Is curvature preferred over angularity? Exploring psychological responses to indoor environments presented in Virtual Reality

Nour Tawil[1]; Izabela Maria Sztuka[1]; Kira Pohlmann[2], Sonja Sudimac[1]; Simone Kühn[1,2]
[1]Max Planck Institute for Human Development, [2]University Medical Center Hamburg-Eppendorf

MAX PLANCK INSTITUTE FOR HUMAN DEVELOPMENT

Lise Meitner Group for Environmental Neuroscience

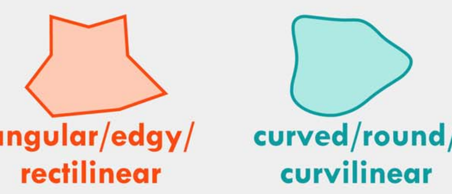
UKE HAMBURG

INTRODUCTION

Given that we spend the majority of our waking time indoors, there has been an emerging interest in understanding how built environments affect brain and behaviour.

The first successful attempts in linking architectural features to psychological responses in human beings concern form parameters, such as "contours".

contour: the edge or line that defines or bounds a shape or an object.



Extending on the robust empirical evidence from various disciplines (e.g. aesthetics, psychology, arts) that support a universal appealing effect of curved stimuli [1], an encouraging body of experimental literature is proposing similar effects in the context of indoor environments. Spaces with curved interiors, as opposed to angular or rectilinear ones, were found to be aesthetically preferred, inducing higher positive emotion [1-4], and activating the medial orbitofrontal cortex (mOFC) [3].

However, to date, most of the known effects relate to unmatched static or schematic stimuli rather than real-life experiences, neglecting the role of body movement in the spatial experience [5].

MATERIALS AND METHODS

We employed a 2x2 within-subject design to systematically examine the curvature preference hypothesis in indoor environments under fully-controlled conditions. We developed a novel photo-realistic VR paradigm that allows measuring the psychological responses to contrasting contours (angular vs. curved) in a closer to reality experience. We included style (modern vs. classic) as an explorative second level variable to account for its influence on the response to form [6].

Outcome variables
Affective & spatial experience (ASE) [1,7-9]
Momentary affect (MAS) [10]
Perceived restorativeness (PRS) [11]
Cognitive performance (mental arithmetic task [12]
Quality of the VR experience
Simulation sickness (SSQ) [13]
Presence (IPQ) [14]

We expected "curved" conditions to positively impact the self-reported ASE & MAS, and to improve cognitive performance as well as self-reported feeling of restorativeness (H1).

THE VR PARADIGM

N = 36-42

Age = 18-40 years old (M = 27.7)

61% females

85.4% Born in Germany

Figure 1. Stimulus material, virtual environments (VEs).

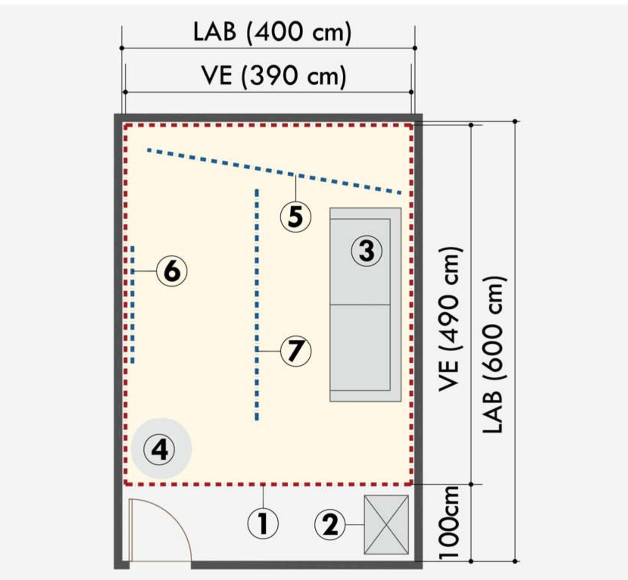


Figure 2. VR laboratory set up.

