Ten Missions, Two Studies

Crew Composition, Time, and Subjective Experience in Mars-Analog Expeditions*

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Note. Figures 1-4 are unavailable in this draft.

Abstract

Results are reported from a pilot study investigating the effects of crew composition, mission duration, and mission phase on rates of deviance/conflict among Mars-analog expeditions, which was preliminary to a more extended project funded by the National Science Foundation. The standardized rates of deviance constructed during the pilot study displayed distinct patterns across different crew profiles and space and polar settings. Contrary to predictions, heterogeneous crews had lower rates of deviance/conflict than homogenous crews, larger crews had lower rates of deviance/conflict than smaller crews, and rates of deviance/conflict were lower for longer duration missions and expeditions. Space missions had higher rates of deviance/conflict than polar expeditions, and the hypothesized "third-quarter phenomenon" (rates of deviance/conflict will be highest just after mission mid-point), was evident among relatively homogenous space missions.

A secondary analysis over the missions in the pilot sample found compelling information to suggest that several factors which create specific differentials between outside (baseline) groups (e.g., mission controllers, "folks back home") and groups in extreme environments need to be investigated. These differentials deal with how the passage of time is subjectivized by the crews and how the expeditionary situation is otherwise defined differently from baseline. These differentials may be useful in explaining why no distinct patterns have emerged from prior studies of performance, cognition, physical and mental well-being which correspond with long- and short-duration missions. The definition of the long-duration mission, such as a mission to

Mars, would seem to involve more than the issue of real-time duration.

Keywords: Deviance/conflict, extreme environments, third-quarter phenomenon, crew characteristics, mission duration, mission phase, long-duration space missions, Mars-analog expeditions, subjective time, situational reality, definition of the situation

1. Introduction to the Pilot Study

The psychosocial aspects of extreme environments fall in the area of human factors. However, rather than being primarily interested in the human-material culture or human-environment interfaces – which are the classical concerns of human factors science – the psychological and sociological aspects of extreme environments are interested in the human-human interface. Though a number of scientists have produced a compelling body of research at this interface, the realities of short-duration space missions and limited space budgets have prevented the footing of any thorough and sustained effort in psychosocial investigation across all space-related organizations. This has accounted for most of the prior neglect in this area of study, and to some degree for the neglect in related biomedical concerns. However, other factors are responsible. A certain amount of prudery has prevailed concerning such public relational sensitive topics as sex in space and the feminine hygiene of female astronauts and cosmonauts. NASA-affiliated researchers have faced some opprobrium for wanting to study such topics in past. Up till late 1997, no pelvic exams had been performed on orbit. As a result of these attitudes, until the senior author of this report wrote a technical note on the subject for the Institute for Biomedical Problems for the 1999-2000 Russian space station simulation, the Russian Space Agency was reported not to have had any such protocol in place although a number of women have flown actual Russian space missions or participated in space analog simulations.

Other factors are the machismo creed of space flyers, which is a holdover from the "right stuff" attitudes of jet pilots, which can even be observed among non-pilot mission specialist scientist astronauts and among women space explorers. There are real fears among the corps of astronauts and cosmonauts that if they are sensitive to psychosocial and related concerns, then they may be viewed as complaining and that might detract from their efforts for a mission.

Tours of duty on the International Space Station and the prospect of long-duration space missions change everything. Various incidents have happened on recent space missions, on recent polar work teams, and in simulations. Actually, such incidents have been happening all along, as the expeditionary record will bear out, but the implications of those incidents and sustained working and living on the high frontier have taken on a significance and urgency as

never before. Suddenly, realization has dawned that we had better start paying attention to the psychosocial aspects of extreme environments and the related biomedical concerns. It is against the dawning of this paradigm shift that the research underlying this report has been conducted.

This report presents the results of a pilot study investigating the effects of crew characteristics, mission duration, and mission phase on rates of deviance/conflict among performance crews in extreme environments (i.e., space missions and polar expeditions). This study, which is preliminary to a more extensive project funded by the National Science Foundation, had three basic objectives. They were to:

1. Develop and test protocols for reliably coding deviance/conflict from written records (e.g., logs, diaries, and narratives) of space missions and polar expeditions;
2. Provide preliminary evaluation of a priori hypotheses concerning the impact of demographic features of crews, and of mission duration, on rates of deviance/conflict among performance teams in extreme environments; and
3. Provide preliminary evaluation of the anecdotal hypothesis that rates of deviance/conflict will peak just after mission midpoint (i.e., the "third-quarter phenomenon").

In the first phase of the pilot study, there were developed protocols and procedures for identifying and coding instances of deviance/conflict from written records of space missions and polar expeditions. The methodology is reported in Dudley-Rowley (1997, 2000). Multiple coders were then able to produce reliable data for a stratified random sample of crews in extreme environments -- three space missions: Apollo 11 (Aldrin 1973), Apollo 13 (Lovell and Kluger 1994), and Salyut 7 (Lebedev 1988); four Antarctic expeditions: the western party field trip of the Terra Nova Expedition (Back 1992), an International Geophysical Year traverse (IGY)

(Pirrit 1967), the Frozen Sea (Lewis and George 1987) and the International Trans-Antarctica (Steger) (Steger and Bowermaster 1992) expeditions; and three Arctic expeditions: the Lady Franklin Bay (Greely 1886), Wrangel Island (Stefansson 1925), and Dominion Explorers' (Pearce 1930) expeditions. Although coders sometimes identified different aspects of an event/incident as being problematic, they quite consistently identified the same events/incidents as evidencing deviance/conflict.

