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► To cite this version:

Michèle Atié, Céline Drozd, Toinon Vigier, Daniel Siret. Method for Evaluating Fidelity of Restitution of Subjective Impressions in Immersive Virtual Reality in Daylit Interior Scenes. CIE 2023-30th Quadrennial Session of the CIE, Sep 2023, Ljubljana, Slovenia. 2023. ⟨hal-04259858⟩

HAL Id: hal-04259858

<https://hal.science/hal-04259858v1>

Submitted on 26 Oct 2023

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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

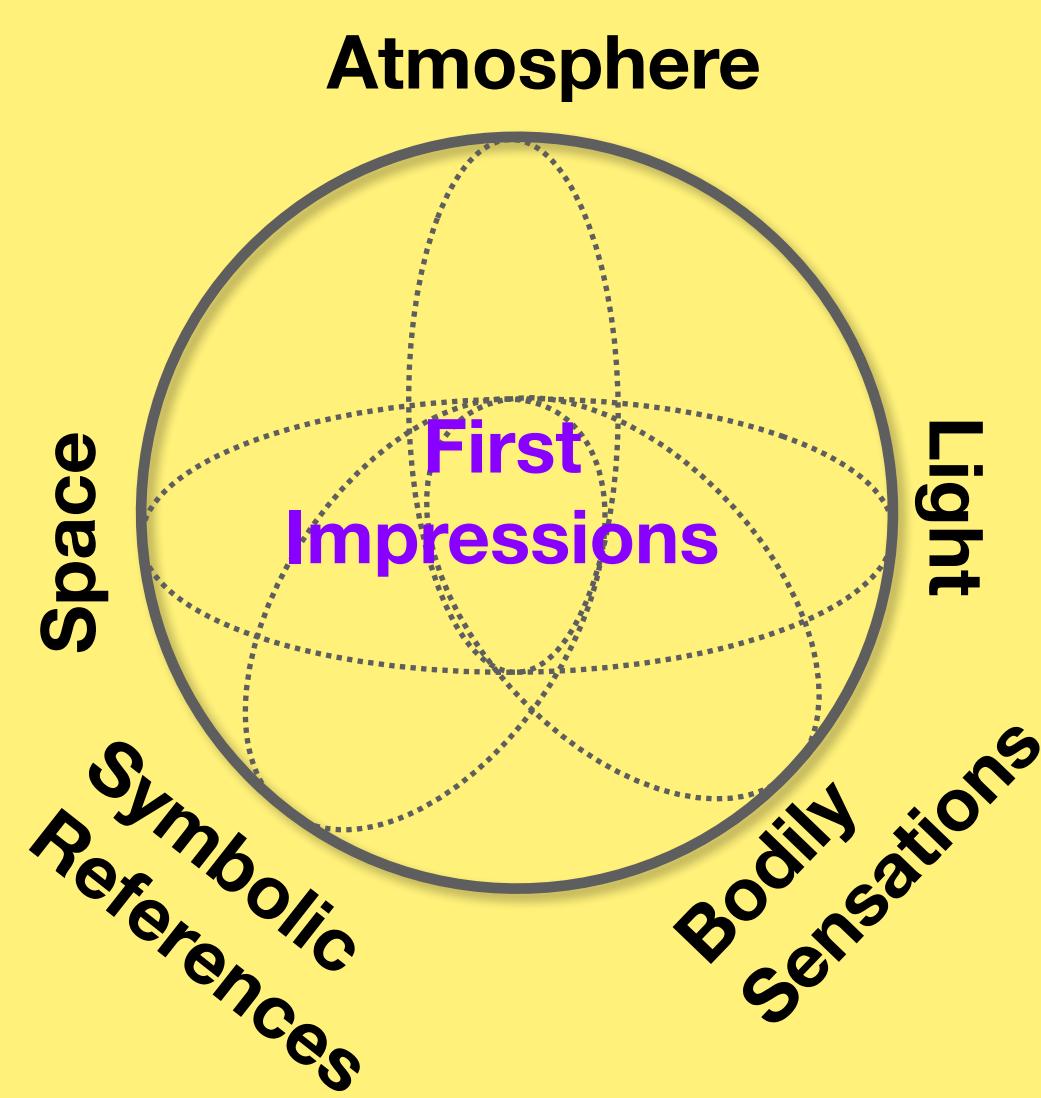
Study's Novel Method: Explores the fidelity of an immersive head-mounted display (HMD) in accurately reproducing subjective impressions related to luminous atmospheres of different buildings

