Façade design and our experience of space: the joint impact of architecture and daylight on human perception and physiological responses

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Daylight has an undeniable impact on our spatial experience, which has been broadly acknowledged in architecture [1]–[4]. However, current lighting practices and metrics tend to limit sunlight penetration, a trend that can lead to monotonous light landscapes [5]. Although daylight characteristics such as contrast and luminance variation [6]–[10], as well as their spatial distribution [11], [12], have been repeatedly linked with impressions of interest in lighting research, we have limited knowledge on how the façade geometry and the resulting sunlight patterns affect perception. This work investigates the architect's intuition on how façade geometry can impact occupant perception and compares this intuition with the evaluations of people experiencing scenes with different façade geometries.

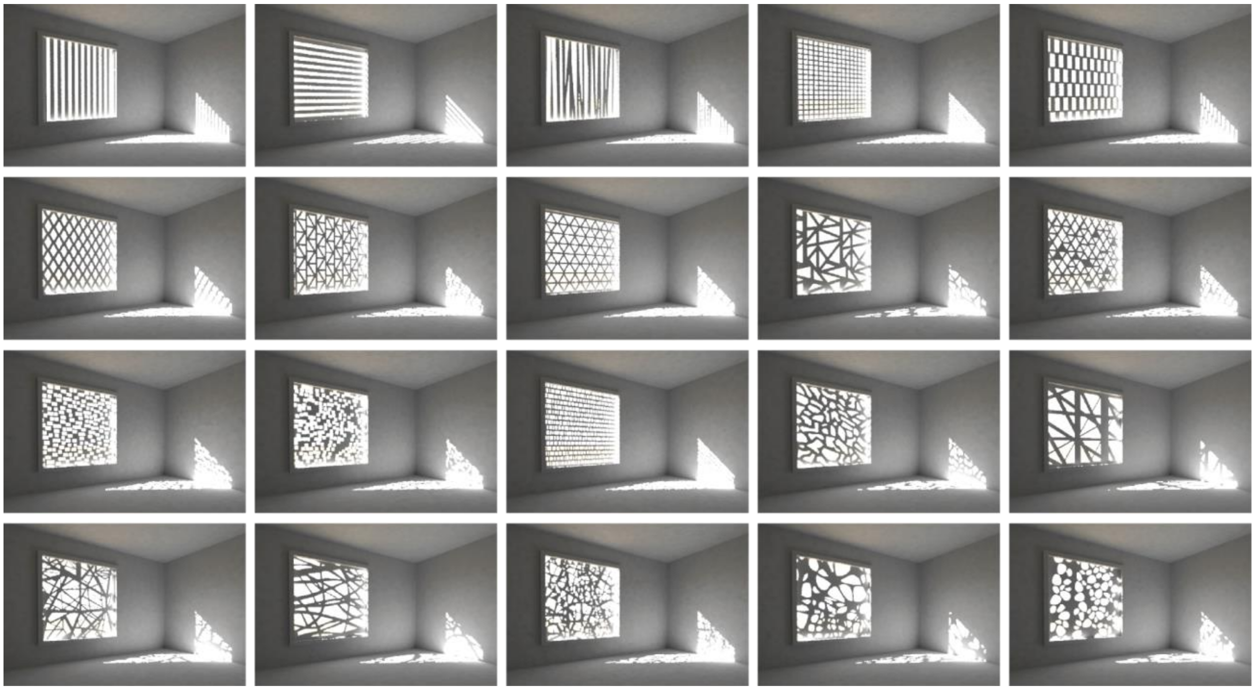

Figure 1. The façade patterns used in the paper-based survey on architects' intuition, based on façades of existing buildings. The patterns have the same perforation ratio and were shown in a random order.

Following an extensive review of architectural case studies, 20 façade patterns from existing buildings were selected and adjusted to a 40% perforation ratio, shown as one of the most preferred [13]. These patterns were applied to a sample scene and rendered with *Radiance* [14]. The resulting renderings (**Figure 1**) were used in a survey where 80 architects working in Switzerland indicated three patterns at a time which would make a space the *most exciting*, the *least exciting*, the *most calming*, and the *least calming*.

