BOLD ENDEAVORS: BEHAVIORAL LESSONS FROM POLAR AND SPACE EXPLORATION

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ABSTRACT

Anecdotal comparisons frequently are made between expeditions of the past and space missions of the future. Spacecraft are far more complex than sailing ships, but from a psychological perspective, the differences are few between confinement in a small wooden ship locked in the polar ice cap and confinement in a small high-technology ship hurtling through interplanetary space. This paper discusses some of the behavioral lessons that can be learned from previous expeditions and applied to facilitate human adjustment and performance during future space expeditions of long duration.

In many ways, the Belgian Antarctic Expedition of 1898 to 1899 was a precursor of things to come. It was the first expedition to camp, although briefly, on the Antarctic continent, and the first to spend an entire year locked in its icy embrace. Most important was the international composition of its crew—eighteen men isolated together in one of the most challenging environments on Earth. In an era when expeditions were expressions of nationalistic tendencies, the cosmopolitan makeup of the Belgian Antarctic Expedition was truly modern, consisting of nine Belgians, six Norwegians, two Poles, a Romanian, and an American, the ship's physician, Dr. Frederick A. Cook.

Dr. Cook had responded to a newspaper advertisement that was placed when the expedition's original physician backed out only a few days before the ship sailed. Commandant Adrien de Gerlache, organizer of the expedition, selected Cook on the basis of his previous Arctic experience. In October 1897, Cook joined the expedition in the roadstead of Rio de Janeiro, Brazil. The *Belgica*, the expedition's ship, arrived in the Antarctic during January 1898. Though late in the season, the crew was able to make several landings to collect geological specimens, lichens, moss, and insects. They conducted more scientific work than had any previous Antarctic expedition, but they probably spent too much time on shore. In March, the ship became trapped in the frozen Bellinghausen Sea and, locked in by pack ice, drifted there for more than a year. The crew was not fully prepared for the experience.

The medical officers of polar expeditions, and later at Antarctic research stations, usually experienced considerable frustration because they found few professional duties to perform. However, this was not to be the case for Dr. Cook. The thirty-two-year-old physician was occupied during the remainder of the expedition with a problem that started when the ship became locked in the ice and grew increasingly acute throughout the long winter night: almost every member of the crew gradually became afflicted with a strange and persistent melancholy. As the weeks blended one into another, the condition deepened into depression and then despair. Eventually, crew members lost almost all motivation and found it difficult to concentrate or even to eat. One man weakened and died of a heart ailment that Cook believed was caused, at least in part, by his terror of the darkness. Another crewman became obsessed with the notion that others intended to kill him; when he slept, he squeezed himself into a small recess in the ship so that he could not easily be found. Yet another man succumbed to hysteria that rendered him temporarily deaf and unable to speak. Additional members of the crew were disturbed in other ways. It was to this dismal condition that Roald Amundsen referred when he later wrote, "Insanity and disease stalked the decks of the *Belgica* that winter."

Dr. Cook believed the malady was caused more by lack of light than by the scurvy they were experiencing. Whatever the actual cause, it is clear that the problem was also psychological. The dreaded polar night is not really that dreadful—it has been endured without ill effects by many explorers and countless indigenous inhabitants of the Arctic regions—but it took a terrible toll on the crew of the *Belgica*. The men suffered from poor circulation, heart troubles, and impaired digestion. Their diet was low in fiber and probably certain vitamins. Although vitamins had not been discovered yet, Dr. Cook believed that the diet lacked some important element. He attempted to remedy the condition by encouraging the men to eat fresh penguin meat, but many found it unpalatable. He also prescribed an exercise program to counter growing symptoms of insanity among the crew, but walks on the ice devolved into a circular path around the ship that came to be known as the "madhouse promenade." Cook's journal entries reflect the depression into which this small society had fallen. The following is an example:

> The darkness grows daily a little deeper, and the night soaks hourly a little more color from our blood. Our gait is now careless, the step non-elastic, the foothold uncertain . . . . Most of us in the cabin have grown decidedly gray within two months, though few are over thirty. Our faces are drawn, and there is an absence of jest and cheer and hope in our make-up which, in itself, is one of the saddest incidents in our existence. . . . The novelty of life has been worn out. . . . We miss the usual poetry and adventure of home on winter nights. We miss the flushed maidens, the jingling bells, the spirited horses, the inns, the crackling blaze of the country fire. We miss much of life which makes it worth the trouble of existence. (Cook [1900] 1980, 319)

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In desperation, Cook devised a method that he called the "baking treatment," in which the most seriously ill sat with their bodies exposed to the warm glow of the ship's stove for an hour each day. This therapy, combined with enforced portions of fresh penguin meat, seemed to help, but Cook observed that "surely one of the most important things was to raise the patients' hopes and instill a spirit of good humor" (Cook [1900] 1980). This he did consciously and persistently throughout the remainder of the expedition.

