Social, Occupational, and Cultural Adaptation During a 12-Month Wintering in Antarctica

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BACKGROUND AND METHODS: Life in isolated and confined environments (ICEs) is subject to important constraints which can generate psychosociologically impaired outcomes. This study investigated psychological, social, occupational, and cultural variables which are among the most important determinants in adaptation to a one-year wintering in Antarctica for 13 international subjects.

RESULTS: Our findings confirm and give further insight into the role of social (Cohesiveness, Social Support) and occupational (Implementation/Preparedness, Counterproductive Activity, Decision Latitude, and Psychological Job Demands) dimensions of adaptation to ICEs. Relationships between various social and occupational dimensions studies reflected detrimental effects ranging from decrements in cohesiveness (ICE 1, $M = 4.44$; ICE 7, $M = 3.33$), social support (ICE 2, $M = 4.93$; ICE 7, $M = 4.28$), and work performance (ICE 1, $M = 4.33$; ICE 6, $M = 3.5$), which differed across professional status and multicultural factors.

DISCUSSION: These psychosocial issues have important implications for pre-mission selection and training, monitoring and support of crews during the mission, and post-mission readaptation. Operational recommendations are suggested to improve adaptation, success, and well-being for long-duration ICE missions, e.g., to Mars and beyond.

KEYWORDS: isolated environments, psychosocial issues, adaptation to extreme environments, long-duration space missions.

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Living and working in isolated and confined extreme environments (ICEs), e.g., polar, submarine or space, are subject to important constraints which can generate both positive and negative psychosocial and occupational outcomes.[15] Participation in ICEs is generally characterized by a tight program of professional tasks combining periods of high and low workloads among a restricted social and cultural group. Psychosocial and occupational factors are recognized as critical components which can impact both well-being, individual and group performance, and, consequently, mission success.[2,16,23] Although social and occupational factors are recognized as crucial factors in adaptation, few protocols have conjointly studied these relationships in a high fidelity ICE that provided a real operational environment characterized by imminent environmental threat, limited resources, difficulty of access and rescue, and limited communication capabilities with the scientific controls usually reserved for laboratory facilities. The French-Italian Concordia Station is one of three permanent all year Antarctic facilities 100% dedicated to scientific research (along with Russia's Vostok and the U.S. South Pole Station) and the first to specifically be designed as an analog facility to study human adaptation to isolated, confined extreme environments. Geographically remote at a high altitude on Dome C in the middle of Antarctica, Concordia is located in one of the coldest, windiest, and driest areas on Earth. The winter-over period at Concordia is also longer with 9 mo of darkness and isolation compared to the 6 mo at McMurdo. Hence, this study aimed to investigate temporal patterns and mutual influences between psychosocial and occupational dimensions and professional and multicultural issues in team members wintering-over at Concordia station in Antarctic.

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When assessing human adaptation to ICEs, in addition to the impact of harsh environmental conditions, social and occupational dimensions have been found to be among the most important potential stressors which may become a serious problem for security and mission success.[2,15,26] Social stressors encompass family/home-life disruption stemming from physical separation and limited telecommunications, forced social interaction with the same limited small group, confinement, and limited privacy. In addition, with teams composed of different nationalities and cultures, as is the case for Concordia, multicultural issues, e.g., different languages and behavioral customs, contribute additional sources of stress. Occupational stressors include monotony and boredom, time pressure, autonomy, alternative high/low workloads, lack of separation between living and working spaces and, thus, work and leisure, and the constant interaction with the same group of individuals in both sets of activities. These psychosocial and occupational stressors have been shown to induce dysfunctional stress responses in long-term ICE situations which in turn has led to detrimental interpersonal tensions and decrements in performance.[12,15]

Numerous reviews have illustrated the breadth and scope of psychosocial issues relating to ICEs.[2,15,26] People on polar expeditions (e.g., trek to the pole) often report high social cohesion because they share clearly defined common goals with specific tasks directly related to achieving those goals.[26] However, in station-keeping missions, e.g., manning a base, interpersonal conflict and crew tension have been repeatedly found to be the greatest sources of stress in prolonged isolation and confinement.[21,23,26,32] The necessity of living together for a long period of time seems to promote reluctance to express tension openly and frequently leads to territorial behavior and withdrawal from interaction with others. In addition to increased risk of interpersonal conflicts, diminution in crew cohesiveness has also been reported in prolonged isolation of small groups in ICEs.[5,19] The impact of cultural and vocational factors on group functioning is recognized as having a significant impact on interpersonal processes and cohesion.[25,30]

Empirical studies addressing possible effects of ICE-related stressors on occupational or professional tasks have often been assessed through cognitive performance. Those who winter-over ("winter-overs") often report cognition impairment with difficulty in memory and concentration and reduction in alertness, attention capacity, vigilance, reasoning, reductions in accuracy, and increases in time response.[26,27] However, other studies have recorded no reduction in cognitive performance.[8,35] Where cognitive performance decrements have been found, they have been attributed to multiple etiologies, including stress and fatigue, the presence of syndromes (e.g., winter-over mental syndrome) and hormone alterations, adaptation problems, individual characteristics, low environmental stimulation, and exposure to cold, isolation, and confinement.[8,35]