1. Virtual space limits
2. PC command area (experimenter)
3. Physical couch, same position as VEs
4. Teleportation spot/exploration start
5. Virtual screen: instructions
6. Virtual screen: cognitive task
7. Virtual screen: ASE & MAS ratings (using controller)

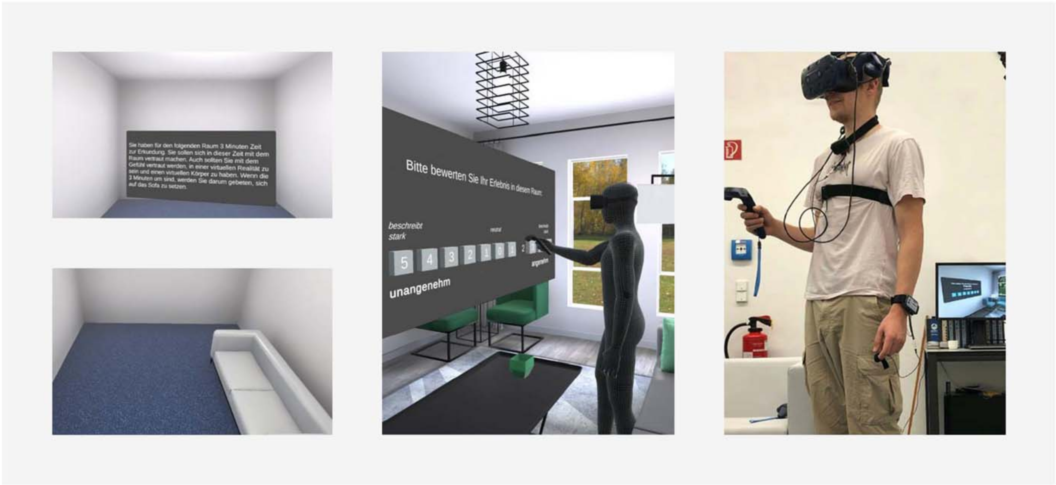


Figure 3.
Left top: teleportation room presented at the start of the VR session and in between each of the rooms. **Left bottom:** virtual training room simulating the lab appearance. **Middle:** Avatar responding to rating task (from reconstructed session). **Right:** VR setup in pilot session with the physical couch shown on the right side of the participant.

