PSYCHOSOCIAL ISSUES IN SPACE: RESULTS FROM SHUTTLE/MIR

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ABSTRACT

Important psychosocial issues involving tension, cohesion, leader support, and displacement of negative emotions were evaluated in a 4 ½-year study involving five U.S. and four Russian Shuttle/Mir space missions. Weekly mood and group climate questionnaires were completed by five U.S. astronauts, eight Russian cosmonauts, and 42 U.S. and 16 Russian mission control subjects. There were few findings that supported our hypothesized changes in tension, cohesion, and leader support in crew and ground subjects using various time models, although crewmembers reported decreasing leader support in the 2nd half of the missions, and astronauts showed some evidence of a novelty effect in the first few weeks. There was no evidence suggesting a 3rd quarter effect among crewmembers on any of the 21 subscales evaluated. In contrast, there was strong evidence to support the hypothesized displacement of tension and negative emotions from crewmembers to mission control personnel and from mission control personnel to management. There were several significant differences in response between Americans vs. Russians, crewmembers vs. mission control personnel, and subjects in this study vs. people in comparable groups on Earth. Subject responses before, during, and after the missions were similar, and we did not find evidence for asthenia in space. Critical incidents that were reported generally dealt with events on-board the Mir and interpersonal conflicts, although most of the responses were from a relatively small number of subjects. Our findings have implications for future training and lead to a number of countermeasures.

INTRODUCTION

During future space missions involving a space station or a trip to Mars, international crews will be engaged in complicated activities over long periods of time. A number of interpersonal issues likely to impact on these missions must be addressed in order to ensure healthy crewmember interactions and optimal performance. Anecdotal reports from previous space missions and studies conducted in Earth-bound space analog environments (Brubakk, 2000; Helmreich, 2000; Kanas, 1985, 1987, 1990, 1998; Kanas and Feddersen, 1971; Lebedev, 1988; Manzey and Lorenz, 1999; Palinkas et al., 2000; Sandal, 2000; Stuster et al., 2000; Vaernes 1993), including our own studies (Gushin et al., 1997, 1998; Kanas et al., 1996; Kelly and Kanas, 1992, 1993, 1994), have isolated a number of important psychosocial issues that may negatively impact on space crewmembers. These issues include tension, cohesion, leadership role, and language and cultural differences.

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During long-duration space missions, there is evidence that time may affect how these psychosocial issues impact on space crews. Some investigators have noted that crewmembers in space or in space analogs (such as Antarctic expeditions, submarines, and hyperbaric chambers) may experience significant psychological and interpersonal difficulties after the halfway point of a mission (Bechtel and Berning, 1991; Gushin et al., 1993, 1997; Palinkas et al., 2000; Sandal et al., 1995; Sheddan, 1995). From this biphasic perspective, a sense of relief that half of the mission is over is outweighed by the realization that another half is yet to come. Another time model incorporates Rohrer's three sequential phases, which are characterized by initial anxiety, mid-mission depression, and terminal euphoria. (Chaikin, 1985; Grigoriev et al., 1987; Rohrer, 1961) This gives a predicted triphasic U-shaped pattern over time, with high initial and terminal affective activation compared to mid-mission. Other time models have emphasized changes in particular quarters of the mission when dysphoria and interpersonal problems are more pronounced. In particular, deficits in the 3rd quarter have been reported that typically are followed by partial recovery in the 4th quarter (Bechtel and Berning, 1991; Gushin et al., 1997; Palinkas et al., 2000; Sandal, 2000; Sandal et al., 1995; Stuster et al., 2000).

The crew-ground relationship also is important since miscommunication or insensitivity between crewmembers and mission control personnel may lead to misaligned work schedules or inappropriate responses during times of danger. A phenomenon that influences crew-ground communication is displacement. This occurs when negative emotions or mistaken beliefs that arise from conflicts among the crewmembers are misdirected or transferred to people in mission control, who then are perceived as being unsupportive and hostile. Behaviors that are suggestive of displacement have been reported previously in space (Belew, 1977; Bluth, 1981; Cooper, 1976; Lebedev, 1988; San Francisco Chronicle. 1983) and in space simulation studies on Earth (Kanas, 1987, 1990; Kanas and Feddersen, 1971; Kanas et al., 1996; Sandal et al., 1995; Vaernes, 1993).