However, the influence of one's occupation cannot be restricted to cognitive performance alone, but concerns more broadly individual and group work and collective tasks as well as leisure activities that may be related to one's profession. Hence, systematic studies addressing the role of occupational and social dimensions in extreme living and working conditions are still needed.[9,14,35] These conditions may be different depending on the cultural background of crewmembers.[12] Language and cultural factors have been shown to be a contributing factor to socially isolated crewmembers representing minority cultures.[10] Studies during long-duration space missions reported differences in perceived leader support, work pressure, and managerial control on the Mir orbital station between Americans and Russians.[10] Thus, cultural backgrounds could explain detrimental effects on mood and performance and, more broadly, on psychosocial adaptation processes.[24,28]

Heterogeneity in cultural backgrounds as well as in professional roles is assumed to increase the risk of interpersonal tensions[15] and counterproductive activity[1] among isolated and confined personnel. The relative certainty of inclusion of members from different cultures in future long-term space missions mandates a better understanding of the interaction between cultural and occupational dimensions, especially with systematic and cross cultural studies conducted in ground-based analogs.[23,26] This information could be vital to improving the psychosocial and work functioning of future long-duration space multicultural crews.[2,35]

The research program at Concordia represents a longitudinal study to examine the time course of both occupational and social components of the adaptation process and their mutual relationships with cultural and professional determinants. Based on the literature, we expected that winter-overs who spent the winter in Concordia would report changes in the social and occupational factors investigated during the ICE period compared to baseline levels. In addition, we expected to find significant relationships among the social and occupational factors. Furthermore, we expected differential patterns of changes and relationships depending on the subjects' cultural and occupational backgrounds.

METHODS

Subjects

The winter-over crew for Concordia included 13 subjects (1 woman and 12 men; 6 French, 6 Italians, and 1 British) from 20 to 54 yr of age (M = 37.14, SD = 11.90) composed of technicians, scientists, a cook, and two medical doctors. One physician was in charge of health issues, the other was responsible for the coordination of the research programs. For analyses, subjects were grouped according to their occupation (logistic: N = 7, M = 35, SD = 9.8, including 4 Italians and 3 French; scientific: N = 6, M = 38.8, SD = 14.5, including 2 Italians and 3 French and 1 British) and nationality (French: N = 6, M = 37.3, SD = 13.02; Italy: N = 6, M = 36.9, SD = 10.75). The British participant was not included in the Nationality analyses.

The subjects were selected from among a larger pool of candidates through a selection process based on educational, professional, medical, and psychological criteria. For the great

majority of the candidates, it was the first time to apply. The psychological examination included an in-depth psychological test with a personal interview. After the selection process and during the predeparture seminar at the French polar institute (IPEV, Institut Paul Emile Victor, Plouzané, France), the subjects attended an oral presentation explaining the study objectives, procedures, and the potential risks of participation. No specific psychological training was supplied to the subjects before the confinement. Afterward, the volunteers gave their written informed consent to participate in this study and were reassured that they were free to withdraw at any time without explanation. According to the Institutional Review Board, this protocol was approved by the ethics committees of the local university and the European Space Agency.

Materials

The items of each questionnaire were translated from the original English version to French and Italian using a back-translation procedure. A bilingual scientist translated the scales, and they were then translated back into English by another bilingual scientist. The translated scales were administered to three French and three Italian subjects in order to identify any unclear items. Based on the ratings and comments provided by the subjects, the items from each questionnaire were closely examined and reworded to improve clarity and adapted to the specificity of the ICE situation. All the questionnaires ask the respondent to indicate the extent to which each statement corresponds to his or her perception, using a Likert-type scale anchored by 1: Never to 6: Always.

Intervention Group Environment Scale. The perceived social climate of group settings was assessed through a newer and shorter version, the Intervention Group Environment Scale[34] adapted from Moos' original 90-item Group Environment Scale (GES).[17] This scale was designed to diagnose group functioning, to monitor and promote change and program improvement, and improve leadership and team building. The IGES is also useful for showing both members and leaders how their behavior influences team climate, and, thus, adaptation process and members' performance and well-being. This version covers 3 factors and 14 items: Cohesiveness (5 items focusing on closeness and support among group members), Implementation and Preparedness (5 items focusing on group orderliness and preparation), and Counterproductive Activity (4 items focusing on negative and counterproductive activity among group members). For this sample, the internal reliability coefficients for Cohesiveness, Implementation and Preparedness, and Counterproductive Activity were, respectively, 0.86, 0.69, and 0.79.

The Job Content Questionnaire. The Job Content Questionnaire[13] (JCQ) was designed to measure social and psychological characteristics of the work environment. The version used for this study contains 18 items distributed across 4 dimensions: 5 items about Decision Latitude; 5 items about Psychological Job Demands; 4 items about Social Support from colleagues; and 4 about Support from superiors in the work environment. Decision Latitude or Job Control refers to the ability of making decisions about one's own work and the possibility of being creative and using or developing skills; Psychological Job Demands refers to the quantity of work, the mental requirements, and the time constraints put on the worker; and Social Support refers to the resources (material, emotional, and informational) and aids provided by others (in this case, coworkers and leaders) to help a person adjust to a situation or cope with stress. These job strain dimensions could contribute to a better understanding of which dimensions of job stress are associated with different outcomes such as work-related stress due to increased Psychological Job Demands and scarce decision latitude regarding the work process. In the present study, alpha coefficients were 0.60 for Decision Latitude and 0.82 for Psychological Job Demands, 0.88 for Social Support.

