Light, architecture, and our experience of space: human responses to façade and daylight composition

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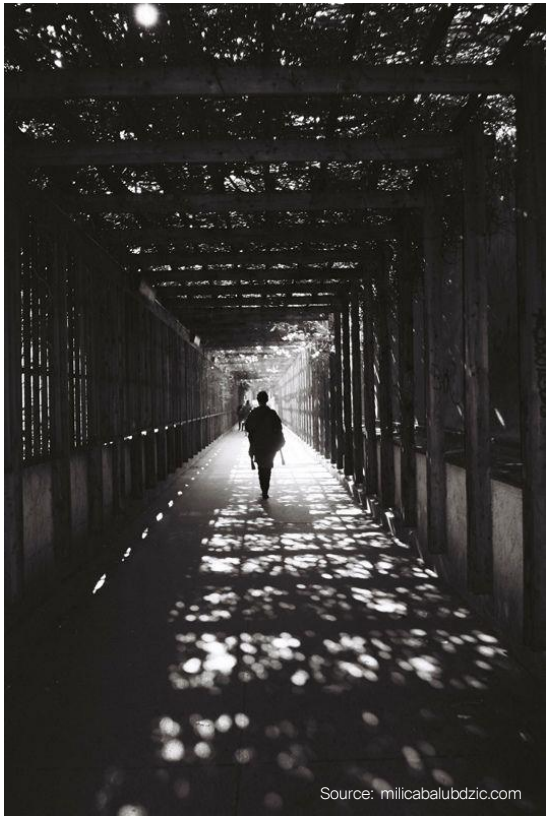
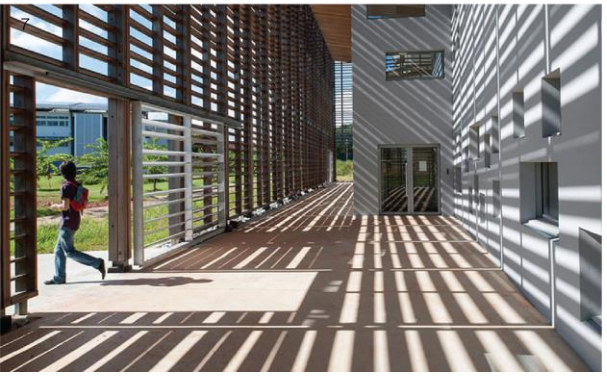
Can the **composition of daylight** change how we **experience** a space?

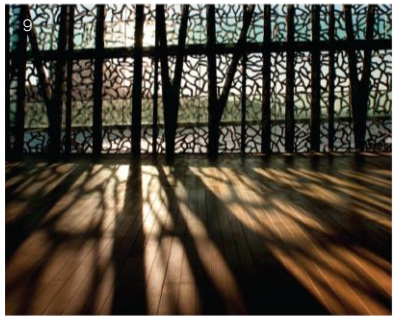
Raas Haveli Hotel, *The Lotus Praxis Initiative,*
Jodhpur, 2011

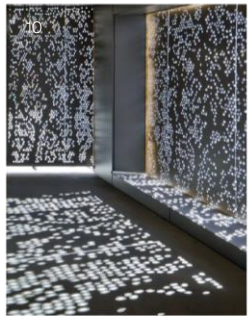


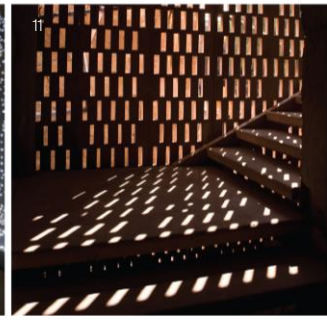
Light through leaves, *Milica Balubdzic,*
Vienna*, 2011*

Façade patterns in **contemporary architecture**









Source: Archdaily.com [1] Mirror Tower, LAN Architecture, Beirut, Lebanon, 2009 [2] Petit Mont-Riond, CCHE, Lausanne, Switzerland, 2015 [3] La Tallera, Frida Escobedo, Morelos, Mexico, 2010 [4] 2Y House, Sebastián Irarrázaval, Colico, Chile, 2013 [5] Carabanchel Housing, Foreign Office Architects (FOA), Madrid, Spain, 2007 [6] Wintergarden Façade, Studio 505, Brisbane, Australia, 2012 [7]] New University Library, rh+ architecture, Cayenne, French Guiana, 2013 [8] FT House, Reinach Mendonça Arquitetos Associados, Bragança Paulista, Brazil, 2014 [9] MuCEM, Rudy Ricciotti, Marseille, France, 2013 [10] Minergie P-EFH Zimmermann, Vomsattel Wagner Architekten, Visp, Switzerland, 2010 [11] Raas Jodhpur, The Lotus Praxis Initiative, Rajasthan, India, 2011.

Can the **façade geometry** and the resulting **daylight patterns impact human responses**?