2. Theoretical Background

The study of these data were informed by the theoretical work of Peter Blau and Bruce Mayhew. In a series of writings in the latter half of his career, Peter Blau outlined a relatively formalized theory of the effects of social structure on rates of intergroup association (1977). His primary concern was to identify factors that either fostered or hindered contact and interaction among people who occupied different positions in a multidimensional social structure. This, because he felt that rates of intergroup association were essential determinants of social solidarity and social cohesiveness.

For Blau's purposes, the assumption, and oft-observed empirical regularity, that, ceteris paribus, people tend to prefer to interact with others who are socially similar -- homophily -- is a largely unexamined predicate for his exploration of how, despite this in-group preference or bias,

differing distributions of people across social dimensions will, by chance alone, promote different rates of intergroup association. For example, if there are two socially distinguishable groups (e.g., males and females) -- a 50:50 distribution will, under the same constraints, promote more intergroup association than a 10:90, or 20:80 distribution.

For our purposes, it is worth examining this assumption more closely. Why homophily? The simplest and most straightforward reasons are: time and energy. Other things being equal, communication among people who are culturally and socially similar is quicker, and less likely to produce misunderstanding and inadvertent offense than it is among those who are different. Think of a continuum ranging from attempted communication among people who speak mutually unintelligible languages and who differently interpret the same physical gestures (e.g., head nodding or hand gestures) to individuals who are so similar in experiences, education, and familiarity that they can complete each others' sentences before they are spoken. In general, communication among those on the latter part of the continuum will be quick and efficient, while among those on the former will be difficult, time consuming, frustrating, and fraught with dangers of inadvertent insult and misunderstanding.

Therefore, although we sometimes enjoy communicating with people of different backgrounds and culture, because it is stimulating and interesting, we welcome the return to less problematic communication with people who "understand us."

2.1 Hypotheses

Coupling this with the insights of Bruce Mayhew, that contacts and conflicts are likely to increase geometrically with increasing group size (Mayhew and Levinger 1976), and become more likely over time, the authors could derive some a priori hypotheses about conflict among the crews of space missions and polar expeditions. These are that:

1. Heterogeneous crews with respect to nationality, sex, age, and experience will have higher rates of deviance/conflict than homogenous crews.
2. Larger crews will have higher rates of deviance/conflict than smaller crews.
3. Rates of deviance/conflict will increase with increasing mission duration.

Finally, based on anecdotal accounts, the authors could hypothesize that rates of deviance/conflict will vary systematically by mission phase. More specifically that:

4. The rate of deviance will peak in the third quarter.

2.2 Measures

To enable comparisons across cases with differing size crews and of differing duration, standardized rates of deviance were computed for each quarter of the missions/expeditions by dividing the total number of coded events in the quarter by average crew size (in a number of cases people left and joined crews during missions/expeditions), and then dividing by quarter duration in days (DaPrRate). To make the numbers more manageable, this rate was multiplied by 1,000. The figures reported for quarterly rates of deviance/conflict, therefore, are per crew

member per 1,000 days. Rates for the complete missions/expeditions were computed by taking the simple average of its rates for four quarters (Table 1).

Heterogeneity was calculated in accordance with "Blau's H." That is, by subtracting the sum of the squared proportions in each category of heterogeneity from 1 (Blau 1977). Intuitively, it is the probability that two randomly selected crewmembers will belong to a different category of the dimension of heterogeneity in question (i.e., nationality, sex, years of experience). Age heterogeneity was indexed by the age range of the crew.

3. Empirical Results

Every one of the a priori hypotheses was challenged by the data analyzed in the pilot study. Contrary to prediction: (1) heterogeneous crews had lower rates of deviance and conflict (Figure 1), (2) larger crews had lower rates of deviance and conflict (Figure 2), and (3) deviance and conflict tended to decline with increasing length of mission (Figure 3).

It is also noteworthy that rates of deviance/conflict were higher in the space missions than they were in the polar expeditions. Salyut 7, which had the lowest rate for the space missions, had twice the rate of deviance/conflict as the highest polar expedition, Wrangel Island. One possibility is that there may be some functional level for the expression of conflict. Somewhat analogous to marriage, it may be the case that crews that never express open disagreement, or those who fight "like cats and dogs," do not function as well as those who confront and constructively work out openly expressed disagreements. Anecdotally, space crews are well-known for suppressing the expression of conflict. The polar expeditions which had the most severely expressed conflicts in the sample were Frozen Sea, Wrangel Island, and Steger expeditions. They demonstrated the highest rates of deviance/conflict compared to the other polar expeditions (Lady Franklin Bay, the Terra Nova field party, Dominion Explorers', and the IGY traverse). Only in the final quarter of the Lady Franklin Bay expedition, when the men were mentally deteriorating from starvation did severely expressed conflictive events occur. Of the space crews in this sample, the Salyut 7 crew more openly expressed more conflict among themselves than both Apollo crews did. Salyut 7 had lower rates of deviance/conflict than those crews.

