

LIFE AT THE FRANCO-ITALIAN CONCORDIA STATION IN ANTARCTICA FOR A VOYAGE TO MARS: Ethological study and anthropological perspectives

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Abstract: For preparing the next interplanetary missions, this study proposes an ethological analysis of the social group building and individual strategies of a multicultural and mixed gender team in isolation and confinement conditions found in a polar mission. A model of adaptation to space environment is stated and implies physiological, psychological and behavioral levels. The behavioral observations were made weekly on the summer personnel and the winterers during a daily life activity over three months of the summer campaign and nine months of the winter period in Antarctica. They were based on a quantitative description of the team-members' spatial behavior (social orientations, space sharing, place preferences) during the morning, midday and evening meals at the cafeteria of the Concordia station. They were completed with quantitative information (collective attendance) and temporal information (collective time). The results show a social cohesion when considering spatial indicators, expressed by an increase of the visual relationships and a more frequently occupied place per gender and nationality, in summer. In the collective activities, the meal duration draws cyclic variations every seven weeks and the meal attendance is differently organized according to the three winter periods. The discussion points out theoretical, methodological and applied issues of this pilot study, and suggests Mars mission scenarios. From a transdisciplinary viewpoint, it is related to anthropological perspectives of the future microsocieties

Key words: human behavior, adaptation, microsociety, isolated and confined group, culture

Introduction

In the future planetary explorations, human behavioral adaptation at the level of the individual and at the level of the group will be the challenge of self-organized microsocieties in isolated and confined environments. Mars mission is regarded as a fundamental opportunity to highlight the physiological issues and the psychological issues of man and woman under particular physical conditions and socio-cultural conditions for very long-term duration. The ethological approach, science of behavior, is particularly concerned with the interface. In these extreme conditions of living and working, it is situated in anthropological perspectives.

During these travels in space and time, the crewmembers will have to adapt to a wide range of environmental factors such as weightlessness, three-dimensional configuration, reduced space, closed habitat, monotonic panorama. No supply will be possible, autonomy will be required and adaptability of the interplanetary crew will be of prime importance. In the NASA history (1985), adapting to unusual and frustrating physical conditions in space are the goal of today's astronauts and tomorrow's interplanetary travelers. Particularly Mars crews will be extracted from the ongoing relationships that are usual on Earth, and will be trust into a new microsociety which will impose its own social deprivation and cultural organization. They will be withdrawn from a larger society with the loss of variety of the social relationships. A corollary is a lessened opportunity to exercise one's typical

social roles in daily life activities. At the same time the crew must cope with the effect of withdrawing from the macrosociety, the crewmember will be confronted with the social challenge within the microsociety.

In anthropological studies, the concept of space colonies (Melchionne & Rosen 1986) is related to these isolated and confined groups and to the reasonable prognosis for survival far from Earth. Few research findings exist. In the approach of the human space colonization, Finney (1985) wrote that even a Moon base represents a social challenge (cited in Pass, 2006). The interest of applied anthropology in extreme environments was examined by Palinkas & Gunderson (1988). They reported the role of microcultures that enable individuals to cope with the stress of prolonged isolation, and the role of health and performance in the group and individual processes of adaptation. With longer and faster missions, the isolated and confined group's behavior with multi-cultural, mixed-gender gender and self-functional characteristics is particularly emphasized. The behavioral activity observed, described and quantified, according to the ethological approach shows objectively and exhaustively the quality of the adaptive strategies as optimizing actions, efficiency at work and quality life.

Experiences in the field: a model of adaptation

The previous ethological studies were concerned with physical adaptation to short-term space flights and were per-

formed to understand the consequences of spatial environment on individual motor behavior. They revealed significant modifications through the different steps of the mission, from the training on ground, to the first confrontation to microgravity in parabolic flight, up to the spaceflight and post-flight period (Tafforin 1994, Tafforin 1999). New motor strategies were described by specific movement, posture and orientation patterns (Tafforin 1996a). The adaptive process started with a spontaneous phase showing sensory-motor reflexes during the first seconds of microgravity, then a preliminary and an integrative phase enhancing cognitive operations during the following hours and days with a prevalence of visual information using (Tafforin 1994, Tafforin et al. 1997).