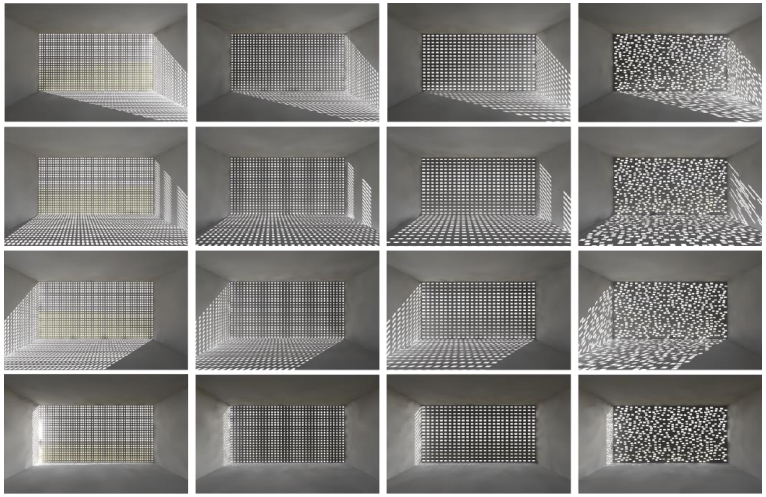
Influence of the expected **space function**

[Butler and Biner, 1987, 1989; Boyce 2003; Wang and Boubekri 2010]

Influence of **regional differences**

[Park and Farr 2007; Liu et al. 2015; Okamura et al. 2016; Veitch et al. 2019]

Subjective experiments with different conditions of **façade and daylight patterns**



VARIATION OF DAYLIGHT

VARIATION OF VIEW

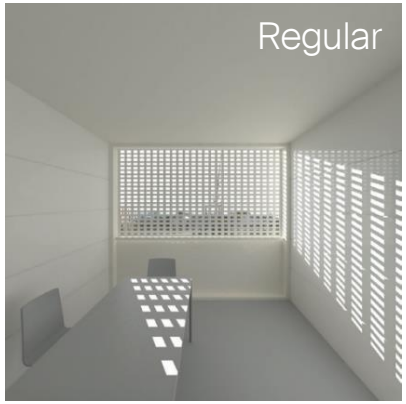
immersive virtual reality
as an **experimental tool**

Is **virtual reality** an **adequate surrogate** for experiments in **real spaces**?

- **VR scenes** using physically-based renderings: **suitable** to **investigate perception of daylit scenes**
- High perceptual accuracy, minimal physical symptoms (sore eyes), high perceived presence

► Chamilothori, K., Wienold, J. & Andersen, M. 2019. Adequacy of immersive virtual reality for the perception of daylit spaces: comparison of real and virtual environments, *LEUKOS,* 15 (2-3), 203-226.

Can **façade** and **daylight pattern** geometry impact our **subjective** and **physiological responses**?



Experimental factors	Levels
Façade geometry*	3 (Irregular, Regular, Stripes)
Spatial context scenario	2 (socializing, working)

*Within-subject factor

Participants	Gender distribution
71*	36 men, 35 women

*58 for physiological responses (30 men, 28 women)

How { pleasant / interesting / exciting } is this space?

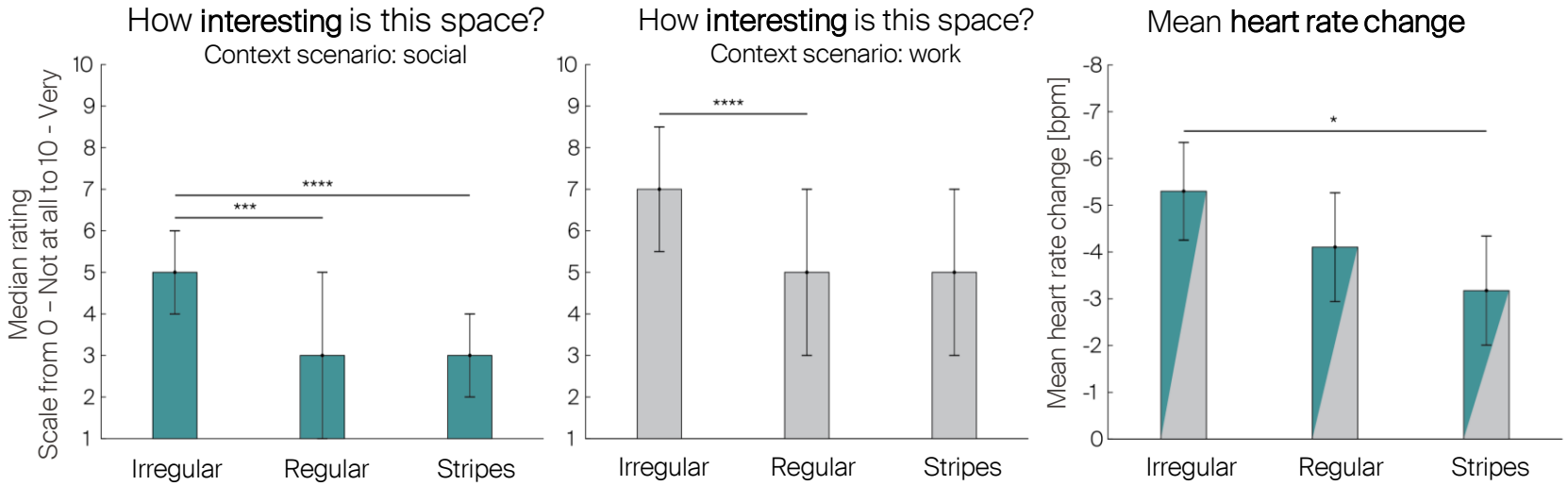
Rating scale: 1 (Not at all) – 10 (Very)

What is the participants' heart rate and skin conductance while immersed in the different scenes in VR?