Patterns exhibiting great consensus regarding their potential to affect spatial experience were selected to further investigate occupant perception (**Figure 3**). Six patterns were applied to the 3D model of an existing building and were used to create omni-directional stereoscopic scenes, following an existing workflow which combines the use of physically-based renderings with projection in virtual reality [15]. The scenes were shown in an experimental study in VR using the Oculus CV1 headset, where 80 participants who have lived at least 2 years in Switzerland saw in random order all six façade variations, under two variations of clear sky, with furniture corresponding to social or working activity (**Figure 2**). The participants' subjective evaluations (such as how *exciting* and *calming* the space was perceived) and physiological responses (skin conductance and heart rate) were recorded using a questionnaire and an Empatica E4 bracelet [16], respectively.

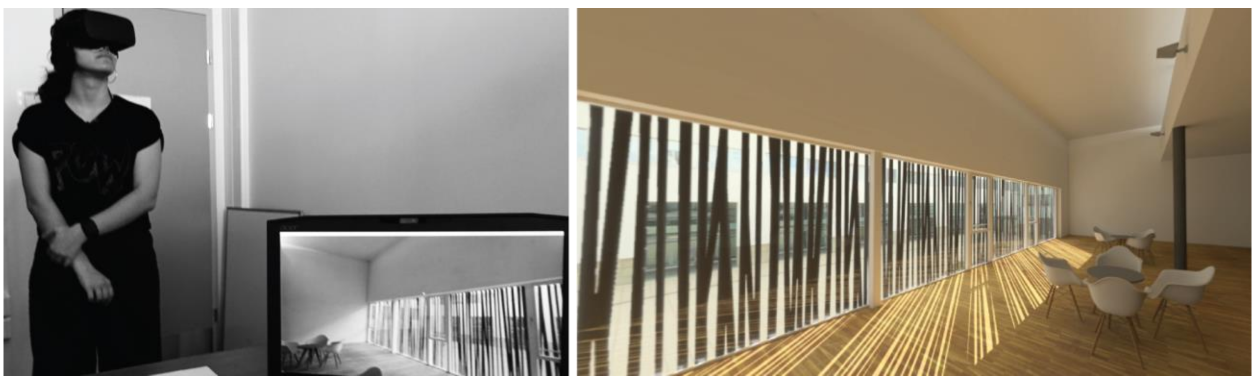

Figure 2. Photograph of a participant experiencing an immersive scene in VR (left) and indicative screenshot of such a scene where a subset of patterns selected from Figure 1 were applied to the façade of a simulated space.

The assessments of the architect's intuition show a high agreement, with cases of patterns chosen by 38-49% of the architects (**Figure 3**). In the experimental study, the direction of participants' evaluations is in agreement with the architects' intuition in the case of low complexity patterns, and differs in cases of high complexity patterns (**Figure 4**). This indicates cases of discord between expert and non-expert perception, and motivates further systematic study. Initial results from the heart rate measures reveal different responses between patterns, and highlight the potential for further research. Upcoming work will focus on the detailed analysis of the experimental results to investigate their relation with previous findings by the authors on the effect of façade characteristics on subjective and physiological responses [17], [18], and broaden our understanding on the complex effects of daylight and architecture on people.