Then, ethological investigations were designed to study the crew social behavior in confinement chambers during European experimental campaigns called ISEMSI (Isolation Study of European Manned Space Infrastructure), EXEMSI (Experimental campaign for European Manned Space Infrastructure) and HUBES (Human Behavior in Extended Spaceflight), during respectively 28 days, 60 days and 135 days. Over time, crewmembers built successively personal, social and public spaces, according to Hall's classification (Tafforin 1993, Tafforin 1996b). Social adaptation was not achieved after 4 months spent in these closed and reduced habitats. Such experiments have demonstrated the need to analyze step by step from short-term,

medium to long-term period, the behavioral adjustments in multi-centre facilities or unusual situations (Tafforin 2005). From space missions to polar missions, the common environmental factors acting on human behavior over long-term stays are isolation and confinement. In the previous ethological studies, the question of social group building and inter-individual relations was raised about such incidence on the team-members' adaptation at the French Dumont d'Urville station in Antarctica (Tafforin 2002). The conclusions had been drawn that socialisation rules promote group building in the first days, and conflict factors and relay steps promote the maintenance of a social cohesion over the mission.

With regard to a future voyage to Mars, such findings allow simulating and help in predicting some features of individual and social behavior observed in isolated and confined teams. They point out new use of available space in a closed habitat analogous to an interplanetary vehicle. They point out re-organization of inter-individual distances analogous to a planetary team during the surface exploration phase. They point out adaptive strategies according the periods of the mission analogous to a long-term interplanetary travel. So, preventing such human factors is the challenge to have efficient Mars crews.

Focusing on this central point, the behavioral adaptation model to space environment (Tafforin 2008) considers the individual as a whole with all the facets concerning the maladaptive reactions and the adaptive strategies. It puts in action a "hard" system, in term of conservative regulation, which tends to recover the initial states, in the sensorial mechanisms and the physiological mechanisms. For instance, deficits or variations from the environment induced by weightlessness would generate at the physiological level a redistribution of the fluid and electrolytes followed by a cardiovascular reaction conducting to endocrinal changes. At the sensorial level, the lack of weight would transfer the information from the inhibited vestibular function to the visual function that would be reinforced. Consequently, the "soft" system would be activated, in term of innovative regulation, to express new behavioral strategies by the adjustments or modifications of body orientations, postural attitudes and motor skills. New motor learning

would conduct to a new representation of the space environment involving the psychological functions as cognitive images, mood and mental health, and sociality.

The major scientific question is how each interplanetary crewmember, with both his or her physiological and sensorial mechanisms, his or her motor instruments and his or her psychological demand will optimize the relation to the environment. The ethological approach deals with this relation individual-environment, in a temporal dynamics. Behavioral monitoring of the winterers in a polar base is an exceptional paradigm to investigate such time variable. This allows identifying step by step the impact of prolonged exposure of outer disturbances on the inner equilibrium of the human subject and the social group. The new question is what happens at the cognitive level when isolation and confinement factors are magnified on a long-term process, thus leading to transformation of the social image of this in becoming micro-society.

A pilot study was conducted in that aim at Dome C in Antarctica where a new station was built and was newly opened to the scientific community. The specific interest was to monitor the adaptive behavioral strategies of the very first isolated and confined team of Concordia station which housed French and Italian personnel, during 13 months, from summer to winter.

An unique experimental paradigm: Concordia station

The Franco-Italian Concordia station is located at the south pole, 75°06'S and 123°21'E. The altitude is higher than 3000 meters and the average temperature is -51° Celsius. It is made of three buildings, linked by enclosed walkways (Figure 1). The first cylindrical building, called the *quiet building*, houses the sleeping quarters, the laboratories and the hospital. The second cylindrical building, called the *noisy building*, houses the workshop, the waste water treatment plant, the communication room, the kitchen and the cafeteria. The third building is made up of eleven container size modules where the electric power plant, the boiler room and a second workshop are located.

The summer campaign started on the 6th of November 2005 and ended on the 8th of February 2006. The winter-over started on the 9th of February 2006 and ended on the 4th of November 2006 with the landing of the first Twin Otter plane. We have considered that the isolation was broken on the 9th of November 2006 with the arrival of the first persons in the summer campaign.