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

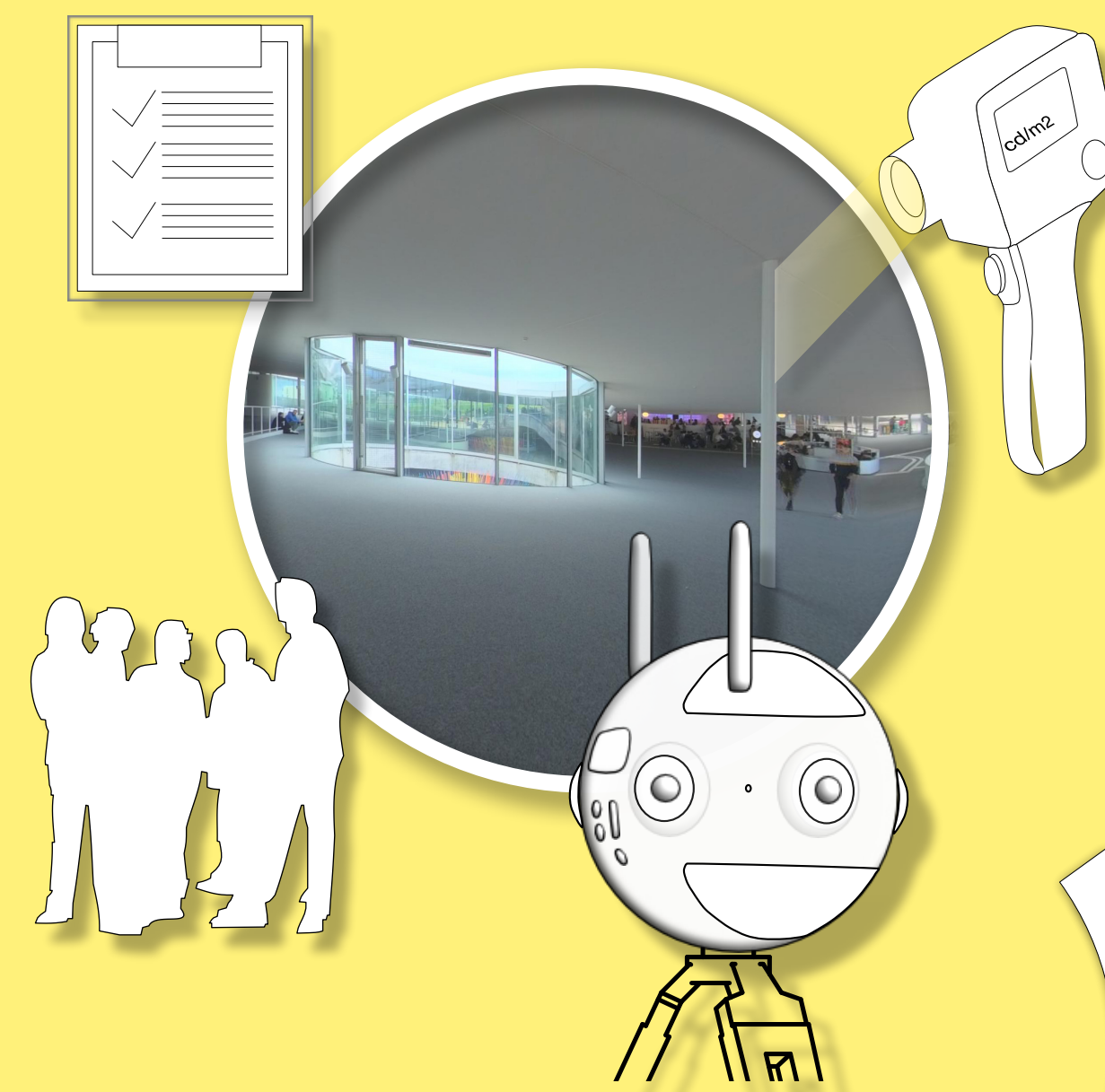
2 Evaluation of Impressions in Real Buildings

