Investigating the Impact of Spatial Design on Emotional and Cognitive Response in Cultural Heritage Spaces

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Abstract

This thesis investigates the extent to which subtle architectural manipulations influence the implicit affective and cognitive states of the museum visitors, specifically lighting temperature, ceiling height, surface color saturation, and interpretive graphics.

This study employs a multimodal experimental design using the Deir el-Medina room at the Museo Egizio (Turin, Italy) as a case study, a controlled laboratory experiment was conducted with 30 participants. Subjects viewed high-fidelity renderings of the museum space across five experimental conditions while their physiological responses were recorded using Electroencephalography (EEG) to measure cognitive workload and engagement, Electrodermal Activity (EDA) to measure physiological arousal, and Eye-Tracking to map visual attention and gaze behavior. These implicit measures were analyzed with explicit self-reported evaluations of the space.

The most robust finding was the impact of spatial compression: lowering the ceiling reduced cognitive workload while increasing visual fixation on the primary artifact and increasing subjective reports of mental effort, effectively acting as a passive mechanism for attention guidance. Conversely, the introduction of interpretive graphics drove higher levels of engagement but dispersed visual attention away from the artifact. Furthermore, conditions with high color saturation and cooler lighting trends indicated increased cognitive workload, suggesting that visual intensity may tax the visitor's cognitive resources in heritage environments.

By quantifying the invisible dialogue between the visitor's brain and the architectural vessel, this research provides an evidence-based framework for designing empathetic cultural heritage spaces that respect the cognitive economy of the visitor.

Keywords: neuroarchitecture, cultural heritage, EEG, EDA, eye-tracking, exhibition design

Chapter 1: Introduction

1.1 Background and Context

Architecture is never a passive container for objects; it acts as a distinct medium of communication. This is particularly true in the context of cultural heritage and museum design, where the built environment frames attention and sets the emotional tone of the visitor's experience. While traditional museology has focused on the explicit narrative through curation, text, panels, and artifact arrangement, the implicit influence of the architectural vessel itself remains less quantified.

Architectural theorists such as Pallasmaa and Böhme have long argued that architecture communicates through its atmosphere, or the multisensory, embodied experience that precedes intellectual categorization. However, translating these qualitative descriptions into actionable design strategies remains a challenge.

With the emerging discipline of neuroarchitecture, the intersection of neuroscience, psychology, and architecture, it is now possible to move beyond intuition. By utilizing biometric tools such as electronencephalography (EEG), electrodermal activity (EDA), and eye-tracking, researchers can capture the physiological signatures of the embodied experience of a space. This study situates itself at this intersection, using the Museo Egizio in Turin as a case study to explore how specific spatial manipulations influence the cognitive and affective states of the observer.

1.2 Problem Statement

Despite the recognition that museum environments shape visitor outcomes, there is a gap in empirical research connecting specific architectural variables to physiological responses within heritage context. Much of the existing neuroaesthetic research focuses on abstract geometric forms or fully immersive but uncontrolled real-world environments. There is a need for controlled, experimental studies that isolate architectural features to understand their discrete impacts on the visitor's conscious and unconscious processing.

There is often a discussion in design surrounding how to draw a visitor's "focus" (attention to an object or particular point) and "engagement" (emotional resonance). Understanding how architectural choices facilitate one potentially at the expense of the other is critical for effective design in the future of cultural heritage spaces.

1.3 Research Objectives

The primary objective of this thesis is to investigate the extent to which specific architectural modifications in a cultural heritage setting influence implicit affective and cognitive response. Specific objectives include to determine if manipulating architectural variables like light temperature, ceiling height, and surface color saturation or the addition of interpretive graphic elements elicits measurable changes in cognitive workload and physiological responses. Additionally, this thesis aims to analyze how these architectural changes alter visual attention and gaze behavior towards particular points of interest and to compare the efficacy of architectural interventions versus integrating interpretive graphs in driving visitor engagement. Finally another goal of this investigation is to correlate implicit physiological measures with explicit self-reported evaluations of the space.

1.4 Methodology Overview

To address these objectives, this study employs a multimodal experimental design. Using high-fidelity renders based on the Deir el-Medina room at the Museo Egizio, a controlled laboratory experiment was conducted with 30 participants. Biometric data was collected using an EEG sensing system, an EDA sensing system, and eye-tracking tools, enabling a triangulation of cognitive load, physiological arousal, and visual attention. This approach allows for the measurement of responses that participants may not be consciously aware of or able to articulate.