Facilities and Procedures

The present study covers 12 mo in Concordia Station located on the high Antarctic plateau (altitude 3232 m) at Dome C (75°06' S, 123°23' E), 9 of which were the winter-over period, consisting of just the 13 crewmembers. Access to the station is only possible during the Antarctic summer, from mid-November to mid-February, when station population rises to approximately 60 visiting scientists and support personnel. The station is largely inaccessible the rest of the year, involving strict prolonged isolated and confined extreme situations in one of the coldest, driest, and most inhospitable locations on Earth. Human presence in Concordia is totally dependent on life support systems (e.g., temperature, constant artificial lights, air conditioning). Life conditions in Concordia involve sensory, intellectual/work, recreational and social monotony. Leisure activities in the station are sparse. The extreme separation and isolation from close relatives and friends leads to limited telecommunications and poor access to information from the outside world, including communication with friends and family. However, each participant has a private room with their personal belongings. Food is generally well prepared by the cook, although it is from frozen and dried ingredients.

The main goal of this station is to conduct research programs operated by the French Polar Institute (IPEV), the Italian Antarctic Research Program (PNRA), and the European Space Agency (ESA). Because of the inaccessibility of the site and to ensure the confidentiality, data were collected by internet during the winter by sending the completed questionnaires directly to the researchers. The first (baseline) administration of the psychological measures (ICE 1) occurred within the first days on-site (i.e., beginning of the study year and when the summer visitors were also present) and, then, subjects received the questionnaire through the internet at the beginning of the winter period at +3 mo when the summer visitors had just left (ICE 2), +5 mo (ICE 3), +6 mo (ICE 4 midyear), +8 mo (ICE 5 which is also just after the midwinter point), +10 mo (ICE 6), and +12 mo (i.e., the end of the winter and mission year-ICE 7), and were required to send it back within 2 d. The baseline measures were expected to be elevated due to the heightened state of excitement, anticipation, and arousal that characterizes all missions.

Comparison with ICE 1 should take into consideration this inflated state when assessing decreases in study variables. However, the second 'baseline' taken at +3 mo immediately following the closure of the base and departure of the summer visitors, although benchmarking a notable event, i.e., the beginning of the 9-mo period of isolation, should reflect a more normalized assessment as the novelty of the environment, habitat, and station would have worn off.

Statistical Analyses

Shapiro-Wilk and Levene's test were applied prior to the statistical analyses to verify the normality of the distribution and the homogeneity of variance for all study measures. Thus, the data for changes and correlations were analyzed using parametric statistics. Changes in social and occupational states were first assessed using repeated measures of variance. After identifying significant variations, a series of paired *t*-test post hoc analyses were performed in order to determine which specific time periods for each measure were significantly different. If necessary, the level of significance was corrected using Bonferroni-type adjustment to preserve the probability of Type-I error at the 0.05 alpha level ($P < 0.008$). Effect sizes (ES) were calculated as the difference between the means divided by the standard deviation of the difference. As a general guideline, an effect size of 0.20 – 0.50 is considered to be a small effect, one of 0.50 – 0.80 a medium effect, and a value > 0.80 a large effect size.[4] Furthermore, bivariate correlations using Pearson's product–moment correlation (*r*) were conducted between social and occupational variables of interest. Internal consistency of all the scales was assessed using Cronbach's alpha coefficient. Means and standard deviations for all scales at each administration are reported in **Table I**.

RESULTS

Both Social [Cohesiveness, Social Support (Coworker/Peer and Hierarchical/Leader Support)] and Occupational (Implementation/Preparedness, Counterproductive Activity, Decisional Latitude, and Psychological Job Demands) dimensions were altered during the 12-mo mission (**Fig. 1**). It is interesting to note the expected change in measures from ICE 1 at the beginning of the year on arrival at the station and at ICE 2, 3 mo into the mission right after the summer visitors have left as the novelty wears off and the arrival excitement abates. For several dimensions (Cohesiveness and Implementation & Preparedness), the immediate post-departure of summer visitors represented a notable low point with some modest rebound over the next two measurement periods, most likely reflecting a period of group bonding and integration. However, peer support and counterproductive activity continue to degrade across time with notable escalation in the last half of the winter (i.e., from ICE 5-ICE 7) (Fig. 1).

