Semi-privacy and Colour Application as Elements of Habitability in Concept Design for Extra-terrestrial Habitation

space architectural investigations during the EMMIHS-II lunar simulation at HI-SEAS

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Elements of Habitability (EoH)

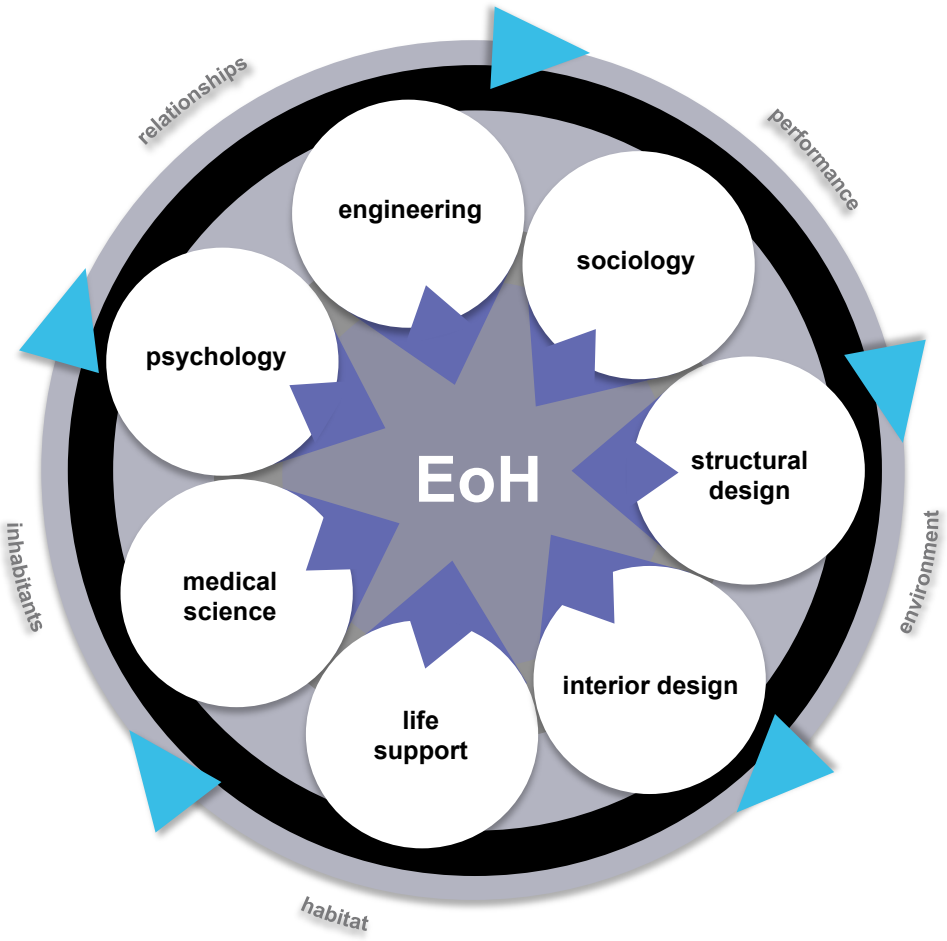


Fig.1 Correlation between EoH and scientific disciplines

- factors to improve the liveability in a habitat
- correlation with numerous disciplines
- vital for both long-term and short-term missions