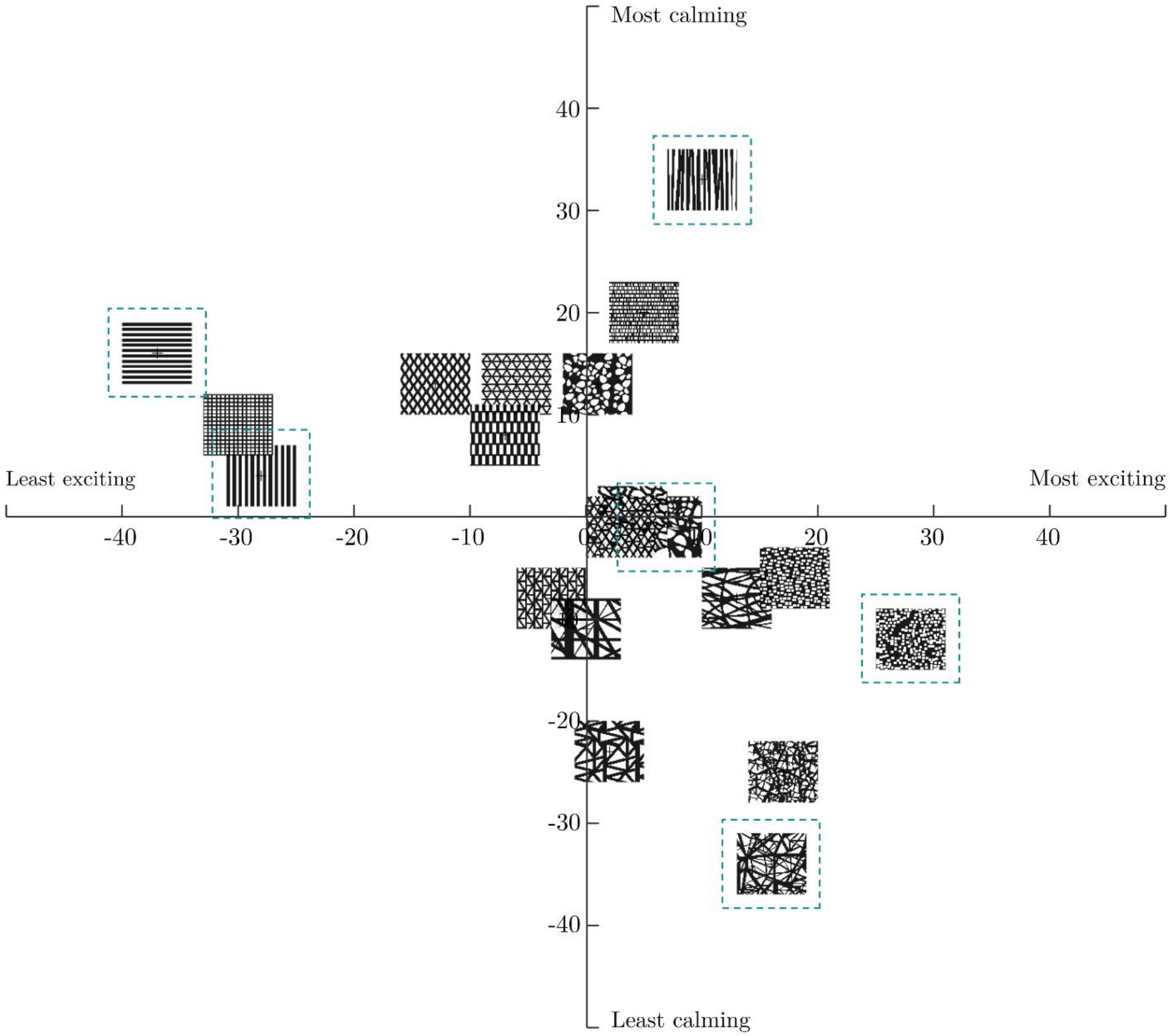

Figure 3. Distribution of the 20 patterns in the dimensions of calming and exciting based on the survey of architect's intuition, corresponding to the difference between how often a pattern was selected as the most and least representative pattern in each dimension. The highlighted patterns were used in the immersive scenes in VR.