Chapter 2: Literature Review

This chapter briefly reviews the theoretical and empirical foundations that inform this study's investigation into how architectural environments shape affective and cognitive responses within museum contexts. It draws together perspectives from environmental psychology, museum studies, and architectural theory to frame how spatial variables can influence emotional engagement and perception. The review also examines emerging approaches that integrate physiological and self-report measures to study spatial experience, highlighting how multimodal methodologies contribute to a deeper understanding of visitor–environment interactions and the interpretation of cultural heritage.

2.1 Theoretical Foundations of Environmental Perception

Perception of architectural environments extends beyond the visual: it integrates sensory, emotional, and cognitive dimensions that shape how individuals experience space. Classical theories, for example, Gibson's ecological perception, suggest that perception is based on affordances offered by the environment-the opportunities for action that the observer perceives directly (Gibson, 1979). Ulrich writes that aesthetic attributes of environments, particularly those associated with natural settings, can elicit measurable affective responses, suggesting that visual qualities play a central role in the emotional appraisal of space (Ulrich, 1983). Architectural theorists later expanded on this idea by emphasizing the embodied, experiential nature of space. Architecture, as described by Pallasmaa, communicates affect and atmosphere through light, materiality, and spatial form (Pallasmaa, 1996/2005).

Environmental psychology has provided key models linking affective response to environmental stimuli. The Pleasure–Arousal–Dominance (PAD) model (Mehrabian & Russell, 1974) remains one of the most influential frameworks for quantifying emotional states.

Pleasure refers to the degree of positive or negative valence.

Arousal denotes the level of physiological activation or alertness.

Dominance represents the sense of control within the environment.

These three dimensions provide a framework for interpreting both implicit and explicit emotional reactions to architectural settings and serve as the conceptual basis for the present study's emotional framework.

Beyond general affective theory, Howard Gardner's Theory of Multiple Intelligences provides insight into how individuals engage with environments differently according to cognitive and perceptual modes (Gardner, 1983). For example, spatial-visual, bodily-kinesthetic, and intrapersonal intelligences all point to ways a visitor may interpret space in an embodied and reflective manner; this is a perspective relevant to museum design and visitor engagement.

In the architectural and heritage contexts, perception and affect are firmly intertwined. Visitors not only see a space but also feel it through its atmosphere, narrative cues, and sensory composition. This atmosphere is a 'quasi-objective sentiment' that is neither purely subjective nor objective, but rather a spatially attuned mood generated by the ecstasies (emanations) of the building's material properties, which is then viscerally perceived by the body (Böhme,1993).

2.2 Emotion and Cognition in Museum and Heritage Experience

Museums are designed not only to transfer knowledge but also to be emotionally engaging and a source of empathy. The museum environment itself acts as a communicative device, shaping visitors' cognitive and emotional orientation through spatial composition and scenographic cues (Minucciani et al., 2012). As evidenced by NEMO's 2021 report, Emotions and Learning in Museums, emotional engagement enhances both learning outcomes and visitor satisfaction. Instead of solely being focused on the transmission of facts, emotionally appealing environments create higher levels of understanding and remembering.

Recent museological research identifies emotion as a central element of visitor experience, influencing engagement, reflection, and memory. With these ideas in mind, the concept of mise-en-scène (the deliberate orchestration of spatial, visual, and auditory elements) comes into play as visitors go through their emotional journeys in exhibitions. Experimental case studies, as performed at the Sarajevo Under Siege exhibit in the Historical Museum of Bosnia and Herzegovina, the Zanis Lipke Memorial in Latvia, and the Riga Motor Museum, show how it is possible to evoke empathy, tension, or curiosity through architectural design and narrative framing (NEMO, 2021). These examples align with the broader argument that museum space produces interpretive meaning not only through texts and artifacts but through atmospheric and sensory cues embedded in its architecture (Bohme, 1993; Minucciani & Saglar Onay, 2019).

Visitor engagement can also be understood through the diverse emotional and cognitive orientations with which visitors approach heritage spaces. Emotional connection may therefore depend on how well a museum accommodates different motivations and intelligences (Falk & Storksdieck, 2005).

In this setting, narrative and empathy become a cluster of design tools. Keen's theory of narrative empathy proposes that narratives are capable of getting observers into a shared emotive state with the vicarious experience and identification with otherness (Keen, 2006). In other words, heritage environments, thanks to story-driven architecture or scenographic clues, can elicit empathetic or reflective engagement with times past.

2.3 Implicit and Explicit Measures of Experience

The study of emotional response in architectural and museum contexts can be approached by either explicit or implicit methods.