Measured with an Empatica E4 bracelet, first 28 seconds of exposure

Datasets used:
Social context (N=35)
Working context (N=36)
Social and working context (N=58)

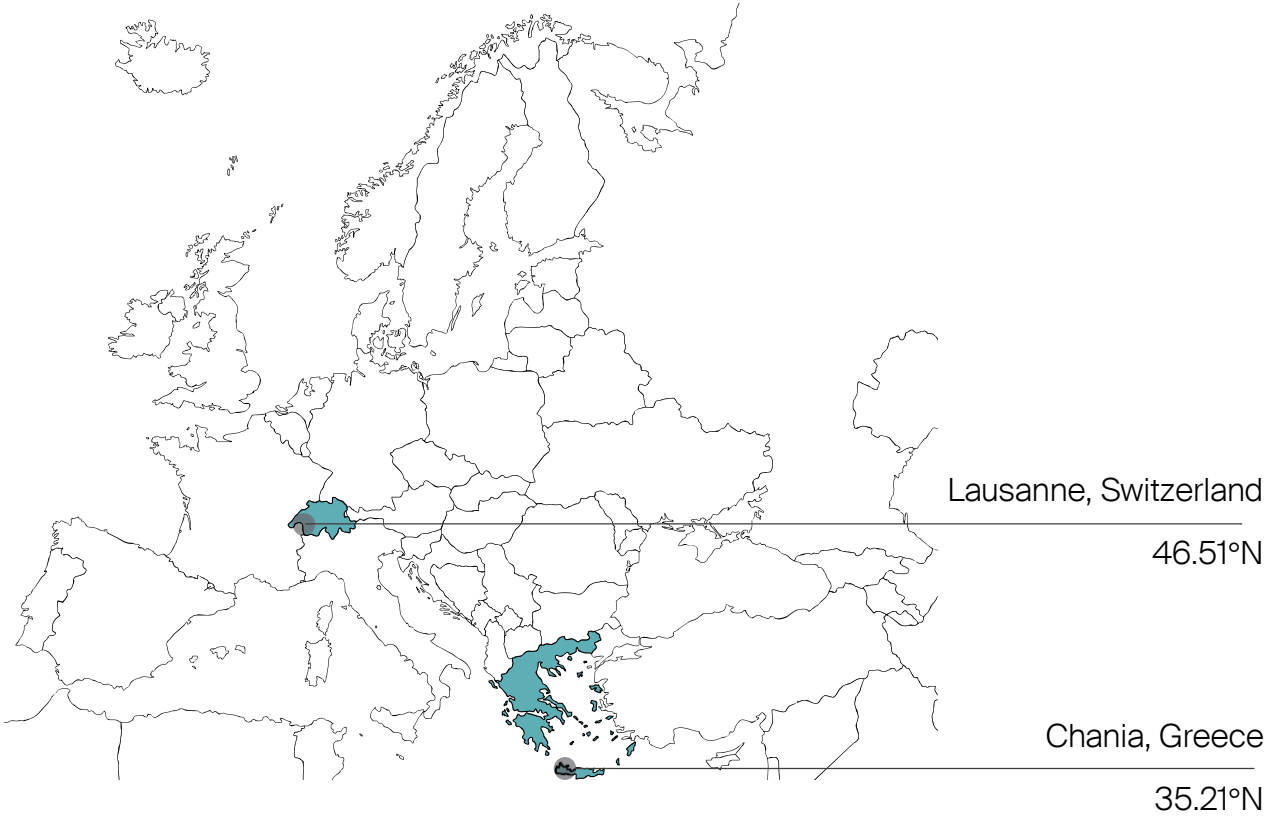
Significance level:
* = p.<.05
*** = p<.001
*****= p<0.0001



- **Effect of façade geometry** on impressions of pleasantness, interest, excitement
- **Irregular geometry** perceived **more positively** independently of context scenario
- Façade and daylight variations affected both **the appraisal of space** and **the participants' heart rate**

► Chamilothori, K., Chinazzo, G., Rodrigues, J., Dan-Glauser, E. S., Wienold, J., & Andersen, M. (2019). Subjective and physiological responses to facade and sunlight pattern geometry in virtual reality. *Building and Environment*, 150, 144-155.

Do **subjective responses** to **façade** and **daylight patterns change** across **latitudes?**



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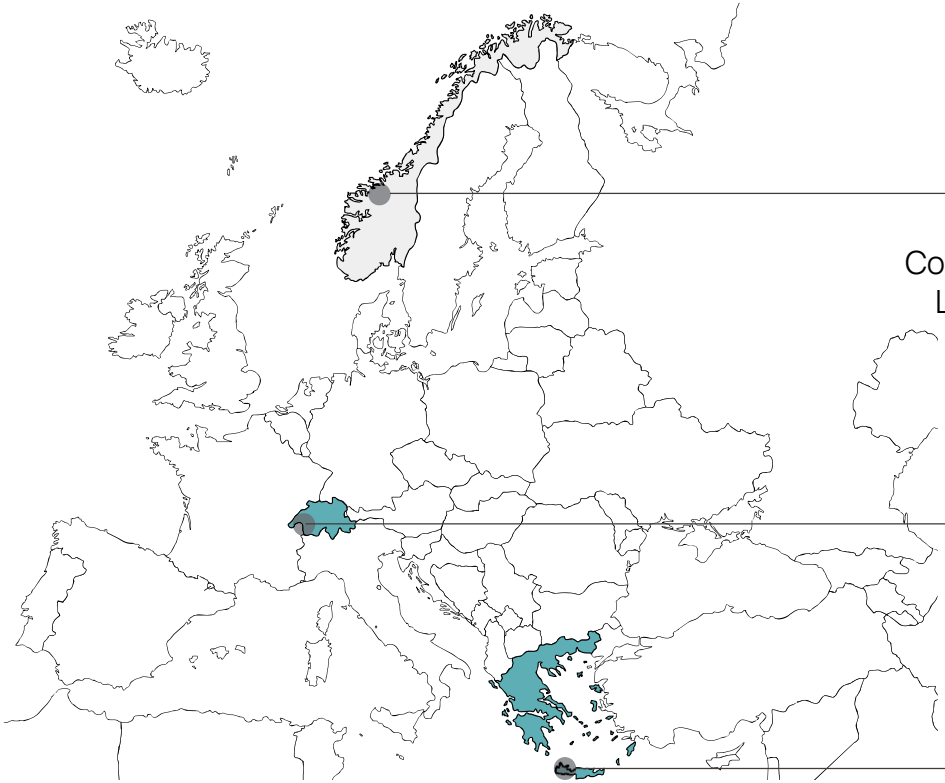


