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# THE EFFECT OF HYPER- AND MICROGRAVITY ON VISUOMOTOR COORDINATION OF AUGMENTED REALITY SELECTION IN CORRELATION WITH SPATIAL ORIENTATION AND HAPTICAL FEEDBACK

**Abstract**

Intra-vehicular operations on manned space stations include the handling of display and control items for operating the on-board systems and performing experiments at payload racks. Future interface technologies will be detached from common displays and input devices, like mice or keyboards. Augmented Reality offers the opportunity for a direct interface to the physical world enhanced with 3D registered virtual information that increases our perception and concentration. An important issue of our research in development of a mobile Augmented Reality assistance system for space operation procedures is related to interactive interfaces where precise pointing movements are involved. In this paper we present an experimentation that was conducted to investigate the effect of hyper- and microgravity on visuomotor coordination while pointing towards virtual targets attached and displayed in the real world by a monocular optical see-through head-mounted display. In response to visual stimuli we verified the interaction between the spatial orientation and the support of haptical feedback for selection tasks onto a virtual keyboard. That resulted in three placement configurations, whereby the spatial orientation was distinguished between inside and outside of the human body frame of reference associated with and without haptical feedback. Therefore we performed a usability study under hyper- and microgravity conditions at the 56th ESA Parabolic Flight Campaign in Bordeaux, France. We evaluated the performance of human hand-eye coordination and workload while applying the placement configurations by a pointing task towards the virtual keyboard. In a within-subject design, we collected 270 datasets of six subjects over three flight days with overall 90 parabolas using the upward hypergravity, the weightlessness phase, and for comparison the 1-g phase. As reference ground measurements we collected 165 data sets one day before the flight and directly after the flight in the airplane. The objective measurements of this experimentation showed a significant requirement of haptic feedback. Because the limited number of data sets we did not find significant differences related to the body frame, but we observed a trend towards the inside human body frame of reference. Also the subjects overall workload measured by the NASA RTLX was improved by pointing towards the keyboard with passive haptic feedback. Filling in a final post-questionnaire the subjects tended to the preference of using virtual keyboards with haptic feedback and outside human's body frame. In future experimentation we plan to identify the corresponding body reference system by evaluating the precision and the accuracy of the pointing gesture.