One additional issue that is in the psychosocial-psychiatric borderland is asthenia. Asthenia is defined as a weakness of the nervous system that may result in fatigue, physical weakness, attention and concentration difficulties, irritability, restlessness, heightened perceptual sensitivities, palpitations and blood pressure instability, and sleep and appetite problems (Kanas et al., in press [b]). Asthenia has been viewed by Russian psychologists and flight surgeons as a major problem that affects most cosmonauts participating in long-duration space missions. First popularized as neurasthenia in the late 1800s by the American George Beard, there is controversy as to the existence of this syndrome, especially since asthenia is not recognized in the current American psychiatric diagnostic system.

Our earlier work has explored several of the above psychosocial issues. In a retrospective questionnaire study of 54 astronauts and cosmonauts who had flown in space (Kelly and Kanas, 1992, 1993, 1994), all subjects stated that having a common language during multinational space missions was important. On a rating scale addressing this issue, astronauts scored higher than cosmonauts, and crewmembers responsible for mission operations scored higher than researchers. In terms of the importance of speaking the same dialect, American and Russian respondents scored higher that "guest" astronauts from other countries that participated in the U.S. program. Factors that influenced both intra-crew and crew-ground communications were identified, and support from loved ones on Earth was seen as being important in enhancing work performance.

In a space simulation project where three male Russian physicians were secluded in the Mir space station simulator in Moscow for 135 days, there was evidence for increasing tension and crew disintegration over time, and the quality and quantity of communication varied with the personnel make-up of the different outside monitoring teams (Gushin et al., 1997, 1998). In addition, there was evidence suggesting that there was less tension and more opportunity for self discovery during the seclusion period than the time before the seclusion; that 2nd half improvements in tension and total mood disturbance may have resulted from a mid-mission resupply event; that significant declines in cohesion during the last 3rd of the seclusion occurred; and that there was displacement of tension and negative emotions to the outside monitoring personnel (Kanas et al., 1996).

The present paper reviews the findings from our recently completed 4½-year study that evaluated the effects of tension, cohesion, leadership role, and displacement from a series of space missions conducted during the Shuttle/Mir space program. Each mission involved two Russian cosmonauts and one American astronaut who worked on the Mir space station for periods of time ranging from 4 to 7 months. We studied both crewmembers and mission control personnel who participated in this program. Our formal hypotheses dealt with a number of important psychosocial issues and are stated below:

1. Crew cohesion will decrease in the 2nd half of the missions.
2. Crew tension will increase in the 2nd half of the missions.
3. Crew perception of crew leader and mission control support will decrease in the 2nd half of the missions.
4. Mission control perception of mission control leader and management support will decrease in the 2nd half of the missions.
5. Crew tension and dysphoria will be displaced to mission control personnel.
6. Mission control tension and dysphoria will be displaced to management.

METHODS

Participation in our study was voluntary. All of the crewmembers and a majority of mission control personnel who where briefed agreed to participate and signed informed consent. Our final study sample consisted of five U.S. astronauts, eight Russian cosmonauts, and 42 U.S. and 16 Russian mission control personnel (e.g., flight surgeons, operations leads, engineers, mission scientists, spacecraft communicators, hardware specialists, psychological support personnel).

The subjects' mood and interpersonal relationships were assessed through the completion of a study questionnaire that was administered in either computerized or hardcopy versions. It consisted of three well-known and standardized instruments: the seven subscales of the Profile of Mood States (POMS) (McNair et al., 1992), the ten subscales from the Group Environment Scale (Moos, 1994[a]), and four relevant subscales from the Work Environment Scale (Moos, 1994[b]). Information on these subscales is presented in Table 1. A Critical Incident Log was also included that asked subjects to describe important events that had occurred and to rate the impact of these events on themselves and their colleagues. At weekly intervals four times pre-mission, during the mission, and twice post-mission, subjects completed this study questionnaire, which took 15-20 minutes (depending on whether or not there were critical incidents to report during the week). The subjects made up a confidential ID code that they always used to indicate their responses. While on the Mir space station, crew subjects completed a computerized version of the questionnaire and saved their data to an optical disk, which later was transferred to Earth on the Space Shuttle. Most mission control subjects preferred to use the hardcopy format, and their questionnaires were sent to our lab in San Francisco from Russia via Federal Express.

