The background of the slide is a dense, overlapping field of 3D-rendered numbers. The numbers are in various sizes and orientations, creating a sense of depth and movement. The color palette is primarily red and orange, with some numbers appearing slightly darker or lighter due to the lighting and perspective. The numbers are scattered across the entire frame, with some being more prominent than others.

A matter of Perception

Investigating the Effect of
Virtual Reality on Spatial
Understanding

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Different Media provide different means to communicate about design between professionals and clients. But which one works best?”

WHY

Background

Within interior design and architecture, spatial perception plays a crucial role in communication. To convey the information required for understanding the proposed design of a space to the client, experts communicate through different media (e.g., traditional drawings, 2D paper plans, moodboards, physical models, 3D screen-based models and animations. However, this is a challenge as the level of spatial understanding between expert and client often differs significantly,

Spatial understanding

The ability to understand the shape, size, location, and texture of an object or space.

Problem

Whereas untrained minds have to use several cues and think carefully to understand visualizations of architectural designs, experts understand these visualizations more easily and are able to translate them from the physical world into the virtual 2D and 3D world

VR

Virtual Reality might provide a “better” solution to close the gap between professionals and clients in spatial understanding

WHAT

POSSIBLE SOLUTION

Virtual Reality (VR)

Since 2016 affordable high-level Virtual Reality (VR) has entered the market. VR is perceived as a promising and more effective medium for architect-client communication.

Why VR: a sense of being there

The capability of creating highly realistic and intuitive experiences sets VR apart from traditional visualization media, which may have a high risk of being too abstract. Technology used in VR helps explain why VR could work better compared to other media. For instance, sensory technology provides the user with a natural eye-height, stereoscopy, and a large Field of View (FOV), thereby increasing perceived realism. Interaction and control technologies might give VR a benefit as users can move and walk around objects, imitating real-life behaviour, which enhances the understanding of virtual spaces. Also, VR allows for better location tracking, which enhances the sense of presence.

However.....

....research on the effect of different visualization media on spatial understanding is missing or unclear. Some studies showed equal effects in spatial understanding. Also, different studies compared different media and different spatial tasks, making it challenging to draw unambiguous conclusions. No study tested the impact of presence on spatial understanding between desktop-based visualization with high-end head-mounted VR devices.

N = 15

N = 15

N = 15

WUFA

Research: compare spatial understanding among non-professionals in three conditions: (a) being in the real space, (b) being in VR and (c) through a traditional desktop screen.

RESEARCH

Design

Between-Subject design: participants experienced an apartment through (a) being in a physical replication of the real space, or (b) being in VR (HTC Vive) or (c) through a traditional desktop screen (13 inch laptop) . Participants could walk around the furniture from different perspectives, for instance, by kneeling or bending sideways. After two minutes of getting used to the environment, they were asked to estimate the size of the room and furniture present. The participants in the media conditions were then asked to fill out a questionnaire.

Participants

45* people that visited a VR center (to reduce VR newness effect).

Age:18 to 54 years (normal or corrected-to-normal vision).

*7 are visual space experts (e.g., engineers, architects, or 3D artists), and were equally distributed over the three conditions.

MATERIAL

The room consisted out of a(n existing) loft apartment without any floor or wall coverings and included a table, two chairs, a bench, a kitchen unit, and a floor lamp. The room height of the loft is 5.08 m, and the length is 6.55 m. The sizes of the furniture items displayed in the virtual environments correspond with their real counterparts.

HOW

1.
2.
3.		<div>Size Estimations</div> <div>depth of the TABLE <input type="text"/></div> <div>Perceived spatial understanding difficult ☐ ☐ ☐ ☐ easy insecure ☐ ☐ ☐ ☐ confident</div> <div>length of the TABLE <input type="text"/></div> <div>Perceived spatial understanding difficult ☐ ☐ ☐ ☐ easy insecure ☐ ☐ ☐ ☐ confident</div>			
4.

MEASURES

MEASURES

Spatial Ability: 12 items from the Mental Rotation Test from Peters et al. (1995). The participant is asked to choose which of the four drawings represent the two rotated versions of the target figure.

Size estimations: estimations of depth, height, length of furniture and room in meters and centimeters

Ease of estimation: difficulty and confidence of estimation using 5-point scales (e.g., ‘difficulty’ versus ‘easy’ and ‘insecure’ versus ‘confident’), combined into one variable. Overall impression: “Please rate how well the medium could convey a good impression of the spatial dimensions” (1 = very bad; 10 =very good).

Sense of Presence: ITC-SOPI scale (29 items over 4 factors: perceived naturalness, engagement, spatial presence and negative effects (5-point Likert scale: 1 = strongly disagree; 5 = strongly agree).

Perceived Usability: Usability Engagement Scale (9 items, 5-point Likert scale: 1 = strongly disagree; 5 = strongly agree). E.g., “I found the medium confusing to use” to “I felt frustrated while trying to estimate sizes in the displayed environment”.

WHAT

RESULTS

RESULTS

Spatial Ability: **equal** average spatial understanding between groups ($M_{\text{physical}} = 6.3$, $M_{\text{vr}} = 6.1$, $M_{\text{desktop}} = 6.70$). Experts showed a better spatial understanding (11 versus 5.4).

Size estimation: **equal** (score of 1.1 in all three conditions). An overestimation of size in all conditions (max 29%). Maximum underestimation: 7% (chair depth). Fairly accurate: table length and depth of chair. Room dimensions estimated accurately in VR and Desktop, although more overestimation in Desktop (8%) compared to VR (7.7%).

Ease of estimation: **small difference** in favor of VR (2 out of 8 measurements). Floor lamp height and length of room more difficult and less confident using desktop. Overall estimation impression did not differ.

Sense of Presence: spatial presence and engagement **stronger in VR** ($M_{\text{presence}} = 3.6$, $M_{\text{engagement}} = 3.9$) compared to Desktop ($M_{\text{presence}} = 2.3$, $M_{\text{engagement}} = 2.9$). Higher engagement, more ease of size estimation (18.5% of variance).

Perceived Usability: **equal** between VR and Desktop, however, in VR participants were **more likely to continue exploring** the furniture and room out of curiosity than in Desktop. Better perceived usability, the higher ease of estimation (37.6 % of variance). The higher novelty, the higher the overall grade (36% of variance). Novelty negatively affects objective spatial understanding (22.3% of variance).

CONCLUSIONS

CONCLUSIONS

VR and Desktop both can be used effectively to estimate space for simple objects and rooms.

The findings support the idea that VR has added value for less familiar and more complicated objects. VR was considered better and easier for sophisticated measures such as the height of an unfamiliar floor lamp or the length of the room. A possible reason for why VR worked better was the interaction dimension: only in VR participants could use their own body as a reference for estimating the lamp height. Because VR and the real-world condition achieved similar ratings for perceived spatial understanding, the general positive effect of VR, which is the predominant attitude in the industry now, can be confirmed. With increasing familiarity with VR, objective spatial understanding in VR may outperform Desktop in the coming years also on more simple objects.

VR also increases engagement and presence. However, we do not know anything about subjective space estimations (how does a room “feel”). Therefore we started a project “Being There”, in which we will mix computer-generated VR with 360 recorded spaces and measure the effect of spatial understanding for non-static unfamiliar rooms and objects related to temporary homes (for immigrant women) for professionals in training. Both studies together will provide a better overview of the potential of VR in the understanding of space.