The crew's spirits began to improve in the spring, but the ice floe that trapped the *Belgica* gave no indication that it would ever break up. It was necessary to escape the Antarctic because, as each man knew, to stay another year would be fatal. Laboring with large ice saws, axes, and explosives, the crew eventually blasted the ship free, but the *Belgica* did not reach open water for another month. In November 1899, the ship arrived in Europe, where crew members were greeted as if they had been to the moon and back.

Frederick Cook described life onboard the *Belgica* as a "hellish existence," but he rose to the occasion and is credited with saving the expedition from psychological disaster.

The cause of the malady that affected the Belgian Antarctic Expedition remains a mystery. The diet and lack of sunlight could have caused anemia and depression, as Cook surmised, or perhaps the crew suffered from a shared hysterical reaction or some other psychological group phenomenon. Simple boredom and depression may have affected all the members of the party and driven some beyond the limits of their endurance. Like most complex phenomena, the crew's experience was probably caused by a combination of factors. Certainly it was of considerable relevance to plans for future long-duration expeditions.

It is increasingly difficult for people to imagine what life was like in the closing years of the 19th century. Today we take for granted the air transportation network and wireless communications that cover the globe, but much of Earth was still inaccessible in the 1800s. The polar regions were among the most consuming mysteries of the natural world yet to be explained. No one knew what conditions to expect—whether land, ice, or sea covered the poles.

Many efforts had been made to reach the farthest north. Most notably, in 1845, the British Admiralty dispatched Sir John Franklin to locate and navigate the Northwest Passage, and it was assumed that Franklin and his carefully selected party would succeed where others had failed. Two ships, the *Erebus* and the *Terror*, were loaded with supplies to support a crew of 129 for four years. After departing England, they hailed a group of whalers off Greenland on their course north, then vanished without a trace.

During most of the next two decades, polar exploration was dedicated to finding and, perhaps, rescuing any survivors of the Franklin Expedition. Among the attempts was an American expedition, thirty-one men commanded by young Lieutenant George Washington De Long, that sailed onboard the *Jeannette* out of San Francisco Bay on 8 July 1879. Telegraph Hill and the Embarcadero swarmed with well-wishers, and more were afloat on the yachts, tugs, and launches that filled the bay as the barque-rigged coal burner steamed through the Golden Gate and set a course for the Arctic. Two months later, the *Jeannette* was beset by ice and trapped, as the *Erebus* and the *Terror* and countless other ships had been over the centuries. The crew stayed with the ship for nearly two years until she was crushed, then made their way to shore and through the Siberian wilderness. Only thirteen men survived the ordeal.

Three years after De Long and his party abandoned their ship, pieces of the *Jeannette*'s wreckage were found on the southwest coast of Greenland, thousands of miles from where, crushed by the ice, she had sunk. This information contributed to a theory that the far north was covered with ice, and that this ice cap moved in a westerly direction across the Arctic. Dr. Fridtjof Nansen, a young scientist, outdoorsman, and curator at Christiania University, developed a bold plan to test the hypothesis. Nansen recently had returned from making the first successful crossing of the Greenland plateau, a remarkable accomplishment that would prove to be only a prelude to one of the world's boldest endeavors.

The genius of Nansen's plan was to build a special ship for the expedition instead of converting an existing vessel. This ship would be designed to rise up out of the ice as the floes pressed against her hull, rather than to resist the full force of the pressure. Critics scoffed at Nansen for his theory and predicted that his expedition would end in failure. However, he persevered and obtained an initial grant from the Norwegian government. There were cost overruns, just as there are in modern programs, when the design was changed to increase the ship's capacity and the margin for crew safety.

