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# Method for Evaluating Fidelity of Restitution of Subjective Impressions in Immersive Virtual Reality in Daylit Interior Scenes

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## Introduction

**Natural Light in Architectural Education:** A significant sensory phenomenon that presents challenges often encountered by architecture students during conceptual design process

**Role of Virtual Reality (VR):** Emerged as a tool in architectural design education to enhance user experience and create immersive scenarios [1]

**Challenges with VR in Daylight Study:** Provides opportunities for visualizing 360° daylit scenes [2], but fidelity must be carefully examined for faithful representation of subjective impressions of luminous atmospheres

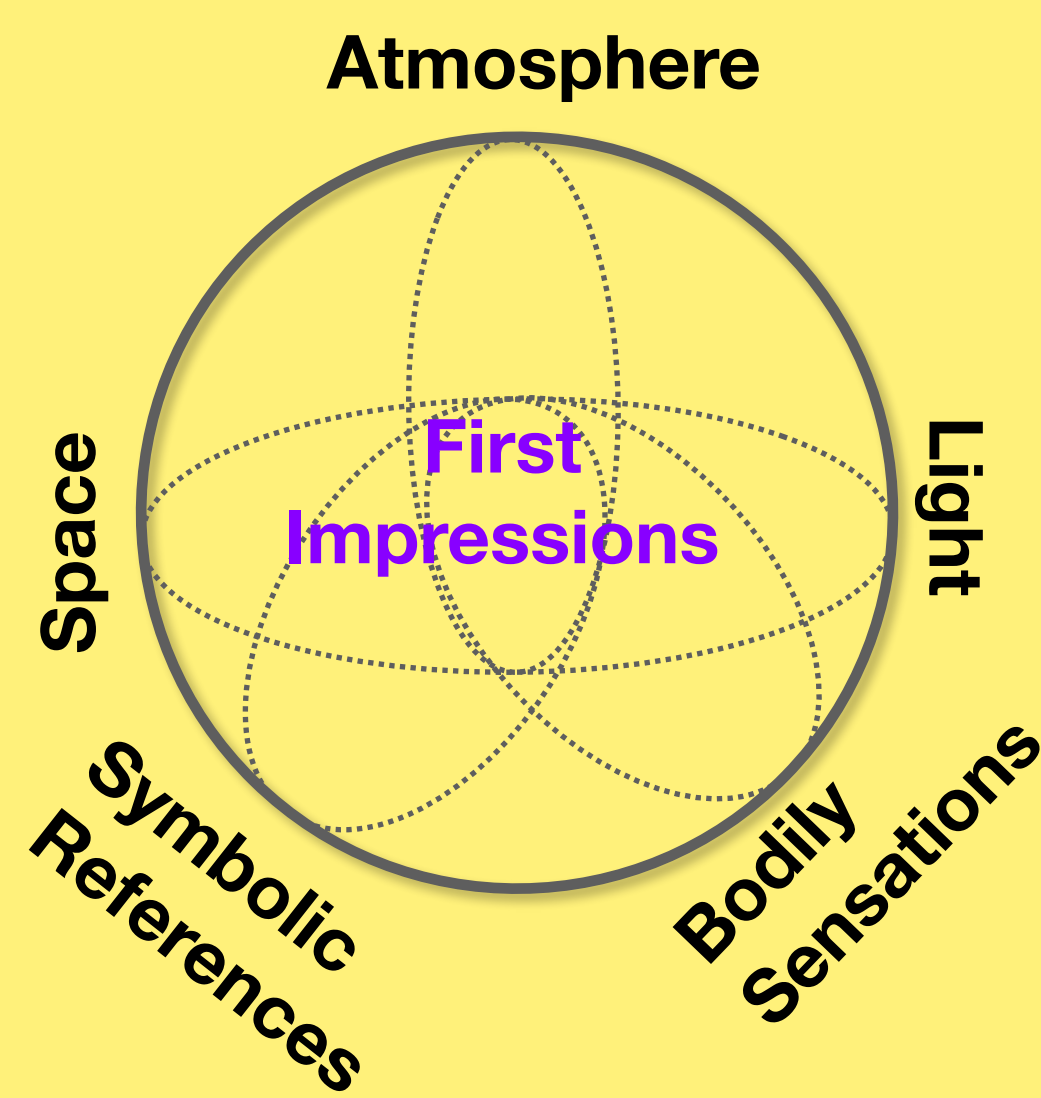
**Study's Novel Method:** Explores the fidelity of an immersive head-mounted display (HMD) in accurately reproducing subjective impressions related to luminous atmospheres of different buildings

## Method

### 1 Selection of Buildings and Questionnaire

**Questionnaire Creation:** Built to evaluate five types of impressions and first impressions

**Expert Source:** Questionnaire derived from experts' vocabulary



**Choice of locations:** Examined seven different locations each offering distinct lighting ambiances designed by renowned architects



