Human Perception in Space Exploration: The effect of proprioceptive input modulation on visual perception and spatial representation in simulated micro-gravitational environment.

In order to study if proprioceptive input manipulation influences spatial representation and, consequently, can contribute to develop a "human-centered design" for future Moon & Mars habitats, we simulated a microgravitational environment performing a visual discrimination experiment with subjects immersed in water.

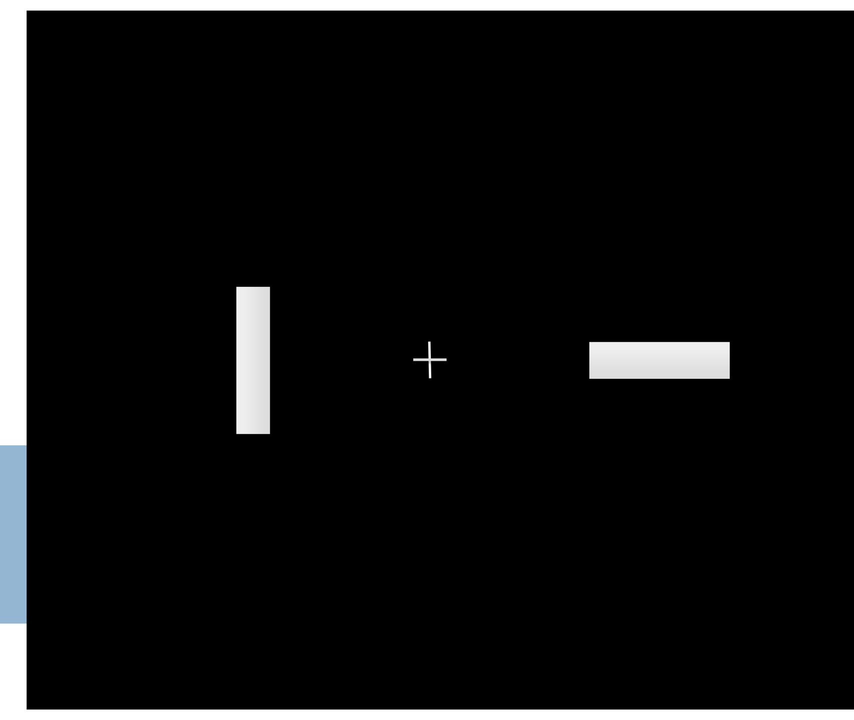
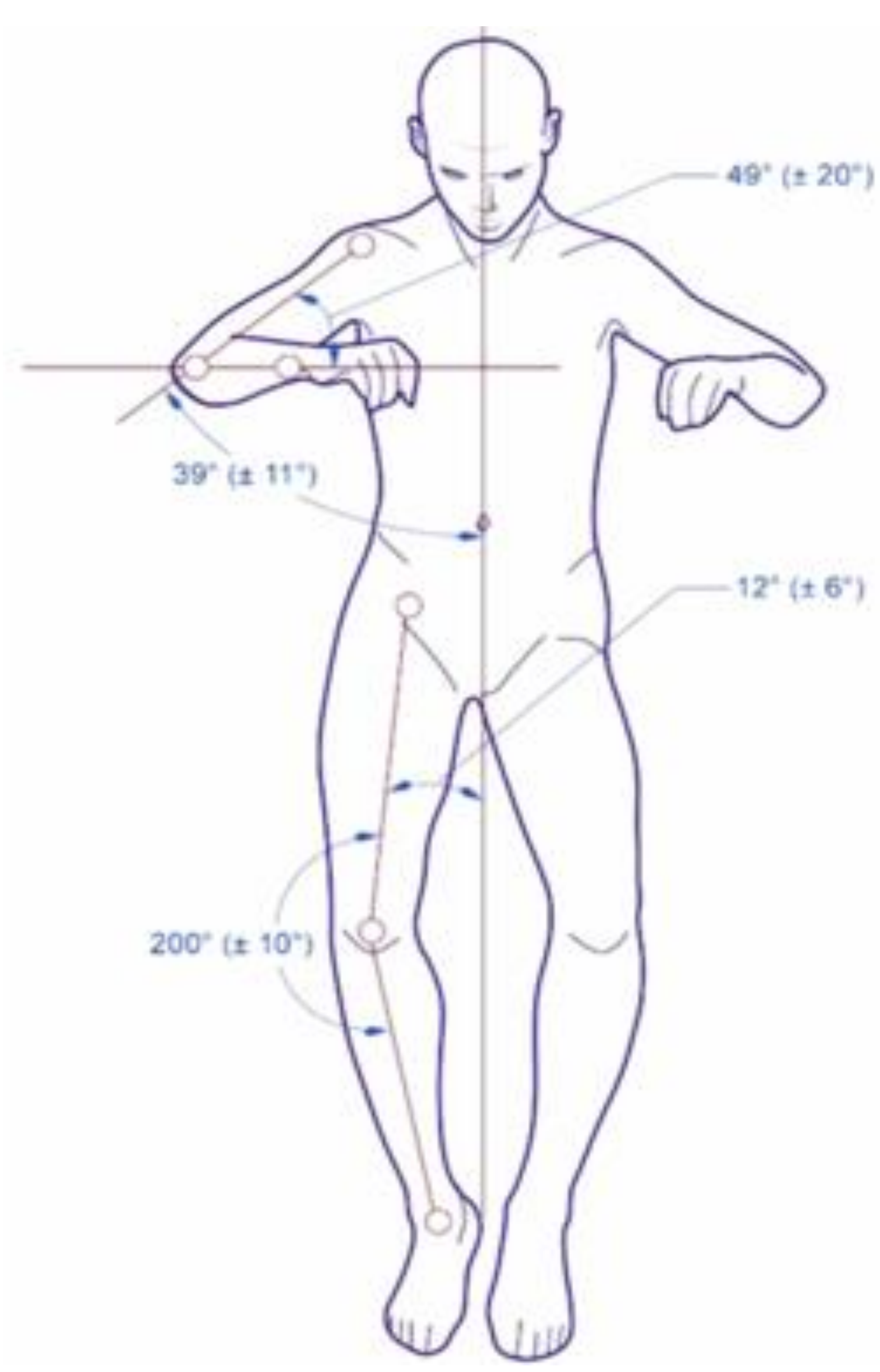