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

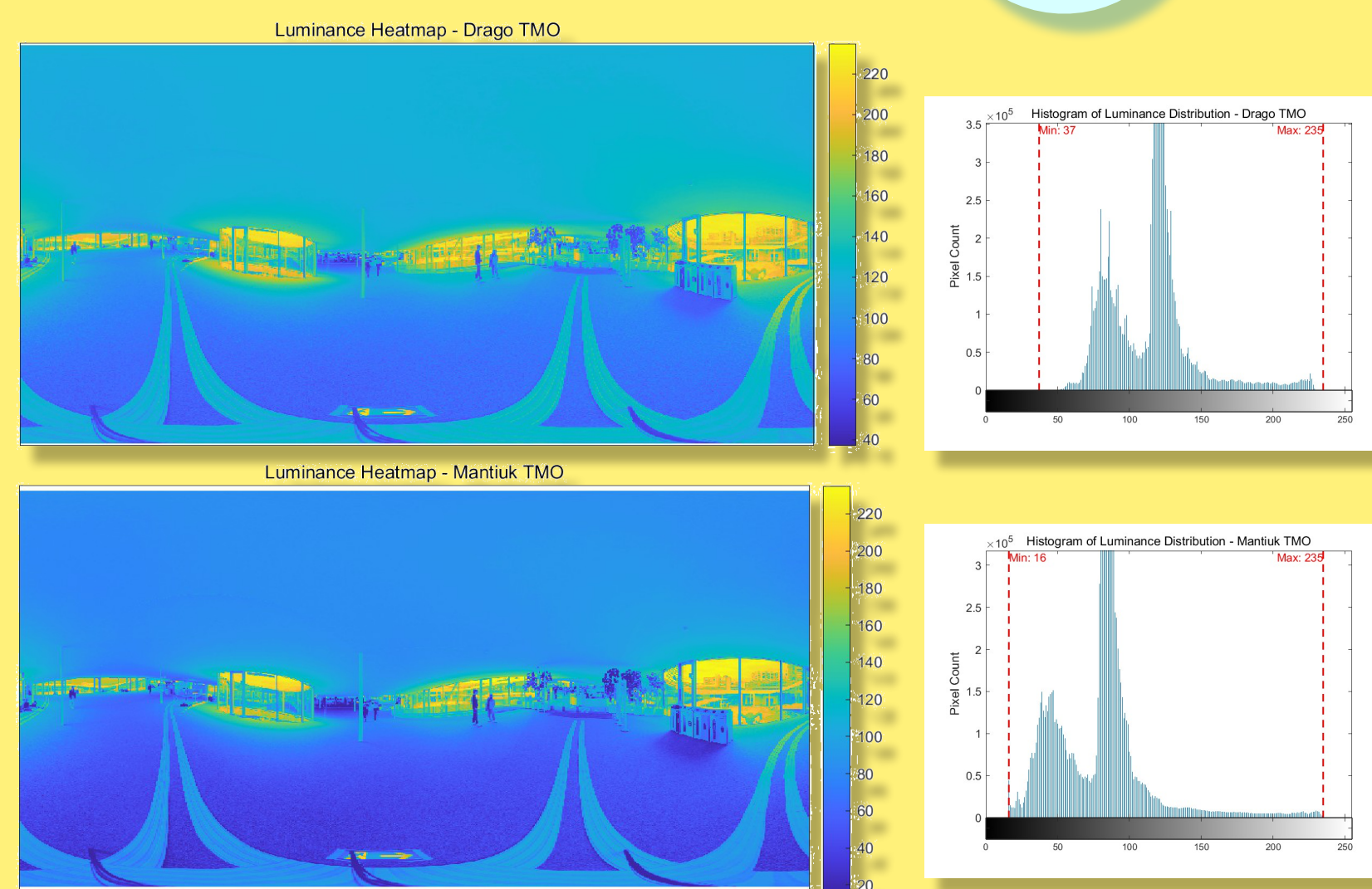
Questionnaire: Used the same as in the real places