unity STEAMVR VIVE PRO

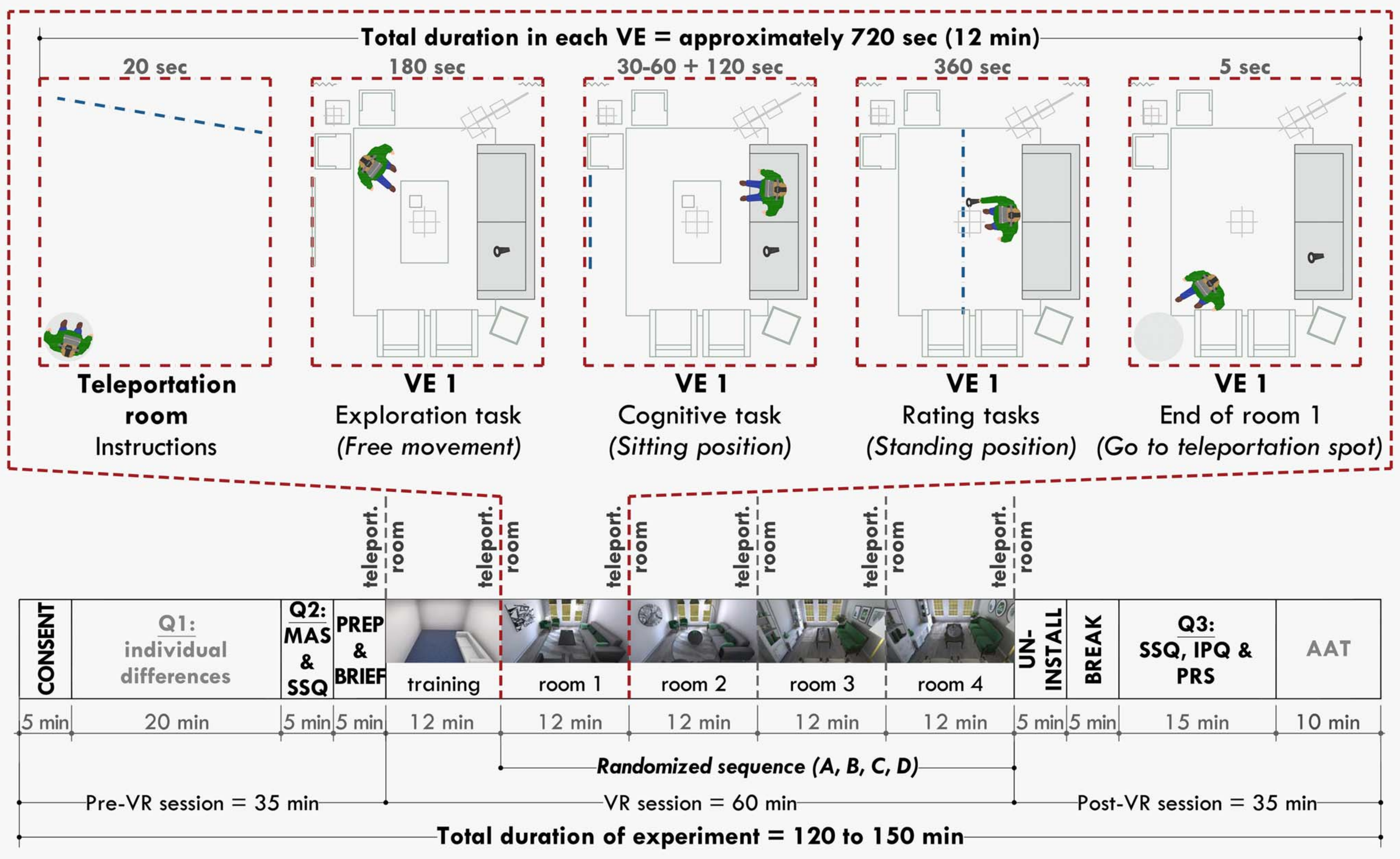


Figure 4. Details of the experimental paradigm.
Bottom: Experiment phases (pre-VR, immersive,and post-VR sessions) and average durations. **Top:** Sequence of events in each of the VEs.

RESULTS

Out of the **33** outcome variables measured, and after correcting for false discoveries (FDR), only two eventually confirmed differences in the contours analysis, in favor of "angular" rooms. Participants rated angular rooms higher compared to curved ones on ***novelty*** ($t(40) = 3.95$, $p < 0.001$) and ***order*** ($t(40) = 6.20$, $p < 0.001$). No statistically significant differences were found in any of the other dimensions of ***ASE*** and ***MAS*** scales.

Similarly, there were no differences in ***cognitive performance*** ($Z = -0.43$, $p = 0.667$) nor self-reported ***restored attention*** ($t(35) = -0.79$, $p = 0.436$) after the exposure to any of the two conditions.