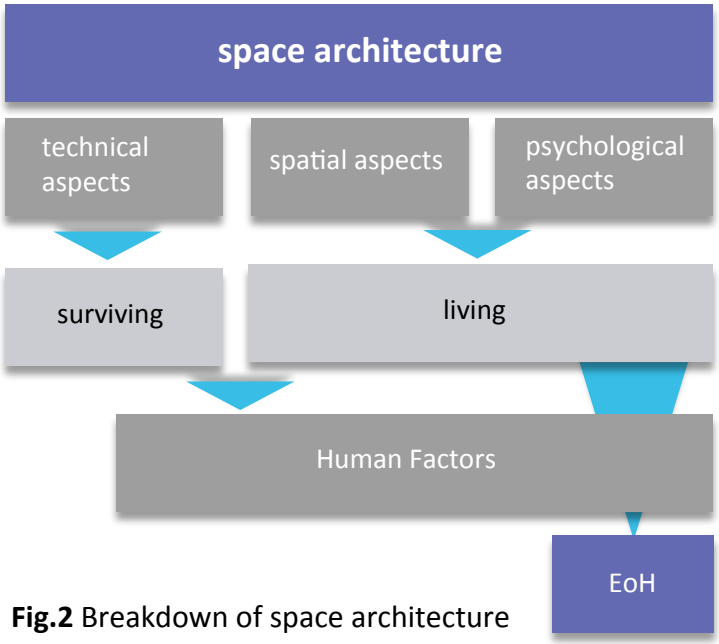


Fig.2 Breakdown of space architecture

Privacy

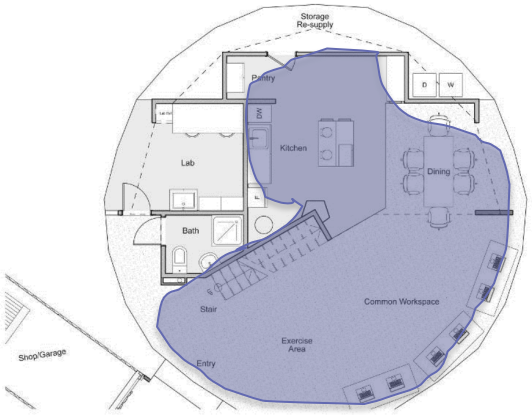


Fig.3 HI-SEAS habitat level 0; privacy situation in the shared living and working area

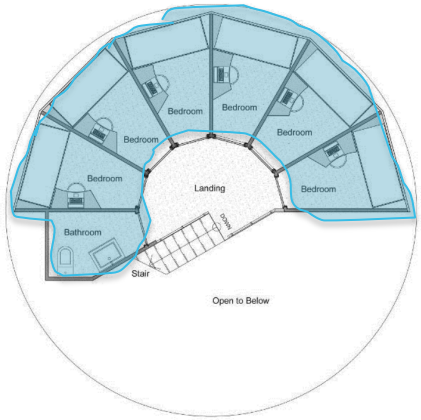


Fig.4 HI-SEAS habitat level 1; privacy situation in private crew quarters

Famous question: How much privacy is necessary for extra-terrestrial habitation?

New question: **What kind** of privacy is necessary for extra-terrestrial habitation?

→ Different manners of privacy, defined by various factors of privacy (FOP):

- Visual barriers
- Auditory barriers
- Olfactory barriers
- Distance
- Size
- Purpose/interaction
- Personal perception
- Extent of above listed factors

Semi-privacy

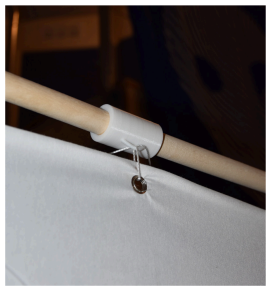
Fig.5-6 Utilization of the semi-private area for small crew gatherings and private working space

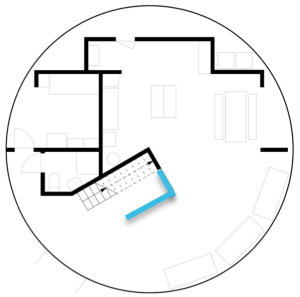
- Lack of one or more FOPs
- Heavily reliant on personal perception of the surrounding space and personal sensitivity
- Highly common in confined habitation

Investigation of semi-privacy during the EMMIHS-II lunar simulation (comparative study during follow-up missions)

a) set-up of a semi private area in the main space of the HI-SEAS habitat

b) elimination of complete privacy (crew quarters) for 48 hours





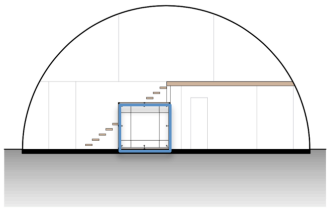
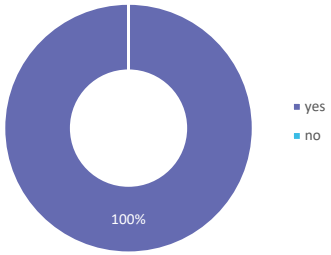
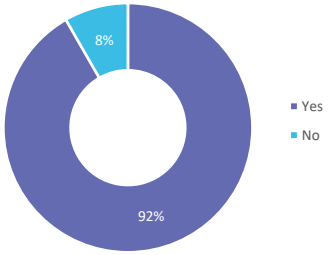