There were 212 observations from the crewmembers and 1088 observations from the mission control personnel. Because there were a total of 21 subscales that could be analyzed, an adjustment was made to the significance threshold for each effect being examined to correct for possible Type I errors. We used the false discovery rate procedure developed by Benjamini and Hochberg, which has some advantages over Bonferroni-type procedures (Benjamini and Hochberg, 1995). For all analyses using regression techniques, non-normally distributed subscales were dichotomized into high and low scores and were analyzed using a Generalized Estimating Equation (Liang and Zeger, 1986). Normally distributed or transformed

Table 1. POMS, GES, and WES Subscales Used in the Study

Subscale		Subscale Range	Used to test Hypothesis:[a]	Type of Regression Analysis Used [b]
POMS	Tension-Anxiety	0 - 36	2, 5, 6	Mixed (log)
	Depression-Dejection	0 - 60	1, 5, 6	GEE
	Anger-Hostility	0 - 48	2, 5, 6	GEE
	Vigor-Activity	0 - 32	1	Mixed (normal)
	Fatigue-Inertia	0 - 28	1	GEE
	Confusion-Bewilderment	0 - 28	-	Mixed (log)
	Total Mood Disturbance	-32 - 200	5, 6	Mixed (log)
GES	Cohesion	0 - 9	1	GEE
	Leader Support	0 - 9	3, 4	GEE
	Expressiveness	0 - 9	-	Mixed (normal)
	Independence	0 - 9	-	Mixed (normal)
	Task Orientation	0 - 9	1	GEE
	Self Discovery	0 - 9	-	GEE
	Anger & Aggression	0 - 9	2, 5, 6	GEE
	Order & Organization	0 - 9	1	GEE
	Leader Control	0 - 9	-	Mixed (normal)
	Innovation	0 - 9	-	Mixed (normal)
WES	Supervisor Support	0 - 9	3, 4, 5, 6	Mixed (normal)
	Work Pressure	0 - 9	2, 5, 6	GEE
	Managerial Control	0 - 9	-	GEE
	Physical Comfort	0 - 9	-	GEE

[a] 1 = Crew cohesion drops in 2nd half; 2 = Crew tension rises in 2nd half; 3 = Crew leader support drops in 2nd half; 4 = Ground leader support drops in 2nd half; 5 = Crew displacement occurs; 6 = Ground displacement occurs

[b] Mixed (log) = Mixed model with log-transformed data; Mixed (normal) = mixed model with normally distributed data; GEE = Generalized Estimating Equation with dichotomized data

subscales were analyzed using a mixed model (Delucchi and Bostrom, 1999; Littell et al., 1996) (Table 1). These strategies allowed us to account for the effects of autocorrelation and to adjust for missing values in our data set.

RESULTS

Time Model Findings

Using a piecewise linear regression analysis, none of the subscale variables used to support the 2nd half decrements as predicted in hypotheses 1, 2, and 4 resulted in significant findings. However, one of the two variables used to test hypothesis 3, Leader Support in crewmembers, showed the predicted significant slope decline for the crew in the 2nd half (beta = -.218, p = .006) (Kanas et al., 2001).

Secondary analyses were conducted on all 21 mood and group environment subscales of the crew data to explore alternative time models. First, a triphasic model of time was tested using a regression approach with a quadratic function, since this yielded a reasonable test of the U-shaped pattern one would expect to see over the course of a mission if this pattern was in operation. There were no quadratic trends when all crewmembers were examined together or when Russians were examined separately. However, for the Americans alone, there were significant quadratic results for Order & Organization (beta = .007, p = .000), Task Orientation (beta = -.007, p = .000), and Self Discovery (beta = -.099, p = .000) (Kanas et al., in press[a]). Of these, only Order & Organization showed a triphasic U-shaped pattern, indicating the expected higher scores at the beginning and the end of the missions. The other two effects showed higher scores at the beginning of the missions that declined in a non-linear fashion during the middle and the end of the missions.