**Methodology:** Compares subjective impressions of luminous atmospheres in different real daylit environments to those in immersive environments using 360° stereoscopic equirectangular images on HMD

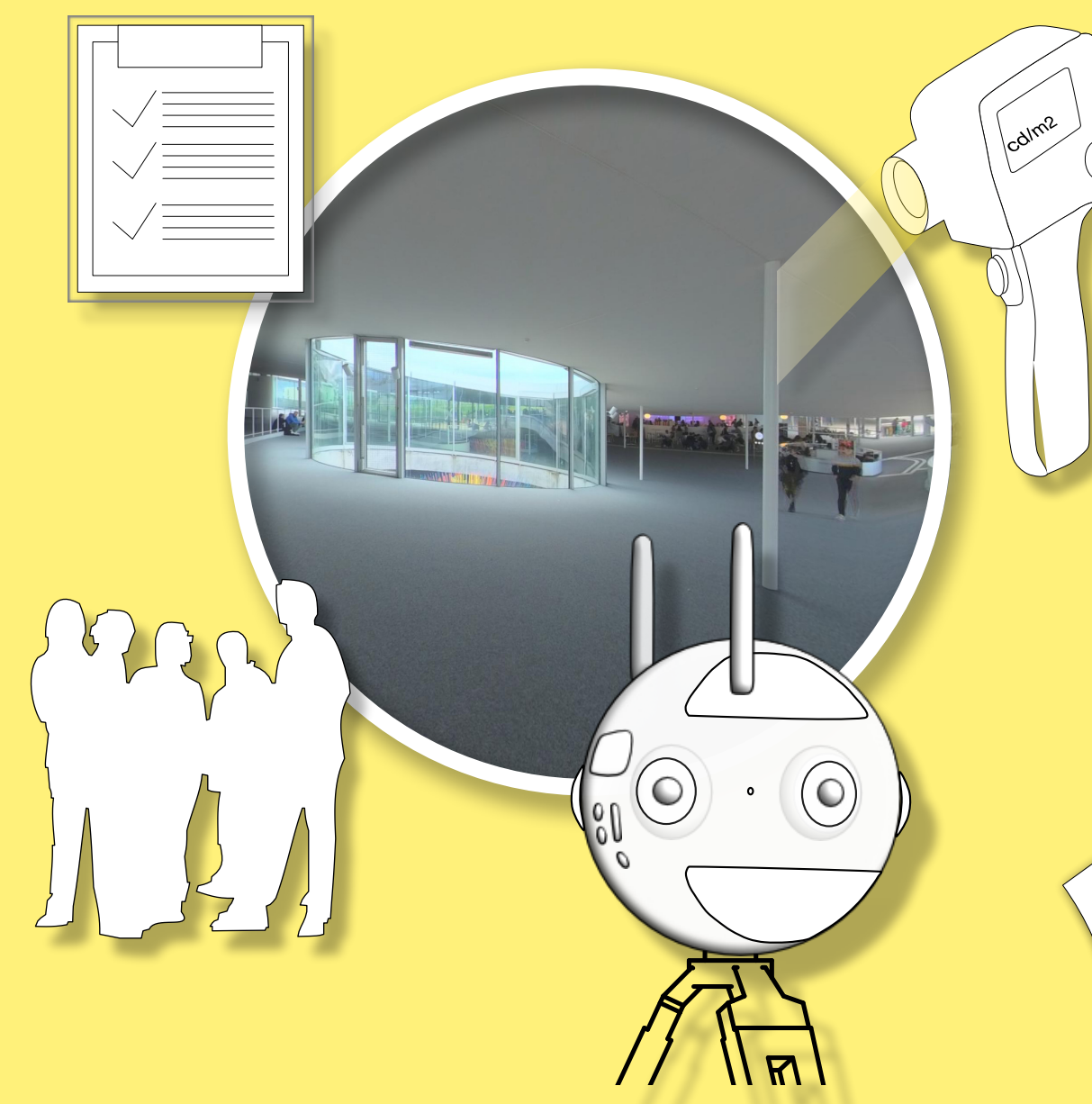
### 2 Evaluation of Impressions in Real Buildings

**Surveys Conducted:** Ran in all selected places across several days and different lighting conditions with built questionnaire

**Image Capturing:** Captured 360° stereoscopic equirectangular images with Insta 360 Pro2 under different light conditions

**Measurements:** Conducted luminance and illuminance with light meter and photometer

**Participants:** 532 participants across all buildings



### 4 Evaluation of Impressions in VR

**Experiment:** Ran using HTC Vive Pro 2

**Participants:** 30 participants

**Scenes Projected:** Selected one scene (light condition) for each of the seven places and projected for all participants

