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Mars-105 study: Time-courses and relationships between coping, defense mechanisms, emotions and depression

Michel Nicolas^{a,*}, Gro Mjeldheim Sandal^b, Karine Weiss^c, Anna Yusupova^d

^aLaboratory of Socio Psychology and Management of Sport (SPMS, EA 4180), Sport Sciences Faculty of Dijon, University of Burgundy, France

^bDepartment of Psychosocial Science, University of Bergen, Norway

^cLaboratory of Social Psychology (LPS, EA 849), University of Nîmes, France

^dLaboratory of Social and Cognitive Psychology, Russian Academy of Sciences, Institute of Biomedical Problems, Moscow, Russia

ABSTRACT

This study investigated the time-courses and the relationships between coping, defense mechanisms, emotions and depression considered as key factors in adaptation to ICE (Isolated and Confined Extreme) environments. During the space simulation, the Mars-105 experiment, positive emotion decreased significantly and significant positive correlations were found between mature defenses and both positive emotions and Task-Oriented Coping (TOC), as well as between Disengagement-Oriented Coping (DOC) and symptoms of depression. These findings show the impact of space simulation on affective states and the relations of defense to both coping and emotion, which underline the role of these psychological constructs involved in psychological adaptation processes. The results of the present study add insights into the effects of space simulation in order to offer the participants a better selection, preparation and follow-up of these psychological components recognized as essential for adaptation to extreme environments.

Keywords:

Coping
Defense
Emotions
Depression
ICE environments
Adaptation

1. Introduction

It has been clearly recognized that psychological and psychosocial factors significantly modify human behaviors and performance during real space flights (Bishop, 2004; Manzey & Lorenz, 1997). Adaptation mechanisms to such an isolated and confined extreme (ICE) environment have become an issue of major importance (Kanas, 1997). Currently, this issue is also one of the main concerns for long space missions such as the Mars expedition project. The effect of long-term isolation and confinement on healthy volunteers can be addressed via ground-based simulations (Manzey, 2004; Nicolas & Weiss, 2009; Sandal, Leon, & Palinkas, 2006). The Mars-105 experiment is a space simulation study designed to investigate the effects of an ICE environment on most of the individual and social psychological outcomes and to prepare the next 520-day mission. Specifically, this paper focuses on time patterns and relationships between coping strategies, defense mechanisms and mood.

During prolonged space missions, the most important stress factors could include microgravity, monotony and boredom resulting from low workload and hypostimulation, lack of comfort, confinement and isolation involving limited social relationships such as the separation from family and friends (Manzey, 2004; Suedfeld, 2005). The adaptation of crewmembers to these living conditions clearly shows a number of psychological factors including individual experiences, personality, leisure activities, and psychological adaptation mechanisms (e.g., coping strategies, defense mechanisms and emotions) used to deal with such stressors (Palinkas, 2003; Williams & Davis, 2005). Behavioral and affective reactions to these stressors can include a variety of symptoms including an increase in stress level, emotional instability, hypersensitivity or depressive reactions (Grigoriev, Kozerenko, & Myasnikov, 1987; Kanas, 1991). The capacity of astronauts and space flyers to cope effectively with these various stressors is a major part of the success of manned space missions (Kanas & Manzey, 2008).

Because of theoretical advancements, it has been recognized that the two major concepts involved in psychological adaptation to constraining situations are coping strategies and defense mechanisms (Cramer, 1998; Parker & Endler, 1996). DM are considered as being more oriented toward inner conflicts and dispositions and part of the individual's enduring personality. Whereas CS are

* Corresponding author. Faculté des Sciences du Sport, UFR STAPS, Université de Bourgogne, BP 27877, 21078 Dijon Cedex, France. Tel.: +33 3 80 39 90 11; fax: +33 3 80 39 67 02.