The station has accommodated up to 31 subjects during the summer campaign and 10 subjects during the winter-over. The winterers' team of the polar mission was composed of six French team-members and four Italian team-members, two of whom were women (one Italian and one French) and eight were men. It was

Figure 1. Architecture of the Franco-Italian Concordia station in Antarctica (Photography K. Weiss, 2007).





Figure 2. Cafeteria in the noisy building of the Concordia station (Photography Ethospace, 2006).

made up of four technicians for station maintenance, four scientists for the research programs, a cook and the medical doctor who was also the expedition chief. They were aged between 23 years and 59 years for an average of 37 years.

The ethological approach: a pilot study

From a general viewpoint, the ethological approach is a non-invasive method based on a quantitative description of the spontaneous motor and spatial behavior of the individuals in daily life situations, at work or during experimental tests. Its specificity is to explore the field of observable events. Two main steps are required. First, a descriptive repertory of the motor actions and the spatial positions is drawn up as they change over time according to both environmental conditions and physiological parameters. Second, these behavioral events are measured in quantitative terms of occurrence (frequency, duration) and sequential organization (transition probabilities) or mapped as cartographic information, thus setting each one within its own functional and spatial frame. Such studies do not only take into account the result of the behavior, i.e. performance, but also the motor patterns leading to it, i.e. behavioral strategies.

From a specific viewpoint, the observations sessions at Concordia station were

conducted by the over-wintering medical doctor with a focus on the sub-group of the future winterers, at mealtimes, in the collective area of the noisy building, namely the cafeteria (Figure 2). Each session consisted of numbering and identifying the subjects, in drawing the locations of the tables and in mapping the position of each subject sitting around the tables. There can be a maximum of ten persons per table. In addition, meal durations were noted with information on the time of the first subject arrival, the first departure and the last departure. The full observation sessions included digital pictures and video scanning. The session frequency was weekly, every Thursday, on the morning, at midday and in the evening. Data collection started in summer when the wintering team of DC2 mission was complete and ended at the isolation breaking.

New behavioral results: Mars mission scenarios

The study has provided new behavioral indicators (collective attendance, social orientations, space sharing, collective time) according to the periods of the mission. It implies theoretical, methodological and applied issues.

In the theoretical issues, the results are expressed in positive terms. The ethological viewpoint is to consider that the adaptive strategies are built for better

physiological and psychological comfort of the team-members in extreme working and living conditions.

Relevant to the physiological sphere, new behavioral strategies regulate changes in the sensorial system. The observed subjects open their visual field more frequently to the other team-members by increasing the number of social orientations at the end of the summer campaign. This could be interpreted as an adaptive indicator through the reinforcement of visual relationships between the team-members. These visual links would be their social landscape during the wintering period.

Relevant to the psychological sphere, the new behavioral strategies can reveal learning mechanisms implemented to have an adequate representation of the social context, to prevent stress manifestations and to solicit cognitive functions. This would contribute to transform the mental images of the environment. The observed changes of space use from the beginning to the end of the summer campaign could be interpreted as an adaptive indicator. The subjects express a common spatial behavior and prefer one unique central place, thus representing the winterers' group in a polar mission.

In the methodological issues, the interest of the ethological method is to carry out tools of objective and irrefutable observations. Their have been largely validated in the space field and were efficiently conducted in the current study in Antarctica. The complementary with anthropological methods is to bring this objective basis and to add a quantitative description of the observed behavior.

For instance, the collective attendance, evaluated by the percentage of presents at the mealtimes, was very low (16%) in the morning, at the highest level (74%) at midday, and quite high in the evening (61%) during the summer campaign. The social orientations, evaluated by the number of winterers in the visual field of one team-member, presented low levels (median values around 2) during the first weeks and an increase in the second half of this period (median values from 2 to 7). The space sharing according to the multi-cultural characteristics (French, Italian, English, Danish and Canadian) and the mixed-gender quality is expressed as the average percentage of subjects from the same nationality and the total number of women observed at tables of the cafeteria (Figure 3). The results showed mono-cultural groupings