The "third-quarter phenomenon," was confirmed in the 10 cases treated (Figure 4). Further examination shows, however, that it is only clearly present in Apollo 13 and Salyut 7. Several issues are raised by this specification. It is possible that it indicates that the third-quarter phenomenon only occurs in relatively homogenous crews. This might help explain its "anecdotal" status; researchers studying homogenous crews find it while those working with heterogeneous crews do not. The fact that it is found in Salyut 7, a relatively long space mission, suggests that it is not simply an artifact of extrapolating rates from very short time frames. But it may indicate that space missions are different from polar expeditions in this regard. More explicit knowledge of the time limits of the mission, and pressure to complete assigned tasks on schedule, may contribute to the effect. These issues will be targeted in the larger study, and every attempt will be made to test this pattern for statistical significance.

4. Discussion and Conclusions of the Pilot Study

Three accomplishments of the pilot study are worth emphasizing. First, it has documented the fact that the protocols and coder training developed for the pilot study produce strong coder agreement (intercoder reliability) on instances of deviance/conflict from mission and expedition narratives. Second, standardized rates of deviance display distinct and intriguing patterns across different crew profiles and space and polar settings. One suggestive pattern is that homogenous crews appear to have low rates of deviance/conflict that tend to dramatically increase over the course of the mission, while heterogeneous crews have initially high rates of deviance/conflict that decline over the course of the mission. This may indicate that homogenous crews (falsely) believe that they have no interpersonal issues or conflicts, or suppress the expression of them, until they are too intense to ignore, while heterogeneous crews expect and acknowledge them at the outset. It may also indicate that members of heterogeneous crews may be better able to find distinct and comfortable "niches," than can members of homogenous crews who are so much alike. Third, the fact that the third-quarter phenomenon was only found among relatively homogenous space missions, also suggests some interesting avenues of exploration in the larger study.

5. Introduction to the Secondary Analysis

Traditionally, long-duration missions in extreme environments have been understood to encompass missions of some undetermined chronological length that is longer than "short" duration. While a general consensus exists that two weeks fall within the "short" duration range, there is decreasing consensus on the threshold that qualifies a mission for "long-duration" status. Classifications based on space missions have a clear break between the 14-16 day shuttle missions to the months-long rotations aboard Skylab, the Salyut stations, and Mir with very little in between. Even earlier space missions lasted from a few hours to a few days in duration. Analog and simulation studies have ranged from 2 weeks to 10 months. Actual polar expeditions, especially the earlier ones, have been in the field for several years.

Efforts to find patterns in performance, cognition, physical and mental well-being which correspond with short- and long-duration mission profiles have not found clear differences. Decrements in performance, cognition, and group dynamics have manifested on missions as short as two weeks. Perhaps we are missing the point and assuming far too much that mission duration alone dichotomizes missions. There may not exist key elements linked to actual real-time duration that require different preparation, support, and training for long-duration missions compared to short-duration missions. Perhaps the key elements we are looking for are linked to those things which "alter" subjective time for extreme environmental crews and which make the mission in the extreme environment situationally different from the baseline societies from which team members derive.

The concern with subjective time and similar factors could be couched as a class of situation awareness problem. In the literature of human factors, the problem of situation awareness typically addresses how conscious the operator of an aircraft or other vehicle is of outside conditions or the fitness of his/her craft (e.g., attitude of a transport plane). In a usual situation

awareness problem, a person watching from the ground might observe that an aircraft "was flying upside down." Radio contact with the cockpit crew might confirm that the operators of the plane were not aware of that. The problem of subjective time and other situational factors emerging from the interplay of the extreme environmental group, its individual members, and its environment is a bit more insidious for the observer. Outside observers whose business it is to be concerned with space and other extreme environmental crews, like mission controllers, are not traditionally trained to recognize that "what is real" for a person or a group away from their larger baseline group can differentiate -- and differentiate quite rapidly -- from "what is real" for the baseline. In examining the expeditionary record, it is obvious that outside observers from baseline societies have had difficulties adequately assessing the situations of extreme environmental teams, which become microsocieties in themselves. Outside observers can be successful in targeting problems of basic quantity (e.g., the crew will run out of breathable air in two hours' time.) But, observers and controllers are likely to be totally oblivious to a wholly different metric which deals with things of a more social psychological nature. A hypothetical example illustrates the point: a projects supervisor at an Antarctic winter-over base, over a three-month period, committed 3,030 "microaggressions" against his teammates numbering 31 persons. His superiors, elsewhere in the world, wonder why the team cannot keep pace with its duties, and why more people than before have reported a higher than average number of ailments ranging from recurring headaches and stomach problems to depression (Pierce 1991). If the psychosocial dimension would become a greater concern among agencies that employ extreme environmental workers, it would produce useful information for the areas of crew selection, training, and mission planning and policy. The importance of the psychosocial dimension and the crew's definition of the situation are things that astute and specially empathetic Capcoms have qualitatively known about for years, as have teams which routinely engage in the rescue of hostages or people in trouble in extreme environments.

Factors of a psychosocial nature have been at work in recent studies preparing for the operation of the International Space Station. While it may be documented that a woman serving aboard a Russian space station simulator for some months in 1999 and 2000, was twice subjected to physically aggressive sexual advances in the simulation by a male co-participant (CBC News 2000, Guly 2000), it is reductionist to say that is all that happened (Sandal 2000). The crew's situation up till the time of these events had taken on a reality which had differentiated from the baseline outside of their chambers from the moment each participant stepped into the simulator. Actions, gestures, settings, materials, and words would have come to have special meaning for the participants. They had formed a microsociety which had begun to deviate from the different cultures from which they derived (Bishop 2000) and this can be said even in light of personal and prior cultural differences. The woman participant found the kisses intrusive, threatening, a prelude to rape, and the fact that she kept a knife close by afterwards makes it clear that she felt a pervasive fear of being assaulted for days after the overtures. It is fair to say that inside the Russian simulator, a kiss was not just a kiss.