E-mail address: michel.nicolas@u-bourgogne.fr (M. Nicolas).

considered to be positively oriented toward adaptation to reality and determined by situation-specific variables (Nicolas & Jebrane, 2008a; Parker & Endler, 1996). However, recent empirical studies among the general population showed that CS and DM are both involved and contribute to the adjustment process in a complementary way in recovery after surgical interventions (Fulde, Junge, & Ahrens, 1995), in adjustment with adolescents (Erickson, Feldman, & Steiner, 1997), or in marital adjustment (Bouchard & Thériault, 2003). These results were reproduced in high-level sport competition, underlining that the simultaneous investigation of coping strategies and defense mechanisms may improve understanding of the complex and dynamic ways in which people deal with the demands of constraining situations (Nicolas & Jebrane, 2008b). Despite the meaningful value of these studies, very little if any research on DM or on the link between CS and DM in outer space situations or in other extreme situations exists.

Results concerning the variations in CS or emotion in ICE environments show inconsistencies probably due to the specificity of the situations and the participants' characteristics. Previous studies reported that coping strategies are likely to increase as time passes in ICE environments, such as a hyperbaric chamber (Palinkas et al., 1989; Sandal, Bergan, Warnche, Værnes, & Ursin, 1996). This was interpreted as a trend for reducing apprehension of the potential risks (Radloff & Helmreich, 1968; Suedfeld & Steel, 2000). However, in the Antarctic environment, a comparison between the CS used before and at the end of the expedition showed a decrease in seeking social support and in problem-focused coping, indicating, a less frequent use of these coping strategies (Peri, Scarlata, & Barbarito, 2000). The authors suggested that the expedition members probably tended to protect themselves from the frustration and emotional deprivation that often characterizes the situation in Antarctica.

In space flights, a quantitative study based on content analysis reported that astronauts used problem-oriented rather than emotion-oriented coping strategies with a predominance of Seeking Social Support Problems before Planful Solving Problems and Endurance/Obedience/Effort Problems, indicating the importance of mutual reliance and cooperation within space crews, as well as supportive conversations with family members (Suedfeld, Brcic, & Legkaia, 2009). Furthermore, coping strategies indicated changes across space flight stages (Pre-, In- and Post-Flight). Two problem-oriented strategies showed significant changes during the flight. Confrontation and Escape/Avoidance were at their lowest level during the in-flight stage compared to the pre and post-flight stages. These phase-related changes in in-flight were mainly explained by the importance of emotionally calm interactions among the crew of the space capsule, and for the pre and post-flight stages by the fact that physical escape in space is impossible, except for scheduled or emergency EVAs. While one of the emotion-oriented coping strategies (Denial) showed an opposite pattern with a peak during the in-flight phase, this may have been a substitute for other less acceptable strategies during flight such as Confrontation (Suedfeld et al., 2009).

Research on the time-course of emotional states during space flights has shown the absence of time effects that may be related to the support of space psychologists in mission control who use a variety of countermeasures such as communication with family and friends on the ground via audiovisual links or e-mails, and gifts or letters sent up from home during resupply missions (Kanas et al., 2006). These activities may have helped to lower the effects of periods of monotony and homesickness on orbit. However, another study showed the development of negative emotions during the first month of space flight which is accompanied by adaptation to microgravity. After six weeks, boredom, depression, anxiety,

irritability and fatigue provoke increases in operators' mistakes (Gushin, 1995). Since the 1960s, the first anecdotal reports in Antarctic mentioned that minor emotional disturbances were very common but pathological cases were extremely rare (Gunderson, 1963). Research conducted among over-winterers for several years suggests that potential candidates for long-duration missions in the Antarctic should demonstrate emotional stability (e.g., Gunderson, 1974; Palinkas, Gunderson, Holland, Miller, & Johnson, 2000; Palinkas & Suedfeld, 2007; Steel, Suedfeld, Peri, & Palinkas, 1997).

ICE environments such as austral winter in Antarctica have long been associated with increases in depression, insomnia, hostility, anxiety, and the use of alcohol (Palinkas & Browner, 1995; Wood, Lugg, Hysong, & Harm, 1999). Among the impaired psychological effects observed during space analog such as head down tilt long-term bed rest, depression was also shown to increase (Ishizaki et al., 1994, 2002; Styf, Hutchinson, Carlsson, & Hargens, 2001). After the midpoint of Russian space missions, symptoms of depression were reported during the second part (Myasnikov & Zaimaletdinov, 1998). Shuttle/Mir and ISS data indicated reports of symptoms of depression during both American and Russian space missions although the level was rarely pathological (Kanas & Manzey, 2008).

