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Behavior, Confinement, and Isolation

Carole Tafforin

Ethospace, Toulouse, France

With long-term space missions, behavioral scientists agree that the personal and interpersonal adaptive processes became of prime importance for crew performance in isolation and confinement. Anecdotal reports from crews of the Russian orbital station (Mir) and the International Space Station (ISS) indicated such psychosocial issues. The crewmembers thus have to adapt to a wide range of environmental factors: reduced and closed space, life-support restriction, group density, delayed communication, far from civilization, lack of variety of food, lack of natural light and surrounding, lack of privacy, and monotony of daily life. These include factors related to space crew heterogeneity: interpersonality, crew demographics, value, culture, and language background. Effective procedures for selection, training, and psychological support will help to determine the outcome of next space missions and space explorations. Psychosocial adaptation to a Mars mission is a new challenge [1] and involves temporal factor in a novel way. Time has definitely an impact on behavior. For simulating those factors, generating on Earth an extra-terrestrial environment would help in getting better knowledge of human factors with a focus on the behavior of confined and isolated crews.

Researches specifically relevant to *confined crews* concern undersea habitats including submarines campaigns and closed-tanks experiments in multi-chamber facilities (i.e., the space simulators).

The current results in Capsule habitats state a positive psychology in terms of salutogenic adaptation [2] although inter-individual conflicts, changes of mood, high levels of tension/anxiety, depression and mental disturbances due to deprivations, dangers, and stresses were detected. They have an impact on coping style, efficiency at work, motivation to the mission goal,

cognitive functioning, crew cohesion, and crewmember's well-being as a result.

During NEEMO[1] missions for instance, the individuals that lived inside the divers' undersea habitat with strict life-support and worked outside for testing equipment in buoyancy, experienced a powerful training that have an enduring value, a benefic effect, and an optimized success for their allotted space missions. High crewmember autonomy would become the norm for future exploratory missions [3].

During submarine missions, the crew is confronted to additional environmental properties: crowding, schedule per quarters, absence of day/night cues, no communication with Earth, no information on underway position, and prolonged dangerous operations. The rigorous and very long crew training that occurs before military deployments and the presence of strong hierarchical rules lead to behavioral stereotypes and over-learned technical responses [4] that do not permit uncertain outcomes in the adaptive process.

Closed tank experiments were justly designed with the aim of studying the crewmembers' behavioral strategies of adaptation. Ethological investigations made during ISEMSI[2], EXEMSI[3], and HUBES[4] experiments described changes in social behavior over time and according to the environmental situation [5]. Within large or open areas, interindividual distances were constant. In reduced habitats, the frequency of personal distances, according to Hall's classification, decreased and the frequency of public distances increased with high levels of social distance and body mobility from the initial period to the final period of confinement. Over the campaigns, living and working together in closed tanks were more and more stressful and the long-term adaptive process was not still achieved after 135 days. In the SFINCSS[5] experiment, comparing one group confined for 240 days and two groups for 110 days, differences in culture and attitudes toward gender were factors identified as having a major impact on the intergroup relationship [6]. Other results indicated coping behaviors. Environmental stresses were identified altering well-being and human performance inside the multi-chamber facilities.

The Mars-500 experiment offered an exceptional paradigm that promoted further advances on crew behavior not only in confinement but also in extended time period and in high autonomy. Summarized results from multidisciplinary

[1]NASA Extreme Environment Mission Operations.
[2]Isolation Study for European Manned Space Infrastructure.
[3]EXperimental campaign for European Manned Space Infrastructure.
[4]HUman Behavior in Extended Space flight.
[5]Simulation of Flight International Crew on Space Station.

approaches [7] showed a progressive reduction in physical activities during the course of the simulation, disturbances in sleep quality and quantity, changes in patterns of language within the high autonomy phase and during Mars landing period, increased perceived homogeneity in personal values, consistency in the most salient personal goals, gain of positive strengths from demanding situation, and increased loneliness particularly at the end of 520-day confinement. An ethological monitoring of the crew globally pointed out time effects, cultural preferences and individual differences in the crew's actions, interactions, expressions and communications during Mars-500 experiment. A personal account by the crewmembers who experienced this simulated interplanetary flight reported, for some of them, difficult periods when few contacts were arriving from outside, and for all of them, the lack of connection with nature, the lack of fresh and variety of food, and the importance of communication channels. Psychological crew support program, implemented as countermeasure in the experiment, provided efficient communication sessions.

