. L. Man-Machine Aspects of a Four-Man Space Cabin Simulator, Paper presented at the SAE National Aeronautics and Space Engineering and Manufacturing Meeting. California, 1965.

104. Byrd, R. E. Little America. New York: Putnam, 1930.

105. Back, K. W. Discussion: Group behavior in long-term isolation. In M. H. Appley and R. Trumbull (Eds.), Psycho-

logical Stress: Issues in Research, New York: Appleton-Century-Crofts, 1965, 290-293.

106. Rohrer, J. H. Inpterpersonal relationships in isolated small groups. In B. E. Flaherty (Ed.), Psychophysiological Aspects of Space Flight, New York: Columbia University Press, 1961, 263-271.

107. Gunderson, E. K. E. Adaptation to extremeenvironments: The Antarctic volunteer. Technical Report 66-4, U. S. Navy Medical Neuropsychiatry Research Unit, April, 1966.

108. Weybrew, B. B. Human factors and the work environment. II. The impact of isolation upon personnel. Journal of Occupational Medicine, 1961, 3, 290-294.

109. Perls, F. Gestalt Therapy Verbatim. Lafayette, California: Real People Press, 1969.

110. Duncker, K. On problem solving. Psychological Monograph, 1945, 58, No. 270.

111. Guilford, J. P. Creativity. American Psychologist, 1950, 5, 444-454.

112. Haefele, J. W. Creativity and Innovation. New York: Reinhold, 1962.

113. Parnes, S. J. Creative Behavior Workbook. New York: Scribners, 1967.

114. Levine, A. L. Prolonged isolation and confinement: A problem for Naval Medical Research. Navy Magazine, 1965, 26-28, 44-45.

115. Cramer, E. H. and Flinn, D. E. Psychiatric aspects of the SAM two-man space cabin simulator. Technical Report No. SAM-TDR-63-27, USAF School of Aerospace Medicine, Brooks AFB, Texas, September, 1963.

116. Alluisi, E. A., Chiles, W. D., Hall, T. J., and Hawkes, G. R. Human group performance during confinement. Technical Report No. AMRL-TDR-63-87. (Contract No. AF 35 (616)-7607), 6570th Aerospace Medical Research Laboratory, Wright Patterson AF Base, Ohio. Lockheed Air Craft Corp., Georgia. November, 1963.

117. Rogers, J. A. Environmental Needs of Individuals and Groups. Paper presented at the California Council of the American Institute of Architecture. California, 1973.

118. Weybrew, B. B. Psychological problems of prolonged marine submergence. In N. L. Burns, R. M. Chambers, and E. Hendler (Eds.), Unusual Environments and Human Behavior. New York: Free Press, 1963, 87-126.

119. Smith, E. E. The effects of clear and unclear role expectations on group productivity and defensiveness. Journal of Abnormal and Social Psychology, 1957, 55, 213-217.

120. Wispi, L. G. and Thayer, P. W. Role ambiguity and anxiety in an occupational group. Journal of Social Psychology, 1957, 46, 41-48.

121. Gerard, H. B. Some effects of status role clarity, and group goal clarity upon the individual's relations to group process. Journal of Personality, 1957, 25, 475-488.