Trondheim, Norway

63.42°N

Collaboration with NTNU,
Light and Colour Group

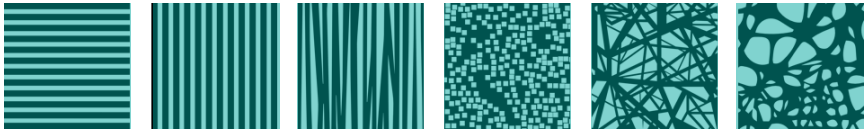
Lausanne, Switzerland

46.51°N

Chania, Greece

35.21°N

Experimental design



Experimental factors

Façade geometry*

Sky type

Spatial context

Country

*Within-subject factor

Participants

120 in Switzerland

138 in Greece

Experimental design

clear sky with high sun angle

clear sky with low sun angle

overcast sky

Experimental factors

Façade geometry*

Sky type

Spatial context

Country

*Within-subject factor

Participants

120 in Switzerland

138 in Greece

Experimental design

social context

working context

Experimental factors

Façade geometry*

Sky type

Spatial context

Country

*Within-subject factor

Participants

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Experimental design

Experimental factors
Façade geometry*
Sky type
Spatial context
Country

*Within-subject factor

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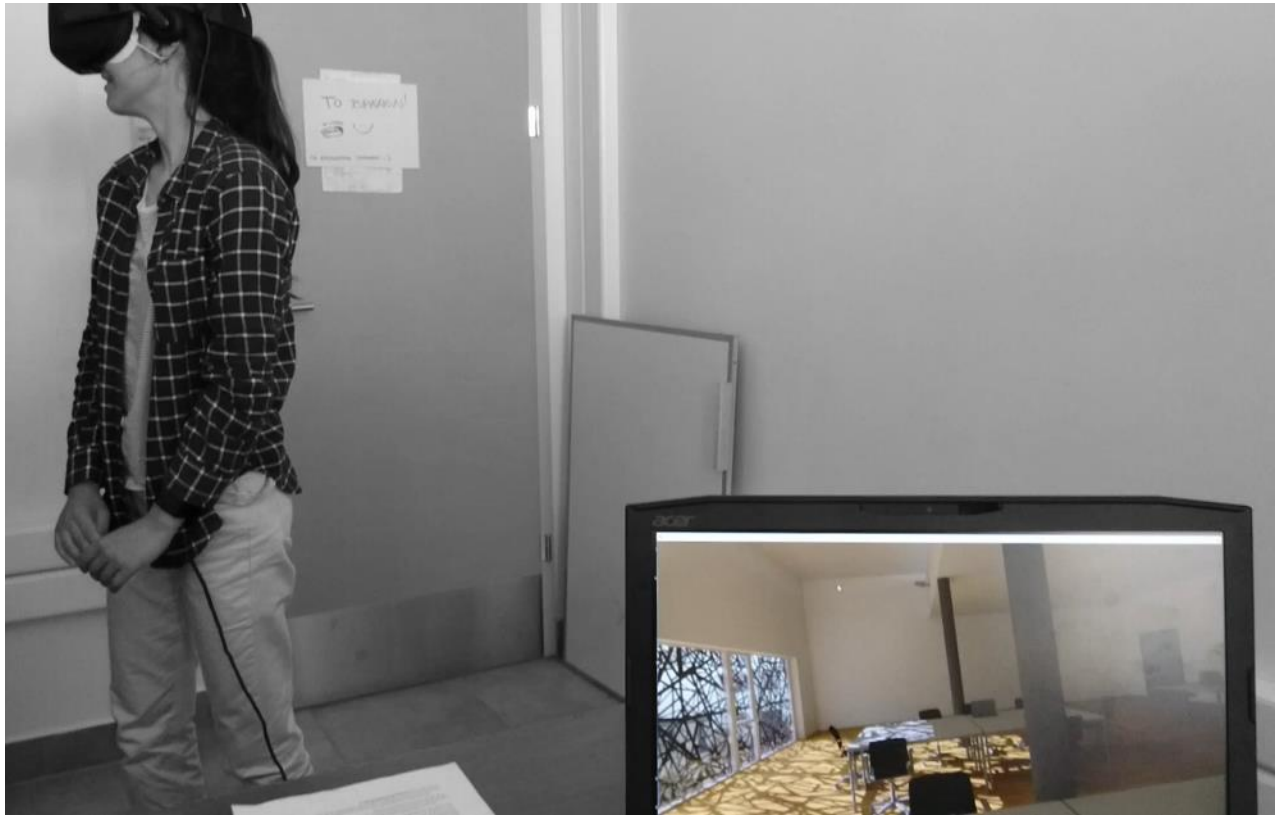


