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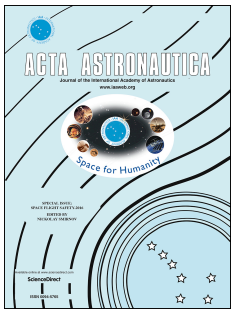

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Application of Virtual Reality for Crew Mental Health in Extended-Duration Space Missions

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Abstract

Human exploration of the solar system brings a host of environmental and engineering challenges. Among the most important factors in crew health and human performance is the preservation of mental health. The mental well-being of astronaut crews is a significant issue affecting the success of long-duration space missions, such as habitation on or around the Moon, Mars exploration, and eventual colonization of the solar system. If mental health is not properly addressed, these missions will be at risk. Upkeep of mental health will be especially difficult on long duration missions because many of the support systems available to crews on shorter missions will not be available. In this paper, we examine the use of immersive virtual reality (VR) simulations to maintain healthy mental states in astronaut crews who are removed from the essential comforts typically associated with terrestrial life. Various methods of simulations and their administration are analyzed in the context of current research and knowledge in the fields of psychology, medicine, and space sciences, with a specific focus on the environment faced by astronauts on long-term missions. The results of this investigation show that virtual reality should be considered a plausible measure in preventing mental state deterioration in astronauts, though more work is needed to provide a comprehensive view of the effectiveness and administration of VR methods.

1. Introduction

1.1 Background

In the early days of US manned spaceflight, relatively little attention was paid to questions of mental fortitude among astronaut corps. Instead, astronauts relied on the discipline required of them during previous careers as military fighter pilots to endure the difficulties of operating in small volume spacecraft. Additionally, mission lengths were on the order of days, not months. These factors of short mission length and a well-disciplined crew helped to facilitate the successes of programs such as Mercury, Gemini, and Apollo in the era of astronaut selection typified by the idea of "the right stuff" [1].

As national interests evolved to include longer stays in more permanent "space stations," a greater emphasis was placed on the human factors involved in spaceflight. The shift from short missions focused on proving technical capabilities gave way to longer missions of human habitation for the purpose of experimentation. The missions that took place on stations Salyut, Skylab, and Mir brought attention to the need for psychological support and coping methods for station personnel. The often cited Skylab "mutiny", during which the crew of Skylab 4 ended communications for a day in order to rest, led to procedural changes like better accommodations for crew stress and workload flexibility [1,2]. In the larger context of extended human spaceflight, however, the incident serves to highlight the central importance of crew mental health in the successful completion of missions. As in any effective strike, it became clear that without the crew, nothing would be accomplished [3,4].

1.2 Isolation, Confinement, and Mental Health

Today, the crafts used in these early space exploration programs would be classified as isolated and confined environments (ICE): inhabitants are physically separated from other people and conventional support systems, and they are confined to a small capsule [5,6]. Furthermore, the extreme environment around them means that a mistake can be catastrophic. While the sample size of people who have flown in space is small, there is a larger and more accessible population that has experienced similar environments: Submariners, inhabitants of Antarctic bases, and participants in dedicated ICE simulation studies have been seen as populations analogous to those in long-duration space missions [7,8,9,10,11].

The psychological effects of living and working in such environments have been documented by studies of these ICE analogues and evidence from past spaceflights. Psycho-environmental factors of ICE habitats include crowding, lack of privacy, social isolation, and sensory restriction [9,10]. Observed behavioural problems include anger, anxiety, interpersonal conflict, social withdrawal, sleep deprivation, decrease in group cohesion, and decrease in motivation [11]. Also documented primarily in Russian crews is "asthenia", which is a disorder often defined by the symptoms of fatigue, concentration and performance decrements, irritability, and sleep disturbances [12]. Though asthenia is not universally classified as a