What goes on in the psychosocial dimension can work for good or ill. Microsocietal formation is also at the heart of the successes in functioning of the Mir-NASA crews in spite of different national agendas. One thing that stood out in the more problematic of these flights is the differential in the timing of task performance and the quantity of tasks scheduled. The Russian space station was set up with a specific work and living cycle in mind that resembled more of a

work day on the ground, and its focus was on missions of real-time longer duration. Enter the American astronauts, trained to do a grueling round of scientific and commercial work within a shorter period. After awhile, it occurs to the astronaut that equipment is not where he can put his hands on it quickly, he is getting overworked and off-track, he cannot eat or sleep at regular times, he is attempting to follow a schedule that is an interminable expansion of a short shuttle mission, he does not have a standard operating procedure to look up what to do in this situation, his Russian fellows have duties and problems of their own keeping the station up and running and cannot help him catch up. In turn, his Russian fellows wonder what is the matter with him? Is he an idiot? The American and his Russian fellows have some heated discussion about their problems with one another and it dawns that they are trying to track along two different schedules from two different national foci. Afterwards, they do the best they can, under the circumstances, to merge their interests and schedules (Burrough 1998).

Attention to the psychosocial human factors and understanding how situations in the extreme environment can deviate from the baseline on the ground or "back home" can lead to the optimization of the objectives of space missions which will become longer and more autonomous. In this vein, it is as important an area of research as are radiation exposure, bone demineralization, and cardiovascular studies.

6. Methods

The secondary analysis began with an insightful question, "Are three months aboard the International Space Station (ISS) really as ‘long-duration’ as compared to three months outbound to Mars?" The pilot study, described above, offered compelling data to answer this question. A secondary analysis of that study’s pilot sample set was done, content-analyzing for other factors which might have distinguished the missions from one another, besides the milieu, crew size, heterogeneity, mission duration, and mission phase which the original study examined. Several items emerged which increased the complexity and danger of missions. Indeed, the notion of duration seemed to change as missions became more complex and dangerous in terms of increasing separation from various aspects of individuals’ normal baseline routines (e.g., home, the training environment, etc.) and with the introduction of different routines shaped by the expeditionary social and physical environments . An hypothesis emerged: As the crew’s control over its environment decreases, its members’ subjective experience of the passage of time and the situation increasingly differs from the point-of-view of its baseline. A vernacular example of what we mean comes from a popular song. Gordon Lightfoot, in singing about the wreck of the Edmund Fitzgerald on Lake Superior during a freak storm, asks, "Does anyone know where the love of God goes when the waves turn the minutes into hours?"

The stratified random sample of Arctic and Antarctic expeditions and space missions in the pilot study was re-analyzed. The Apollo missions to the moon ranged from 6-8 days, and the Salyut 7 orbital mission lasted over 200 days. The Lady Franklin Bay and Wrangel Island expeditions to the Arctic were the longest missions at 1080 and 720 days respectively. The Frozen Sea and Steger’s expeditions were 480 and 224 days respectively. The IGY field traverse, the Dominion Explorers’ Expedition, and the Terra Nova western party field trip were 88, 72, and 48 days respectively.

Seven factors emerged which seemed to co-occur with the subjectivization of time and the differentiation of situational reality for the crews from baseline . These were:

1. increasing distance away from rescue in case of emergency (lessening chances of "returnability");
2. increasing distance from Earth (which is in the same category as increasing proximity to unknown or little-understood phenomena);
3. increasing reliance on a limited contained environment (where a breach of environmental seals means death or where a fire inside could rapidly replace atmosphere with toxins);
4. increasing difficulties in communication with Ground or Base;
5. increasing reliance on a group of companions who come to comprise a microsociety as time, confinement, and distance leave the larger society behind, and where innovative norms may emerge in response to the new sociophysical environment;
6. increasing autonomy from Ground's or Base's technological aid or advice; and
7. diminishing resources needed for life and the enjoyment of life.

The presence and prevalence of these factors in each of the sample missions/expeditions are discussed in the context of mission summaries below. The numbers in parentheses within the summaries correspond with the numbered items in the list above.

7. Results

7.1 The Lady Franklin Bay Expedition

The primary record of this expedition shows that the everyday routine of the expeditionary party was initially experienced in much the same way as an army unit in garrison in the world-at-large. There were regular meals which were well-planned and painstakingly prepared, there were regular cycles of interesting work and leisure, sub-groups formed with the men enjoying their social niches, and the years in the field appeared to fly by for the party until a combination of events exerted a deadly toll. In its final months, time seemed to stand still, with men begging to die, to end what seemed to them an unceasing wait for starvation to claim them.