When considering all subjects as a group, throughout the year the social dimensions Cohesiveness [$F(6, 48) = 5.62$, $P < 0.001$, $\eta^2 = 0.41$] and Social Support in its Peer components showed significant decreases [$F(6, 48) = 2.74$, $P < 0.05$, $\eta^2 = 0.26$]. Post hoc analyses showed that Cohesiveness demonstrated a large significant decrease from the baseline measure at the beginning of the year (ICE 1) compared to the last measure ICE 7 at the end of the year and after 9 mo of wintering [$t(8) = 3.82$, $P < 0.008$, $d = 1.12$]. Peer Support reflected a moderately significant decrease from ICE 2 (beginning of winter) to ICE 7 (the end of the winter period) [$t(10) = 3.73$, $P < 0.008$, $d = 0.63$] (Table I). Differential occupational differences were observed for the social dimensions of Cohesiveness with scientists reporting substantial significant decreases from ICE 1 (beginning of the year) compared to ICE 2 (beginning of winter) [$t(5) = 5.86$, $P < 0.008$, $d = 2.39$] and compared to ICE 6 [$t(4) = 6.67$, $P < 0.008$, $d = 2.98$] (Table I). The significant decrease for only the scientists on these dimensions at the beginning of winter suggests a greater perceived loss in cohesiveness and peer support with the departure of the summer team members. Similarly, the scientists were the only occupational group to demonstrate a significant difference in cohesiveness at 10 mo (ICE 6) compared to arrival, suggesting that this may be a vulnerable point in time when projects are being readied for closure and stresses with resource and role demands erodes group cohesion.

For all the crew, the occupational dimension of Counterproductive Activity showed a moderately significant increase [$F(6, 48) = 14.26$, $P < 0.0001$, $\eta^2 = 0.64$] (Table I) with the expected but very large significant increases between ICE 1 and ICE 7 [$t(8) = -6.74$, $P < 0.008$, $d = 2.25$] and, more importantly, significant increases between winter onset (ICE 2) and winter/year end (ICE 7) (Table I).

According to their cultural or occupational groups, crewmembers reported different changes for Implementation/Preparedness with a significant decrease only for French [$F(6, 24) = 5.25$, $P < 0.01$, $\eta^2 = 0.57$], who demonstrated large significantly lower scores at ICE 3 [$t(10) = 2.90$, $P < 0.02$, $d = 1.77$] and ICE 4 [$t(10) = 2.28$, $P < 0.05$, $d = 1.4$] compared to Italians (Table I). Interestingly, Implementation/Preparedness showed a moderately significant interaction between occupation and nationality [$F(1,6) = 7.34$, $P > 0.05$, $\eta^2 = 0.55$] and between time, occupation, and nationality [$F(6,36) = 3.37$, $P > 0.05$, $\eta^2 = 0.35$] (**Fig. 2**), indicating that for French scientists Implementation/Preparedness increased regularly compared to French logistic personnel, whereas it was the opposite for Italian scientists. Implementation/Preparedness decreased regularly compared to Italian logistic personnel throughout the year. There were significant decreases throughout the year only for Italians in Psychological Job Demands [$F(6, 24) = 2.51$, $P < 0.05$, $\eta^2 = 0.39$] as well as for Decisional Latitude [$F(6, 24) = 3.38$, $P < 0.05$, $\eta^2 = 0.46$]. Moreover, Decisional Latitude decreased significantly throughout the year only for the scientists [$F(6, 24) = 2.63$, $P < 0.05$, $\eta^2 = 0.40$], such as Implementation/Preparedness at ICE 6 [$t(4) = 5.67$, $P < 0.008$, $d = 2.54$] compared to baseline measure ICE 1.

Given the small group sizes when comparing across occupational and cultural subgroups, an assessment of noteworthy relationships is better weighed using effect size than statistical significance alone.[4] Criteria for correlational effect size is 0.10

Table I. Post Hoc Comparisons Over Time for All Participants and National, Occupational Split.