Each participant is shown all **six façade variations**

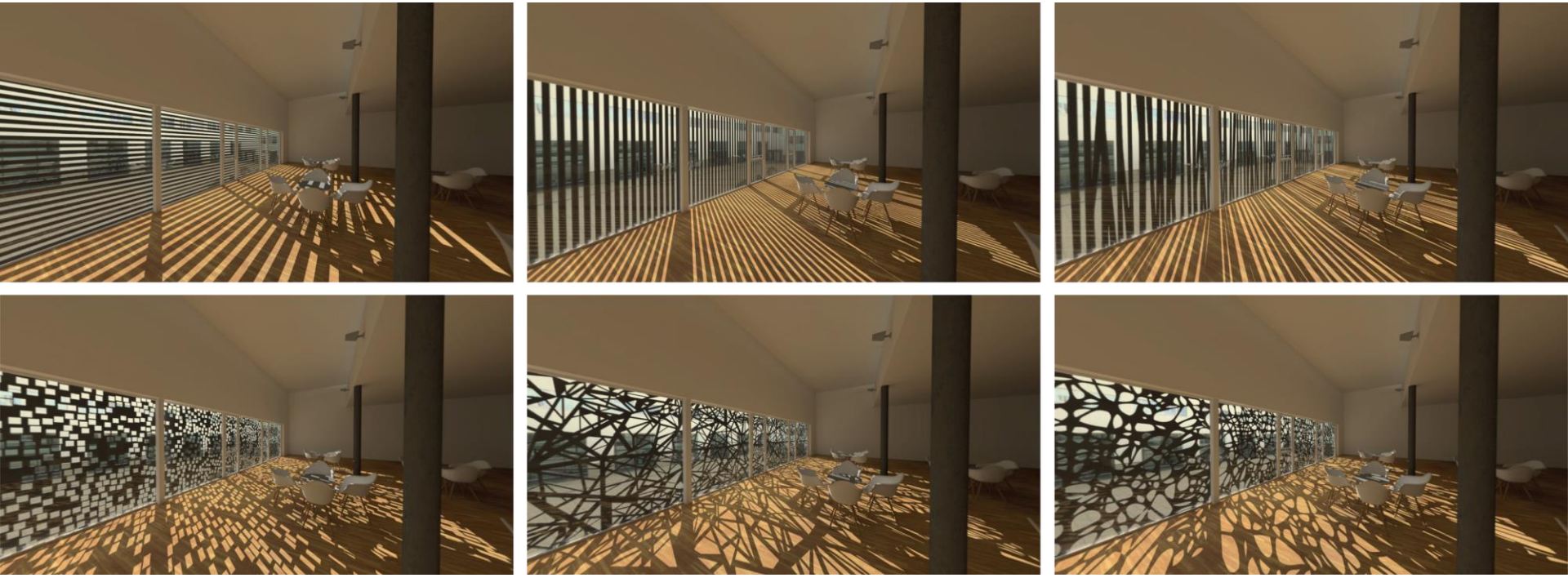
How { pleasant / interesting / exciting / calming } is this space?

How { complex / spacious / bright } is this space?

How satisfied are you with the amount of view in this space?

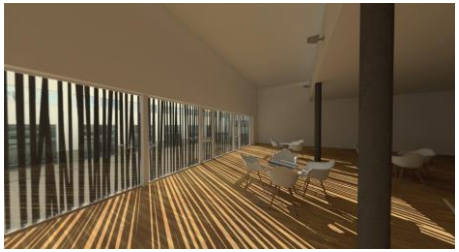
Rating scale: 0 (Not at all) – 10 (Very)