The Lady Franklin Bay Expedition was one of the first American expeditions mounted for the purposes of knowledge-gathering in cooperation with an early global geophysical effort. Not organized for military purposes, it was nonetheless handed to the U.S. Army to carry out, and the U.S. Navy was ordered to provide transportation and logistical support to it. It was poorly financed and initialized. It was characterized by not just "distance from rescue in case of emergency" (1), but was literally abandoned in the field (6). Its abandonment had to do with a poorly understood phenomenon at the time: semi-permanent pack ice (2). The expeditionary party became unreachable by the naval vessels of the period because the "ice-free" inlet where they were dropped off had become choked with pack ice. Instead of staying where they were, where there were food stocks and game, where they could have endured another year or more, they had orders to trek to a more southerly locale where there might have been open water and where the Navy was supposed to have stocked supplies. There was no open water at this locale, either, and the Navy officers responsible for contingent provisioning had failed in their duties. That they could not communicate with authorities made the situation worse (4). Innovative

norms to cope with their situation did arise within this microsociety. The most outstanding of these was the execution of Private Henry, whose demise resulted from an unrelieved history of stealing food from the group, thereby jeopardizing the lives of his companions. While there was a legal basis for his execution under the military regulations of the day, it defied the genteel mores of the larger society his companions derived from, some whom were scholars who had taken Army enlistments to join the expedition. His execution came only after giving him many chances to withdraw from his course of action; and only after he agreed to be shot and after his surviving companions voiced their assent. The order for execution was formalized in writing by the Army commander of the expedition (5). Their environment was contained in the sense that they had to be protected from the Arctic elements. Two or three fires threatened their habitats, but the worst environmental hazard to their quarters occurred when all hands were nearly killed when a carbon monoxide build-up overcame them (3). This expedition was reduced from 25 healthy men to seven owing to diminishing resources needed for life and the enjoyment of life (7). The seven who survived only made it back owing to the efforts of the commander's wife who posted a bounty among naval, whaling, and merchant ships plying the waters of the Eastern Arctic.

7.2 The Wrangel Island Expedition

The Wrangel Island Expedition was largely a private American venture staffed by young men, a few whom were college boys. The objective was to acquire a Western Arctic island for a reindeer ranching operation, among other things. Though not terribly far away from rescue (only 90 miles from the Siberian coast), the same phenomenon which lent to the destruction of most of the Lady Franklin Bay party was at work on this expedition. The semi-permanent pack ice blocked off a resupply ship, taking the party into another winter. The condition of the pack ice between the island and the mainland was underestimated in its stability, and an attempt by part of the party to cross over likely met with disaster (2). Their bodies were never found. Owing to the physical barriers, there was no way to communicate or go get help (1, 4, 6). Diminishing store-bought food combined with a lack of knowledge about game-hunting techniques, or sometimes what seemed a failure to hunt when they could and knew how, lent to a whittling down of resources for sustaining life (7). This, and that another of the party had fallen physically ill, drove the desperate attempt to cross unstable ice. An examination of the records they left behind show that the norms changed in their microsociety over time. Left on their own, the party initially tried to patiently deal with the emergent mental illness of the only woman in their number, a young widowed mission-educated Eskimo seamstress, as well-brought-up young men of the period would be expected to do. Her illness appeared to emerge as a response to winding up the only woman in the party, with a load of domestic work which she was not prepared to handle alone, and a feeling of betrayal at being told there would be other sewing women coming along. But, as her behaviors became more abnormal, those behaviors came often to be dealt with harshly by the men. Eventually all their dysfunctional behaviors became too expensive for them to sustain in the face of a situation becoming increasingly desperate. They made a better effort to pull together, and the party became more cohesive as a group. With most of the party not returning from the ill-fated cross over, and the only man left behind dying of an unknown ailment, the young woman rallied and learned to hunt game and to trap to keep herself and the man alive as long as possible. The man, however, died only a short time before rescue of the female sole survivor. Several innovations in the norm are observed in light of the changing

sociophysical environment (5). There did not seem to have been any difficulty with their environmental habitats, but they did suffer from a shortage of the right kind of equipment to be successful in their environment. Even that, however, was replaceable with substitutes constructed from the equipment they had. They essentially suffered from a good knowledge base of their extreme environment and a disinclination to innovate safer solutions to their situation.

Initially, the males of the party engaged in scientific and commercial endeavors, interrupted by episodes of attempting to deal with the woman's increasingly odd behaviors. Their subjective experience of time seemed unremarkable until the ship with the replacement crew did not appear. Their riskier decisions began to occur after that. Diary entries address the feeling of getting behind in their college curricula or missing career chances. Interviews with the woman afterward speak of her disappointment that other sewing women could not be employed, which left her without a social niche, without helpers, with a mountain of chores always in front of her, and with never seeing her young son again. Her earlier state, which showed features of depression, may have meant that she had begun to subjectivize time and their situation differently earlier than her male companions.

7.3 The Dominion Explorers' Expedition

The Dominion Explorers' Expedition was a mineral survey mission in the Canadian Arctic. Chronologically, this was a short-duration expedition which was exacerbated by being marooned owing to the changeable nature of sea ice covering an inland bay -- quite similar to the problems experienced in the Lady Franklin Bay and Wrangel Island expeditions (2). They did not lack for rescue because they were assisted by Eskimo operating in the area, who became part of the party and who contributed to their knowledge base to survive. Their environmental habitat was limited, but other than some trouble with the roof of their makeshift shelter, they were in no great danger from that. They had no communications with their base (4). However, there was not enough time for them to invent new norms to govern their microsociety. They were relatively autonomous from their base's technological advice and aid, although a search party was put afoot to hunt for them (6). Store-bought resources diminished, which diminished the enjoyment of life somewhat, but indigenous resources kept them alive.