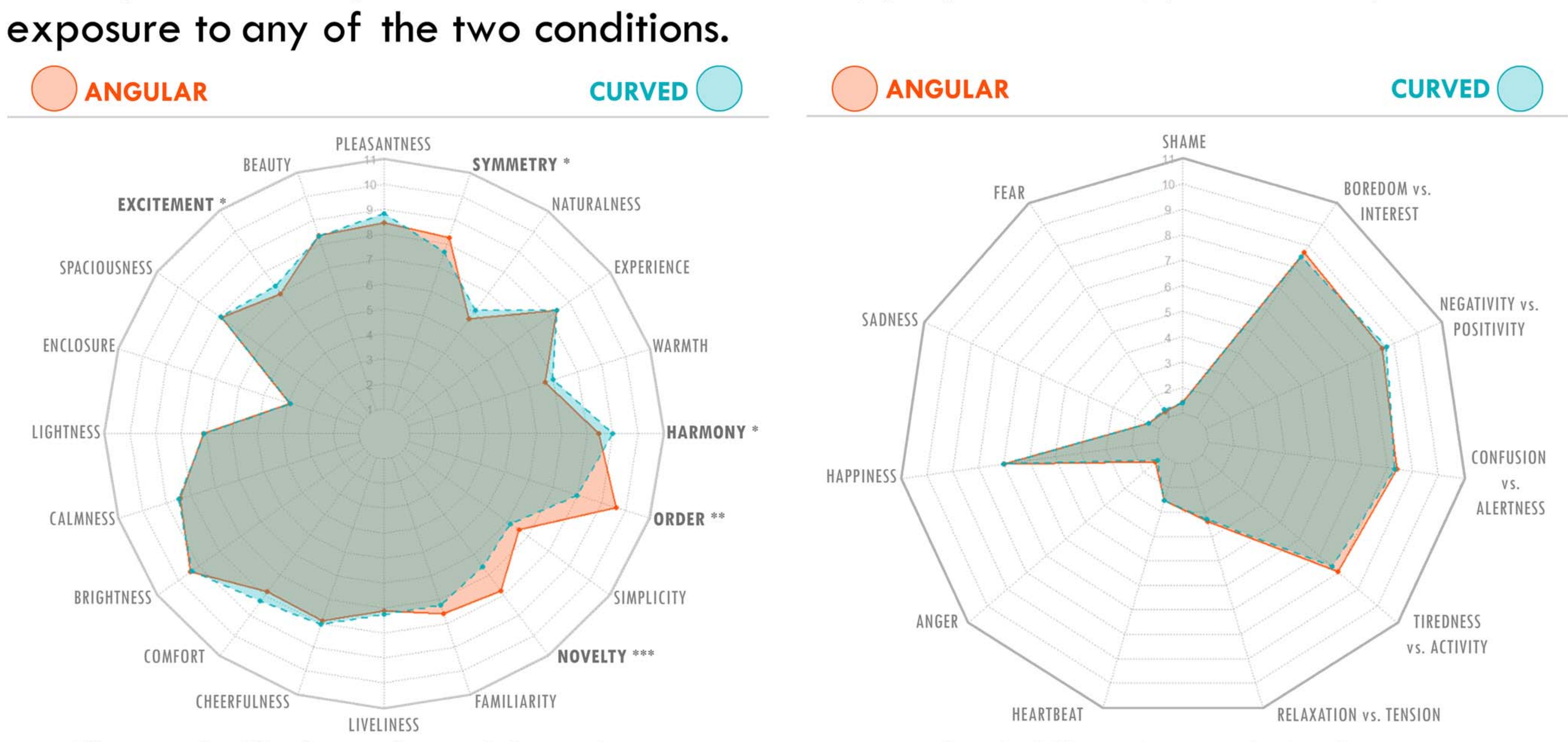


Figure 4. Display of participants' mean responses to the in-VR rating task in the contour analyses (angular vs. curved). **Plot (a)** displays results of the affective and spatial experience (ASE) scale [8-10], and **plot (b)** shows results of the momentary affective state (MAS) scale [11]. Significant dimensions (before FDR correction) are marked with asterisks.

Results of additional analysis using the Bayesian framework were in line with those of the frequentist approach, indicating strong evidence for H_1 for the dimensions ***order*** ($BF_{01} = 0.00002$) and ***novelty*** ($BF_{01} = 0.0116$), and particularly surprising, the nearly anecdotal evidence for H_1 in the case of ***pleasantness*** ($BF_{01} = 0.959$), substantial evidence for H_0 for ***beauty*** ($BF_{01} = 5.607$) and ***calmness*** ($BF_{01} = 4.487$) and other ***arousal*** dimensions.