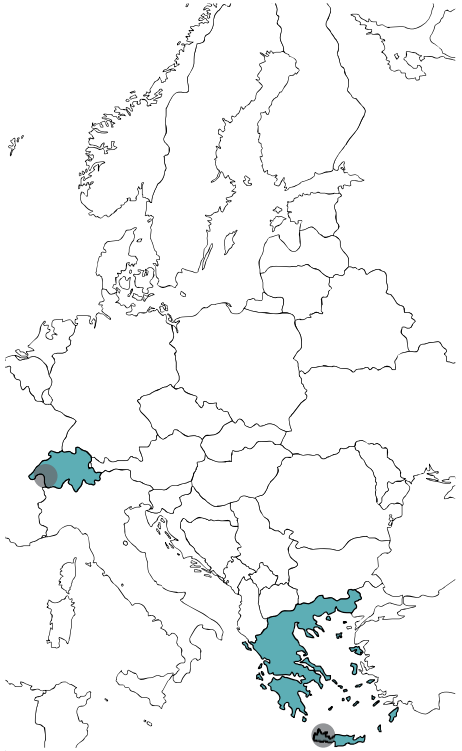
Results



- **Significant effects** of **façade geometry** for all studied attributes

Results



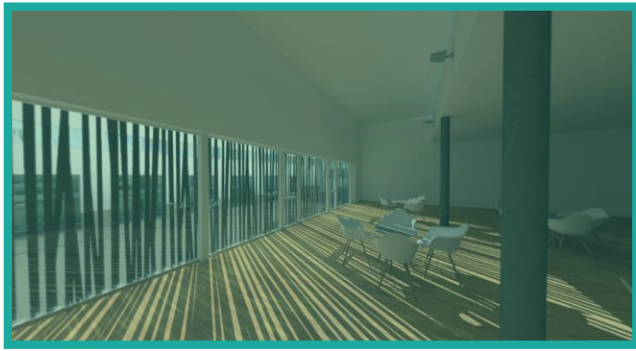
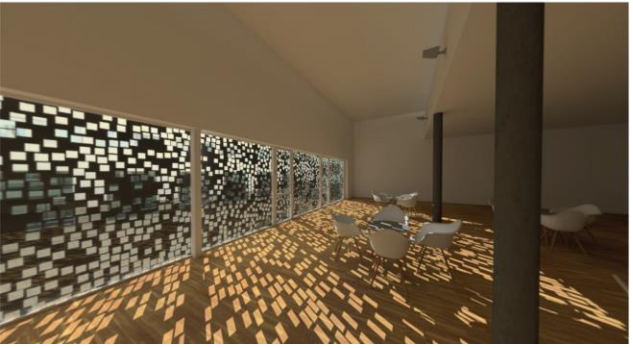
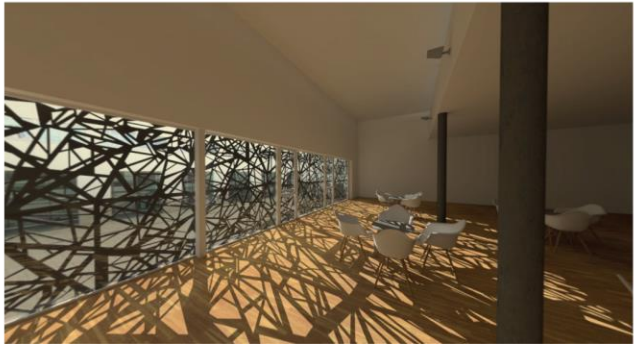
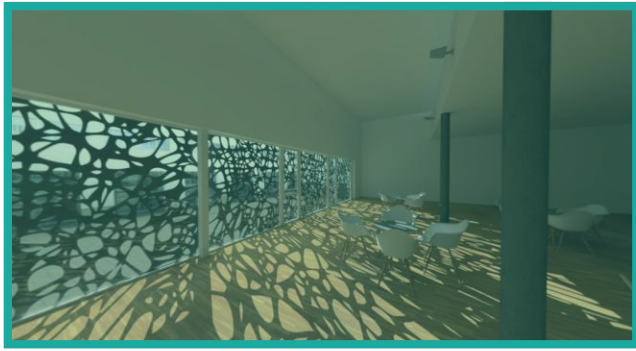


- No effect of sky type
- No effect of spatial context
- No regional differences

How **pleasant** is this space?

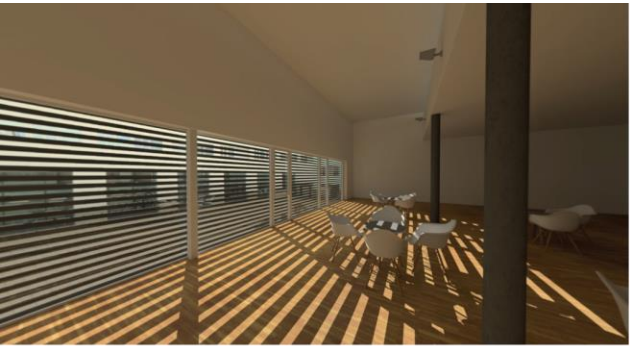
How **calming** is this space?

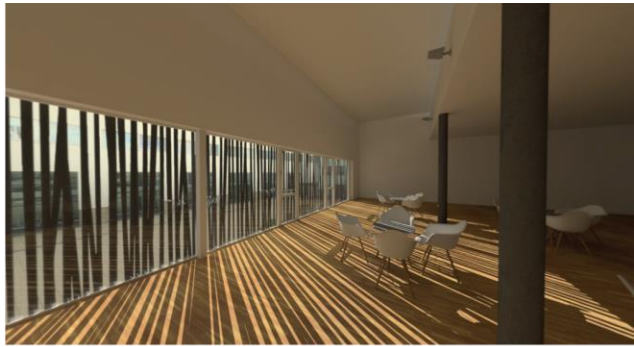
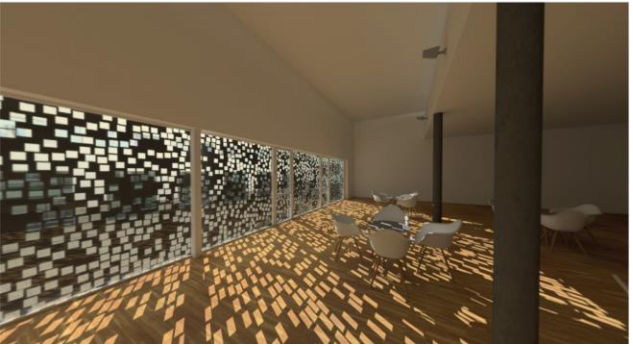
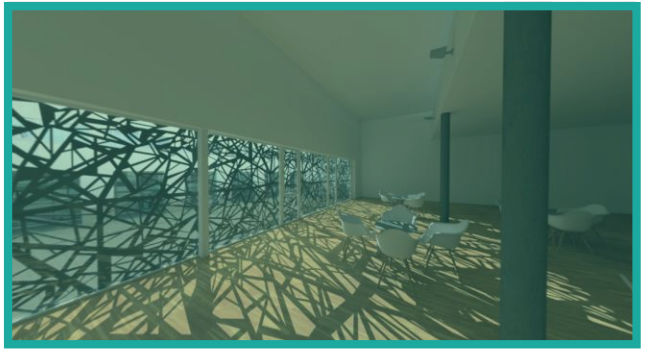
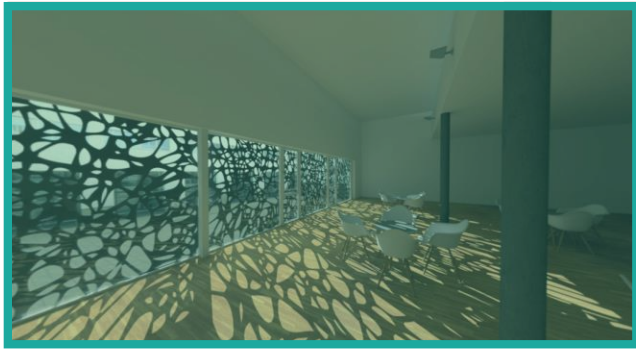