The primary record of this expedition shows no notable shifts in how the passage of time was experienced beyond some impatience expressed by some members of the party to cross newly forming ice to arrive at their intended destination.

7.4 The Terra Nova Field Party

This expedition was part of a longer duration expedition launched for scientific goals and national glory. In itself, it was a short-duration expedition. Although the need for rescue was not there, the men of this party were most of the time many days or weeks away from rescue, provided at least one of them could walk out to make contact with their base (1, 4, 6). Little understood phenomena did play a part in endangering them and their habitat (few maps of crevasse fields being in existence and the rigors of camping on thin sea ice) (2). However, they did not suffer much in terms of dangers within their work and living habitats. They never lacked

for resources. There was not enough time and other factors to bring about an alteration of norms to cope with life in a microsociety divorced from the larger society.

The primary record of this field trip does not indicate that the party experienced remarkable differentials in the way time was subjectively experienced or from the situation at base camp.

7.5 The IGY Field Traverse From Byrd Station to Amundsen Sea and Return

This was a short-duration expedition as part of the larger International Geophysical Year effort. The crew was never very far away from means of rescue in spite of miles traversed. When a man developed a bleeding ulcer, the U.S. Navy came out to the field and retrieved him. When they were becoming a little dysfunctional from each others' cooking, the Navy brought a cook out to them. They also had an advanced enough technology to transport themselves back to base. The unmapped nature of crevasse fields did make their expedition a bit removed from everyday life (2). They were in no danger from events within their work and living habitats. They always had communication with Base. Their microsociety did not come to innovate norms to cope with their situation. They were never really autonomous from their base's aid and advice. And, no resources diminished to reduce their chances at life and its enjoyment.

The primary record of this traverse does not report any differences from baseline in the ways that time or the situation was experienced by the team.

7.6 The Frozen Sea Expedition

This was a long-duration expedition taken to meet scientific goals, but was more in the realm of recreational exploration which might have appended some national glory. The crew was always within reach of rescue for the most part. The team was never exposed to any condition which put them at a disadvantage to an unknown or little-understood phenomenon. There were some incidents which could have put them at risk within their contained environment (e.g., letting their water tanks freeze and almost burst, letting their stove fall into disrepair) (3). There was no difficulty with communication with Base. A microsociety did form with innovative norms emerging, two heterosexual couples pairing off, and two women-less men bothering the two attached females for sexual favors which were never given over. The annoying demands of these two men (who increasingly displayed personality quirks) may have, in fact, led the two women to make the sexual choices they did early on in the expedition (5). They were never really autonomous from an Australian base nearby. And, when one of the quirky men had to be med-evac'ed for mental health reasons, that base provided the transportation. Their store-bought supplies were enough and never adequately diminished their chances for life or enjoyment of life.

The narrative which emerged from this expedition does not mention any ways that time was subjectively experienced by the crew (that was different from baseline).

7.7 The Steger Expedition

This was a fairly long-duration expedition taken to meet scientific goals, but was more in the realm of recreational exploration which might have brought national glory for the different nationalities involved. They were never really distant from rescue, supported logistically by a company doing business in the Antarctic. Unknown or little-known phenomena did not play a role in this expedition. They were never in any danger from any of their contained environments. They had few difficulties with communication with Base (they had a satellite uplink facility). They did not develop much in the way of new norms to cope with being out of society-at-large. This was probably because of their constant contact and being visited by reporters or themselves visiting established bases along the way. They had relatively constant contact with technological aid and advice. Their resources never dwindled to the point that they were at risk of their lives or even its enjoyment.

Nothing in the record indicated a difference in the way they subjectivized time or their situation from baseline.

7.8 Apollo 11

This was a short-duration mission taken to largely meet Cold War goals. There was incredible distance involved in terms of rescue (1). There was actual distance from the Earth, not just distance from everyday life, and much was unknown (2). There was complete reliance on a 100% contained environment where fire or toxins could have made short work of the crew and mission (3). However, there was actually little difficulty with communication with Ground.

There was not enough time for the crew to develop innovative norms. In fact, because of the tremendous pressures of being the first men on the moon, some individual factors may have kept this crew from cohering as well as it could have during training. While much of their technological systems were not solely autonomous, they were truly away from the Earth and Earth orbit, and most of the party were dependent upon getting themselves down to the surface of the moon and back into lunar orbit again, giving them an autonomy no expedition has ever enjoyed prior to this (6). Because of the shortness and success of this mission, resources did not have a chance to dwindle to subtract from life and its enjoyment.

There did occur a differential in the way the crew experienced the timing of their tasks on the lunar surface that deviated from the schedule that had been planned out for them. The realities of the situation simply required more time than mission planners had allotted.

7.9 Apollo 13

This was a short-duration lunar landing mission. Lives and the mission were put in danger because of an explosion aboard the spacecraft (3). They had to rely on the resources at hand to assist in their rescue. There was indeed an increasing distance away from rescue during an emergency, especially since the rescue plan meant putting more distance between the crew and the Earth to slingshot them around the moon (1). There was not only the distance from Earth, but unknown factors crept in, in terms of a space rescue never having been done before (2). There

was not much in the way of difficulties with communication with Ground. This team did have to come together in innovative ways, at times being surly with Ground to get information they needed to assist in their rescue (5). They were not completely autonomous from Ground's aid and advice, but there was sufficient autonomy, especially in this situation which called for some manual and innovative use of equipment and systems aboard the crippled spacecraft (6). There were diminishing resources needed for life and the enjoyment of life (water, heat, and good air being at a premium) (7).