Next, a linear model of change was tested using a regression approach. In an analysis of all crewmembers combined and of Russians taken separately, no significant linear effects were found. But when the Americans were examined separately, there was a significant linear decline in Cohesion as the mission progressed (beta = -. 144, p = .003) (Kanas et al., in press [a]). Taken together, the quadratic and linear analyses suggested that a novelty effect occurred for the Americans, where they exhibited high scores on several measures in the first few weeks that declined as the mission progressed.

As mentioned earlier, there has been some suggestion from anecdotal space reports and analog studies that subjects score differently in one quarter of the mission compared to the other quarters. This quartile model was tested previously using one-way ANOVA's on the 21 subscales, whereby crew means were compared across the four quarters of the missions, and no differences were found (Kanas et al., 2001). We also conducted a similar analysis on Russian and American crewmembers taken separately, and we found no significant differences for the Russians. However, there were two significant findings for American crewmembers for Task Orientation (F = 9.77, p = .0015) and for Self Discovery (F = 9.05, p = .0021). The respective means across the four quarters for Task Orientation were: 7.48, 7.08, 6.95, and 6.05, and the means for Self Discovery were: 3.53, 1.36, 1.21, and 0.55. As can be seen, the highest means were in the first quarter, with subsequent means declining in value thereafter. This pattern was reminiscent of the novelty effect described above for the U.S. astronauts.

Because of recent publications supporting the existence of the 3rd quarter phenomenon (Bechtel and Berning, 1991; Gushin et al., 1997; Palinkas et al., 2000; Sandal, 2000; Sandal et al., 1995; Stuster et al., 2000), we conducted one-way ANOVAs for each of the 21 subscales that compared the crewmember mean score for the 3rd quarter of the missions versus the mean score for the other three quarters combined. We were looking to see if the 3rd quarter gave unique values that indicated decrements in functioning. Applying the Benjamini and Hochberg (1995) adjusted significance level threshold of p = .0024, we found no significant differences on any of the 21 subscale variables for all crewmembers, Russians alone, or Americans alone. There was one borderline finding for all crewmembers for Fatigue-Inertia that gave an F = 8.60 and p = .013, but the means were in the opposite direction of that predicted by the 3rd quarter effect being tested (3rd quarter mean = 1.38 vs. combined means for other quarters = 1.97).

Displacement Findings

Strong support was found for the presence of displacement effects as defined by hypotheses 5 and 6 using a regression analysis (Kanas et al., 2001). Displacement was operationally defined as occurring when there were significantly lower levels of perceived support from outside supervisors during periods of higher intra-group tension and dysphoria, as measured by the six subscale variables shown in Table 2. As indicated in the table, all six subscales showed the predicted negative relationships with Supervisor Support for all subjects taken together. There were no significant differences

Table 2. Relationship Between Six Subscale Indicators of Displacement and Outside Supervisor Support for All Subjects (summarized from Kanas, et al., 2001)

Subscale	Relationship to Supervisor Support (beta)	p^a
Tension-Anxiety	-0.039	0.005
Depression-Dejection	-0.019	0.009
Anger-Hostility	-0.024	0.009
Total Mood Disturbance	-0.008	0.000
Anger & Aggression	-0.109	0.002
Work Pressure	-0.092	0.000

[a] All p-values exceed the adjusted significance level threshold (Benjamini & Hochberg, 1995) of p=0.050

between crew and ground subjects except for Work Pressure, where the slope reached significance for crewmembers alone (beta = -.401, p = .000) but not for the mission control subjects, although there was a trend in the predicted direction (beta= -.052, p = .087).