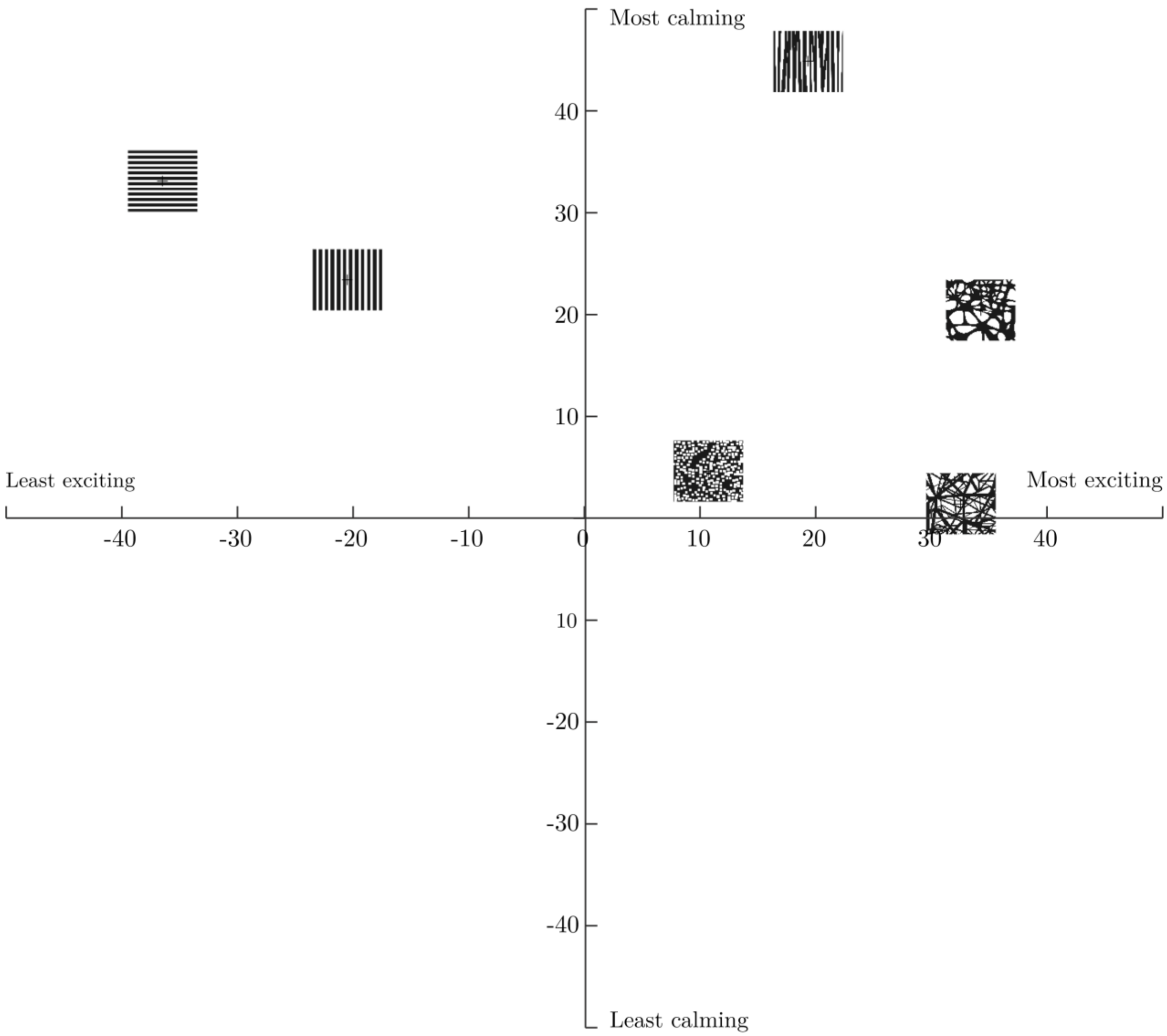

Figure 4. Distribution of the subset of patterns from Figure 3 in the dimensions of *exciting* and *calming* based on difference between the percentage of responses where each pattern was evaluated in the positive range (>5) and the negative range (<5) on a rating scale from 0 (Not at all) to 10 (Very) in the experiment in virtual reality.

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