The narrative written by the commander of the mission reveals a contrast in the way ground crews and the Apollo 13 flight crew subjectivized time. Ground crews hustled to "work the problem." The flight crew often found itself impatient with waiting for lists and instructions to be communicated.

7.10 Salyut 7

This was a long-duration orbital space station mission. There was distance away from rescue although they could have ditched the station in their spacecraft harbored at the station (1). There was distance from Earth, although not in terms of the lunar missions which took crews out of orbit and away from the Earth (2). There was a reliance on environmental seals, identical to all space missions (3). There was little difficulty with communication, although some "windows" of opportunity appeared more optimal than others. Norms did emerge as this microsociety found themselves at loggerheads with ground control from time to time (5). That it was a space mission made it autonomous although aid and advice were also available (6). There was no appreciable diminishment of resources which would risk life or its enjoyment, since this station was constantly resupplied while the crew was there.

The friction which emerged between ground controllers and the flight crew was in part owing to the different ways the two groups subjectivized time and other situational factors. On the face of it, it is easy to attribute this friction as stemming from a conflict in how the communications links would be used. Cosmonauts would become impatient and frustrated, when after waiting for opportunities to communicate with ground, communicators on the ground would not allow them to talk about things they wanted to communicate. Instead, oft times all that would be communicated up to them were evaluations of their performance or directions to perform tasks which sometimes were not even in line with the reality of the situation on board the space station, with the ground communicators doing most of the talking. Ground communicators were following pre-arranged schedules of crew evaluations, equipment maintenance and usage, and task performance. The cosmonauts had fallen into their own routine which was shaped by the situation of life aboard the station.

It is widely known in the study of disasters and hazards, both natural and human-caused, that the subjectivization of time and other situational factors are experienced differently from baseline. One expects the most severe disasters to generate the greatest differential in the reality of the situation from baseline. By analogy, one might expect extreme environmental missions and expeditions of most severity or greatest risk to generate the greatest differential in the reality of the situation from baseline. If we were to rank the missions and expeditions in this sample

according to this line of reasoning, we might expect to see the greatest difference from baseline, from high to low in the following groups:

- Space and polar missions where there were deaths and disasters.
- Space missions where deaths and disasters did not occur.
- Early polar missions where much was unknown about the Arctic and Antarctic, and where was unavailable the level of technology to alleviate risk and make working and living in these regions more like baseline.
- Modern polar expeditions where technology does much to alleviate risk and make living and working in these regions similar to baseline.

8. Discussion and Conclusion of the Secondary Analysis

The missions and expeditions were ranked by prevalence of the seven factors which might correspond with the differentiation in the subjectivization of the passage of time and in the situational reality for the crews from baseline . From high to low, the ranking revealed:

- 7. Lady Franklin Bay
- 6. Wrangel Island, Apollo 13
- 5. Salyut 7
- 4. Terra Nova, Apollo 11
- 3. Dominion Explorers'
- 2. Frozen Sea
- 1. IGY
- 0. Steger

This ranking is quite consistent with the ranking generated from the disaster analogy. The Lady Franklin Bay Expedition suffered 18 deaths of its complement of 25, and the rest were starving when found. The Wrangel Island Expedition suffered four deaths out of its crew of five. Apollo 13 was a catastrophe which was remarkable in its recovery of the crew intact. The Salyut 7 mission, the Terra Nova western field party, and the Apollo 11 mission all had a high degree of risk. The later polar expeditions rank below these missions.

All the space missions and the earliest polar expeditions are above or hover just below the median (3.5). Although this sample is too small to say anything definitive, there is something suggestive of the idea that there are similarities in space and early polar exploration in how humans subjectify mission/expedition duration or in how their situational reality deviates from baseline. Compellingly, deviation from baseline in experience of time and situational definition occurred in the Lady Franklin Bay and Wrangel Island expeditions, Apollo 11, Apollo 13, Salyut 7 missions, and perhaps arguably, to a small degree, in the Dominion Explorers' Expedition. The Terra Nova field party, just above the median, did not record any differential in the way its crew subjectivized time or defined the situation from their base camp. Even so, these results suggest that as extreme environmental crews' control over their environment decreases, their subjective experiences of time and the situation increasingly differ from their baselines.

Factors 1 and 2: increasing distance from rescue and increasing distance from Earth (or increasing proximity to unknown phenomena) co-occurred six out of eight times one or the other occurred. They co-occurred in all the six expeditions above the median. This may suggest that it is hard to plan and provide rescue when there are a critical number of unknowns.

Factor 3 (reliance on a contained environment where breach of environmental seals might result in death) occurred in all the space missions, of course, but also occurred in two of the seven polar expeditions, an older Arctic expedition and a modern Antarctic expedition.

Factor 4 (increasing difficulties in communication with Ground or Base) occurred four times. This factor played a major role in the difficulties or demise of three of four of those expeditions (Lady Franklin Bay, Wrangel Island, and Dominion Explorers').