Country and Group Findings

Overall differences in response between Americans and Russians and between crew and ground subjects were examined using an analysis of variance (ANOVA) (Kanas et al., 2000[a], 2000[b]). The results are summarized in Table 3. Note that the subjects generally endorsed positive adaptive responses. That is, they tended to score in the upper half of subscales that measured positive attributes and in the lower half of subscales that measured negative attributes (compare with subscale ranges shown in Table 1). But the American subjects seemed less satisfied with their interpersonal and work environments than their Russian counterparts: Americans reported more Vigor and Work Pressure, and Russians scored higher on measures of Leader Support, Task Orientation, Self Discovery, Managerial Control, and Physical Comfort. Mission control subjects scored higher than crewmembers on four measures of dysphoric emotions; however, each group scored significantly lower than comparable work groups from other studies on Earth on these four subscales (Kanas et al., 2000[a], 2000[b], in press [a]). In terms of interaction effects, for three subscales (Leader Support, Expressiveness, and Independence), Russian crewmembers scored higher than their American counterparts, and Russian ground subjects scored lower than Americans. In all cases, U.S. astronauts scored the lowest.

Crewmember versus Normative Sample Findings

T-test analyses of the on-orbit data for all 21 subscales were conducted that compared crew means with published means from similar Earth-based work groups that were not involved in space-related activities (McNair et al., 1992; Moos, 1994[a], 1994[b]). For six of the seven POMS mood state variables, the crewmembers endorsed significantly less dysphoria than the normative samples (there was no difference in the Vigor-Activity subscale). The crewmembers also scored lower on measures of group Expressiveness, Independence, Anger & Aggression, and Innovation; and higher on measures of Cohesion, Leader Control, and Managerial Control (Kanas et al., in press [a]). These significant subscale differences were similar for Russian and American crewmembers when compared with the normative samples, although a given difference did not always reach significance (probably due to the smaller sample sizes).

Pre-Launch, Mission, and Post-Return Findings

The overall crew responses for the 21 mood and group environment subscales during the on-orbit phase of the missions were compared to their pre-launch baseline scores and to their post-return scores using one-way ANOVAs. Analyses also were conducted separately for Russians and Americans (for the latter, the post-return comparisons could not be made for subscales assessing group environment since Americans and Russians were not together after they returned to Earth). There were no significant differences among the on-orbit and pre- and post-mission periods for all crewmembers combined or for U.S. and Russian subjects taken separately (Kanas et al., in press [a]).

Asthenia Findings

Our study provided an opportunity to look for evidence of asthenia in space. We identified eight items of stage one asthenia from the POMS and compared crewmember scores with a prototype derived from six Russian space experts using t-tests (Kanas et al., in press [b]). Our subject scores were significantly lower than the expert scores on seven of the eight items, and they generally fell in the “not at all” to “a little” range. Consequently, we could not demonstrate the presence of clinically meaningful asthenia in space based on this methodology. Mean scores did not differ across the four quarters of the missions, and there were no differences in response between astronauts and cosmonauts.

Critical Incident Log Findings

Two of us, NK and EMG, independently examined the critical incident logs and assigned each reported incident to one of 17 categories that were chosen a priori by the American research team to be relevant to our study. The inter-rater reliability, as determined by a kappa coefficient, was .685. A single best consensus rating was made for those items where the raters initially disagreed. Overall, crewmembers contributed 4% of the total number of critical incidents, and mission control subjects contributed 96%. Related categories from the original 17 were collapsed together, thus producing the eight categories that are shown in Table 4. Note from the Table that one subject accounted for 62% of the astronaut responses, and another subject accounted for the only two cosmonaut responses. There was better representation by the mission control subjects, but again a few of the more verbal participants contributed over half of the responses. Because of this sample response skewing, and the fact that subjects sometimes gave us more than one response per questionnaire, we could not statistically test for critical incident effects. Consequently, our findings only will be presented descriptively.

Table 3. Significant Country, Group, and Country x Group Findings From the 21 Subscales Using an Analysis of Variance (summarized from Kanas, et al., 2000 [a], 2000 [b])

Country Main Effect

	Means			
Subscale	**US**	**Russian**	**F**	**p[a]**
Vigor-Activity	19.33	15.07	11.71	0.001
Leader Support	5.66	7.51	6.90	0.011
Task Orientation	7.43	8.41	7.06	0.010
Self Discovery	2.01	4.53	17.59	0.000
Work Pressure	7.75	5.38	11.46	0.001
Managerial Control	5.31	6.75	14.54	0.000
Physical Comfort	1.49	2.86	6.78	0.011