How **interesting** is this space?

How **exciting** is this space?



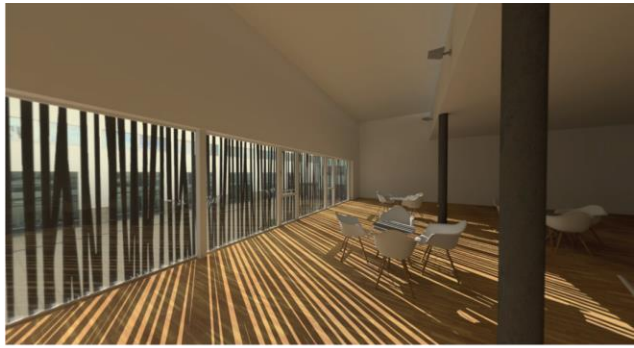
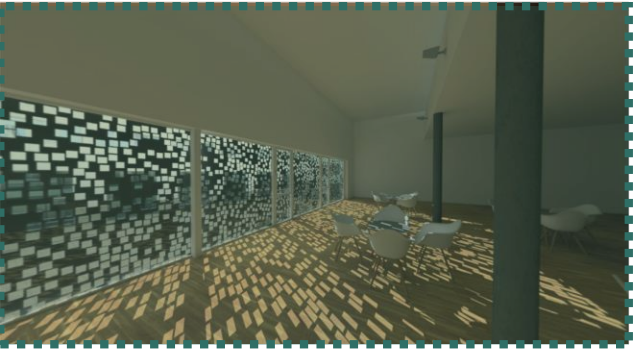
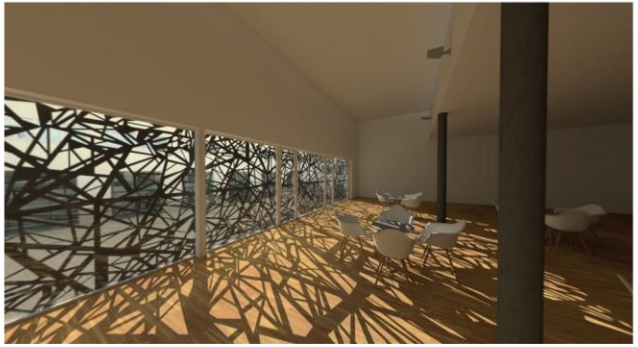
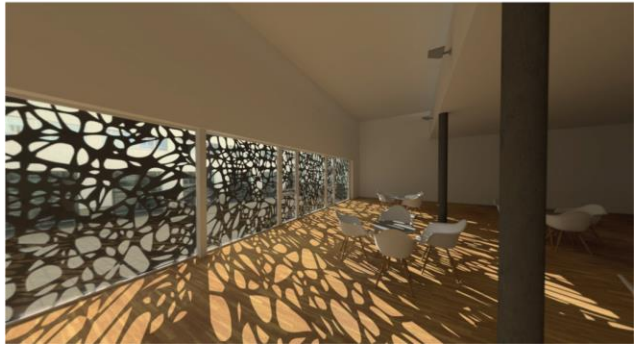





How **spacious** is this space?

