PERCEIVED INTEREST AND HEART RATE RESPONSE TO FAÇADE AND DAYLIGHT PATTERNS IN VIRTUAL REALITY

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1. SUMMARY

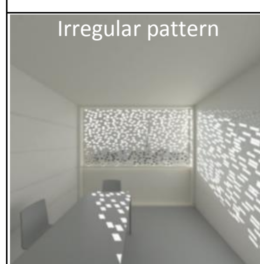
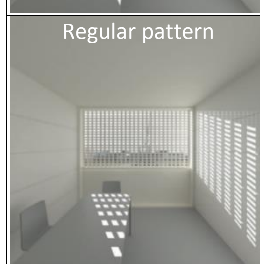
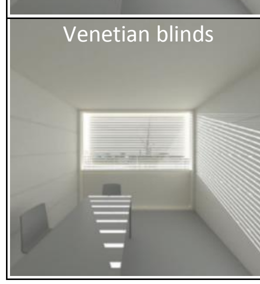
This contribution introduces an experimental study aiming to provide concrete evidence on how façade and daylight pattern geometry can affect the emotional responses triggered by a space. The study was conducted in Virtual Reality (VR) where participants were exposed to 360° scenes of an interior space with three different façade patterns. Their subjective evaluations and heart rate were recorded. The results show a statistically significant effect of façade on the perception of space, as well as the mean heart rate change. Specifically, during exposure to a façade with an irregular pattern, participants rated the space as more interesting and their mean heart rate was lower, resulting to a greater mean heart rate change compared to the resting state, providing quantifiable measures of the impact of façade characteristics on human perception and physiological behavior.

2. METHODOLOGY AND RESULTS

The profound impact of daylight on the subjective experience of a space has been widely acknowledged in the field of architecture (Pallasmaa, 2012; Zumthor, 2006). Current design practices tend to limit sunlight penetration in favor of visual comfort and energy efficiency, which has been criticized as leading to a monotonous light landscape (Corrodi and Spechtenhauser, 2008). Although various studies have highlighted the importance of contrast and luminance variability for the creation of interest (Parpairi et al., 2002; Rockcastle et al., 2016; Wymelenberg et al., 2010), we have limited knowledge on how the façade geometry and the resulting distribution of daylight patterns affect the experience of a space. Previous research has shown the importance of perceived order and complexity of the façade (Omidfar et al., 2015) and the irregularity in the distribution of openings on a façade (Chamilothori et al., 2016) based on evaluations with rating scales. Although this is an important step in uncovering the perceptual effects of façade geometry, the validity of rating scales in quantifying the perception of a lit environment has been questioned (Houser and Tiller, 2003). A two-step approach, combining subjective evaluations with an objective measure, has been suggested instead (Tiller and Rea, 1992).

Following this approach, the authors conducted a within-subject experiment where participants were immersed in VR scenes with different façade geometries, investigating the relation between façade patterns and emotion responses through subjective evaluations, but also measures of heart rate and skin conductance (Felnhofer et al., 2015; Izso et al., 2009; Lang et al., 1993). Three variations of façade patterns were investigated, with, as shared attributes, the façade material and the ratio of aperture (open to total façade surface), and as varied attributes, pattern regularity and geometry of aperture **(Table 1)**. The variations were developed following the workflow described in Chamilothori et al. (2016) and were projected in VR, which has been shown to accurately convey the perception of real spaces lit with daylight (Chamilothori et al., 2018). The three scenes were presented in random order to 72 participants (36 men and 36 women), however 16 were excluded after visual inspection of the physiological data due to anomalies or technical problems. The participants verbally evaluated

Table 1. The studied façades and the shared (✓) and unique (X) attributes between them.

Front view of interior scenes in virtual reality	Ratio of aperture	Clarity (Material)	Aperture geometry	Pattern regularity
Irregular pattern 	✓	✓	✓	X
Regular pattern 	✓	✓	✓	✓
Venetian blinds 	✓	✓	X	✓

how pleasant, interesting, and exciting the space was perceived (subjective response), while their heart rate and skin conductance were simultaneously recorded with the Empatica 4 wristband (McCarthy et al., 2016). For the sake of brevity, we discuss here solely the results regarding the perceived interest and the heart rate. A Friedman's ANOVA for the three façade types showed statistically significant differences of pattern geometry on both subjective and objective responses (perceived interest: chi-sq = 40.86, p<.001, mean heart rate change: chi-sq = 6,99, p<.05). Specifically, during exposure to the irregular pattern, participants rated the interest of the space higher, and had a stronger decrease in heart rate **(Fig. 2)**, which may witness coherent orienting effect (Laumann et al., 2003) toward this pattern. Pair-wise analysis with a Wilcoxon Signed-Ranks Matched-Pairs test showed significant differences between the irregular pattern and i) the venetian blinds (W = 101.5, p<.001, effect size r = 0.69) as well as ii) the regular pattern (W = 60.5, p <.001, r = 0.63) on the perceived interest, and only between the irregular pattern and the venetian blinds (W = 1111, p<.05, r = 0.34) on the heart rate change. The calculation of Spearman's rho showed a statistically significant negative correlation between mean heart rate change and interest (rho = -0.24, p<.05).

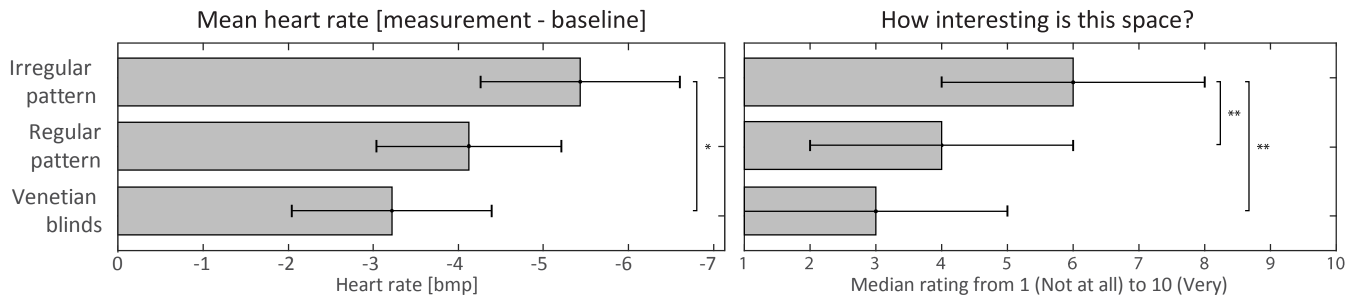


Fig. 2. Mean heart rate change and standard error of the mean for a 28s response window after event onset, measured with a frequency of 1Hz (left), and median reported interest and median absolute deviation (right) during exposure to different façades in VR. The paired comparisons with statistically significant differences are marked as follows: * = p<.05, ** = p<.001.

3. FUTURE WORK

Our results confirm that the effect of architectural façade elements on human experience is quantifiable and highlight the need for further studies on the perceptual and physiological effects of built environments. This study is part of a wider experimental investigation of the effect of façade characteristics on human perception and physiological behavior.

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