	ICE 1		ICE 2		ICE 3		ICE 4		ICE 5		ICE 6		ICE 7	
GES Factors	**M**	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**
Cohesiveness														
All participants	4.44 [2,3,6,7]	0.17	3.72 [1]	0.19	3.5 [1]	0.27	3.84 [7]	0.30	3.71	0.32	3.37 [1]	0.30	3.33 [1,4]	0.34
French	4.24	0.21	3.52	0.26	3.00	0.33	3.40	0.36	3.24	0.40	2.80	0.23	2.92	0.40
Italian	4.28	0.31	3.64	0.27	3.72	0.31	3.96	0.52	3.76	0.53	3.52	0.54	3.16	0.71
Scientist	4.28 [2,6]	0.23	3.58 [1,6]	0.24	3.26	0.37	3.32	0.43	3.28	0.45	2.88 [1,2]	0.27	2.80	0.53
Logistic	4.33	0.26	3.67	0.25	3.57	0.31	3.93	0.37	3.70	0.41	3.47	0.44	3.27	0.49
Counterproductive Activity														
All participants	1.25 [2,4,5,6,7]	0.09	1.71 [1,6,7]	0.16	2.1 [6,7]	0.34	2.06 [1,6,7]	0.26	2.47 [1,6,7]	0.28	2.94 [1,2,3,4,5]	0.3	3.58 [1,2,3,4,5]	0.40
French	1.35 [7]	0.15	1.75	0.21	2.50	0.55	2.30	0.41	2.65	0.39	2.95	0.50	3.85 [1]	0.52
Italian	1.1 [6,7]	0.06	1.80	0.29	1.85	0.26	1.95	0.24	2.10	0.36	3.15 [1]	0.41	3.3 [1]	0.53
Scientist	1.35 [5,6,7]	0.13	1.775 [5,7]	0.13	2.275 [7]	0.47	2.15 [7]	0.38	2.8 [1,2]	0.31	3.4 [1]	0.38	4.2 [1,2,3,4]	0.44
Logistic	1.125 [7]	0.09	1.75	0.27	2.00	0.37	2.08 [7]	0.26	2.00	0.30	2.71	0.37	3.17 [1,4]	0.42
Implementation Preparedness														
All participants	4.33 [3,6]	0.19	4.16 [6]	0.27	3.71 [1]	0.31	3.96 [6]	0.25	3.96 [6]	0.28	3.5 [1,2,4,5]	0.31	3.58	0.44
French	3.96	0.16	3.76	0.32	3.04	0.20	3.48 [6]	0.21	3.52	0.32	2.88 [4]	0.22	2.80	0.48
Italian	4.20	0.38	4.36	0.35	4.32	0.36	4.36	0.41	4.12	0.44	3.94	0.47	3.56	0.78
Scientist	4 [6]	0.34	4.08 [6]	0.27	3.44	0.29	3.48	0.26	3.72	0.30	2.96 [1, 2]	0.30	3.08	0.64
Logistic	4.30	0.25	4.10	0.36	4.00	0.42	4.27	0.32	3.93	0.41	3.85	0.38	3.50	0.62
JCQ Factors														
Psychological Job Demands														
All participants	3.14	0.31	3.07	0.34	2.96	0.29	2.96	0.32	3.02	0.39	3.02	0.27	3.04	0.34
French	2.62	0.26	2.52	0.33	2.76	0.10	2.60	0.25	2.67	0.33	2.84	0.32	3.12	0.48
Italian	2.76	0.45	2.56	0.52	2.12	0.39	2.40	0.45	2.36	0.64	2.34	0.48	2.12	0.51
Scientist	2.82	0.64	2.68	0.72	2.84	0.64	2.80	0.67	2.75	0.67	2.80	0.54	2.84	0.67
Logistic	2.97	0.26	2.83	0.30	2.53	0.23	2.67	0.27	2.70	0.46	2.68	0.35	2.63	0.38
Decisional Latitude														
All participants	4.69	0.25	4.59	0.25	4.39	0.19	4.20	0.18	4.58	0.18	4.62	0.20	4.22	0.18
French	4.32	0.29	4.36	0.40	4.20	0.20	4.12	0.19	4.56	0.21	4.40	0.20	4.12	0.14
Italian	4.68	0.31	4.40	0.36	4.20	0.39	4.08	0.39	4.00	0.36	4.22	0.42	3.92	0.31
Scientist	4.72	0.34	4.42	0.38	3.98	0.33	3.92	0.28	4.48	0.41	4.44	0.41	4.04	0.31
Logistic	4.50	0.29	4.43	0.33	4.50	0.22	4.27	0.25	4.27	0.22	4.38	0.26	4.17	0.22
Peer Support														
All participants	4.86	0.19	4.93 [7]	0.18	4.88	0.25	4.64	0.15	4.58	0.20	4.47	0.18	4.28 [2]	0.22
French	4.70	0.29	4.95	0.32	4.85	0.41	4.45	0.22	4.70	0.20	4.55	0.28	4.20	0.23
Italian	4.35	0.64	4.35	0.53	4.10	0.78	3.80	0.88	3.95	0.59	3.63	0.77	3.55	0.87
Scientist	4.90	0.26	5.18	0.22	4.58	0.54	4.25	0.33	4.50	0.31	3.95	0.51	3.85	0.47
Logistic	4.54	0.33	4.33	0.31	4.63	0.33	4.42	0.36	4.25	0.34	4.21	0.37	3.92	0.47
Hierarchical Support														
All participants	4.47	0.46	4.27	0.30	4.13	0.42	3.99	0.44	3.89	0.47	3.53	0.51	3.78	0.45
French	4.25	0.54	4.15	0.35	4.05	0.49	4.10	0.32	4.20	0.40	3.65	0.44	3.60	0.56
Italian	4.35	0.64	4.35	0.53	4.10	0.78	3.80	0.88	3.95	0.59	3.63	0.77	3.55	0.87
Scientist	4.55	0.60	3.84	0.40	3.79	0.54	2.88	0.70	3.45	0.65	2.95	0.75	3.25	0.74
Logistic	4.33	0.53	4.50	0.37	4.25	0.59	4.46	0.44	4.17	0.46	3.77	0.55	3.75	0.58

Note. In brackets, significantly different from time measures indicated using Bonferroni adjustment with $P < 0.008$.