The *Fram*—the name means "onward" in Norwegian—was heavily built, but constructed with no edges below the water line that might give ice a purchase on the ship. The keel was recessed, and all fittings could be removed to create a smooth and rounded profile. Departing the beautiful Hanseatic port of Bergen on 1 July 1893, she sailed north and east, crossed the Barents and Kara seas, and skirted the northern coast of Siberia. Three months later, at a point closer to Alaska than Norway, she headed into the ice pack, where she was intentionally locked in the ice just north of 78° latitude. As the floes encroached and the forces on the *Fram*'s hull increased, the sturdy little ship rose out of the ice and remained cradled above the pressure ridges, drifting with the ice pack across the top of the world for nearly three years. Nansen's design worked according to plan, and the theory of polar drift was confirmed. When it appeared that the *Fram*'s course would take her no farther north across the polar ice cap, Nansen selected Hjalmar Johansen to accompany him on a dash to the pole with kayaks, sledges, and dogs.

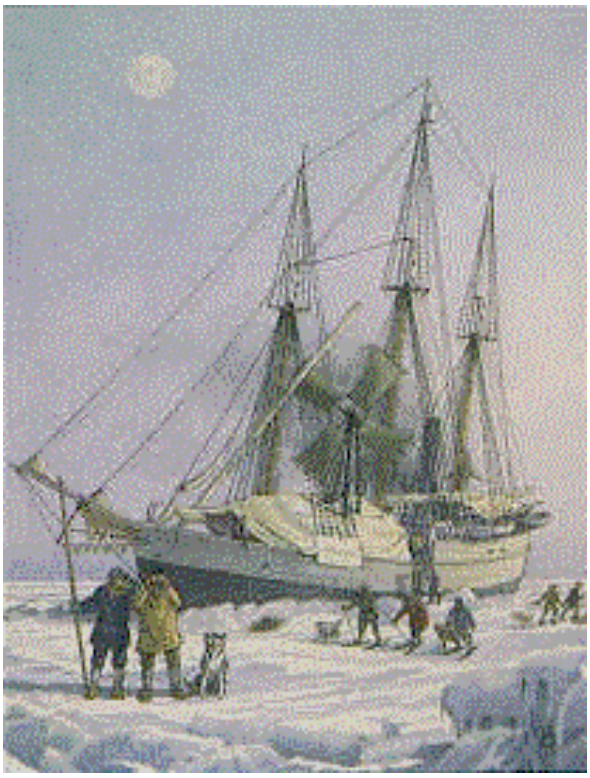

Figure 1. "Fram in the Ice" by William Gilkerson, 1894. *(Courtesy of the author)*

By 7 April 1895, Nansen and Johansen were making only a mile headway each day over rough ice, so they turned back at 86º13' north latitude—160 miles farther north than any explorer had previously achieved. Navigating with erroneous charts and caught by an early winter, they made it to Franz Josef Land and built a small hut out of stones and walrus hides, in which they would live in complete isolation and confinement. Life in the six-by-ten-foot hut was unpleasant in many ways, not the least being the decline in personal hygiene they endured because they lacked supplies, including fuel for melting snow. For the entire nine-month Arctic winter, they cooked their food and illuminated their world with the small flame of a blubber lamp, coating the hut and themselves with soot and grease. The best way they found to clean themselves, scraping their skin with their knife blades, produced usable quantities of fuel that they recycled in their lamp. Conditions were about as bad as humans can reasonably endure. Nansen and Johansen's dreams were filled with Turkish baths and visits to clothing stores.

The two explorers lived together as one might imagine Neolithic hunters who had ventured too far and become stranded by an early winter storm; but Nansen and Johansen survived the experience. They suffered from the mind-numbing sameness of their days and the other health-threatening conditions, but emerged from their den early in the spring of 1896 to expertly perform all of the technical tasks necessary to fight their way through pack ice to the safety and comforts of civilization. They survived the extreme austerity of their life with no apparent ill effects, and pressed on eagerly in their kayaks. Walruses attacked them, and at one point the explorers nearly lost their kayaks and equipment when their small craft drifted away from the ice flow onto which they had climbed. A month after departing their hut, they encountered the English explorer Frederick Jackson in one of history's most remarkable chance meetings. They stayed with the Jackson Expedition nearly two months, waiting for its relief ship. The day that Nansen and Johansen set foot on Norwegian soil, the *Fram* broke free from the ice on the opposite side of the Arctic and headed for Spitzbergen and then Tromsö, Norway. Here her crew was reunited after seventeen months of separation. A few weeks later, on 9 September 1896, the *Fram* steamed up Christiania Fjord three years and three months following her departure. Nansen and his crew were greeted as if they had just returned from another planet.