Fig.1 Example of the stimulation used

The aim of this pilot study was to explore the effects of the modulation of the proprioceptive input on the spatial representation of the horizontal and vertical dimensions. To investigate this issue, a computer-based length-comparison task was proposed under partial water immersion conditions of participants. The task consisted in comparing the longest dimension of pairs of rectangles presented on a pc screen (Fig.1). The rectangles were located either to the left or to the right, or above or below with respect to a central fixation cross. The rectangles could be oriented along the vertical or the horizontal meridian. All possible combinations composed of different pairs were created and presented in a pseudo-random sequence. The task was executed under two different conditions: during water immersion (the head surfaced) and outside water. We observed that immersion in water (Fig.2) modulated vertical-horizontal comparisons. In particular, the verticality bias, i.e. the normal tendency to overestimate the vertical relative to the horizontal dimension, significantly decreased when the vertical element was located to the right of the fixation point.



The results show that proprioceptive input modulation (i.e. a decreased body weight-related proprioceptive input) influences spatial representation, inducing an underestimation of the vertical relative the horizontal dimension. We interpret this finding hypothesizing that spatial representation varies according to the proprioceptive input intensity in order to optimize information processing for possible action execution. Along this line of reasoning, a reduced proprioceptive input would require by the sensory-motor system an adaptive response in terms of force and trajectory vectors applied to possible movements directed to potential targets. In order for the system to optimally adjust to this change, also spatial representation needs to be reconfigured accordingly. Specifically, a reduced body weight would need a reduction of movement-related force/trajectory vectors in order to precisely aim for targets; a correspondent reduction of the vertical dimension of the underlying spatial representation is compatible with this interpretation, subserving the motor system with a more adaptive spatial framework to execute more precise aiming movements.

Fig.2 The neutral body position

Ongoing research in collaboration with ILEWG (International Lunar Exploration Working Group), DLR (German Space Agency) and KIT (Karlsruhe Institute of Technology) is investigating walking patterns and interactions of astronauts inside and outside the habitat using the swimming pool of the Neutral Buoyancy Facility at the European Astronaut Centre and at KIT. Moreover, similar data will be collected in simulated hypogravity with a modified treadmill where subjects will be held by a wide padded belt, with the upward forces applied to the belt simulating different levels of hypogravity.

In conclusion, we believe that the above mentioned studies can contribute to the safety and performance of future Moon and Mars human missions.

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