2.3.1 Explicit measures

Explicit methods depend on conscious self-reporting through questionnaires, semantic differentials, or rating scales. They give very valuable information about participants' subjective experience but, again, suffer from introspection and social desirability biases (Bradley & Lang, 1994). A Visual Analogue Scale (VAS) and Likert-type measures are commonly used for affective dimensions-pleasure, arousal, and dominance. In this experiment, a series of VASs were shown to each participant during interstimulus intervals and post-experiment questionnaires were used to collect self-assessed emotional responses from the participants for each stimulus image.

2.3.2 Implicit Measures

Implicit measures are based on physiological or behavioral signals reflecting non-conscious emotional and cognitive processes, such as neural activity, autonomic responses, and attention patterns.

EEG (Mindtooth Touch System): records cerebral signals and infers mental states related to engagement, workload, and emotional valence.

EDA (Shimmer System): The Shimmer system measures changes in skin conductance linked to sympathetic nervous system activity, providing an index of arousal.

Eye-tracking (Tobii Pro X2-30): provides information via monitoring gaze patterns, fixation duration, and changes in the diameter of pupils, providing an indication of the degree of interest and attention.

These modalities together provide a comprehensive user experience. EEG serves as an indicator of cognitive effort or engagement, EDA indexes physiological arousal, and eye-tracking identifies focal points of visual attention (Zhu & Lv, 2023; Shi et al., 2025). Each one of these, when combined with self-reported data, forms a multimodal data set that links implicit emotional reactions with explicit cognitive interpretations. Such multimodal approaches have become increasingly central in neuroarchitecture research, where combining EEG, EDA, and visual attention measures has proven effective for detecting nuanced emotional responses to spatial stimuli (Jelić et al., 2016; Vartanian et al., 2013).

2.4 Conscious and Unconscious Dimensions of Cultural Perception

Perception in cultural heritage settings emerges from both conscious interpretation and unconscious, automatic embodied responses. Neuroaesthetic research indicates that emotional appraisals often originate pre-consciously (Di Dio & Gallese, 2009); viewers react to visual cues such as color intensity, symmetry, contour, or lighting before forming conscious judgements (Ulrich, 1983). These rapid processes influence visitors subsequently to attend to or engage with cultural objects.

Phenomenological perspectives further argue that spatial experience is rooted in the body's orientation and affective attunement to the surrounding environment (Mallgrave, 2013). In a museum setting, this means visitors experience a room not only visually but through atmospheric impressions, sensory cues, and affective resonance.

This distinction between conscious and unconscious perception is central to the present work, which integrates physiological measures (EEG, EDA, eye-tracking) with explicit self-report data. Because implicit responses can diverge from conscious evaluations, multimodal data provide insight into how architectural features influence affective and cognitive states even when participants do not verbally report noticing differences.

2.5 Applications in Virtual and Real Architectural Environments

Investigations into spatial experience and architectural perception have now been considerably advanced through digital technologies of visualization that allow architects and researchers to study environmental perception under controlled conditions of visual stimulation. Virtual and augmented reality environments, panoramic tours, and high-fidelity renderings enable the systematic manipulation of spatial variables while maintaining ecological validity (Slater, 2003; Styliani et al., 2009).

In the framework of cultural heritage, virtual tours and reconstructions create unique opportunities to test how visitors experience heritage spaces; they allow for experimentation without interfering with real environments and render design variations observable under controlled conditions. Previous studies have demonstrated that virtual representations can elicit affective and cognitive responses comparable to real-world experiences, especially in situations in which realism and immersion are high. Research comparing virtual and physical environments suggest that high-fidelity digital scenes can reliably evoke behavioral, attentional, and affective responses similar to real-world settings. Specifically, studies by Gulhan et al. (2021), Styliani et al. (2009), and Vartanian et al. (2013) have shown that visual fidelity in virtual scenes is key to evoking responses comparable to those in real-world environments (Gulhan et al., 2021; Styliani et al., 2009; Vartanian et al., 2013).

However, a distinction must be made between immersion and experimental control. While fully immersive VR or physical constructions offer high ecological validity, they often introduce confounding variables such as motion artifacts or uncontrolled environmental noise. The present study uses a static 2D image derived from the Museo Egizio online virtual tour and altered renderings based on that image. This method ensures that visual stimuli are consistent while allowing the manipulation of specific architectural variables including lighting, ceiling height, color saturation, and contextual graphics. By testing responses to these controlled visual modifications, the research makes a contribution to understanding how design interventions may alter visitor perception and affect within museum environments while maintaining the scope of the experiment within reasonable limits by not having to construct spaces or model virtual reality environments.