During his isolation and confinement, Fridtjof Nansen experienced a lethargy that was similar to that described a few years later by Dr. Cook of the *Belgica*. Nansen described his feelings in his journal:

> My mind is confused; the whole thing has got into a tangle; I am a riddle to myself. I am worn out, and yet I do not feel any special tiredness. Is it because I sat up reading last night? Everything around us is emptiness, and my brain is a blank. I look at the home pictures and I am moved by them in a curious, dull way; I look into the future, and feel as if it does not much matter to me whether I get home in the autumn of this year or next. So long as I get home in the end, a year or two seem almost nothing. I have never thought this before. I have no inclination to read, nor to draw, nor to do anything else whatever. The only thing that helps me is writing, trying to express myself on these pages, and then looking at myself, as it were, from the outside. (Nansen 1897, vol. 1, 372-73)

Thanks to better equipment, procedures, leadership, and, most important, the extensive planning that preceded the Norwegian Polar Expedition, the malaise onboard the *Fram* was short-lived and more effectively contained than that suffered by the crew of the *Belgica*. How did the Norwegian Polar Expedition endure more than three years with scarcely a problem, while the Belgian Antarctic Expedition nearly collapsed within its first year?

The primary characteristic that distinguished Nansen from most other polar explorers was that he approached all aspects of expedition planning with scientific precision. He started by reading accounts of previous expeditions to learn from the experiences of his predecessors. Nansen remarked in his diary that, to his surprise, most of the problems confronting him already had been addressed and, in many instances, solved by previous explorers: wear appropriate clothing, pay special attention to the food, select crew members who can get along, and keep the crew busy and entertained. Nansen developed special high-calorie rations and systematically tested every item of food; he developed and evaluated sledges, harnesses,

protective clothing, and other equipment; and he invented solutions to equipment problems that still are used by polar travelers. He evenequipped his ship with wind-powered electric lights to illuminate the winter darkness at a time when electricity was still a novelty, and he fostered group solidarity with an egalitarian approach to his crew during an era when expeditions were managed autocratically. Modern exploration really began with Fridtjof Nansen and his Norwegian Polar Expedition. All who came after him benefitted immensely from his experience, and his experience is relevant to the full range of behavioral issues confronting expedition teams of the future.

The Norwegian Polar Expedition provides an appropriate model for modern explorers in many ways. Nansen's systematic simulation, testing, and evaluation of every item of equipment and his meticulous attention to every detail and possible contingency set him apart from all previous and most subsequent explorers. But, most important, Nansen recognized that the physical and psychological well-being of his crew could make the difference between success and failure. Accordingly, he provided a well-designed habitat, insightful procedures, and exceptional leadership to a qualified and compatible crew. "The human factor is three quarters of any expedition," wrote Roald Amundsen, the most successful of all explorers. Before Amundsen, Nansen knew that human factors were the critical component in any expedition; in Nansen's words, "It is the man that matters."

Despite superficial similarities to other space missions and Earth-bound analogues, lunar and Martian missions—involving extended durations and astronomical distances—will be far more difficult and dangerous. Crowded conditions, logistics and equipment problems, radiation concerns, communication lag times, workloads, language and cultural differences, and a variety of other issues will conspire to impair the performance and affect the behavior of crew personnel. Above all stressors, however, the long durations of missions will impose the greatest burdens and extract the most severe tolls on the humans involved. On long-duration space missions, time is likely to be the factor that will compound all issues, however trivial, into serious problems.

Anecdotal comparisons frequently are made between future space missions and expeditions of the past. From an engineering perspective, spacecraft are far more complex than sailing ships, and one of the factors that drives spacecraft complexity is the requirement to support the crew in the hostile environment of space. The technological differences are significant. From a behavioral or psychological perspective, however, the differences between confinement in a small wooden ship locked in the polar icecap and confinement in a small, high-technology ship hurtling through interplanetary space are probably few.

