Monitoring Facial Expressions During the Mars-500 Isolation Experiment

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There are many long-term missions that are performed by small crews in isolation. As examples we can mention missions performed on the international space station, polar research stations, submarines, oil platforms, meteorological stations and etc. Success of such missions strongly depends on emotional states of the crew members as well as on interpersonal relationships between them. Emotional problems of crew members and/or conflicts in a team can lead to a complete failure of a whole mission. The problem of the psychosocial health is also very important because the long-term isolated missions are usually accomplished by extreme physical conditions (such as weightlessness, low or high temperature, radiation, bad lighting and so on) which often have a strong and negative influence on the psychosocial atmosphere in the team. Moreover, these missions are also accomplished by negative psychological factors such as the isolation itself, spatial and social confinement, risks and so on. In this context it is very important to develop methods for monitoring and improvement of psychosocial atmosphere in isolated goal-oriented teams. In the present work we address the question of measuring of emotional states and interpersonal relations of small crews performing long-term missions in a strong isolation.

Among the methods for monitoring of psychosocial atmosphere we can distinguish the following three classes: usage of questionnaires, monitoring of nonverbal behavior (facial expressions [1,2], body movements [3,4], voice intonations [5]) and monitoring behavior of team member in cooperative computer games [6,7,8]. One of the advantages of methods based on questionnaires is that crew members can directly provide comprehensive information about their emotional states and interpersonal relations. However, people can be biased and not honest especially if they need to reveal their feelings and their vision of the conflicts that they are involved in. Moreover, a regular answering of extensive questionnaires can be very boring. In this context two other approaches becomes very useful. By nature people express their emotions through facial expressions and voice intonation which makes monitoring of nonverbal behavior very interesting. Interpersonal relationships are naturally expressed through interactions between people. In this context a use of computer games is very promising because they provide a way to formalize and simplify interactions between people as well as an easy way to measure behavior. More details about strength and shortcomings of different approaches as well as how they can be combined can be found in our earlier works [9,10] in which we described the design of our monitoring system used within the Mars-500 isolation experiment [11].

In the Mars-500 isolation experiment six participants have been isolated for 520 days to model a flight to Mars. Within this isolation experiment the six crew members biweekly participated in our experiments which were approximately half-an-hour long each. In the experiments the participants interacted with each other using software that we have provided. The interaction consisted of playing computer games and teaching each other. During the experimental sessions we made video records of the facial expressions of the participants. This work presents analysis of the obtained videos.

The extraction of the facial expressions from the video was done by FaceReader [12] software developed by Noldus Information Technology Company. The software automatically recognizes facial expressions by distinguishing six basic emotions plus natural. The accuracy of the facial expressions recognition was reported to be about 89%. More particularly, FaceReader classifies happy, angry, sad, surprised, scared, disgusted and neutral. The facial expressions recognition is based on Ekman and Friesen's theory of the Facial Action Coding System (FACS) that states that basic emotions correspond with facial models [13].

In total 33 experiments have been conducted. Every experiment provides 6 videos corresponding to different participants of the experiment. The average duration of the video is about 30 minutes.

To detect a long-term effect of the isolation on the emotional states of the crew members we have analyzed how different components of the facial expressions changes with time. The video data has been separated into two approximately equal parts: before the simulation of the landing on Mars and after that. The difference between the average components of the facial expression, corresponding to the two parts of the experiment, has been calculated. The statistical significance of the difference between the average values has been estimated and found to be low (ranging from 0.06 to 0.73 for different crew members).

To study the short-term effects we have studied a correlation between the facial expressions from the neighboring experiments (*i.e.* experiments separated by two weeks). To derive information about the interpersonal relations in the crew we have analyzed correlation between facial expressions of different crew members. The Pearson product-moment correlation coefficients between the components of the facial expression of different participant were found to be very low. However, the statistical significance of the values is very high. To study the relation between the facial expressions of different crew members in more detail, we have considered the joint distributions of the components of the facial expressions corresponding to two different crew members. Deviations of these distributions from the distributions of unrelated variables have been calculated and found to be statistically very significant. The relation between the emotional states of different crew members can be used as a measure of how emotionally bound two persons are. The form of the relation can be used not only do describe the strength of the bonding but also its type.

To get more information about the emotional states of the crew member within a given experiment we have analyzed not only the distribution of different facial expressions but also their time dynamics. In particular we analyzed how stable different emotional states (facial expressions are) and how frequently they changes.

To find the most condensed and complete description of the facial expressions we searched for independent degree of freedom in the components of the facial expressions. In order to get a better intuition of the emotional states of the crew member we used the FaceReader to extract a set of the most representative facial expressions. The representative expression can be used by people to interpret the emotional states of the crew members and then the real facial expression can be replaced (as an approximation) by the closest representative expression.

We have also presented general recommendations to researches and potential participants of similar experiments to help to prevent problems that we have encountered during our experiments.

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