However, these results observed during wintering, polar expeditions, space analog environments or orbital space flights should evolve in a different way during long-term interplanetary voyages. These missions have specificities such as the length of the mission (at least two years), communication delays, greater crew autonomy, a severe sense of isolation and separation from the Earth with the so-called "Earth-out-of-view phenomenon", infrequency or impossibility of receiving supplies, the impossibility of evacuation for a medical or psychiatric emergency, the stronger impact of habitability and harsh living conditions in a space habitat with a lack of privacy and personal space that is more likely to become essential in such settings, the restricted range of environmental cues, the specific workload imposed on the astronauts, complex psychosocial issues due to the monotony of social contacts with the same crewmembers, the lengthy separation from the usual social network of family and friends, and other environmental hazards such as microgravity, exposure to high doses of radiation and potential collisions with micrometeorites (Kanas, 2011; Kanas & Manzey, 2008; Manzey, 2004; Palinkas, 2001; Sandal et al., 2006; Suedfeld, 1991).

Thus, more empirical work is needed to define the mechanisms and processes (e.g., coping strategies, defense mechanisms and emotional stability) that promote optimum adaptation to these specific challenges during long-duration space missions (Kanas, 2011; Palinkas, 2001; Sandal et al., 1996; Suedfeld & Steel, 2000). Given the previous results in the literature, we supposed that a confined and isolated situation of 105 days would involve changes and relationships between coping, defense mechanisms, emotions and depression.

2. Methods

All volunteers underwent a thorough clinical examination, both medical and psychological, and received verbal and written explanations about the study objectives, procedures and potential risks of the experiment before participating in the Mars-105 campaign sponsored by the European (ESA) and Russian Space Agencies (Roscosmos). The participants gave their written informed consent to participate in this experiment. The study was approved by the ethics committee of the European Space Agency and the Institutional Review Board of the Institute for Bio-medical Problems (IBMP).

2.1. Participants

The crew consisted of six men ranging in age from 25 to 40 (32.7 ± 5.9 years, mean \pm SD) representing different European nationalities, four Russians and two Europeans (German and French). For European candidates, the selection process started with some 5600 applicants. Four candidates were finally selected. From these four candidates, two were assigned as prime crew-member and the two others were acted as their backup, to replace a prime crewmember until the last moment if necessary. The selection was based on educational, professional, medical and psychological criteria similar to those required for potential space flyers.

2.2. Procedure

The Mars-105 campaign was designed to investigate the social and individual psychological conditions in long-term missions such as a space mission to Mars. Mars-105 was a ground-based space simulation reproducing with higher fidelity the conditions of an actual space flight apart from the microgravity. The conditions reflect the 3 main characteristics of a space simulation: (1) environmental conditions that simulate an artificial atmosphere at normal barometric pressure; (2) the relevant operational activities (e.g., timeline, organization, occupation, autonomy), and (3) participant characteristics similar to actual space flyers (e.g., demographics, multicultural, personality).

This experiment was a 105-day ICE environment study conducted at the Institute for Bio-Medical Problems (IBMP) in Moscow with the participation of the European Space Agency (ESA) and the Russian Space Agency (Roscosmos). The current study was a longitudinal single-group design with repeated measures across 12 assessments during 3 periods (baseline, ICE period, and post-isolation) over a 4-month period.

Psychological measures were assessed at baseline -14 , -7 , -3 days before ICE period (BDC 1, BDC 2, BDC 3), at 1, 23, 44, 65, 86 and 99 days for the ICE period (ICE 1, ICE 2, ICE 3, ICE 4, ICE 5 and ICE 6), and in post-ICE period at $+1$, $+3$ and $+7$ days after the ICE period (Post 1, Post 2, Post 3). Prior to the confinement period, the procedures and administration of the self-evaluation questionnaires were clearly explained to all the participants by the first author during pre isolation under the same conditions (personal computer in an individual room in the habitat module) and measures were taken to ensure that the participants understood the project requirements and the items on the questionnaires. The other questionnaires were administered and collected on the personal computer located in each individual room.