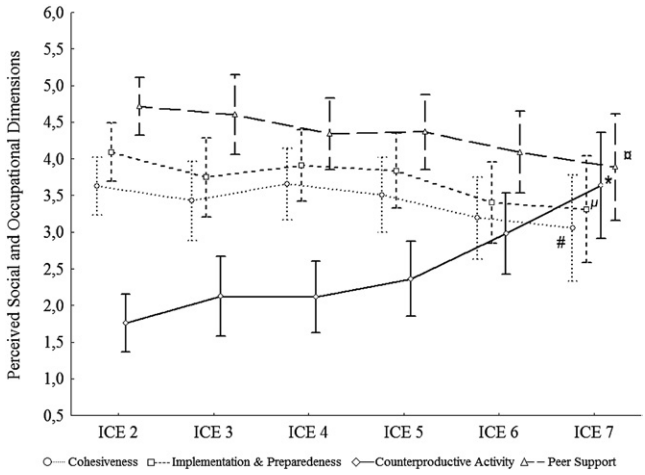

Fig. 1. Time course of Social and Occupational dimensions throughout the experiment and during 1 yr in an Isolated and Confined Environment (ICE). Post hoc analysis ($P < 0.008$). ¤Significantly different from ICE 1 for Peer Support; ᵘsignificantly different from ICE 1 for Implementation/Preparedness; *significantly different from ICE 1 for Counterproductive Activity; #significantly different from ICE1 for Cohesiveness.

for small, 0.30 for moderate, and 0.50 for large. Several interesting differential patterns emerged when comparing the two cultural groups and the two professional groups (**Table II**). Cohesiveness demonstrated a large, significant, positive pattern with scores on Implementation/Preparedness and Hierarchical Support overall and across all subgroups reflecting stronger perceptions of cohesion under conditions where perceptions of implementation and preparedness or social support were also high. All other factors showed group specific patterns. For instance, Cohesiveness was substantially related to Peer Support for all groups except the French. Most noteworthy was the opposite pattern of relationships between Decisional Latitude with Cohesiveness, Counterproductive Activity, and Hierarchical Support when comparing the French to Italian groups. For the French group, it appears that higher Decisional Latitude was related to higher perceptions of Counterproductive Activity and lower perceptions of Cohesiveness and Hierarchical Support, whereas the Italians felt the opposite.

In several cases, differential patterns were in evidence across occupational groups. Large and positive relationships were demonstrated only for scientists between Psychological Job Demands, Decisional Latitude, Peer and Hierarchical Support with Cohesiveness, and Implementation/Preparedness reflecting the beneficial impact of higher cohesion and preparation. For the logistic group, Cohesiveness demonstrated a similar large positive relationship with Implementation/Preparedness and a large negative association with Counterproductive Activity reflecting a linkage between lower levels of cohesiveness and elevated levels of counterproductive activity.

DISCUSSION

This study investigated psychological, social, occupational, and cultural variables which have been found to be among the most important determinants in adaptation to a 1-yr mission in Antarctica. As expected, the ICE situation impacts social and occupational dimensions differentially as indicated by noteworthy variations in the patterns of the findings. The data reflect detrimental effects which range from decrements in cohesiveness, social support, and work performance according to professional status and cultural group. Our findings confirm the complexity of psychosocial adaptation processes and improve our understanding of their social and occupational components in ICEs. The results support the existence of psychosocial and occupational links between crewmembers and highlight the importance of cultural and professional dimensions for adaptation outcomes.

The social dimensions indicated significant changes with decreases for Cohesiveness between the beginning and the end of the year period and Social Support in its Peer component more importantly between the beginning of winter and isolation and the end of winter. These results are in agreement with the literature in extreme environments reporting that the greatest sources of stress in Antarctic crews are interpersonal conflicts and tensions, with a significant erosion of social support.[32] However, people living and working in space orbital missions do not routinely experience increased tension or decreased cohesion during the second half of the mission.[11] Winter-overs have often reported that interpersonal conflicts and negative experiences within small crews were relatively limited.[26] Tension or conflict within the same small social sphere has been attributed to social comparisons frequent during the group formation, ostracism of crewmembers who do not adhere to group norms, and group heterogeneity characterized by differences, for instance in professional status.[2,19]

The occupational dimensions of Implementation/Preparedness decreased significantly and Counterproductive Activity increased significantly for the group as a whole. Research has suggested that ICE environments can cause detrimental effects on cognitive and psychomotor processes and, more specifically, degradations of occupational (e.g., logistic, research programs) and operational performance (e.g., errors in mission tasks).[18,23] Operational inefficiency is of prime importance and could cause serious hazardous problems in extreme situations involving security and negatively impact crewmembers' health.[23]

Cultural differences were noted for occupational dimensions with a significant decrease in Psychological Job Demands and Decisional Latitude only for the Italians, whereas only the French reported a significant decrease for Implementation/Preparedness. Furthermore, Cohesiveness was positively associated with the occupational dimensions Psychological Job Demands and Peer Support only for the Italians, as Hierarchical Support was positively linked with Implementation/Preparedness and negatively with Counterproductive Activity. These relationships highlighted the importance of social dimensions in occupational tasks, especially for the Italians. Cross-cultural research in ICE suggests that cultural background has an impact on the way people work and their effectiveness.[7] People from different cultures may have different representations of what efficient work processes and outcomes entail.