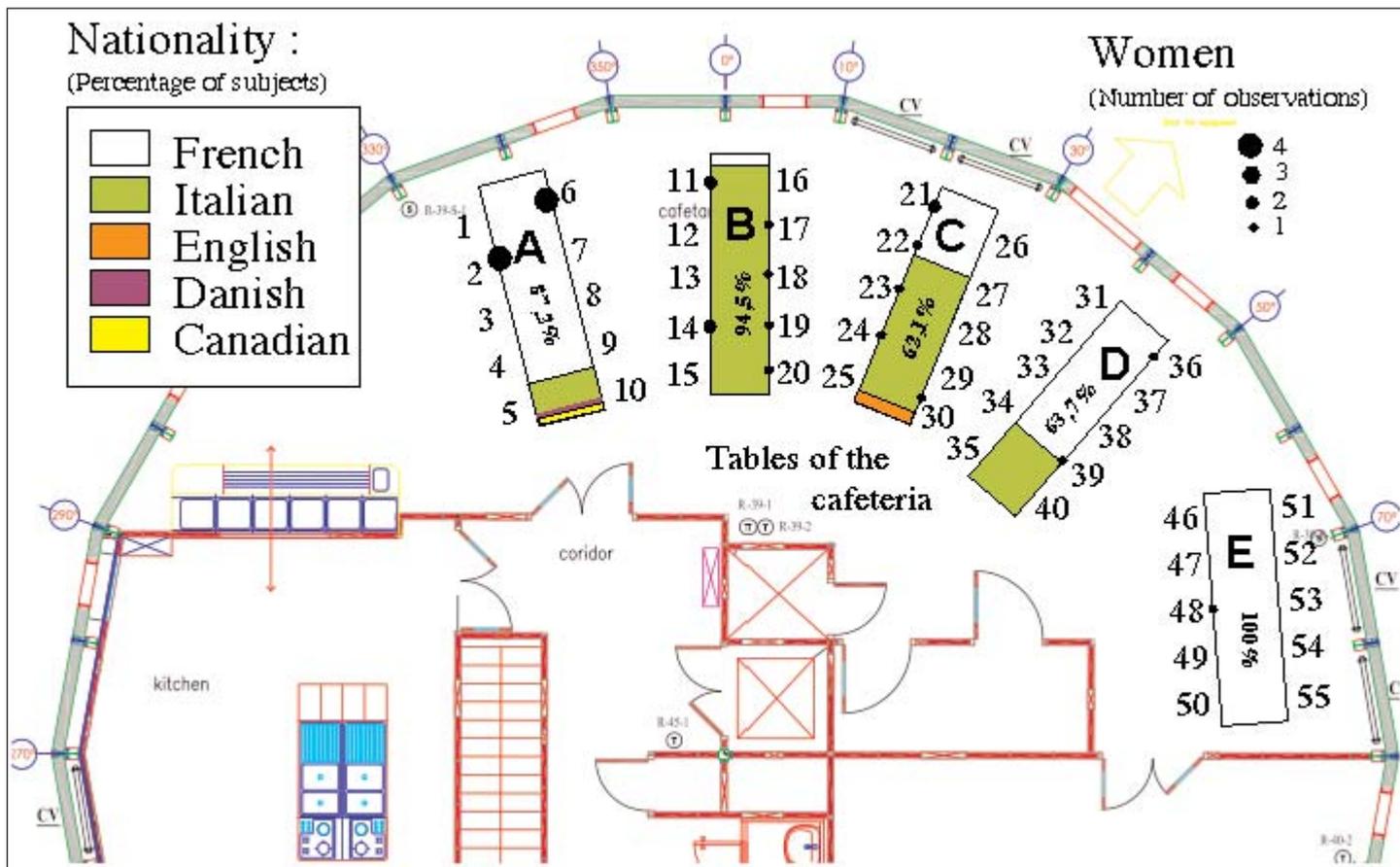


Figure 3. Space sharing according to culture and gender during summer campaign at Concordia station.

and multi-cultural groupings. The two main tables (A and B), more frequently occupied by the winterers' team in summer, were shared between the French group (87,2%) and the Italian group (94,5%) respectively. Then in the winter-over, an unique table was shared by each sub-group of nationality and place preferences were observed according to the gender. The collective time, evaluated by the arrival time of the first winter at the cafeteria, the leaving time of the first winter and the leaving time of the last winter, showed cyclic variations every seven weeks, during the three winter periods.