**Effect Studied:** Studied the effect of TMOs on the evaluation of impressions

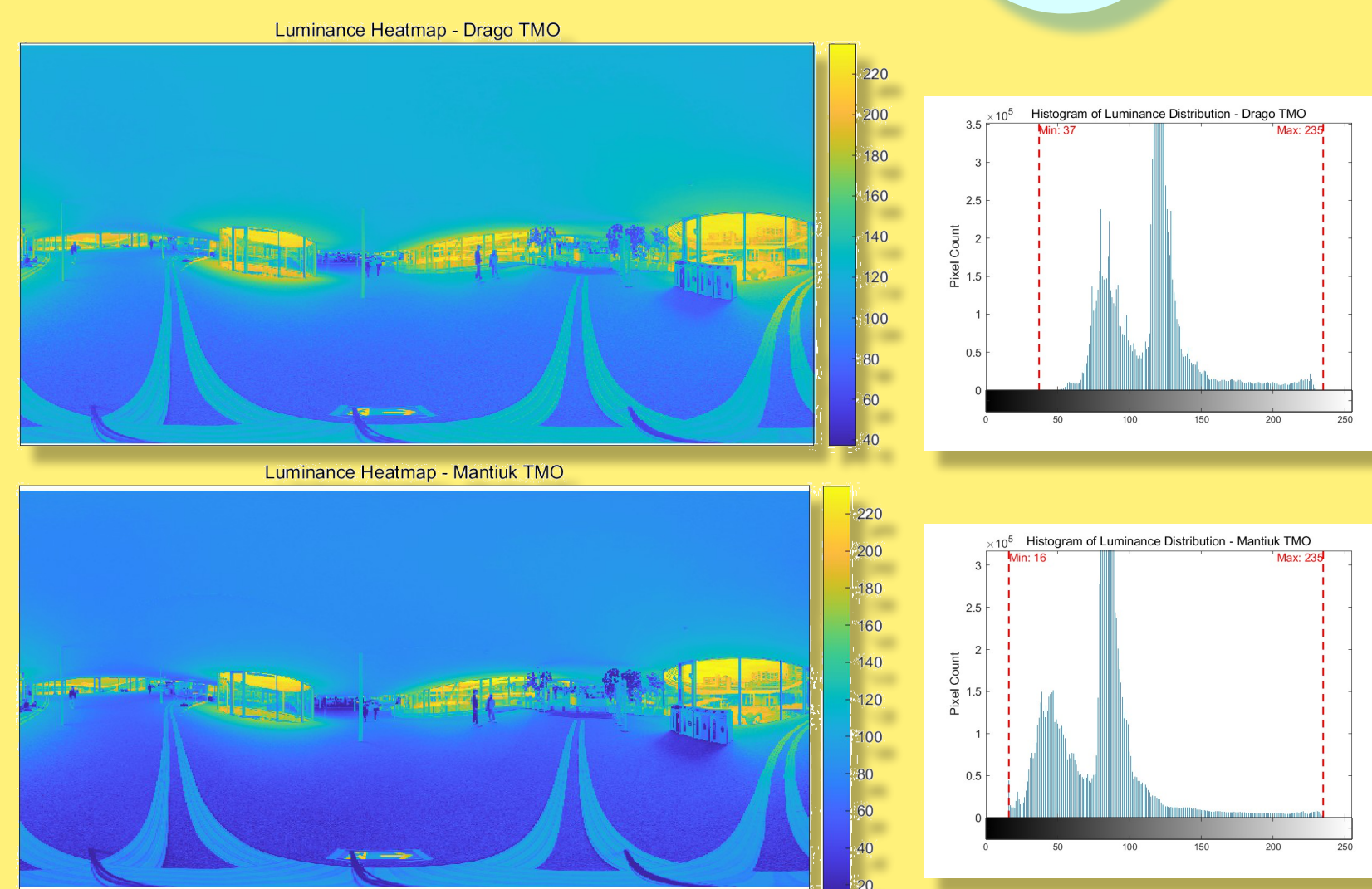
**Questionnaire:** Used the same as in the real places