Figure 2. Models of the *Nina, Pinta,* and *Santa Maria* in Front of Launch Pad 39A. *Like NASA, Columbus believed in triple redundancy. With fewer than three hulls the expedition might not have survived, as the Santa Maria went aground on Christmas Day, 1492. (Courtesy of NASA)*

BEHAVIORAL THEMES

I began a chronological review of past expeditions with accounts of Columbus's first voyage to the New World in 1492. Although the outward-bound trip for Columbus's three small ships took only thirty-three days and the total voyage lasted about seven months, accounts of this expedition have considerable relevance. Columbus faced many of the same problems, including strong-willed and independent subordinates, that will confront leaders of future expeditions. My review also included accounts of Charles Darwin's famous 1831–36 voyage onboard the *Beagle*, of commercial whaling and sealing voyages, and of more recent adventures (e.g., Thor Heyerdahl's *Kon-Tiki* and *The Ra Expedition*). Although my range was broad, late-nineteenth- and twentieth-century accounts of polar expeditions predominate. Notable among these are Fridtjof Nansen's Norwegian Polar Expedition (1893–97); the Belgian Antarctic Expedition (1898–99); the Amundsen and Scott race to the South Pole (1910–12); Ernest Shackleton's British Trans-Antarctic Expedition (1914–16); Admiral Richard E. Byrd's two expeditions to Antarctica (1928–30 and 1933–35); and the International Biomedical Expedition to the Antarctic, or IBEA (1980–81). I also studied other examples of human experience characterized by isolation and confinement, including such underwater habitats as Sealab and Tektite; offshore oil platforms; saturation chambers; submarines; Skylab; and remote-duty military and scientific environments. Recently, I completed an analysis of diaries maintained by the leaders and physicians at French remote-duty stations, providing the first quantitative data on the relative importance of behavioral issues.

My research methods have resulted in an alternative to the traditional behavioral science perspective on life in isolation and confinement. This alternative perspective places new emphasis on the many examples in which humans have operated successfully for long durations despite their austere, isolated, and confined conditions. The well-known disasters are instructive, because they remind us of the need to be careful in

the design of habitats, equipment, and procedures and in the selection of personnel for special duty. The successes, however, are perhaps more instructive, providing considerable encouragement to those who will be called upon to endure the inevitable stressors associated with space station missions and life on future lunar bases and interplanetary spacecraft.

The main themes to emerge from my research are as follows:

- There are highly predictable behavioral responses to isolation and confinement.
- Minor interpersonal and psychological problems are common, but serious problems are avoidable if proper precautions are taken.
- Future long-duration space expeditions will more closely resemble sea voyages than the test flights that have served as models up to now.
- Valuable lessons concerning the design and conduct of future expeditions can be learned from studying the experiences of remote-duty personnel and previous explorers.
- Humans can endure almost anything.

Twenty-two categories of behavioral issues have emerged from my research. All of these issues are involved, to varying degrees, in an individual's adjustment to living and working in isolation and confinement. They are listed below in their order of salience, as determined by the content analysis of remote-duty diaries (Stuster, Bachelard and Suedfeld, 1999):

Group Interaction
Outside Communications
Workload
Recreation & Leisure
Medical Support
Adjustment
Leadership
Events
Food Preparation
Organization & Management
Equipment
Sleep
Safety
Personnel Selection
Waste Management
Internal Communications
Exercise
Habitat Aesthetics
Hygiene
Personal Hygiene
Privacy/Personal Space
Clothing

Recommendations range from special theme dinners—to promote group solidarity and help mark the passage of time—to private quarters designed to mitigate the cumulative stress that results from the unrelenting proximity of one's comrades. Remaining comments address the most salient category, "Group Interaction."

Mark Twain said that the best way to learn if you like someone is to travel with that person. However, the crews of future space expeditions will experience interpersonal problems even if friendship and compatibility have been established through years of selection, simulation, and training together. While individuals cause *some* difficulties, most interpersonal problems within isolated and confined groups are rather the inevitable result of fundamental forces and processes that are characteristic of the experience. Sustained, close personal contact can be extremely stressful, and interpersonal problems are exacerbated by additional sources of stress, such as danger, time pressure, equipment malfunctions, and heavy workloads (or, conversely, boredom). This stress is cumulative, and behavioral consequences are likely if there is no way to eliminate its source—for example, by removing oneself from the group temporarily. But, as the physician of the Belgian Antarctic Expedition described in the following diary entry, it is impossible to get away from one's comrades when living in isolation and confinement:

> 20 May 1898: I do not mean to say that we are more discontented than other men in similar conditions. This part of the life of polar explorers is usually suppressed in the narratives. An almost monotonous discontent occurs in every expedition through the polar night. It is natural that this should be so, for when men are compelled to see one another's faces, encounter the few good and the many bad traits of character for weeks, months, and years, without any outer influence to direct the mind, they are apt to remember only the rough edges which rub up against their own bumps of misconduct. If we could only get away from each other for a few hours at a time, we might learn to see a new side and take a fresh interest in our comrades; but this is not possible. The truth is, that we are at this moment as tired of each other's company as we are of the cold monotony of the black night and of the unpalatable sameness of our food. Now and then we experience affectionate moody spells and then we try to inspire each other with a sort of superficial effervescence of good cheer, but such moods are short-lived. Physically, mentally, and perhaps morally, then, we are depressed, and from my past experience in the Arctic I know that this depression will increase with the advance of the night, and far into the increasing dawn of next summer. (Cook 1980 [1900], 290-91)

Imagine living in a medium-sized motor home, locked in with five other adults for a period of three years. Socially, this situation approximates a mission to Mars. The crew will be excited following departure from Earth orbit and extremely busy

with important technical tasks, contingency planning, and mission-abort rehearsal activities. But a change will occur as the excitement dissipates and the days begin to blend into weeks, then months—as the crew makes the transition to the cruise phase of the voyage. Each crew member's repertoire of jokes, anecdotes, personal experiences, and opinions will become well known to the other members of the tiny, closed society (if this has not already occurred during years of premission training and simulations). Nothing that anyone says or does will seem new, and previously innocuous mannerisms will be magnified into intolerable flaws as crew members become increasingly weary of each other. The lavatory and the small compartments that serve as private sleep chambers offer the only escapes from others. Interpersonal friction and overt conflicts among crew members are the inevitable consequences of these conditions.

The stresses associated with isolation and confinement consistently result in minor interpersonal problems; sometimes major conflicts occur, but they are rare. Typically, exaggeration of trivial issues causes most of the interpersonal conflicts that occur within isolated and confined groups—issues that under normal conditions would be considered inconsequential. The most trivial of issues are predictably exaggerated beyond reasonable proportions by the relentless proximity of comrades and by the other stresses of isolated and confined living that accumulate over time. Dr. Desmond Lugg's final, predeparture words to Australian Antarctic personnel concern what he has named "The Rule of 10": that is, when one is isolated, the strength of one's initial reaction—be it to someone within the group or to a communication from the outside—should be divided by ten to achieve the appropriate measure before responding.

An account of the International Biomedical Expedition to the Antarctic (IBEA), written in 1988 by Jean Rivolier and his colleagues, provides the most relevant examples of interpersonal problems. The IBEA, composed of a total of twelve scientists from five nations, was conducted, in part, to obtain information about group interaction that might be useful to future space missions. This objective was achieved; the interpersonal problems experienced during the IBEA are extremely relevant to plans for future expeditions. Rivolier et al. describe the problems:

> There were times such as at the onset of the laboratory programme in Sydney and at the arrival of the group in Antarctica when the group worked with a will as a team to unpack and test their gear. But the harmony was short-lived. Individuals asserted themselves. They competed with each other for status and responsibility, and they drew apart in their national groups. Occasionally they regrouped according to their antipathy to particular experimenters, and even less occasionally they forgot their differences to enjoy each other's company. (1988, 91)

Figure 3. Card Games During Richard E. Byrd's First Expedition to Antarctica Helped the Men Pass the Long Winter Night. *(Courtesy of the National Archives)*

On the twentieth day of the seventy-one-day motorized traverse that began near the Dumont d'Urville station, one member of the expedition had to be evacuated for psychological reasons. The others endured the entire mission but returned from the traverse "humorless, tired, despondent, and resentful." None of the participants found their Antarctic experience enjoyable, not due to climate or hardships but to the "inconsiderate and selfish behavior" of colleagues. Most of the interpersonal problems were precipitated by disagreements over the performance of necessary communal work and camp chores. These trivial issues were aggravated by underlying rivalries and cultural and language differences among members of the party. Despite the efforts of the organizers, the group was fragmented and lacked a unifying spirit or sense of mission. Fortunately, no serious emergency occurred that would have required a coordinated response.