Group Main Effect

	Means			
Subscale	**Crew**	**Ground**	**F**	**p[b]**
Tension-Anxiety	4.18	7.89	12.80	0.001
Fatigue-Inertia	2.01	4.83	9.69	0.003
Confusion-Bewilderment	1.87	3.50	7.30	0.009
Total Mood Disturbance	-6.30	10.48	10.22	0.002

Country x Group Interactions

	Means					
Subscale	**US Crew**	**Russ. Crew**	**US Ground**	**Russ. Ground**	**F**	**p[c]**
Leader Support	4.78	8.84	6.54	6.17	9.88	0.003
Expressiveness	2.49	4.28	5.13	3.33	9.56	0.003
Independence	4.38	6.42	6.40	5.80	9.19	0.004

[a] **All p-values exceed the adjusted significance level threshold (Benjamini & Hochberg, 1995) of p = 0.0167**

[b] **All p-values exceed the adjusted significance level threshold (Benjamini & Hochberg, 1995) of p = 0.0095**

[c] **All p-values exceed the adjusted significance level threshold (Benjamini & Hochberg, 1995) of p = 0.0071**

In terms of the two most frequently cited incidents in Table 4 by the crewmembers, 7 of the 13 incidents reported by the astronauts concerned interpersonal problems that affected their group (e.g., feeling unsupported by other crewmembers, conflicts with mission control personnel), and the other 6 pertained to negative events on-board the Mir (e.g., accidents, equipment failures). The only two Russian responses were from the same cosmonaut, who cited two negative events on-board the Mir that affected the physical environment.

Table 4 also gives a frequency count of the critical incidents reported by the mission control subjects. For the Americans, 49 of their 106 reported incidents were related to interpersonal problems that affected their group (e.g., disagreements with each other, the leader, crewmembers, and Russian colleagues), and 16 pertained to negative events on-board the Mir (e.g., accidents, equipment failures). For the Russian mission control subjects, 86 of their total of 273 responses were related to negative events on-board the Mir (e.g., accidents, equipment failures), and 60 pertained to inadequate resources and delays in receiving their salary due to fiscal problems in Russia.

Subjects rated the impact of each critical incident on themselves and on their group on the following tension scale: "none" (scored as "0"), "a little" (scored as "1"), " moderate" (scored as "2"), "quite a bit" (scored as "3"), and "extreme" (scored as "4"). In terms of the six negative categories shown in Table 4, the overall means for personal tension were: 2.23 (U.S. crew), 3.50 (Russian crew), 2.42 (U.S. ground), and 2.53 (Russian ground). Comparable

Table 4. Critical Incidents Reported by Crewmembers and Mission Control Personnel

	Crew		Mission Control	
	US (n=5)	Russian (n=8)	US (n=42)	Russian (n=16)
# Subjects providing at least 1 incident response	4[a]	1[b]	23[c]	14[d]
# Questionnaires with at least 1 incident response	13	2	106	273
Category Frequencies				
Negative events on board Mir	6 (46%)	2 (100%)	16 (15%)	86 (32%)
Interpersonal problems in group	7 (54%)	- -	49 (46%)	19 (7%)
Resource and salary problems	- -	- -	3 (3%)	60 (22%)
Crew medical / psychological problems	- -	- -	1 (1%)	27 (10%)
Family concerns and homesickness	- -	- -	7 (7%)	5 (2%)
Other negative events	- -	- -	13 (12%)	40 (15%)
Positive events	- -	- -	10 (9%)	25 (9%)
Neutral events / Insufficient information	- -	- -	7 (7%)	11 (4%)

[a] One subject provided 62% of the responses.
[b] One subject provided 100% of the responses.
[c] Four subjects provided 54% of the responses.
[d] Three subjects provided 53% of the responses.

means for group tension were: 1.62 (U.S. crew), 3.50 (Russian crew), 1.58 (U.S. ground), and 2.24 (Russian ground).