It is acknowledged that this approach separates visual perception from the full sensorimotor experience of space. While 2D renderings are good for visual attention, they may not elicit physiological arousal compared to real-world settings. This aligns with findings in environmental psychology that embodied movement and proprioception significantly affect emotional appraisal of space, suggesting that real-world navigation may amplify or alter the responses observed in 2D static viewing (Mallgrave, 2013; Jelić et al., 2016). Therefore, while static viewing may dampen the intensity of physiological responses linked to a participant being in a space, it remains a valid method for evaluating the cognitive and attentional impacts of visual spatial composition variables.

2.6 Implications of Spatial and Visual Modifications

Architectural environments function as communicative systems. Even subtle spatial or visual adjustments, such as changes in lighting, shifts in ceiling height, increased color saturation, or the addition of interpretive graphic elements, carry communicative meaning that shapes how visitors interpret both space and objects. Museum environments mediate understanding not only through labels and narratives but through the atmospheric and spatial qualities of the architecture itself (Minucciani et al., 2012).

Research in museum communication emphasizes that architectural and scenographic elements operate as elements that guide visitors' expectations, focus, and emotional state (Hooper-Greenhill, 1999; Black, 2005). Modifying environmental variables can therefore alter how strongly an exhibition communicates calmness, intensity, clarity, immersion, or narrative orientation.

From a physiological perspective, studies in neuroarchitecture show that spatial features influence underlying emotional and cognitive states, even when visitors are not consciously aware of these differences. Previous research endeavors demonstrate that changes in enclosure, contour, and spatial proportion correspond with measurable neural activity related to attention, arousal, and cognitive load (Vartanian et al., 2013; Jelić et al., 2016). These studies support the idea that environmental cues communicate on both explicit and implicit levels.

The following are four architecture variables that have been identified to cause emotional and cognitive responses in visitors in previous studies.

Lighting: Lighting has been shown to affect both cognitive and emotional responses in interior spaces . Cooler lighting may influence perceived spaciousness, clarity of displays, and overall mood, making it a relevant variable to test within heritage contexts (Zhang et al., 2022).

Ceiling height: Ceiling height affects perceived spatial volume and enclosure, which can modulate comfort, attention, and emotional reactions (Strachan-Regan & Baumann, 2024).

Surface saturation: Color saturation can alter the perceived vibrancy and materiality of architectural surfaces . Increasing saturation across walls, floor, and ceiling tests whether the visual intensity of the color of architectural elements impacts emotional or cognitive engagement with the space (AL-Ayash et al., 2015; Jaglarz, 2023).

Contextual graphics (added interpretive imagery): Interpretive graphic overlays and visual aids are widely considered effective tools in museum exhibition design to enhance visitor engagement and comprehension (Black, 2005). Empirical research shows that variations in museum display information elements, such as imagery and text, influence gaze behavior and engagement in museum settings (Shi et al., 2025).

In this study, the four manipulated variables can be understood as controlled communicative interventions. Each modification subtly reframes the emotional "atmosphere" of the room. The physiological results therefore reflect how spatial communication unfolds not only through conscious interpretation but also through pre-reflective embodied responses.

2.7 Identified Research Gap

The existing literature underlines the importance of emotional engagement in museums and the increasing adoption of physiological measures in the evaluation of spatial experience (Zhang et al., 2023; Castiblanco Jimenez et al., 2023). While several studies have employed eye-tracking, electrodermal activity, or EEG in museum and architectural contexts, relatively few have combined multimodal implicit–explicit approaches, particularly EEG, EDA, and eye-tracking together, to investigate how specific architectural variables influence affective and cognitive responses in heritage museums. The prior work by Gulhan et al. (2021) and Zhu & Lv (2023), for example, largely focuses on immersive virtual environments and mobile in-situ measurements, respectively, rather than controlled image-based experimental setups comparable to the present study (Gulhan et al., 2021; Zhu & Lv, 2023). Additionally, two foundational theses (Iacob, 2021; Tempora, 2022) that informed the current experimental setup, which used rendered architectural scenes and explicit questionnaires, specifically relied on creating renderings of theoretical spaces and did not incorporate any form of biometric tracking in their methodology, although they referenced its potential.

Chapter 3: Methodology

This study investigates how subtle architectural modifications in museum environments influence visitors' perceptual and emotional responses. The experiment focuses on a single gallery room within the Museo Egizio in Turin, Italy, examining how changes to spatial or visual qualities affect the way people experience the space.

Five stimulus images were developed based on a baseline view of the Deir el-Medina room. Each variation alters one architectural variable: lighting, ceiling height, surface saturation, or visual graphics. However, the display contents and perspective of the room remain the same. Participants' physiological and ocular responses were recorded while viewing each image, followed by a post-experiment questionnaire assessing subjective impressions and familiarity with the museum.