Such studies have demonstrated the interest to extend ground simulations of the psychosocial environment encountered during very long-duration stays in isolation and confinement. This conducted to a focus on the isolation factor.

Researches specifically relevant to *isolated crews* concern polar regions stays in Antarctica and in Arctic and dessertic lands (i.e., the analogue environments).

The most salient data collected from numerous winterovers in South Pole stations led to propose four characteristics regarding psychosocial adaptation to isolation in extreme settings: adaptation is *situational*, adaptation is *social*, adaptation is *cyclic*, and adaptation is *salutogenic* according to Palinkas cited in [8]. However, a significant increase in depressed mood was emphasized in men and women who spent a year at Mac Murdo Station and Amundson-Scott station in Antarctica [9], for example. All-female crews are rare and mixed-gender expeditions were developed. This provides evidence of the heterogeneous groundwork of a crew to cope, regulate, and adapt for a better equilibrium in isolation conditions. Considering multi-cultural crews, cross-cultural comparisons have provided some findings that suggest a characteristic personality trait profile in the Antarctic expeditioner [10] that may be considered in the future to select space explorer.

Studies performed at the FMAR[6] in Devon Island, indicated differences between individual coping styles across time. Stress decreased for females

[6]Flashline Mars Arctic Research Station.

while it increased for males who demonstrated higher levels of excitement, tiredness, and loneliness [11]. The results concluded that simulations of prolonged real isolation and hostile natural environment appear to provoke true demands for adaptation that actually approaches interplanetary missions. Depending on weather conditions, the crew stays for short-term (mimicking Moon landing) or for long-term missions (mimicking Mars landing). In both cases, the adaptation is *situational*.

As test beds for field operations, studies at the MDRS[7] in Utah desert investigated crew selection protocols, tested key habitat design features, replicated space food packages, compared mission crews with backup crews, analyzed the high workload on crew vigilance, and examined communications in multi-lingual crews, among other investigations. Preliminary works on language skills revealed that verbal and nonverbal expressions were influenced by the cultural background such as native language, by their respective roles within the crew and the crewmembers' spirit [12]. They contributed to show that the adaptation is *social*.

The most recently built station in Polar Regions was Concordia at Dome C. This South Pole base serves as research laboratories with a particular interest on space life sciences. The crews who stay there are considered as winterers but also as interplanetary crewmembers because of similarities with the personnel composition, architectural structure, and temporal scale. With an emphasis on the long-duration factor, ethological observations made weekly during a collective activity at meal times, allowed to describe and quantified certain profiles of social behavior according to the mission day. Interesting data were on the collective attendance and collective time. The results showed for instance, periodic changes in the number of winterers attending the meals, over three periods of 13 weeks each (Figure 26.1) and cyclic variations in the time spent altogether at meals, every 7 weeks (Figure 26.2). A Mars mission scenario on different crew organizations over time could be applied in real mission. These findings further demonstrated that the adaptation is *cyclic*.

With the opportunity of Tara expedition in Arctic, the environmental properties became more and more stressful because of the combined isolation and confinement factors in synergy with the associated periods of winterover totalizing 507 days in duration like a Mars mission. Preliminary results [13] showed that the irregularity of collective time and the variations of inter-individual positions were behavioral indicators that would prevent the

[7]Mars Desert Research Station.