Fig.7-10 Flexible set-up with on-site 3d printable connection parts

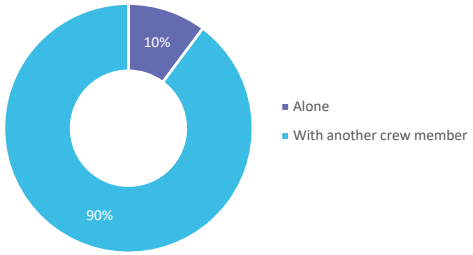
Semi-privacy – lessons learned



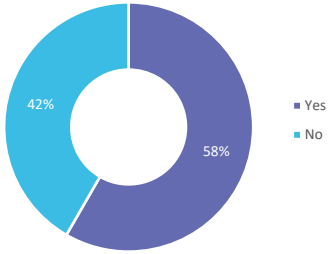
Was there an improvement in emotional state and mood after using the semi private area?



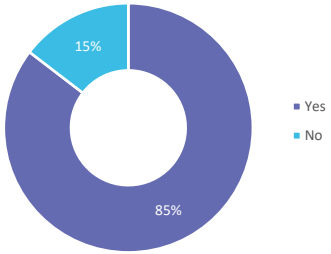
Was there an increase of stress levels during the 48-hour experiment?



Would the semi-private area rather be used alone or as a space to socialize with another crew member?



Did the crew feel closer to each other on a personal level during the 48-hour experiment?

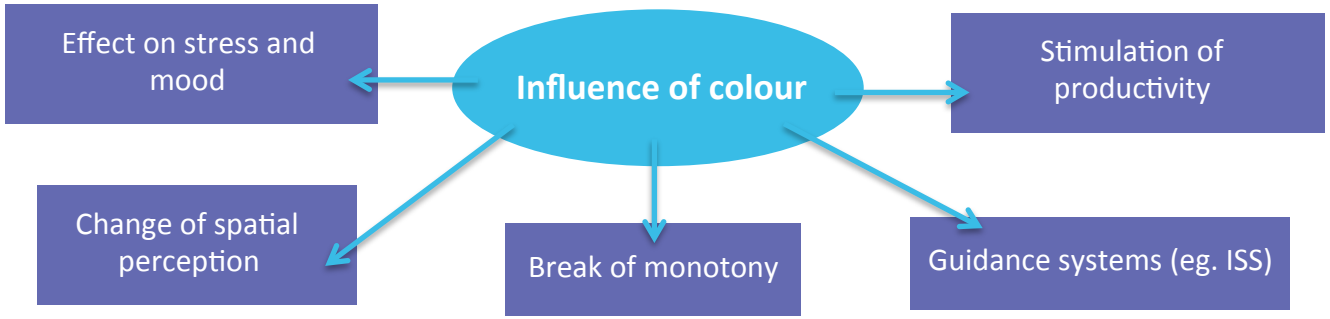


Are the private dormitories perceived as a retreat?

Fig.11-15 Findings based on daily crew surveys during EMMIHS-II and EMMIHS-III

- Creating a semi-private space that allows the crew some manner of privacy while still being able to interact with other crew members lowers stress and the feeling of isolation
- Important value of semi-private areas are the social aspects, allowing interaction in small groups while still offering a private space
- Personal quarters with distinct privacy are vital but also create distance and isolation between crew members if used as the only means of privacy
- Privacy and semi-privacy have to be seen as two separate architectural elements; both aspects should be present in a space habitat - an abundance of one can not fully replace the other

Colour application



Investigation of colour application during the EMMIHS-II lunar simulation

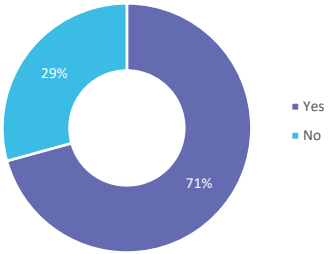
→ Investigate the crew's reaction to disparate color situations. Influence on mood, stress levels and productivity?