2.3. Facilities

The Mars-105 isolation facility was located at the IBMP site in Moscow. The layout of the isolation facility comprised four hermetically sealed interconnected habitat modules (principal living quarters, medical, storage and Mars landing simulator modules), plus one external module, which was used to simulate the 'Martian surface'. The total volume of the habitat modules was 550 m³.

The principal living quarters, which was the main living quarters (3.6 \times 20 m), included a kitchen-dining room, a living room, the main control room, a toilet and six individual rooms (2.8–3.2 m²) with a bed, a desk with a personal computer, a chair and shelves for personal belongings. The medical module (3.2 \times 11.9 m) was designed for routine medical and telemedical examinations, a laboratory, diagnostic investigations and isolation of an ill crewmember if necessary. The storage module (3.9 \times 24 m) housed a food storage room, an experimental greenhouse, a bathroom

(without water), a sauna and a gym. The crew stayed in these modules under conditions of artificial atmospheric environment at normal barometric pressure.

2.4. Instruments

2.4.1. Coping

Coping was assessed with the short version of the COPE scale which was designed to assess the ways people respond to stress (Carver, 1997). Participants were instructed to indicate the extent to which each item represented how they tried to deal with stress during the experiment over the past three days. The 28 items were rated on a 7-point Likert-type scale ranging from 0 (*never*) to 6 (*always*). On the basis of a hierarchical organization of the coping construct (Skinner, Edge, Altman, & Sherwood, 2003), coping strategies were grouped into two second-order dimensions of coping: task-oriented coping (TOC, active coping, planning, and positive reappraisal) and disengagement-oriented coping (DOC, behavioral disengagement, self-blame, and denial). The internal consistency of the coping dimensions was examined using Cronbach's alpha coefficient and was acceptable: task-oriented coping ($\alpha = 0.81$) and disengagement-oriented coping ($\alpha = 0.73$).

2.4.2. Depression

The Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996) is the most widely used questionnaire for assessing severity of depression in psychiatric and normal populations in both clinical and research settings. This questionnaire is a 21-item self-report measure evaluating depressive symptom (e.g., sadness, crying, indecisiveness). The response format is from 0 to 3 to reflect the intensity of the symptom corresponding to the diagnostic criteria for depressive disorder as defined by the *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association, 1994)*. The following cutoff scores and interpretive labels correspond to scores on the BDI-II: minimal (0–13), mild (14–19), moderate (20–28), and severe (29–63) depression. The psychometric properties of the BDI have been well documented and received strong support (Steer, Rissmiller, & Beck, 2000). The internal consistency was deemed acceptable with a score of 0.82.

2.4.3. Emotions

The Positive Affect Negative Affect Schedule (PANAS, Watson, Clark, & Tellegen, 1988) is a valid and reliable measure of affective states categorized into higher-order dimensions of affective experience called positive and negative affect (Watson et al., 1988). This self-report adjective checklist consists of two 10-item subscales designed to measure positive (i.e., active, alert, attentive, determined, enthusiastic, excited, inspired, interested, proud, and strong) and negative affect (i.e., afraid, ashamed, distressed, guilty, hostile, irritated, jittery, nervous, scared, and upset) experienced during a given time frame.

In the present study, we instructed the participants to rate the extent to which they experienced each affective state during the previous three days. Individuals responded to each item on the following scale: (1) very slightly or not at all, (2) a little, (3) moderately, (4) quite a bit, and (5) extremely. Positive affect represents the "extent to which individuals feel enthusiastic, active, and alert" (Watson et al., 1988). A high score on the positive affect scale denotes an optimal state of energy, concentration, and pleasurable engagement whereas a low score reflects sadness and lethargy. Negative affect represents a general dimension of subjective distress subsuming a variety of states such as anger and anxiety. A high score on the negative affect scale indicates distress and unpleasant engagement whereas a low score denotes calmness

and serenity. Its adequate psychometric properties have contributed to the widespread use of the PANAS (Watson et al., 1988; Watson & Clark, 1997). In the present study, Cronbach's alphas were 0.84 for the positive affects, and 0.78 for the negative affects.