3.1 Ethical Considerations and Data Management

This experiment was conducted as part of Meta-Museum, under ethical approval granted by the Comitato Etico del Politecnico di Torino on 26 February 2025, Protocol Number 18069/2025. All procedures adhered to the approved protocol, and participants provided informed consent prior to participation.

Identifiable participant data were pseudonymized using randomly assigned numeric codes, and all subsequent experimental observations were associated only with these codes. Only digital data from the Tobii eye tracker, Mindtooth, Shimmer, and LimeSurvey platforms were stored for analysis. Printed interstimulus question sheets were used solely for procedural compliance. Data confidentiality and processing were conducted in accordance with EU Regulation 2016/679 (GDPR)

Data were exported into two files:

File 1: Containing user ID and identifying information (secure storage).

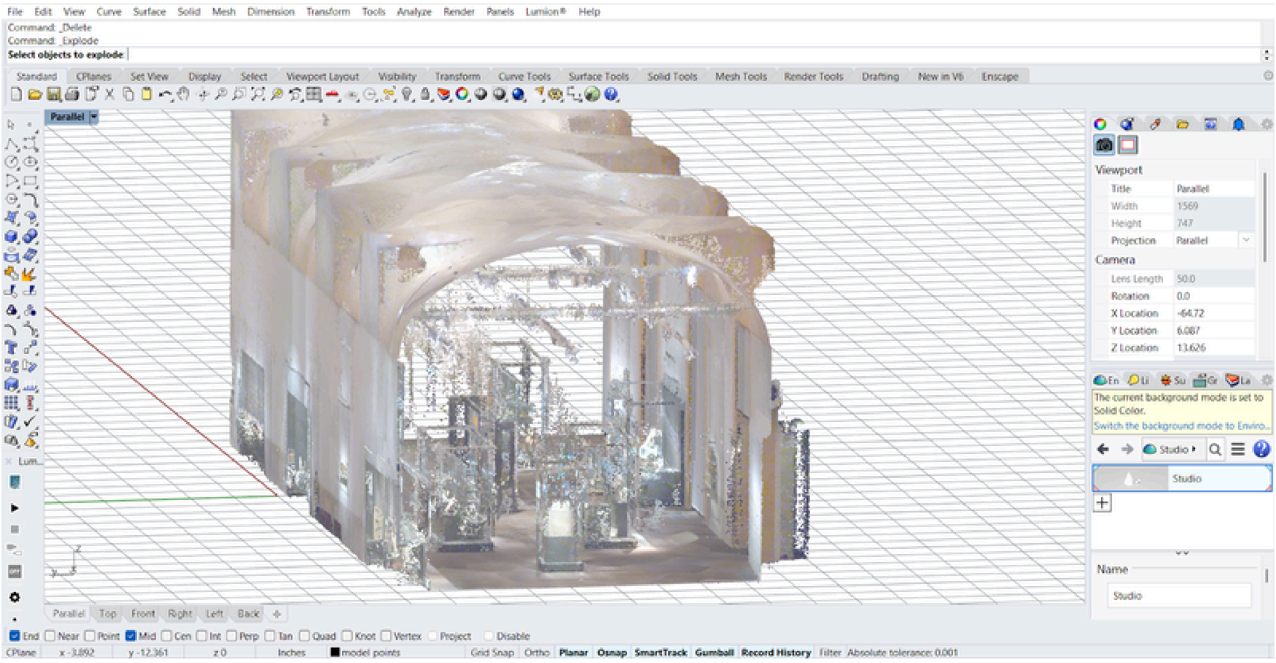
File 2: Containing user ID, physiological, eye-tracking, and survey data (for analysis).

Analyses compared baseline and variation conditions using both physiological and self-reported measures. The goal was to evaluate whether subtle architectural changes elicit measurable cognitive or emotional responses, even when participants may not have consciously perceived the differences.

3.2 Stimuli Design

The design process for the visual stimuli renderings originated from an analysis of the current display of the Strike Papyrus at the Turin Museo Egizio. The initial phase involved the acquisition of 3D point cloud data of the existing exhibition room, which served as the foundation for a precise digital reconstruction of the papyrus's vitrine.

Figure 1. 3D point cloud of the Deir el-Medina room in the Museo Egizio.



Early design iterations were exploratory in nature, testing the generation of entirely new theoretical environments and alternate display case designs.

Figure 2. Early unfinished theoretical space rendering.

However, to ensure the study's findings remained applicable to the practical realities of heritage management, the scope was subsequently refined. Rather than pursuing purely speculative or theoretical spaces, the final design strategy focused on realistic architectural interventions within the existing spatial context of the museum.