Week 1: elimination of all colour in the HI-SEAS habitat (architectural components, tools, appliances, personal objects, clothing,...)

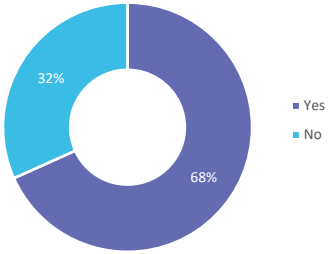
Week 2: reintroduction of colour for comparative measures

Fig.16-18 Creating an environment devoid of colour in the HI-SEAS habitat

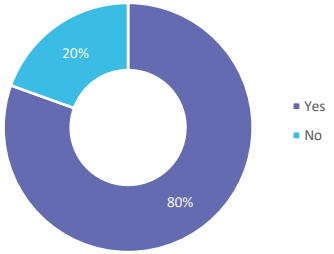
Colour application – lessons learned



Did the crew feel in any way affected by the lack of colour?



Did the crew percieve the lack of colour as a stressor?



Was there a change in the crew‘s emotional state after the reintroduction of colour?

Fig.19 Living in an environment devoid of colour, the EMMIHS-II crew was only allowed to wear black and white clothes

Fig.20-22 Findings based on daily crew surveys during EMMIHS-II

- A completely colorless environment showed visible negative effects on the crew‘s mood, stress and patience
- Importance of free choice of the colour situation at personal workspaces and in personal quarters → flexible systems for custom choices are vital
- Colourful, personalized clothing in a mono-coloured environment has a great effect; colourful, personalized clothing in a coloured environment has little effect

Leveraging colour applications as EoH

for long-term missions

- Flexibility
- Variety
- Personal choices
- Colour coding areas → create structure and spatial distinction

for short-term missions

- Flexibility and variety as possible
- Personal choices
- Leveraging personal items and clothing as source of colour and alternation

Lessons learned for our current situation?

Comparing the COIVD-19 measures to extra-terrestrial habitation/analog simulations

- Living in isolation
- Wearing protective gear when leaving the habitat
- Limited social contact/direct contact with a very small circle of people
- **Confined habitation and possibly privacy issues**

Leveraging EMMIHS-II findings to improve habitability in self-isolation

- Paying attention to privacy – creating semi-private areas within large open living areas allows some amount of privacy while staying in the same room
- Small interventions (eg moving a desk) can create visual segregations of a room; especially important when sharing a home office
- Flexibility – breaking the monotony with flexible systems or changes in the usual set-up can boost mood and productivity and lower stress levels
- Paying attention to the colour situation in workspaces; small changes can have big effects on productivity and mood

Credits

Fig 3: Envision Design, LLC
Fig 4: Envision Design, LLC
Fig 9: EMMIHS-II, based on Envision Design, LLC
Fig 10: EMMIHS-II, based on Envision Design, LLC

Affiliations

[1] International Moonbase Alliance (IMA), United States, [2] ILEWG EuroMoonMars programme & EMMIHS (EuroMoonMars-International Moonbase Alliance- HISEAS), [3] International Moonbase Alliance (IMA) & Hawai´i Space Exploration Analog and Simulations (HI-SEAS), United States [4] Institute of Robotics and Cybernetics, Faculty of Electrical Engineering and Information Technology STU in Bratislava, Slovakia, Slovak Organisation for Space Activities (SOSA), Bratislava, Slovakia, [5] Vrije Universiteit Amsterdam, [6] ESA ESTEC & ILEWG, Noordwijk, [7] sabrina.kerber@outlook.com; [8] ariane.wanske@icloud.com; [9] musilova@moonbasealliance.com; [10] bernard.foing@esa.int