DISCUSSION

There was little evidence to support the presence of moderate to strong time effects in space in accordance with the previously described biphasic, quadratic (e.g., triphasic), linear, and quartile models. But the biphasic model did reveal an overall 2nd half decline in perceived support from the commander, as judged by the crewmembers. This is especially interesting since half of our cosmonaut subjects were mission commanders who were evaluating their own level of support. The effects of the long missions may have influenced the ability of the commander to be as supportive as before, or perhaps there was a greater need for leader support by the crewmembers as the missions progressed over time. The triphasic finding for astronauts suggested that Americans in space felt that their interpersonal environment was more organized at the beginning and end of the on-orbit period than during the middle. This may have been due to the fact that the new astronauts were formally oriented to the Mir shortly after arriving by the departing astronauts and by the continuing cosmonauts. In addition, the preparation for the return to Earth required all of the crewmembers to undergo specific procedures during the end of their mission, and the American responses may have reflected this increase in structure during the last part of the missions. The other two significant quadratic subscale findings for the Americans (Task Orientation and Self Discovery) and the significant linear finding for Cohesion suggested that the American crewmembers might have been impacted by the novelty of the situation during the first few weeks of their missions: they initially viewed their crew environment as one where orientation to tasks was high, where they could learn about themselves, and where there was a strong degree of cohesiveness. Over time, declines in these areas may have indicated that the novelty of the situation simply disappeared, or the drops may have been due to an emotional change in the Americans due to homesickness or other psychosocial factors. One might be tempted to invoke asthenia as a contributor to these declines, except for the fact that we found no evidence to support the presence of clinically meaningful asthenia overall or in any particular quarter of the missions.

The absence of differences in subscale scores among the four quarters of the missions suggests that no single quarter was unique in terms of our measures, with the exception of two subscales whose trends seemed to parallel the patterns found in the linear model for Americans. Furthermore, we found no evidence to support the 3rd quarter phenomenon. Perhaps our sample size of 13 crewmembers gave us insufficient power to test for this occurrence. In addition, we took a more conservative approach by controlling for Type I errors through the use of the stricter adjusted significance level threshold instead of using the standard significance criterion of p = .05; however, even if we had adopted this criterion, none of the subscales would have been significant in the expected direction for all subjects taken together, Russians alone, or Americans alone. Since studies suggesting the occurrence of a decrement in 3rd quarter functioning have mainly been conducted in space analogs, it is possible that people working in space experience different time effects than people working in similar environments on Earth, since no simulation can exactly replicate the psychosocial environment found in space (Kanas, 1998; Kanas et al., 1996). At any rate, more work needs to be done to evaluate the presence of the 3rd quarter phenomenon, both in space and in analog conditions.

The strong support for displacement (as we operationally defined it using our measures) has important ramifications for future space missions. Displacement may result in the transfer of on-board or mission control emotions and misperceptions to the outside rather than allowing them to be dealt with more appropriately in the group. In addition, displacement can lead to distortions in communication between crewmembers and mission control personnel and between mission control personnel and management staff. People working in space missions need to recognize and deal with the emergence of displacement before communication problems emerge. Pre-flight countermeasures could include formal lectures and briefings that address this phenomenon and team-building exercises that involve both crewmembers and mission control personnel. During the mission, the crew and ground interpersonal climate should be monitored by specialists trained to detect psychosocial problems and displacement effects, and if present, counseling sessions aimed at helping both parties deal with the relevant intra-group and inter-group conflicts could be conducted.

American subjects, especially U.S. crewmembers, reported more dissatisfaction with their interpersonal environment than Russians. As U.S. citizens on-board a Russian space station where the commander was always a cosmonaut and where operational activities were usually conducted in the Russian language, the American astronauts probably were more negatively affected than the Russians by psychosocial pressures. In addition, since the crew composition typically consisted of two Russians and one American, the latter was a true minority and did not share the same cultural background and native language with anyone else. This might have led to the astronauts feeling socially and culturally isolated during the missions.

Mission control subjects reported higher levels of negative emotions than crewmembers, as measured by four of our mood subscales. Perhaps the latter were more enthusiastic and better trained for their work environment than the former. After all, many of our crewmember subjects had been dreaming and preparing to fly in space for years, and they may have overlooked problems in their interpersonal and physical environment due to their overall satisfaction with being on-orbit. But one should be cautious in interpreting the meaning of this crew-ground difference, since both crewmembers and mission control personnel scored in the more positive adaptive ranges of the subscales than people in other work settings, as determined by published norms from samples in other studies on the ground. Therefore, the relative degree of unhappiness by the mission control personnel needs to be interpreted with this comparison in mind.