In the applied issues, the results of the study set up a list of hypotheses highlighting the individual and collective group organization from summer to winter at the Concordia station:

- The team-members do not express a social cohesion over the summer period, when considering temporal indicators. An irregularity of collective time was observed.
- In the preparatory phase just before the winter-over, the spatial grouping of the team-members and the large opening of their visual fields are frequent in

anticipation of the isolation period. When considering spatial indicators, an increase of the social orientations was observed.

- When critical phases of adaptation occur, a social organization appears with cultural rapprochements. The women's sub-group is also linked. A more frequently occupied place per gender and nationality was observed.

The summer period of the polar mission, with turn-over of the personnel and the possibility to go outside the station could refer to the first phase of the future inter-planetary missions with an eventual passage via an orbital station or a lunar base. This argues that in the first period of a Mars mission, the absence of a strong social cohesion indicates that the adaptive process is in progress. Any change observed over time is a new behavioral strategy to reach the optimal one. This could be considered as a nominal state vs. a critical phase in such scenario.

Then during the winter-over, the isolation and confinement factors were exacerbated with time, social constraints and spatial restraints. Their incidence revealed states of organization, disorganization and reorganization of the social group with critical

phases. This draws progressive steps of adaptation for Mars travelers:

- The team-members' behavior seems to be cultural and gender dependant, when considering the overall duration of the winter. Such spatial indicators express spontaneous sub-groupings delineating French and Italian areas and individual place preferences in men more than in women. These habits related with a common culture and different personality traits, could prevent group tensions and mood profiles.
- The meals duration follows cyclic variations. An increase of the leaving time of the last winter was observed according regular temporal intervals, without alloying the social cohesion when considering collective time. Such temporal indicators could reveal a strategy to cope with the monotony of daily life activities and the stress of a long-term mission.
- The meals attendance is differently organized according to the period of the winter-over. When considering such social indicators, a strong group cohesion was observed on the first period, then an unstructured group on the second period including the critical

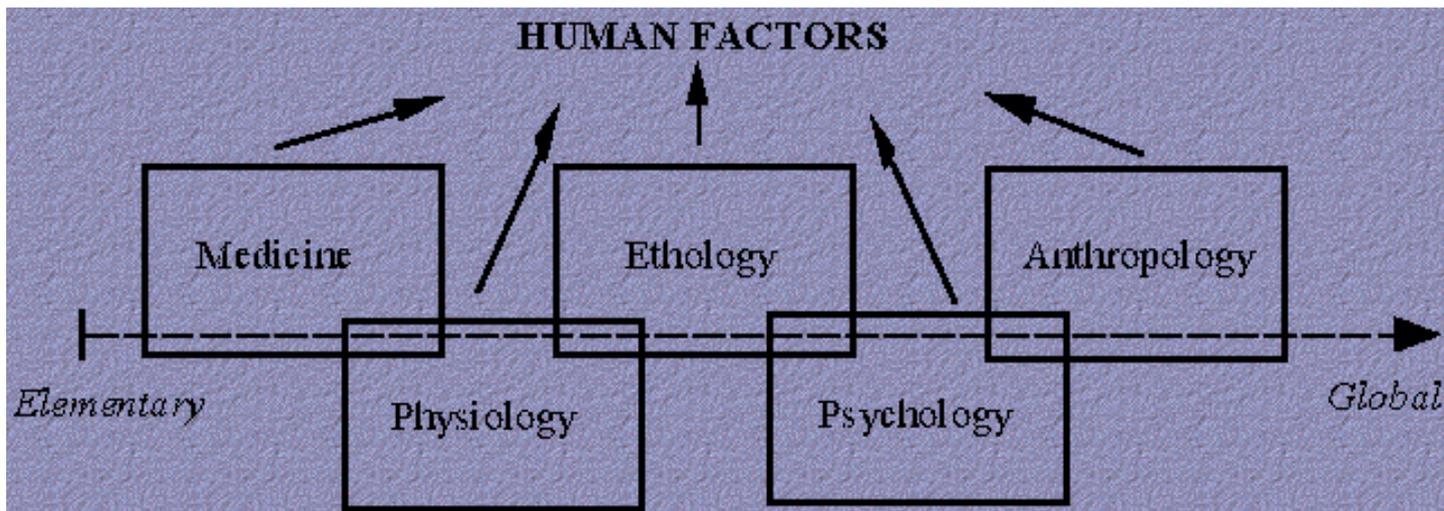


Figure 4. Trans-disciplinary feature of human factors from Space to Antarctic, Isolated and Confined Environments.

point of the mid-winter, followed by recovering stages of group cohesion in the third period. This whole adaptive process draws three equal temporal intervals.