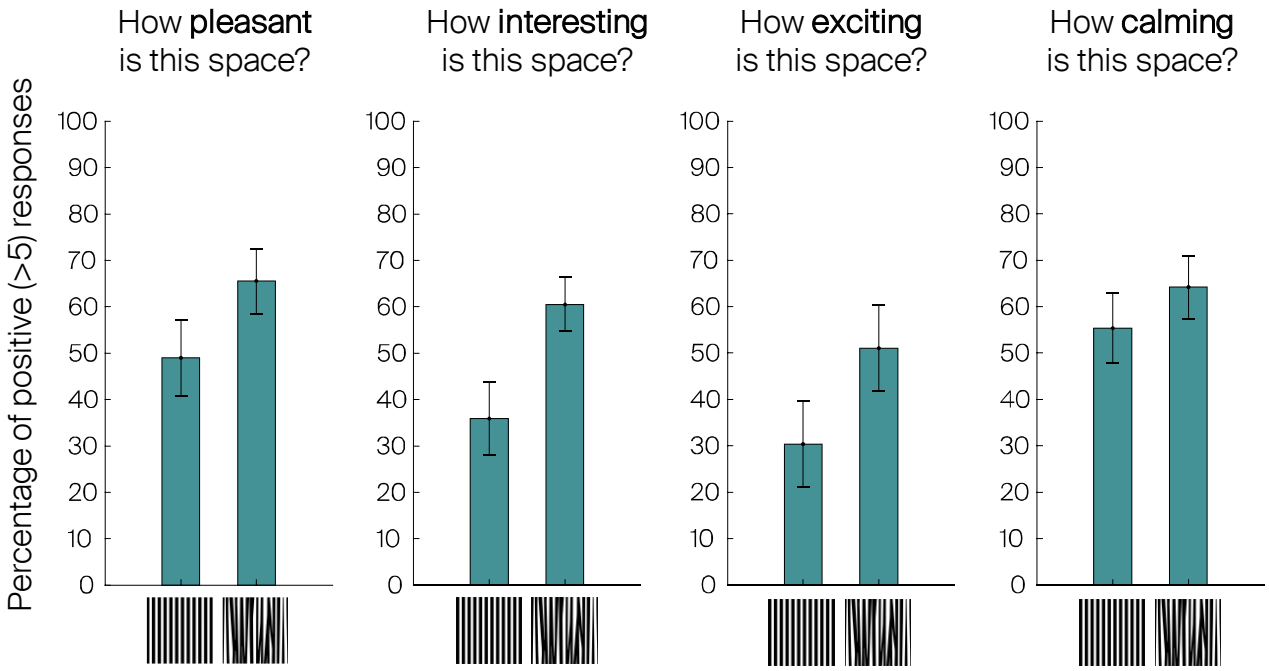
How **bright** is this space?

How **satisfied** are you with the **amount of view** in this space?



Straight versus slightly skewed vertical elements






- **Façade geometry** is shown to be the **main driver** of **spatial experience,** inducing **robust perceptual effects** that **do not differ** between different **sky types, spaces, window sizes,** or **latitudes**

Key outcomes

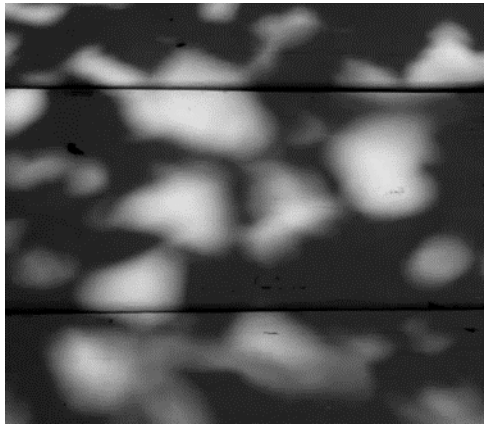
- **Development** and **validation** of a **novel experimental method** that combines photometrically accurate images with immersive virtual reality

- Demonstrated for the **first time that façade elements** and their **interplay with light** can have a quantifiable **physiological effect** on humans

- Even seemingly **small changes** in the façade geometry can have a **strong effect** on **perception**

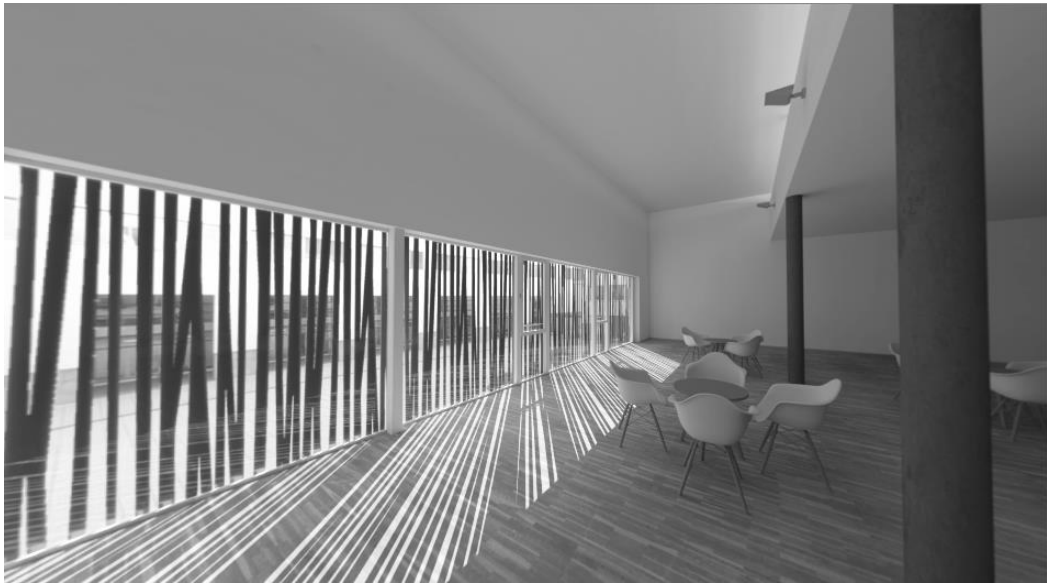
Future research directions

- **Replication** of experiments in **real space**
- Can the **light pattern** alone influence **human responses**?
- **Static** and **kinetic façades,** applications in **dynamic lighting**



Dappled Light,
Jody Verser,
2015

Qiyao Interactive Entertainment Company Offices,
Joe Ho Associates,
Guangzhou, China, 2017



Thank you!