If trivial issues are inevitably, sometimes dangerously, blown out of proportion, it seems clear that a way to minimize the potential for this phenomenon would be to eliminate, to the extent possible, differences among the members of an expedition. In this regard, it is important to note that the most successful (i.e., remarkable) expeditions have been conducted by relatively homogeneous groups or groups that have been organized specifically on the basis of compatibility. The most salient examples are Fridtjof Nansen's group of thirteen Norwegians who sailed onboard the *Fram* (Norwegian Polar Expedition, 1893–96), and the twenty-seven men carefully selected by Ernest Shackleton to conduct an ambitious expedition to Antarctica onboard the *Endurance* (Imperial Trans-Antarctic Expedition, 1914–15). The *Fram*'s crew endured three years of isolation and confinement and, in the process, reached what was then the point farthest north achieved by humans, an accomplishment of such magnitude at the time that modern readers might find it difficult to comprehend. In contrast, the

Endurance never even reached Antarctica; but the performance of Shackleton's crew in surviving the loss of their ship may have been an even greater achievement than that of the Norwegians. It is true that both of these exemplary expeditions experienced some interpersonal problems, but not nearly to the extent of contemporary expeditions composed of heterogeneous crews.

It is not feasible to select a homogeneous crew for future space expeditions because of the social and economic realities of these endeavors. International cooperation will be necessary to finance such large-scale undertakings as lunar bases and interplanetary voyages. Thus, many future space crews will be composed of individuals from different countries and cultures. In short, it appears inevitable that cultural differences, such as those that contributed to divisiveness during the Belgian Antarctic Expedition and the IBEA, will be a component in future space expeditions. What can be done to mitigate the disruptive effects of these differences?

It would be prudent to develop countermeasures to minimize the possibility of conflict in crews composed of individuals of different genders, technical specialties, ages, and cultural and national backgrounds. Personnel selection procedures, training programs, formal policies, and informal practices and customs could greatly reduce the potential for serious interpersonal problems. The ideal personnel selection system would identify those candidates who are both willing and capable of working with others under special conditions, and it would actually select crews, at least in part, on the basis of specific intracrew compatibilities.

An extensive program of behavioral research at early U.S. Antarctic stations was precipitated by a severe psychosis that emerged among the Navy crew that was preparing a base for the International Geophysical Year (IGY) in 1957. The research, largely conducted by Eric Gunderson and Paul Nelson, involved several hundred winter-over personnel and the identification of three clusters of behavioral traits that were highly correlated with effective performance at Antarctic stations. Gunderson labeled the clusters (1) emotional stability, (2) task performance, and (3) social compatibility. *Emotional stability* involves an individual's ability to maintain control of his or her emotions, despite the stresses of isolated and confined living; "calm" and "even-tempered" are the ideal characteristics. *Task performance* refers to both task motivation and proficiency; "industrious" and "hard-working" describe the ideal traits in this category. *Social compatibility* includes a number of personal characteristics, such as likability, cheerfulness, and consideration for others; "friendly" and "popular" are the ideal characteristics. Navy psychologists and psychiatrists have used these categories for the past three decades to guide the screening of volunteers for Antarctic duty.

Gunderson and his colleagues at the Naval Health Research Center estimated the relative importance of the three behavioral clusters to overall performance at U.S. Antarctic stations, as perceived by Navy and civilian winter-over personnel (Doll and Gunderson, 1970; Gunderson, 1973b). Crew ratings of their colleagues on the three behavioral traits were correlated with responses to a criterion item: "If you were given the task of selecting men to winter over at a small station, which men from this station would you choose first?" A fourth variable, friendship, was included in the analysis to serve as a control. Table 1 presents the three behavioral clusters and the control variable in rank order of importance, as indicated by the magnitudes of the correlations with the criterion. Civilians judged social compatibility to be the most important cluster of traits, whereas military personnel favored emotional stability. Social compatibility refers to an individual's ability to get along with others, a difficult process for some in the tension-filled environment of a remote-duty station. Similarly, emotional stability refers to an individual's capacity for avoiding extreme moods and behavior. It is essential to note that both groups found personality traits, rather than task performance, the most important factors determining the kind of individual with whom experienced personnel would want to share another year in isolation and confinement. These results are as statistically and intuitively valid today as they were when the studies were conducted, and they could be applied to the development of personnel selection criteria for other remote-duty environments, such as future long-duration space expeditions.

The following is a list of personal characteristics required for successful adaptation to isolation and confinement. It is based on the Navy research and on my review of original and secondary sources concerning expeditions and voyages of discovery.