3.2.1 Baseline Image

The baseline stimulus was created from a captured frame of the Museo Egizio's publicly available 3D virtual tour (Museo Egizio, 2025). Navigation icons and interface elements were removed in post-processing to create a clean baseline image, which was then used to generate the four experimental variations.

Figure 3. Baseline stimulus image, edited from screenshot (Museo Egizio, 2025)

The selected viewpoint shows the Deir el-Medina room, including the papyri vitrine and several adjacent vitrines, providing a comprehensive view of the ceiling, walls, and floor surfaces. This baseline was chosen for its representative composition and its ability to display both the architectural enclosure and the exhibition display elements of the space, aligning with the study's focus on the spatial and atmospheric perception of museum interiors.

3.2.2 Experimental Variations

Four derivative images were created from the baseline, each modifying a single architectural attribute while preserving all other conditions (viewpoint, scale, and object arrangement). Selected to represent typical environmental interventions in museum interiors, the architectural variables were lighting, ceiling height, surface saturation, and contextual graphics. Each variable was chosen based on its potential influence on visitor perception, attention, and emotional response:

Figure 4. Cooler lighting stimulus image

Figure 5. Lowered ceiling stimulus image

Figure 6. High surface saturation stimulus image

Figure 7. Added interpretive graphics stimulus image

All stimuli were rendered in 1080p HD resolution and displayed on an Asus Vivobook Pro laptop screen at maximum brightness to ensure consistent visual presentation conditions.

Rationale Summary. Together, these variables allow the experiment to test both perceptual and emotional responses to subtle architectural interventions that are feasible in heritage settings. By maintaining consistent viewpoints and displaying content, the design ensures that observed effects are attributable to the manipulated architectural qualities, rather than differences in scene composition or content.

3.3 Participants

Participants were recruited volunteers; inclusion criteria required participants to be adults (aged 19 to 58) with normal or corrected-to-normal vision. Individuals with visual impairments or neurological disorders were excluded.

Each participant was assigned a unique user ID to ensure anonymity and compliance with ethical data management protocols. Identifying information was stored separately from experimental data in two distinct files:

File 1: user ID + participant’s first and last name (for consent tracking only). This file has been encrypted and stored by the Politecnico di Torino.

File 2: user ID + physiological, eye-tracking, and survey data (for analysis) shared with Sapienza University of Rome.

3.4 Apparatus

During the experiment, participants wore three synchronized biometric devices:

Mindtooth Touch. EEG-based monitoring of cognitive and emotional states. The EEG data was recorded using the Mindtooth Touch headset, in conjunction with the ClickOn amplifier. The device supports up to eight EEG channels (plus reference and ground), with Bluetooth Low Energy transmission and sampling rates of 125, 250, or 500 Hz. The headset geometry comprises five frontal sensors and additional parietal sensors on the rear mount, and is designed to adapt to varying head shapes and hairstyles (Mindtooth, 2025).

Figure 8. Mindtooth Touch headset. (Mindtooth, 2025)

Shimmer3R GSR+. Physiological measurements such as heart rate and electrodermal activity. Both signals were acquired through the use of the Shimmer3 GSR+ unit applied via a bracelet to the non-dominant hand: for the EDA two sensors were fixed to the first and second fingers; while for the SCL a sensor on the thumb was used (Shimmer, 2023).

Figure 9. Shimmer3R GSR+ unit and sensors worn. (Shimmer, 2023)

Tobii Pro X2-30. Recording gaze position and pupil movement during the experiment. This is a magnetic mounted eye-tracking camera with sampling frequencies of up to 250 Hz, two eye tracking cameras and captured real-time ocular data throughout the experiment (Tobii, 2024).

Figure 10. Tobii Pro X2-30 screen-based eye tracker device. (Tobii, 2024)

All devices were time-synchronized to align physiological and gaze data with stimulus presentation.

3.5 Procedure

Each experimental session followed a standardized sequence of phases designed to establish physiological baselines, control for attention, and capture responses to each stimulus image.

The experiment included five stimuli images: one baseline (a screenshot from the Museo Egizio virtual tour) and four variations that each altered a single architectural variable. Although the baseline image served as the conceptual reference condition, the presentation order of the five stimuli was counterbalanced across participants to minimize order and learning effects.