2.4.4. Defense mechanisms

The Defense Style Questionnaire assesses an individual's conscious derivatives of defense mechanisms (DSQ, Andrews, Singh, & Bond, 1993). The respondent is asked to indicate the extent to which each statement corresponds to his or her perception using a Likert-type scale going from 0 (*strongly disagree*) to 6 (*strongly agree*). The DSQ-60 is a 60-item version with three higher-order factors: Mature, i.e., the tendency to use problem-solving behaviors; Intermediate, i.e., the tendency to manifest altruistic and prosocial behaviors or attitudes; and Immature, i.e., the tendency to express affect through reactions of withdrawal or acting out. The DSQ-60 was validated for adequate psychometric properties (Bonsack, Despland, & Spagnoli, 1998). In the present study, alpha coefficients were 0.77 for the Mature factor, 0.75 for the intermediate factor and 0.72 for the Immature factor.

2.5. Statistical analyses

Inherent to this type of experimental condition, the sample size was small (6 participants). Consequently, the data were analyzed using non-parametric statistics. Changes in psychological states were assessed first using Friedman's test, which is a non-parametric, one-way, repeated-measures analysis of variance by ranks. If differences were detected, the Wilcoxon signed-rank paired *t*-test was applied in an attempt to determine which specific values were significantly different. The level of significance for these analyses was corrected using Bonferroni-type adjustment in order to maintain the Type-I error probability at the 0.05 alpha level. In addition, correlations were made using the Spearman rank correlation coefficient (r_s) between the mean scores of psychological variables. All values in the text are presented as means and standard deviations. Means and standard deviations of the dependent variables both for each participant and the group are reported in Table 1.

3. Results

The Mars-105 experiment was conducted successfully. All the participants completed the ICE period with no major medical problems or psychological disorders, and completed an average of more than 93% of the scheduled questionnaires. No subject completed less than 89% of his sessions.

3.1. Time-course in coping, emotion, defense mechanisms and depression over time

The effect of isolation and confinement in this 105-day ground-based simulation on mechanisms involved in the psychological

adaptation process reported few changes in the following psychological variables: coping, emotion, defense mechanisms and depression.

Among the several psychological variables assessed, only emotion measured with the PANAS indicated changes throughout the experiment. Positive emotion decreased progressively (*F*-test, $\text{Chi}^2 = 22.81, p < 0.02$, see Fig. 1) during the 105-day experiment for all the participants, whereas changes in negative emotion were not significant (*F*-test, $\text{Chi}^2 = 15.53, p = 0.16$), nor were changes in coping strategies (Task-Oriented Coping (TOC) and Disengagement-Oriented Coping (DOC) (respectively *F*-test, $\text{Chi}^2 = 0.26, p = 0.87$ and *F*-test, $\text{Chi}^2 = 4.33, p = 0.11$)), defense mechanisms (Mature Factor (*F*-test, $\text{Chi}^2 = 7.87, p = 0.34$), Intermediate Factor (*F*-test, $\text{Chi}^2 = 3.75, p = 0.81$), Immature Factor (*F*-test, $\text{Chi}^2 = 3.67, p = 0.82$)), and depression level (*F*-test, $\text{Chi}^2 = 4.73, p = 0.69$).

3.2. Relations between coping, emotion, defense mechanisms and depression

Correlational analyses showed relationships between coping, emotion, defense mechanisms and depression. Coping strategies were related to defense mechanisms, emotions, and depression. Throughout the experiment, the mean of TOC was positively associated with mature defenses ($r_s = 0.89$, see Table 2), DOC was positively correlated with the mean depression score ($r_s = 0.84$, see Table 2), and mature defenses were positively related to positive emotions ($r_s = 0.89$, see Table 2).