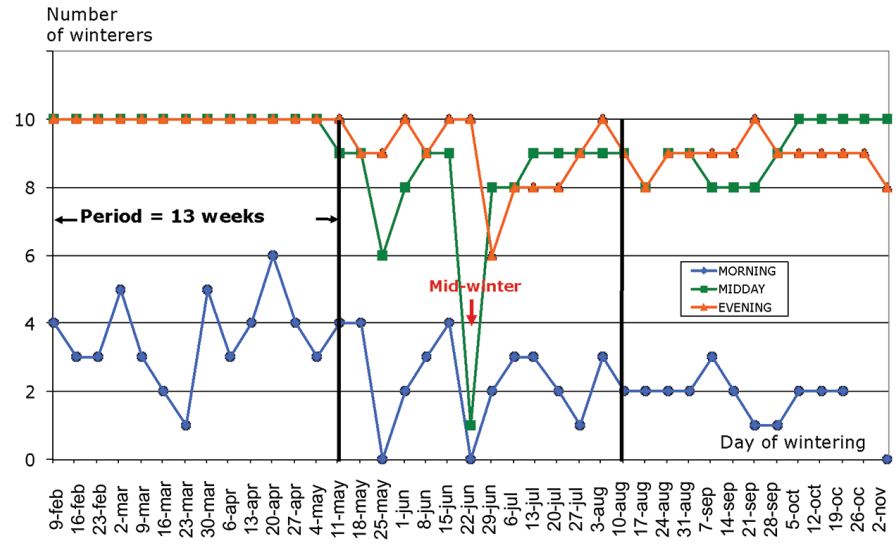

Figure 26.1 Collective attendance at the morning meal, midday meal and evening meal, at Concordia station in Antarctic, according to the days (mission DC2, 2006).

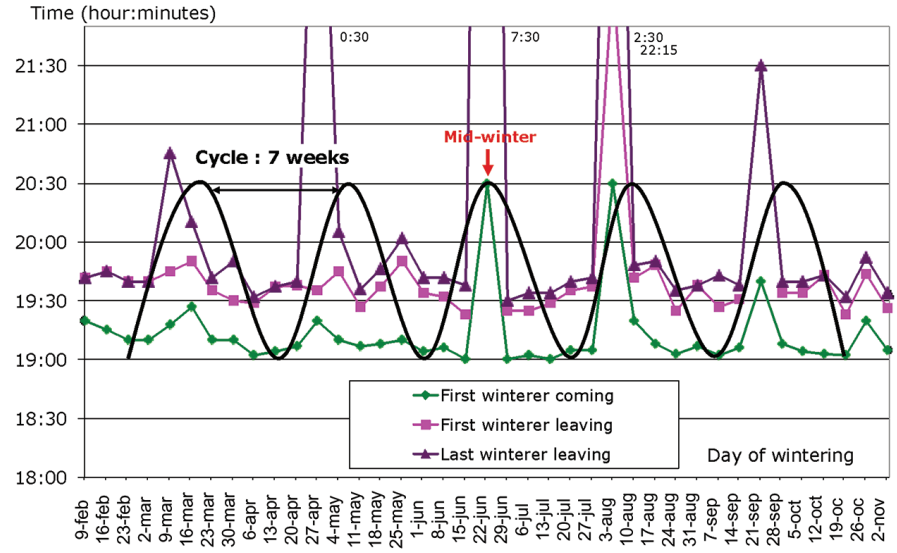

Figure 26.2 Collective time at the evening meal, at Concordia station in Antarctic, according to the days (mission DC2, 2006).

monotony of daily life. A complete study is in process. It should support the statement that the adaptation is *salutogenic*.

These examples highlight the key issues relevant to researches on isolated and confined crews' behavior in order to provide the space crews with the best quality of life and success of missions. A synthesis on psychology of space exploration exhaustively reviewed contributions in the area [8].

Future researches might include further studies on cognitive issues in terms of new crewmember's representation of the crew and in terms of new crewmember's representation of the outsight.

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