All of these behavioral indicators could be used to profile scenarios for preparing voyages to Mars. A particular attention would be paid to the multi-cultural and gender dimension of the future crew as an individual identity and a resource of diversity in the prevention of the monotony factors induced by prolonged exposure to isolation and confinement. Specific emphasizes would be to take into account the periodic feature of a long trip to Mars. A scenario could reflect three sub-periods of organization, disorganization and reorganization of the team within each three phases of the Mars mission, i.e. the interplanetary flight Earth-Mars, the Mars surface operations, the interplanetary flight Mars-Earth. An other scenario could integrate these three phases as the three adaptive periods with the Mars landing as the critical temporal point.

Anthropological perspectives

On the steps of the polar expeditions, new planetary exploration remains a fascinating challenge when men and women will live and work together for very long-term missions in closed and reduced habitats (interplanetary flares and planetary bases), and social deprivation (solar system planets far from Earth). The Arctic and Antarctic involve likely more mixed-gender teams with cultural identities. This could enhance the monotony of the isolation conditions thus varying the social context. Including women in a

wintering group seems to have had positive effects on the general climate of the group by reducing men's rude behavior (Rosnet et al. 2004). Women added an element of emotional support and helped other members (Leon & Sandal 2003, Leon 2005). Regarding gender differences, the social support was reported to be perceived less by female leaders and more by female followers in Antarctic expeditions (Schmidt et al. 2005). Female expeditioners would be similar to male or mixed-gender expeditioners in many respects but would be more sensitive to emotional concerns (Makis et al. 1994). All-female teams were rare until recently. This provides evidence of the heterogeneous groundwork of a group to cope, regulate, and adapt for a better equilibrium in isolation and confinement conditions. Considering multi-cultural groups, cross-cultural comparisons have provided some findings that suggest a characteristic personality trait profile in the Antarctic expeditioner, irrespective of national origin (Musson et al. 2002). However, intercultural effectiveness and its relevance to multicultural crews in space were discussed from research on isolated and confined groups (Kealey 2002). Increases in the heterogeneity of space crew's composition (cultural and gender differences) would be a risk that could negatively influence the formation of a cohesive group and that would depend on a common way of perceiving one's social environment (Gushin et al. 2001). Few studies have been performed in polar missions with regard to international polar teams. Despite the language barriers limiting communication between team-members (Ursin et al. 1990), the

trans-polar expeditioners responded positively to a multicultural experience. They reported the multicultural richness of relationships within the team (Etienne 1990). In fact, it is important to consider the individual, man or woman, in an organizational culture, with his or her own personality traits (Sarris 2006, Palinkas & Suedfeld 2007). The present ethological observations show behavioral profiles of these crews of the future. From the medical viewpoint to the anthropological viewpoint (Figure 4), the adaptation strategy of each or any crewmembers will be revealed with its multiple facets, from its elementary parameters (e.g. blood pressure, heart rate, hormone level, immune response, brain activity) to its global expressions (motor behavior, cognitive demand, social interactions, verbal communication, cultural profiles, living habits). The common view of such transdisciplinary approach is to investigate the synergetic effects of the multiple determinants involved in human factors from physical ones to cultural ones (i.e. cardiovascular regulation, immune reaction, neuro-sensorial compensation, new motor skill, cognitive demand, task performance, workload, diet, stress tolerance, group dynamics, language problems, social rules). That could contribute to the prevention of human factors incidences for a future voyage to Mars related to individual adaptability and micro-society survivability.

In anthropological perspectives, the discussion is opened. Human nature would be developed in outer space frontiers with new properties to research in both a physical evolution and a cultural evolu-

tion. This study raises new questions of evolving societies in unexplored environments. Outer space colonization or inter-planetary humanization present theoretical and practical problems which anthropology can help solve. The big steps that men and women will do in the future space travels will be is a small step toward a future space anthropology...

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