- Likability
- Emotional control
- Patience
- Tolerance
- Self-confidence (without egotism or arrogance)
- A team approach (willingness to subordinate one's interest to that of the group)
- Sense of humor
- Social resourcefulness (easily entertained)
- Technical competence

Participants in future long-duration expeditions should receive instruction in the behavioral and psycho-logical problems that can occur during an expedition and in techniques to help deal with circumstances as they arise. The astronauts who returned

Table 1. Relative Importance of Behavioral Traits to Successful Performance at U.S. Antarctic Stations

Order	Navy Personnel	Civilian Personnel
1	Emotional stability	Social compatibility
2	Task performance	Emotional stability
3	Social compatibility	Task performance
4	Friendship	Friendship

from Mir recognized this requirement, and they convinced their colleagues that long-duration isolation and confinement is qualitatively different from previous experiences, such as shuttle missions. As a consequence, a training program has been developed and pilot-tested with a group of twelve astronauts who are members of NASA's Expedition Corps, astronauts who are candidates for missions to the International Space Station. The two-day training program covers a broad range of issues and includes specific examples of the habitability and behavioral principles that have been identified in the analogue and experimental literature. The training program also offers fairly simple guidelines, such as the following:

- Avoid controversial subjects.
- Consider the possible consequences before you say or do something.
- Do more than your share of communal tasks.
- Be considerate; more than that, try to avoid being annoying in any way.
- Consciously attempt to be cheerful and supportive of your teammates.
- Be polite and respectful.

A particularly divisive source of interpersonal problems occurs when the normal tendency for subgroups to form escalates into the development of cliques. Although the tendency for subgroups to form is unavoidable, the environment should be structured to encourage maximum communication across subgroups to offset, to some extent, the increased communication among members within subgroups. Subgroups serve as coping mechanisms for some individuals, but they can be disruptive and dangerous, because one person (or more) inevitably is excluded.

Meals offer an opportunity for the type of communication that will help to mitigate the tendency for subgroup formation among members of an isolated, confined crew. Eating together as a group is a natural activity that most people seem to enjoy; the benefits to group solidarity of eating together are so well known as to be a behavioral cliché. The requirement for daily nutrition and the apparent human tendency to find some pleasure in dining together offer valuable opportunities to encourage interpersonal communication that will foster group solidarity and counter the potentially negative effects of subgroup formation. Some crew members are bound to find reasons to eat by themselves and withdraw from the group in other ways. It is important, however, that the design of equipment and procedures encourages eating together at least once each day, as well as at frequent special dinners (e.g., theme dinners and celebrations of holidays and mission milestones).

A FINAL NOTE

The point is made in the preceding discussion that interpersonal problems are inevitable among individuals living in isolation and confinement for long periods, and that the inordinate incidence of these problems is a normal consequence of living in close proximity to others with no opportunity for variety or escape. Interpersonal problems are certainly common, but serious problems are not inevitable, especially if the individuals are particularly compatible or if their solidarity is essential to their survival. For example, Lansing ([1959] 1994) writes of Shackleton and the crew of the *Endurance* adrift on their ice floe:

> It was remarkable that there were not more cases of friction among the men, especially after the Antarctic night set in. The gathering darkness and the unpredictable weather limited their activities to an ever-constricting area around the ship. There was very little to occupy them, and they were in closer contact with one another than ever. But instead of getting on each other's nerves, the entire party seemed to become more close knit. (42)

Individual compatibility and recognition of the need to maintain solidarity are among the ingredients of a successful long-duration expedition. Perhaps it was one or both of these factors that permitted Fridtjof Nansen and Hjalmar Johansen to endure nine months of confinement together in a crude Arctic hut *without a single argument*:

> Our spirits were good the whole time; we looked serenely towards the future, and rejoiced in the thought of all the delights it had in store for us. We did not even have recourse to quarrelling to while away the time. (Nansen 1897, vol. 2, 464)

After their return to Norway, Johansen was asked how they had gotten along during the winter, and whether they had quarreled. Reporters were as eager for controversy 100 years ago as they are now and they recognized it would be a severe test for two men to live so long together in perfect isolation. Johansen replied, "Oh no, we didn't quarrel; the only thing was that I had the bad habit of snoring in my sleep, and then Nansen used to kick me in the back." He would shake himself a little then sleep calmly. Nansen was shocked when he read Johansen's comment in a newspaper. Nansen admitted to giving Johansen many a well-meant kick, but it was a surprise to learn so long afterward that Johansen had awakened sufficiently to realize that he had been kicked.

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