Factor 5 (increasing reliance on a group of companions who form a microsociety over time) occurred five out of 10 expeditions/missions. Each time, microsocial innovations occurred as a means to handle stress or pressure from within the group or directly associated with the field expediency of the situation.

Factor 6 (autonomy from Ground's or Base's technological aid or advice [whether or not it was needed]) occurred seven out of the 10 cases. Where autonomy does not occur is in the more modern Antarctic expeditions. All the missions/expeditions above and around the median saw some degree of autonomy from Ground Control or Base as compared to these.

Factor 7 (diminishing resources threatening to life or enjoyment of life) occurred three out of the 10 cases (Lady Franklin Bay, Wrangel Island, and Apollo 13). The Lady Franklin Bay Expedition's numbers were whittled down directly as a consequence of this, the Wrangel Island Expedition suffered a slightly more deadly result as a consequence of this, and Apollo 13's mission objectives took on a far different parameter when resources necessary for life diminished rapidly.

No factor in isolation, even the last one, appears to have had more weight than the others in corresponding with differentials in subjectivization of time and perception of the situation from baseline. This content analysis suggests that increasing factors in combination do correspond with such differentials.

It has often been noted by travelers that time moves differently in one country than another. And, it is known that the pace and cycle of daily life is different in an agricultural society than in an industrial one. Such is the nature of difference in subjective time and situational reality between life in space and life at mission control; or perhaps life in any extreme environment and life "back home."

It seems compelling to expect that psychosocial human factors and situational reality formation could play a role in how well or how poorly future space crews carry out their mission objectives. Further research would need to make finer elaboration and operationalization of the hypotheses and the related factors in order to examine them adequately. Other research might consider advanced telecommunications and use of virtual reality (VR) to bring space crews

closer to baseline. Other research, still, might look at the efficiency of "situation awareness training" for ground controllers and communicators in bringing Ground/Base and crews closer together in definition of the extreme environmental situation.

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Table 1. Data for 10 Polar Expeditions and Space Missions

Qtr./Mis.	Dur.	AvCrew	SexHet.	NatHet.	AgeRn.	ExpHet	Year	DevActs	DaPrRate	x1000
1 Frozen	120	6	0.44	0.66	40	0.44	82-83	23.5	0.03	30
2 Frozen	120	6	0.44	0.66	40	0.44	1983	11	0.02	20
3 Frozen	120	6	0.44	0.66	40	0.44	1983	10.5	0.01	10
4 Frozen	120	5.5	0.46	0.69	40	0.38	83-84	7.5	0.01	10
MisMean	120	5.88	0.45	0.67	40	0.43		13.13	0.02	20
1 Salyut 7	53	3.5	0	0.53	2	0	1982	10	0.05	50
2 Salyut 7	53	3.5	0.18	0.41	6	0	1982	8	0.04	40
3 Salyut 7	53	2	0	0.5	0	0	1982	9	0.08	80
4 Salyut 7	53	2	0	0.5	0	0	1982	5.5	0.05	50
MisMean	53	2.75	0.05	0.49	2	0		8.13	0.06	60
1 Wrangel	180	5	0.32	0.56	10	0.48	1921	58.5	0.07	70
2 Wrangel	180	5	0.32	0.56	10	0.48	1922	1	0	0
3 Wrangel	180	3.5	0.41	0.53	10	0.24	22-23	22	0.03	30
4 Wrangel	180	1.5	0.25	0.27	10	0.12	1923	1	0	0
MisMean	180	3.75	0.33	0.48	10	0.33		20.63	0.03	30
1 LFB	270	26.5	0	0.21	25	0.23	81-82	16.5	0	0
2 LFB	270	25	0	0.22	25	0.22	1882	22	0	0
3 LFB	270	25	0	0.22	25	0.22	1883	24.5	0	0
4 LFB	270	16	0	0.23	20	0.23	83-84	103.5	0.02	20
MisMean	270	23.13	0	0.22	23.75	0.23		41.63	0.01	10
1 Steger	56	6	0	0.82	10	0	1989	6.5	0.02	20

2 Steger	56	6	0	0.82	10	0	1989	8	0.02	20
3 Steger	56	6	0	0.82	10	0	89-90	2	0.01	10
4 Steger	56	6	0	0.82	10	0	1990	4.5	0.01	10
MisMean	56	6	0	0.82	10	0		5.25	0.02	20
1 Terra	12	4	0	0.63	11	0.38	1911	0	0	0
2 Terra	12	4	0	0.63	11	0.38	1911	0	0	0
3 Terra	12	4	0	0.63	11	0.38	1911	1	0.02	20
4 Terra	12	4	0	0.63	11	0.38	1911	1	0.02	20
MisMean	12	4	0	0.63	11	0.38		0.5	0.01	10
1 DomEx	18	9	0.16	0.23	60	0	1929	0.5	0	0
2 DomEx	18	15	0.42	0.46	60	0	1929	1	0	0
3 DomEx	18	19	0.53	0.46	60	0	1929	2.5	0.01	10
4 DomEx	18	21	0.54	0.44	60	0	1929	5	0.01	10
MisMean	18	16	0.41	0.4	60	0		2.25	0.01	10
1 IGY	22	8.5	0	0.64	20	0.1	1959	2	0.01	10
2 IGY	22	9	0	0.62	20	0.2	1959	0	0	0
3 IGY	22	9	0	0.62	20	0.2	59-60	0	0	0
4 IGY	22	9	0	0.62	20	0.2				