4. Discussion

The purpose of this study was to investigate the time-courses and the relationships between coping, defense mechanisms, emotions and depression considered as key factors in adaptation to ICE. During the 105 days of isolation and confinement, only emotion showed a significant variation. A significant decrease in positive emotion was found for all the participants throughout the experiment, indicating that ICE environments might induce some changes in psychological states. Furthermore, relations between coping and both defense and depression were noted. Coping strategies on the task-oriented dimension were associated with mature defense, which was also associated with positive emotion. Coping strategies on the disengagement-oriented dimension were linked to symptoms of depression. These findings show the impact of a space simulation on affective states, and the relations of defense to both coping and emotion, underlining the role of defense in psychological adaptation processes.

4.1. Time-course in coping, emotion, defense mechanisms and depression over time

Longitudinal analyses revealed that the average of the positive emotions varied significantly across the phases for all the participants throughout the experiment. Positive emotion showed a

Table 1
Means and standard deviations (in parentheses) of coping, emotion, defense mechanisms and depression for each participant and group.

Participants	TOC	DOC	Mature defenses	Intermediate defenses	Immature defenses	Positive emotions	Negative emotions	Depression symptoms
1	5.33 (1.12)	0.79 (3.18)	3.94 (0.25)	1.63 (0.22)	1.94 (0.35)	3.30 (0.29)	1.06 (0.01)	0.03 (0.06)
2	5.17 (1.03)	0.23 (2.43)	4.22 (0.15)	2.4 (0.22)	1.9 (0.47)	3.90 (0.30)	1.00 (0.01)	0.00 (0.00)
3	3.16 (0.8)	0.30 (1.55)	3.51 (0.14)	2.81 (0.30)	2.4 (0.33)	2.68 (0.33)	1.16 (0.07)	0.00 (0.01)
4	2.18 (1.18)	0.89 (1.03)	3.19 (0.33)	2.48 (0.30)	2.25 (0.42)	2.95 (0.25)	1 (0.01)	0.01 (0.01)
5	2.37 (0.72)	0.66 (1.53)	3.01 (0.21)	1.98 (0.35)	1.51 (0.52)	3.24 (0.24)	1.14 (0.10)	0.00 (0.00)
6	3.76 (0.5)	1.14 (1.78)	4.18 (0.19)	2.25 (0.17)	1.64 (0.67)	3.49 (0.29)	1.11 (0.06)	0.04 (0.06)
Group	3.66 (0.89)	0.67 (1.92)	3.68 (0.21)	2.26 (0.26)	1.94 (0.46)	3.26 (0.28)	1.07 (0.04)	0.01 (0.02)

Notes: TOC: task-oriented coping; DOC: disengagement-oriented coping.

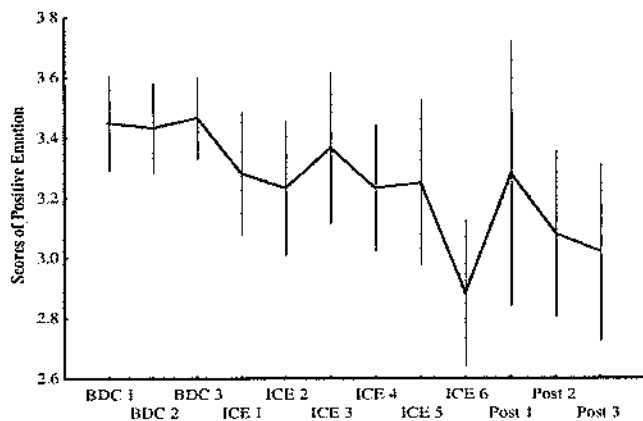


Fig. 1. Time-course of positive emotion throughout the experiment and during the different periods (e.g. BDC, ICE and post).

significant decrease between the three periods of the experiment, before, during and after the ICE period. During the last days of the ICE (ICE 86 and ICE 99), a lower score of positive emotion was observed for all the participants. This suggests that the participants felt less enthusiastic, less active and less alert throughout the 105-day experiment and especially at the end of the ICE.