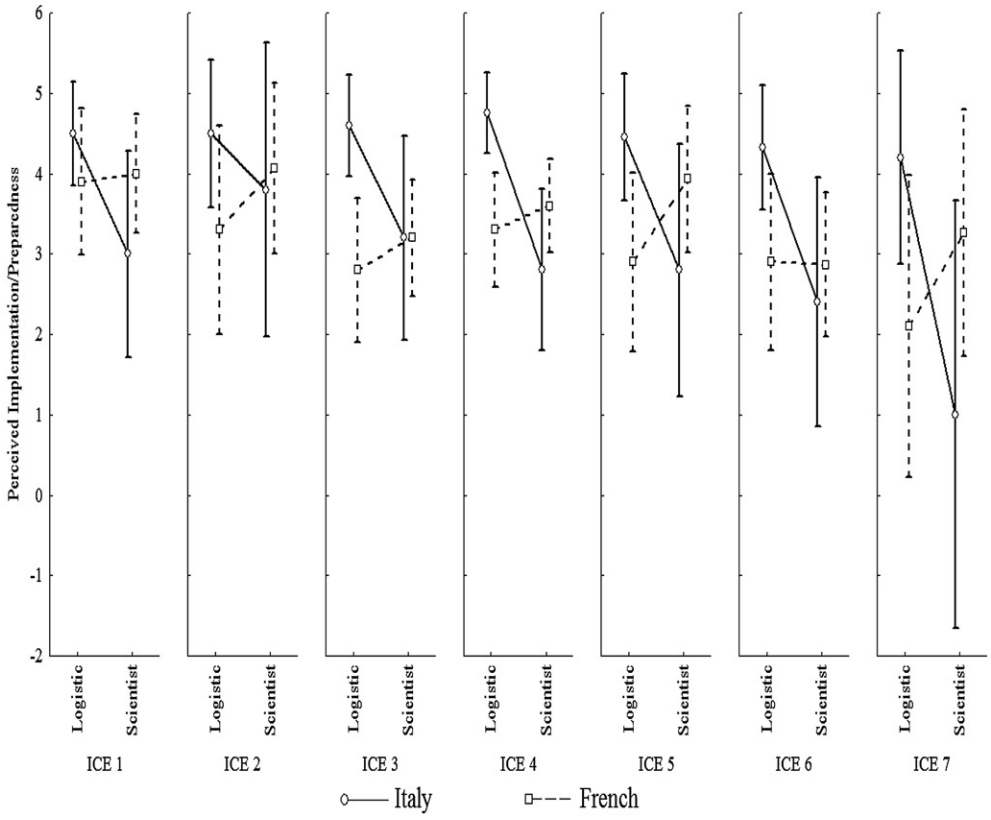

Fig. 2. Interaction between occupation (Logistic, Scientific) and nationality (French, Italian) for Implementation/Preparedness during 1 yr in an isolated and confined environment (ICE).

These differences may result in frustration and tension in crewmembers if these differences are not perceived and accepted.

However, cultural heterogeneity is not always reported as involving detrimental effects.[35] Cultural and gender differences within the group may become facilitators for psychological adjustment, based on the sharing of an extraordinary experience, shared general values and aims of the group, and acceptance of cultural differences toward empathetic interrelations.[6] For our study, crewmembers from France and Italy belong to the same organizational culture (European Space Agency) and are from bordering countries, which may reduce the impact of national diversity.

Our findings indicated that performance may depend, on one hand, on the cultural background of crewmembers and, on the other hand, on the different perceptions of professional status. Only the scientists reported significant decreases for Cohesiveness, Implementation/Preparedness, and Decisional Latitude between the beginning and the end of the year, indicating professional status differences for these social and occupational dimensions. Furthermore, Psychological Job Demands and Decisional Latitude was positively associated with Cohesiveness and Implementation/Preparedness only for the scientific group. Differences between support personnel and scientists have been frequently demonstrated in Antarctica. In a French Antarctic station, scientists expressed a greater need for privacy while technicians preferred the social leisure area.[33] The extent to which a group experiences conflicts or cohesion depends on cultural and personal characteristics and on the size and structure of occupational subgroups.[23]

Our findings support that differences among crewmembers in professional status (e.g., personnel, militaries, young trainees, scientists) involved different perceptions and goals embedded in sociocultural differences, which may lead to increased interpersonal tensions and conflicts. Studies conducted in space analog environments have identified tensions between individuals with different occupations or different career objectives.[29] During debriefings, crewmembers reported that tensions also occur when some crewmembers value their roles as being more important than those of other crewmembers.

As expected, relationships between social and occupational variables indicated that Cohesiveness was strongly and positively associated with Peer and Hierarchical Social Support and Implementation/Preparedness and negatively with Counterproductive Activity. Furthermore, Hierarchical Social Support was also related negatively with Counterproductive Activity and positively with Implementation/Preparedness. Several studies in mainstream psychology highlighted that high levels of Psychological Job Demands, low levels of decision latitude, and low levels of social support at work were significant predictors of psychological distress, well-being, and mental health.[3] The ways in which crewmembers interact and function as a group can affect productivity and the accomplishment of mission goals in the stringent conditions of ICE settings. For the repetitive tasks (e.g., sampling of biopsies or ice floes), support from other members really helps to complete projects. In ICE environments, individuals interact with the unchanging restricted group both for work and leisure activities. This constant interaction may foster social conflict among coworkers and the formation of cliques.