During interstimulus periods, participants briefly viewed printed question sheets while digital data collection remained limited to the eye-tracking software. These interstimulus questions were VAS ratings (1 to 7) with the goal of determining the participants' cognizant impression of the previous image in regards to emotional valence, activation or arousal, aesthetic involvement or attractiveness of the image, and cognitive load the image required to process. This approach was implemented in accordance with ethics committee requirements to ensure no unnecessary personal data were recorded digitally other than on the approved software

Prior to exposure to the stimulus image series, participants were given explanations on the purpose of each device and what specific biometric data was being measured; however, participants were not informed what images they would be seeing or what responses were the desired results of the experiment before or during the experiment protocol. Before beginning the experiment, participants were seated comfortably in front of the display monitor. The Mindtooth EEG headset was fitted to the participant's head, and the Shimmer EDA sensors were attached to two fingers of the non-dominant hand. Both devices were connected and calibrated using their respective acquisition software to ensure optimal signal quality. The eye tracker was then calibrated and verified before each trial to ensure reliable gaze tracking, following standard eye-tracking validation criteria (Holmqvist et al., 2011).

To ensure hygienic conditions and reliable sensor performance, the Mindtooth and Shimmer devices were cleaned with disinfectant wipes between each participant, and the areas of skin where the sensors made contact were disinfected prior to placement. This procedure improved the quality of signal acquisition by ensuring consistent skin–sensor contact.

Participants' viewed each stimulus image for 12 seconds, a time interval selected to balance the sufficient time to fully observe the image while mitigating fatigue (Lee et al., 2015). After the viewing phase, participants completed a post-experiment questionnaire via LimeSurvey, which included, self-reported emotional responses to each image, evaluations of spatial qualities (comfort, atmosphere, engagement), and questions on familiarity or prior experience with the Museo Egizio.

3.5.1 Stimuli Sequences

Six different presentation sequences were created, ensuring that each variation appeared in multiple positions within the series. This design allows the analysis to focus on differences in participants' cognitive and emotional responses to architectural features rather than effects introduced by viewing order. Table 1 - 6 show the six presentation sequences as well as the experiment procedure and what participants saw on the screen during the data capture. Figure 11 shows a participant engaged in the experiment procedure.

Figure 11. Participant during experiment procedure

Table 1. Sequence A

Phase	Duration	Description	Screen Image
Eyes closed baseline	30 s	Participants sat quietly with eyes closed to establish a physiological baseline.	-
Eyes open baseline	30 s	Participants sat quietly with eyes open to establish an open-eye baseline.	
Initial fixation cross	30 s	A central fixation cross normalized attention before stimulus presentation.	+
First stimulus viewing (Baseline)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for first stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image. A short fixation cross appeared between	
Interstimulus fixation cross	0.7 s	previous questions and following stimuli.	+
Second stimulus viewing (Cooler Lighting)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for second stimulus	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image. A short fixation cross appeared between	
Interstimulus fixation cross	0.7 s	previous questions and following stimuli.	+
Third stimulus viewing (Lower Ceiling)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for third stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image. A short fixation cross appeared between	
Interstimulus fixation cross	0.7 s	previous questions and following stimuli.	+
Fourth stimulus viewing (Graphics)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for fourth stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image. A short fixation cross appeared between	
Interstimulus fixation cross	0.7 s	previous questions and following stimuli.	+

Phase	Duration	Description	Screen Image
Final stimulus viewing (High Saturation)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for final stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Final fixation cross	30 s	Concluded physiological data collection.	

Table 2. Sequence B

Phase	Duration	Description	Screen Image
Eyes closed baseline	30 s	Participants sat quietly with eyes closed to establish a physiological baseline.	-
Eyes open baseline	30 s	Participants sat quietly with eyes open to establish an open-eye baseline.	
Initial fixation cross	30 s	A central fixation cross normalized attention before stimulus presentation.	+
First stimulus viewing (High Saturation)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for first stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	+
Second stimulus viewing (Baseline)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for second stimulus	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	+
Third stimulus viewing (Graphics)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for third stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	+
Fourth stimulus viewing (Cooler Lights)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for fourth stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	+

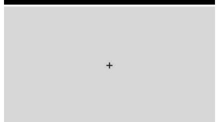
Phase	Duration	Description	Screen Image
Final stimulus viewing (Lower Ceiling)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for final stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Final fixation cross	30 s	Concluded physiological data collection.	

Table 3. Sequence C

Phase	Duration	Description	Screen Image
Eyes closed baseline	30 s	Participants sat quietly with eyes closed to establish a physiological baseline.	-
Eyes open baseline	30 s	Participants sat quietly with eyes open to establish an open-eye baseline.	
Initial fixation cross	30 s	A central fixation cross normalized attention before stimulus presentation.	+
First stimulus viewing (Graphics)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for first stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	+
Second stimulus viewing (Lower Ceiling)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for second stimulus	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	+
Third stimulus viewing (High Saturation)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for third stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	+
Fourth stimulus viewing (Baseline)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for fourth stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	+

Phase	Duration	Description	Screen Image
Final stimulus viewing (Cooler Lighting)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for final stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Final fixation cross	30 s	Concluded physiological data collection.	