The lack of pre-flight/on-orbit/post-fight differences was surprising in light of the fact that we found such differences in an earlier simulation study (Kanas et al., 1996). Perhaps the crewmembers felt similar emotional and interpersonal pressures to perform in training as they did on-orbit and in the immediate post-mission period. Alternatively, our subjects may have been the kind of people who take all kinds of assigned tasks in stride, whether they are in space or on the ground, with their degree of emotional response remaining relatively stable in both settings.

As operationally defined using the POMS, we could not demonstrate the presence of asthenia in space. However, this measure only addressed some of the emotional, and none of the physiological, aspects of the syndrome. Further research on the existence and characteristics of asthenia in space needs to be done that includes physiological measures and other measures that are specific to this syndrome.

In discussing the critical incident log results, it should be remembered that a few verbal subjects provided most of the critical incidents, notably in the crewmember sample. Nevertheless, in all four groups studied (Russian and American crew and ground groups), one of the top two categories in terms of frequency pertained to accidents and equipment failures that occurred on-board the Mir space station. Since activities on-board the Mir were the focus of the missions, it is understandable that negative events that took place there were on the minds of both crew and ground personnel. It is interesting that the most frequently cited incident for Americans in both the space and ground environments pertained to interpersonal problems. Perhaps being away from home and working in Russia on a program that was operationally managed by Russians may have sensitized the Americans to be aware of interpersonal factors. Next to events on the Mir, the most frequently cited incident cited by Russian mission control subjects pertained to resource and salary concerns, which represented real issues related to political changes in Russia and the fact that many of these subjects did not receive their salary for several months due to budgetary limitations.

The personal tension levels from these negative critical incidents were scored as producing a “moderate” to “quite a bit” amount of tension, whereas the group tension levels were rated as being “a little” to “quite a bit”. In both cases, the two cosmonaut responses accounted for the “quite a bit” scores, which is understandable since they addressed the effects of serious and potentially life-threatening malfunctions on-board the Mir. The degree of personal tension associated with the negative critical incidents seems appropriate for the kinds of stresses being reported, and this is in contrast to the less dysphoric responses reported above for some of the subscales. However, in the latter case, the subjects were rating a week's worth of experiences, whereas for the critical incidents they were rating specific events. In addition, it is possible that the more emotive subjects were more likely to report negative critical events than subjects who were less verbal or felt less impacted by stressful occurrences.

CONCLUSIONS

Our study demonstrates that psychosocial research can be conducted in space provided that careful attention is paid to issues of confidentiality and to subject time and scheduling considerations. Both crewmember and mission control personnel need to be studied. Although time effects appeared to be weak, there was evidence for drops in perceived crewmember leader support during the 2nd half of the missions and for a novelty effect at the beginning that influenced American astronauts. We found no evidence to support the 3rd quarter phenomenon. We did find strong evidence suggesting that displacement of in-group tension and dysphoria to outside supervisory staff occurred in both crewmembers and mission control personnel. Americans seemed less happy with their interpersonal and work environment than Russians, and in space this may have resulted from the fact that the U.S. astronauts may have felt socially and culturally isolated. Crewmembers also reported lower levels of negative emotions than people in mission control, but both groups reported less dysphoria than other work groups on Earth. Crewmember responses on-orbit were similar to those before and after the missions. Using one of our measures, we found no evidence of clinically meaningful asthenia in space, although further studies need to be done that include physiological indicators of this syndrome. Despite some skewing in response by a few more open and verbal respondents, all subject groups listed negative events on board the Mir as important critical incidents, with Americans also citing interpersonal problems and Russian mission control personnel also citing resource and salary issues. Finally, management should be aware that negative interpersonal phenomena that occur during long-duration space missions may be related more to psychological and interpersonal pressures that affect people working under stressful and confined conditions than to individual personality weaknesses, and that psychosocial problems in future space missions may be prevented through proper training and support.

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