### 3 Post-Processing

**Image Processing:** Stitched and merged nine exposures for all scenes for both left and right eye into HDR images

**Tone-Mapping (TMOs):** Applied three TMOs on all HDR scenes



## Results

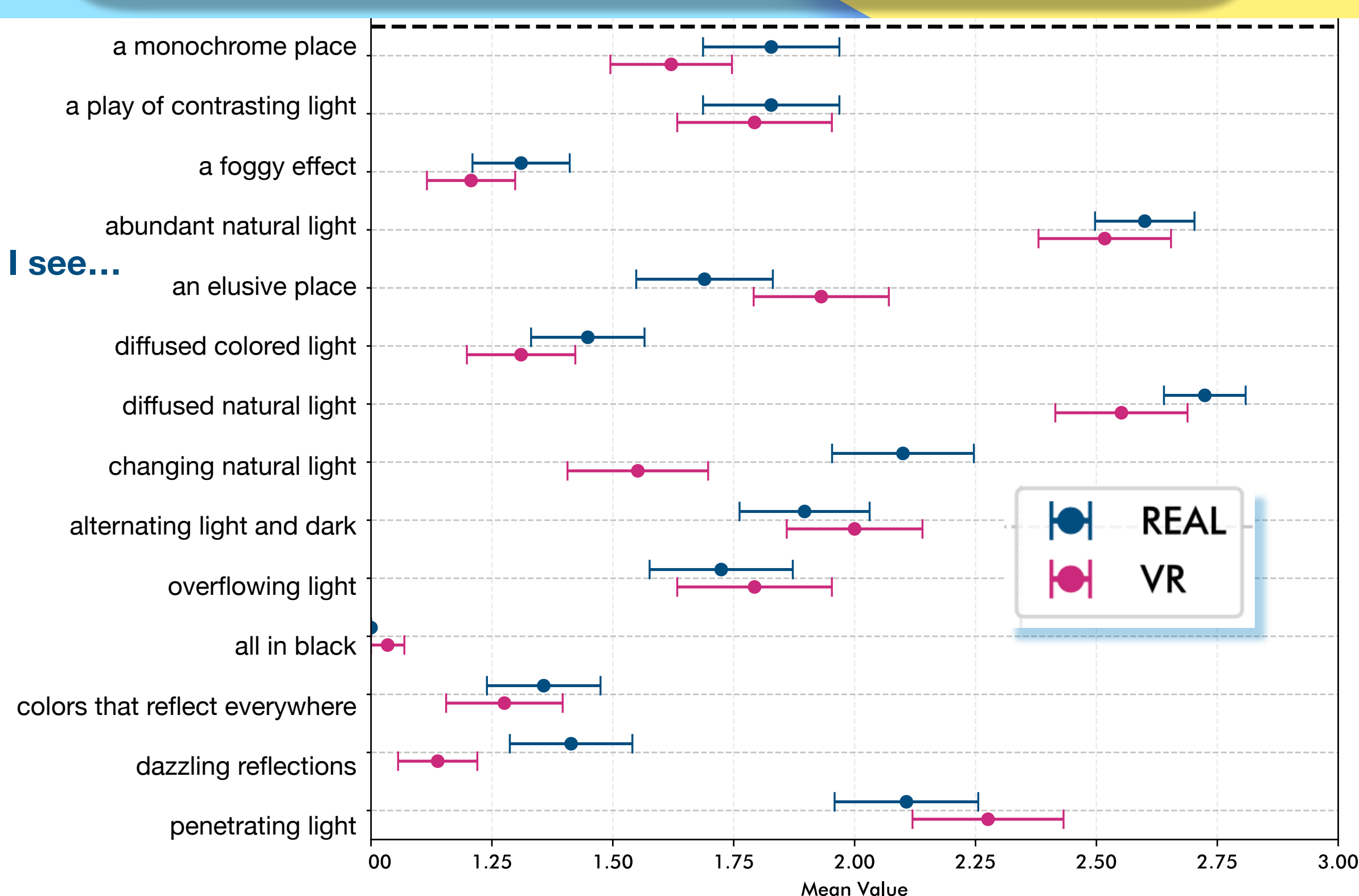
**Data Excerpt:** 30 participants in one real light condition of one location "Bourse de Commerce, Paris"

30 participants in VR

Focus on **light impressions in one location**

**Differences:** "Dazzling reflections" and "Changing natural light" less important in VR

**Overall Findings:** Most impressions match between real and VR



## Discussion and Future Work

**Conclusions and Limitations:** Findings indicate that HMD offer a high level of fidelity in restituting one aspect of subjective impressions for a single real light condition in one location. Differences in dazzling and changing light observed due to the limited contrast ratio of the screen and varying weather conditions in real location, respectively.

**Future Work:** Future studies will examine all aspects of impressions across all buildings as well as effect of TMOs on the evaluation of these impressions.

### References

- [1] Antonieta Angulo. 2015. Rediscovering Virtual Reality in the Education of Architectural Design: The immersive simulation of spatial experiences. *Ambiances. Environnement sensible, architecture et espace urbain* 1 (2015).
- [2] Kynthia Chamilothoni, Jan Wienold, and Marilyne Andersen. 2019. Adequacy of immersive virtual reality for the perception of daylit spaces: comparison of real and virtual environments. *Leukos* 15, 2-3 (2019), 203-226.

### Acknowledgments

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