Openness in communication among crewmembers has been shown to promote better performance within the working teams. Research in Antarctica has revealed the key roles supervisors play in working team performance, decreases in stress, and in tension among individuals. Clear communication of roles and responsibilities, sensitivity to the needs and well-being of the individuals and the team, and exemplarity have been identified as the corner stones of supervisors' efficiency and credibility.[22,31] A key factor that supports successful adaptation of the group is the individual's capability to

Table II. Means Correlations in Each Groups.

Groups	Occupational & Social factors	1	2	3	4	5	6
All participants ($N = 13$)	Cohesiveness (1)	-					
	Implementation Preparedness (2)	**0.89***	-				
	Counterproductive Activity (3)	**-0.52**	**-0.50**	-			
	Psychological Job Demands (4)	0.44	0.47	-0.06	-		
	Decisional Latitude (5)	0.38	**0.52**	-0.25	**0.73***	-	
	Peer Support (6)	**0.62***	0.43	-0.30	0.32	0.34	-
	Hierarchical Support (7)	**0.67***	**0.63***	**-0.64***	0.05	0.25	**0.55**
French Group ($N = 6$)	Cohesiveness (1)	-					
	Implementation Preparedness (2)	**0.91***	-				
	Counterproductive Activity (3)	-0.37	-0.25	-			
	Psychological Job Demands (4)	-0.09	0.19	0.40	-		
	Decisional Latitude (5)	**-0.55**	-0.26	**0.78**	**0.70**	-	
	Peer Support (6)	0.34	0.29	-0.08	-0.42	-0.49	-
	Hierarchical Support (7)	**0.77**	**0.79**	**-0.53**	0.14	**-0.53**	0.47
Italian Group ($N = 6$)	Cohesiveness (1)	-					
	Implementation Preparedness (2)	**0.96***	-				
	Counterproductive Activity (3)	**-0.63**	**-0.61**	-			
	Psychological Job Demands (4)	**0.86***	**0.76**	**-0.54**	-		
	Decisional Latitude (5)	**0.78**	**0.71**	**-0.90***	**0.79**	-	
	Peer Support (6)	**0.87***	**0.79**	**-0.62**	**0.65**	**0.71**	-
	Hierarchical Support (7)	**0.73**	**0.83***	**-0.83***	0.42	**0.70**	**0.66**
Scientist Group ($N = 6$)	Cohesiveness (1)	-					
	Implementation Preparedness (2)	**0.97***	-				
	Counterproductive Activity (3)	-0.37	-0.49	-			
	Psychological Job Demands (4)	**0.76**	**0.79**	0.03	-		
	Decisional Latitude (5)	**0.67**	**0.74**	-0.25	**0.63**	-	
	Peer Support (6)	**0.65**	**0.59**	-0.35	0.40	**0.58**	-
	Hierarchical Support (7)	**0.73**	**0.63**	**-0.58**	0.12	0.35	**0.71**
Logistic Group ($N = 7$)	Cohesiveness (1)	-					
	Implementation Preparedness (2)	**0.84***	-				
	Counterproductive Activity (3)	**-0.65**	-0.49	-			
	Psychological Job Demands (4)	0.22	0.26	-0.30	-		
	Decisional Latitude (5)	0.29	0.49	-0.42	**0.91***	-	
	Peer Support (6)	**0.70**	0.39	-0.34	0.27	**0.91***	-
	Hierarchical Support (7)	**0.61**	**0.63**	**-0.70**	-0.01	0.27	**0.50**

Bolded = large effect size ≥ 0.50 ; *also $P < 0.05$.

share the general values and aims of the group and to establish empathetic relations with partners.

Nevertheless, these findings should be considered with caution. The small sample size, the diversity and complexity of the situations, and the heterogeneity of the crews preclude generalization to other groups. In addition, it is important to highlight that the logistical difficulties and the reduced number of subjects are inherent characteristics in most ICEs, especially with professionals who are not recruited as experimental subjects. Thus, the collection of data is long, difficult, and limits its statistical analyses.

Our study confirms and gives further insight to the role of social and occupational dimensions in adaptation to ICE environments. Social interactions with the same few persons over a long period of time are linked to a decrease in professional performance which could jeopardize adaptation to isolated and confined extreme environments. These psychosocial issues have important implications not only for pre-mission selection and training, monitoring and support of crews during the mission, but also, often neglected, during post-mission readaptation.

Although some progress has been made in this area, it bears reiterating those factors that have persistently been supported by ICE studies. For selection, the development of methods to choose subjects at the individual but also the group levels. Pre-mission training should include pragmatic skills in interpersonal group dynamics, with team-building exercises involving both crewmembers and family and mission control personnel during pre-mission training,[2,10] and at the individual level, self-monitoring and enhancement in coping repertories.[20] During the mission, support should be oriented to telehealth (medicine and psychology) to prevent and assist with external specialists for in situ persons. These interventions and training can result in better interpersonal relationships and work performance. For long duration missions when real-time expert consultation will not be feasible, onboard artificial intelligence systems need to be targeted to both the individual level and the group as a whole. Just as it may take a village to raise a child, it will take the entire crew to successfully conclude a long-duration space mission.

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