DISCUSSION

In summary, to date, most of the (scarce) evidence for curved contour preference in architectural settings depend on static unmatched or unrealistic stimuli.

The present study addressed previous limitations and found that the exposure to contrasting contours in photo-realistic virtual interiors did not elicit significant differences in response to a broad set of psychological dimensions, with tasks and questionnaires administered in the virtual spaces to record an immediate response.

The fact that we assessed multiple domains during a close-to-reality architectural experience of fully controlled stimuli, not finding major effects in any of them, makes the study the most comprehensive in the field until now. This further highlights the complexity of the psychological response to indoor design and suggests caution when extending an observed effect of contour upon perceiving a static stimulus onto experiencing it in real scale from different angles and perspectives [5]. These results, therefore, will help to convey a more real-life perspective of the response to the architectural experience in experimental settings and point out the necessity for further investigations by providing directions for future research, namely:

- presenting stimuli from different angles/perspectives
- maximizing the control for confounding variables in stimulus design by providing well-matched high- and low-level properties
- ensuring balanced samples in terms of sex
- focusing on implicit cognitive measures
- controlling for inter-individual differences

Link to publication

REFERENCES

1. Vartanian et al. (2019). Preference for curvilinear contour in interior architectural spaces: Evidence from experts and nonexperts. *Psychol. Aesthet. Creat. Arts*, 13, 110–116.
2. Dazkir & Read (2012). Furniture forms and their influence on our emotional responses toward interior environments. *Environ. Behav.*, 44, 722–732.
3. Vartanian et al. (2013). Impact of contour on aesthetic judgments and approach-Avoidance decisions in architecture. *Proc. Natl. Acad. Sci.* USA, 110, 10446–10453.
4. Banaei et al. (2017). Walking through architectural spaces: The impact of interior forms on human brain dynamics. *Front. Hum. Neurosci.*, 11, 477.
5. Nasar (1994). Urban design aesthetics: The evaluative qualities of building exteriors. *Environ. Behav.*, 26, 377–401.
6. Ng (2020). Perception and evaluation of buildings: The effects of style and frequency of exposure. *Collabra Psychol.*, 6.
7. Franz et al. (2005). An empirical approach to the experience of architectural space in virtual reality—exploring relations between features and affective appraisals of rectangular indoor spaces. *Autom. Constr.*, 14, 165–172.
8. Vecchiato et al. (2015). Electroencephalographic correlates of sensorimotor integration and embodiment during the appreciation of virtual architectural environments. *Front. Psychol.*, 6.
9. Ângulo & de Velasco (2013). Immersive simulation of architectural spatial experiences. In Proceedings of the XVII Conference of the Iberoamerican Society of Digital Graphics: Knowledge-Based Design Blucher Design Proceedings, Valparaíso, Chile; CumInCAD: Sao Paolo, Brazil, 2014; pp. 495–499.
10. Stemmler et al. (2001). Constraints for emotion specificity in fear and anger: The context counts. *Psychophysiology*, 38, 275–291.
11. Schönbauer (2013). Das Potenzial Privater Gärten Für Die Wahrgenommene Gesundheit. Ph.D. Thesis, University of Vienna, Vienna, Austria.
12. Mostajeran et al. (2021). Effects of exposure to immersive videos and photo slide shows of forest and urban environments. *Sci. Rep.*, 11, 3994.
13. Kennedy et al. (1993). Simulator sickness questionnaire: An enhanced method for quantifying simulator sickness. *Int. J. Aviat. Psychol.*, 3, 203–220.
14. Schubert (2003). The sense of presence in virtual environments. *Z. Für Medien.*, 15, 69–71.