The findings of the present study support previous investigations, such as Peri's (1988) research on an Italian Antarctic expedition, which showed that positive emotional states (tranquility, satisfaction, agreeableness) tend to decrease at the end. However, later psychometric studies carried out on Italian expeditions during their Antarctic stay showed substantial emotional stability (Peri et al., 1998; Peri & Tortora, 1989). This result is important because (1) a small decrease in positive emotions may perhaps represent the onset of tiredness, even exhaustion or sadness (Peri et al., 2000), and (2) numerous research studies on polar expeditions and wintering have identified emotional stability as being one of the most important factors of optimum performance and adaptation (Gunderson & Kapfer, 1966; Palinkas et al., 2000; Sandai et al., 1996; Steel et al., 1997; Taylor, 1987).

The decrease in positive emotional states found in the present study and the previous psychometric study seems to support the interpretation of a moderate but progressive reduction of emotional regulation (Peri et al., 2000). However, as mentioned in the introduction, Gunderson (1963) found that minor emotional disturbances were very common and cases of major emotional disturbance were extremely rare at Antarctic stations. The expressions of decrease in positive emotions among the marsonauts increased in the final stages of the 105-day ICE environment, and the low scores on negative moods suggest that overall the

crewmembers' experience was not a negative and a major emotional disturbance.

Actually, given that the scores of positive emotion were high at the beginning and that moods never reached the level of prominent and persistent manifestations of tension, anxiety or hostility, the decrease in positive emotions may have been induced by the critical period at the end of the experiment. In informal interviews after the experiment, the participants reported that the separation of the crew into two groups for the landing on Mars was experienced as breaking up the group, and it created a feeling of living in a vacuum for those who stayed in the principal module. A possible explanation for this emotional variation could be the propensity for defensiveness or to deny the difficulties with a general emotional withdrawal characterized by a self-distancing from positive feelings to protect oneself from possible frustrating events (Rivolier, Goldsmith, Lugg, & Taylor, 1988). Thus, emotionally, the marsonauts tended to invest much less in what went on around them in order to protect themselves from the frustration and emotional deprivation that is often observed in ICE environments. This type of defense was qualified as a sort of frozen reactivity characterized by a low emotional response to the unwanted stimuli (Peri et al., 2000). All the findings collected up to now seem to support this type of emotional leveling (Barbarito, 1998) which is typical of personnel returning from an Antarctic campaign (Peri et al., 2000). For the present study, this interpretation was supported by informal interviews made in situ at the end of the experimentation with some of the marsonauts.

4.2. Relations between coping, defense, emotion and depression

As hypothesized, the findings showed significant relationships between coping strategies, emotional states, defense mechanisms and symptoms of depression. Significant positive correlations were found between mature defenses and both positive emotions and Task-Oriented Coping (TOC) and also between Disengagement-Oriented Coping (DOC) and symptoms of depression.

The associations between mature defenses and either positive emotions or TOC are in accordance with findings of previous studies conducted on adaptive situations such as recovery after surgery (Fulde et al., 1995), adjustment during adolescence (Erickson et al., 1997) or marital adjustment (Bouchard & Thériault, 2003). These results were confirmed in another constraining situation, sport competition (Nicolas & Jebrane, 2008). Previous research studies led the authors to agree that the relationships between coping strategies and defense mechanisms in different constraining situations could indicate that they are both involved in psychological adaptation processes which concern not only coping strategies but also defense mechanisms. The simultaneous investigation of coping strategies and defense mechanisms has proven to

Table 2
Correlations between coping, emotion, defense mechanisms and depression.

	TOC	DOC	Mature defenses	Intermediate defenses	Immature defenses	Positive emotions	Negative emotions	Depression symptoms
TOC								
DOC	0.20							
MD	0.89*	-0.31						
Int. D	0.49	-0.26	-0.54					
Im. D	0.09	-0.14	-0.43	0.66				
PE	0.66	-0.03	0.89*	0.49	-0.60			
NE	0.14	-0.09	-0.29	0.06	-0.03	-0.49		
DS	0.23	0.84*	-0.06	0.20	0.14	0.06	-0.04	

Notes: * $p < 0.05$, TOC: task-oriented coping; DOC: disengagement-oriented coping; MD: mature defenses; Int. D: intermediate defenses; Im. D: immature defenses; PE: positive emotions; NE: negative emotions; DS: depression symptoms.

be the most fruitful path for studying adaptation (Bouffard & Crocker, 1992; Parker & Endler, 1996), and may improve understanding of the complex and dynamic ways in which participants such as space flyers deal with the demands of constraining situations.

