Influence of navigation mode on spatial memory in mixed-reality

Project Presentation
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Introduction

✓ The paradigm of navigation in virtual reality covers a broad spectrum of research topics related to spatial memory, presence and narrative.

✓ Navigation mode in a virtual reality environment has consequences for:
   A. What is remembered;
   B. The level of immersion experienced.

✓ Ecological validity of VR assessment

The question: How crucial is the navigation modality for spatial memory recollection?
**Methods (I)**

The eXperience Induction Machine (XIM): multi-user mixed-reality space equipped with a number of sensors and effectors

Empirical studies on human experience and behavior in complex, ecologically valid situations that involve full body movement and interaction
Methods (II)

Overview of the Guided Tour House

<table>
<thead>
<tr>
<th>Room</th>
<th>Global Features</th>
<th>Local Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Wallpaper “Scottish” style</td>
<td>• 4 wall lamps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 1 table</td>
</tr>
<tr>
<td>B</td>
<td>Monochromatic walls color</td>
<td>• 1 book shelf</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 2 big jars</td>
</tr>
<tr>
<td>C</td>
<td>Walls made of stone</td>
<td>• 1 painting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 1 chair</td>
</tr>
<tr>
<td>D</td>
<td>Monochromatic walls color</td>
<td>• 1 plant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 1 painting</td>
</tr>
</tbody>
</table>

"overall" features

objects in the room
Methods (III)

Local

Furniture

Rooms

Global
Experimental Setup (I)

H1: navigation mode influences the participants’ spatial memory and experience

Independent Variables \rightarrow Navigation Mode
- Active
- Passive

Dependent Variables:
- Spatial memory
- Spatial Presence, Engagement, Ecological Validity/ Naturalness, Negative Effects
- Valence, Arousal, Dominance
- Behavioral data
Experimental Setup (II)

- Spatial Memory (MAP)

Global Score:
• 0 incorrect
• 1 correct

Local Score:
• 0 wrong room
• 1 right room
• 2 right wall
• 3 right position
Experimental Setup (III)

- Spatial Presence, Engagement, Ecological Validity/Naturalness, Negative Effects (ITC-SOPI questionnaire)
Experimental Setup (IV)

- Valence, Arousal, Dominance (SAM scales)

Each subject and each room:

Arousal:
The scale refers to the calm vs. excited state, which ranges from a sleepy state (left) to a wideawoken state (right).

Dominance:
The scale refers to the controlled vs. incontrol state, which ranges from feelings of being completely controlled (left) to autonomous (right).

Valence:
The scale refers to the unhappy vs. happy state, which ranges from a frown (left) to a smile (right).
Experimental Setup (V)

- Behavioral data (XIM tracking data, navigation data)
Experimental Setup (VI)

Sample
10 Subjects (8 males, mean age 27.3, SD ±3.129) equally divided into two groups (Active and Passive)

Duration of the a single experimental session
~30 minutes

Single trial details
Time spent in the house (Active and Passive):
• 400s Passive Mode (6 minutes + 4 transitions of 10s each);
• 400s Active Mode.
Event log recording (timestamp, location, tracking data)
Results: questionnaires

• *Spatial Presence, Engagement, Ecological Validity/Naturalness, Negative Effects* (ITC-SOPI)
  No significant differences between the two groups
  (N.B. Significant gender difference in Presence ...but the sample is too small)

• *Valence, Arousal, Dominance* (SAM scales)
  No significant differences between the two groups
Results: spatial memory test

• Local Spatial Score significantly higher in Passive group compared to Active ($p < .05$) in room B and room C

• No difference for Global Spatial Score (Wallpapers) ($p > .05$)

• Total Spatial Score (Global + Local) significantly higher in Passive group compared to Active in Room B ($p < .05$) and in Room C ($p < .01$)

Total Spatial score among groups in rooms B and C
Results: spatial memory test (II)

• Although not statistically significant, the Overall Spatial Score (all rooms) is higher in the Passive group compared to the Active ($p = .072$)
Results: Behavioural Data – Overview
Results: Behavioural Data – Room A

Mean time spent in Room A:
Active: 32.6s (SD ± 10.95)
Passive: 90s (SD = 0)

Mean number of visits Room A:
Active: 3.8 (SD ± 1.3)
Passive: 1 (SD = 0)
Results: Behavioural Data – Room B

**Mean time spent in Room B:**
Active: 27.92s (SD ± 20.77)
Passive: 90s (SD = 0 )

**Mean number of visits Room B:**
Active: 3.4 (SD ± 0.89)
Passive: 1 (SD = 0 )
Results: Behavioural Data – Room C

Mean time spent in Room C:
Active: 40.23s (SD ± 16.83)
Passive: 90s (SD = 0 )

Mean number of visits Room C:
Active: 4 (SD ± 1.22)
Passive: 1 (SD = 0 )
Results: Behavioural Data – Room D

Mean time spent in Room D:
Active: 60.51s (SD ± 4)
Passive: 90s (SD = 0)

Mean number of visits Room D:
Active: 6.2 (SD ± 1.09)
Passive: 1 (SD = 0)
Discussion (I)

- The total spatial score is significantly higher in Room B and C between the two groups.

Room B and C have 2 local features each (A and D have, respectively 5 and 3 local features): easier to remember?

- The Overall Spatial Score (Map test) is higher in the passive group.

Our prediction is that this effect will become significant when increasing the sample size.

![Total Spatial score among groups in rooms B and C (p < .05)](image1)

![Overall Spatial score among groups (p = .072)](image2)
Discussion (II)

- **XIM tracking - ROOMS A,B,C,D - All subjects (active Vs. passive)**

**Active Group:**

Participants moved along a cross-shaped path (movements on the paths that join the active tiles)

**Passive Group:**

- In Room B subjects moved along a diagonal trajectory following the location of the objects;
- Predominance in the center of the XIM (in particular Room C)
Discussion (III)

▪ XIM tracking - ALL ROOMS - All subjects (active Vs. passive)

Active group:

- Cross-shaped path

Passive group:

- Wider range of movement of the participants (lower level of interaction compared to the active mode → more time to explore the environment)
Future improvements

- Collect participants’ direction and gaze;
- Statistical analysis of the tracking data;
- Use physiology to measure the participants’ “arousal” (ECG and GSR replace the subjective assessment).

Ideas

- Conduct the same experiment in a virtual Vs. real environment;
- Change the location of the objects into the rooms and then repeat the experiment;
- Show a map of the house with the objects correctly positioned in the corresponding rooms before the experiment starting;
- Perform the spatial memory test at different time intervals after the experiment.
Acknowledgments

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- Other BCBT Groups (we monopolized the XIM for two days and they didn’t complain too much)