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



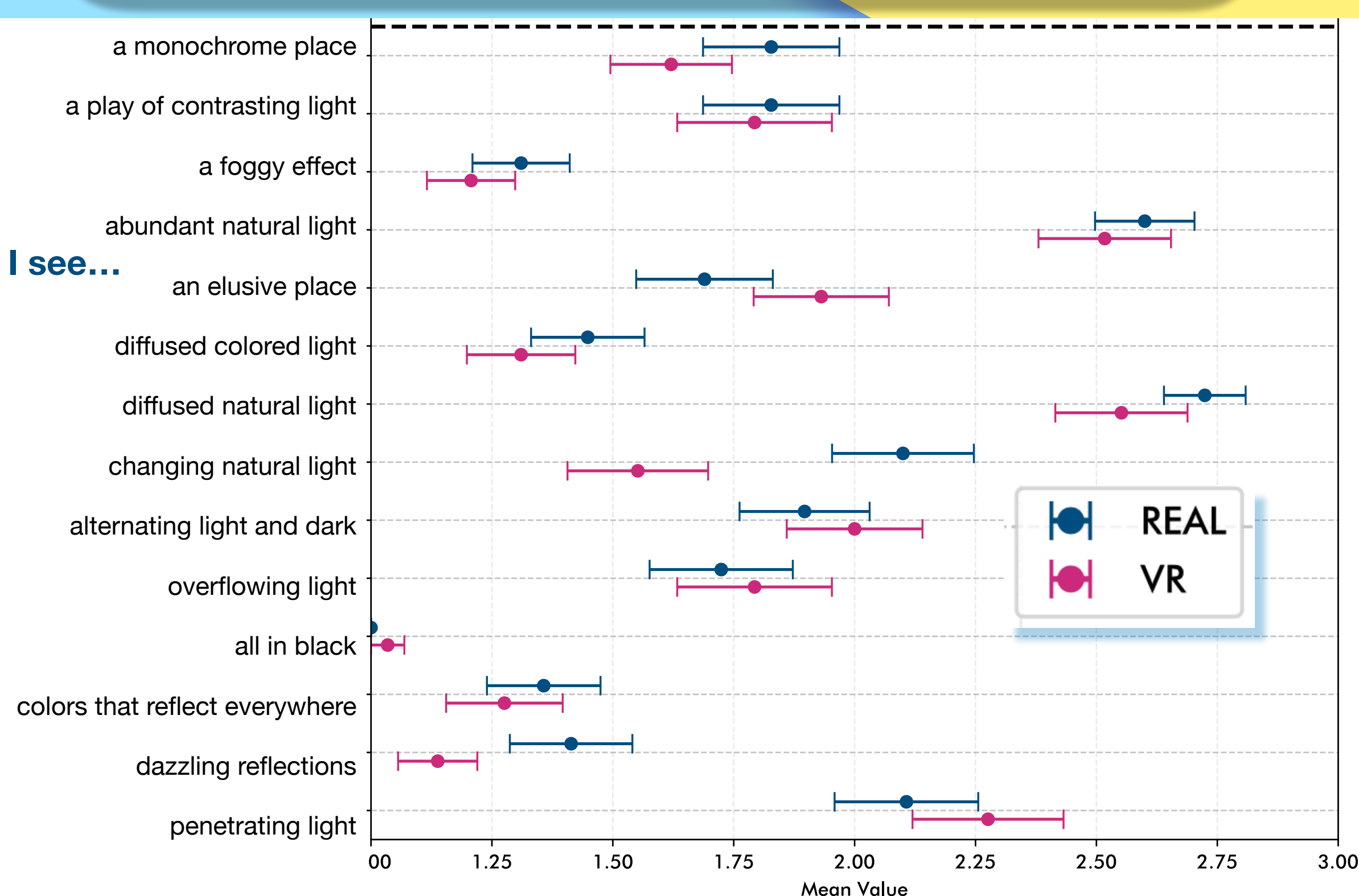
Results

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

This project is funded by the "Agence Nationale de la Recherche-ANR-19-CE38-0010"