Furthermore, this study points out the relevance of measuring CS and DM at a particular point in the training period in order to obtain a clearer and more valid psychological profile of the participants' psychological adaptation processes. Psychologists responding to the specific needs of individuals at a specific moment would then be able to intervene more effectively depending on the period of the mission. Finally, considering the often contradictory results, all attempts to accurately identify which type of CS is most effective in constraining situations such as sport competitions have failed (Anshel & Kaissidis, 1997). Consequently, during psychological preparation, psychologists should encourage participants to expand their coping strategy repertoire to cope with the stress of the specific and evolving demands of different situations.

4.3. Limits

Because this longitudinal study was conducted in a ground-test space simulation, there are certain intrinsic limitations that have to be mentioned. Inherent to these experimental conditions, the serious limitation of the present study is its small sample (6 men) which precludes generalizations and deeper correlational analyses. In spite of previous research indicating divergent results including the appearance of negative emotions and symptoms of depression, other studies found no evidence for variations in psychological states and suggested that they are of little risk to the health and well-being of crew or to the success of the mission (Leon, McNally, & Ben-Porath, 1989).

Several reasons could explain the stability of most of the psychological variables: (1) Isolated and confined extreme environments are not intrinsically stressful (Suedfeld & Steel, 2000); stress is not inherent in ICE environment situations (Grigoriev & Fedorov, 1996), or in other extreme situations such as simulated high altitude (Nicolas et al., 1999), or polar expeditions (Palinkas & Suedfeld, 2007; Suedfeld, 1998). (2) The candidates were tested to ensure their capacity to stay and conclude this type of experiment. Therefore, the rigorous choice of the participants may also explain the low variation in the psychological variables. The meticulous selection process involved here suggests that this population is highly motivated (Palinkas, 2003). Thus, the participants were more able to tolerate the trying conditions of isolation and confinement and to maintain high levels of performance over long periods of time (Palinkas & Browner, 1995).

The issue of the assessment method and the classic criticisms about self-report must also be raised. Future studies would benefit from the use of clinical assessment reports by external observers instead of self-reports to assess psychological variables such as CS and DM (e.g., Cramer, 1991). Finally, due to the Bonferroni correction, the lower threshold was defined as the strict value of 0.0125. In addition to the small number of participants and in spite of the high value of the Spearman correlation coefficient (r_s) between several variables (see Table 2), the significant relationships between the different factors were difficult to reach.

5. Conclusion

The results of the present study offer additional insights into previous research on the effects of space simulation on psychological factors which are considered as essential in adaptation to ICE. They mainly suggest that ICE environments might induce some changes in psychological variables leading to

subsequent alterations in affective states. The nonlinear pattern of change in emotion suggests that adaptation to prolonged isolation and confinement in an extreme environment might involve a significant decrease in positive emotion. This finding is important given that emotional stability is considered as a personality variable which can influence the degree of adaptation in these specific contexts (Palinkas & Suedfeld, 2007). In addition, the relationships between emotion, coping and defense point out the interactive effect of ICE environments on psychological states and consequently a better understanding of the links between the parameters involved in psychological adaptation processes.

In a more integrative approach, our results confirmed previous research in different extreme situations which found that coping and defense are psychological constructs involved in psychological adaptation processes. Adaptation processes should be taken into account in order to improve the selection and screening of space flyers on the basis of psychosocial characteristics such as emotional stability and the development of coping strategies. In the perspective of space flights of long-duration such as the future missions to Mars, and given the limits presented above which require some caution regarding the generalization of the results, additional experiments are needed to further investigate the affective parameters of space flight-induced changes. Further research would improve knowledge in order to offer participants a better selection, preparation and follow-up of these psychological components recognized as essential for adaptation to extreme environments.

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