Table 4. Sequence D

Phase	Duration	Description	Screen Image
Eyes closed baseline	30 s	Participants sat quietly with eyes closed to establish a physiological baseline.	-
Eyes open baseline	30 s	Participants sat quietly with eyes open to establish an open-eye baseline.	
Initial fixation cross	30 s	A central fixation cross normalized attention before stimulus presentation.	
First stimulus viewing (Baseline)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for first stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	
Second stimulus viewing (High Saturation)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for second stimulus	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	
Third stimulus viewing (Cooler Lighting)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for third stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	
Fourth stimulus viewing (Graphics)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for fourth stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	

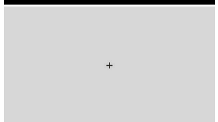
Phase	Duration	Description	Screen Image
Final stimulus viewing (Lower Ceiling)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for final stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Final fixation cross	30 s	Concluded physiological data collection.	

Table 5. Sequence E

Phase	Duration	Description	Screen Image
Eyes closed baseline	30 s	Participants sat quietly with eyes closed to establish a physiological baseline.	-
Eyes open baseline	30 s	Participants sat quietly with eyes open to establish an open-eye baseline.	
Initial fixation cross	30 s	A central fixation cross normalized attention before stimulus presentation.	
First stimulus viewing (Cooler Lighting)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for first stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	
Second stimulus viewing (Graphics)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for second stimulus	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	
Third stimulus viewing (Baseline)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for third stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	
Fourth stimulus viewing (Lower Ceiling)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for fourth stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	

Phase	Duration	Description	Screen Image
Final stimulus viewing (High Saturation)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for final stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Final fixation cross	30 s	Concluded physiological data collection.	

Table 6. Sequence F

Phase	Duration	Description	Screen Image
Eyes closed baseline	30 s	Participants sat quietly with eyes closed to establish a physiological baseline.	-
Eyes open baseline	30 s	Participants sat quietly with eyes open to establish an open-eye baseline.	
Initial fixation cross	30 s	A central fixation cross normalized attention before stimulus presentation.	
First stimulus viewing (Lower Ceiling)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for first stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	
Second stimulus viewing (Graphics)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for second stimulus	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	
Third stimulus viewing (Cooler Lighting)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for third stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	
Fourth stimulus viewing (High Saturation)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for fourth stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Interstimulus fixation cross	0.7 s	A short fixation cross appeared between previous questions and following stimuli.	

Phase	Duration	Description	Screen Image
Final stimulus viewing (Baseline)	12 s	Participants viewed first stimulus image	
Interstimulus questionnaire for final stimulus image	Free time	Participants answered four questions (VAS 1-7) about the previous stimulus image.	
Final fixation cross	30 s	Concluded physiological data collection.	

Chapter 4: Results

This chapter presents the results of the controlled experiment designed to investigate how variations in architectural elements influence participants' affective and cognitive responses within a cultural heritage context.

Five room variations were tested, differing in lighting, color saturation, graphics, and spatial articulation, while maintaining constant object and viewpoint conditions.

The analysis integrates data from three biometric instruments, the Mindtooth EEG system, the Shimmer3 GSR+ device, and the Tobii Pro X2-30 eye-tracking system, combined with participants' self-reported questionnaire responses collected through interstimulus Visual Analogue Scales (VAS) and a post-experiment questionnaire.

The following sections describe the data processing pipeline, summarize key descriptive results, and present statistical comparisons across experimental conditions.

4.1 Data Preparation and Processing

4.1.1 Data Cleaning and Preprocessing

Data were collected from a total of 30 participants (20 female, 10 male, mean age = 27 years, SD = 8.2). All data files were checked for completeness before analysis.

EEG (Mindtooth Touch) Processing. EEG data processing was performed using proprietary software developed within the Laboratory of Industrial Neuroscience at Sapienza University of Rome, adhering to current standards in signal analysis. EEG recordings were band-pass filtered with cut-off frequencies of 2 Hz (high-pass) and 40 Hz (low-pass). After filtration, the signal quality was inspected for artifacts, and segments exhibiting poor quality were rejected. Ocular artifacts were corrected using the protocol established in a previous experiment performed in the same lab (Giorgi et al., 2024). Finally, neurometrics were computed from the clean EEG signal: the Workload Index (WL), the Approach–Withdrawal Index (AW), Attention, Engagement, and Mental Effort.

The neurometrics generated were normalized by using the Baseline rendering as the reference condition. Thus a normalized score of:

1.0 = equal to Baseline

>1.0 = higher than Baseline

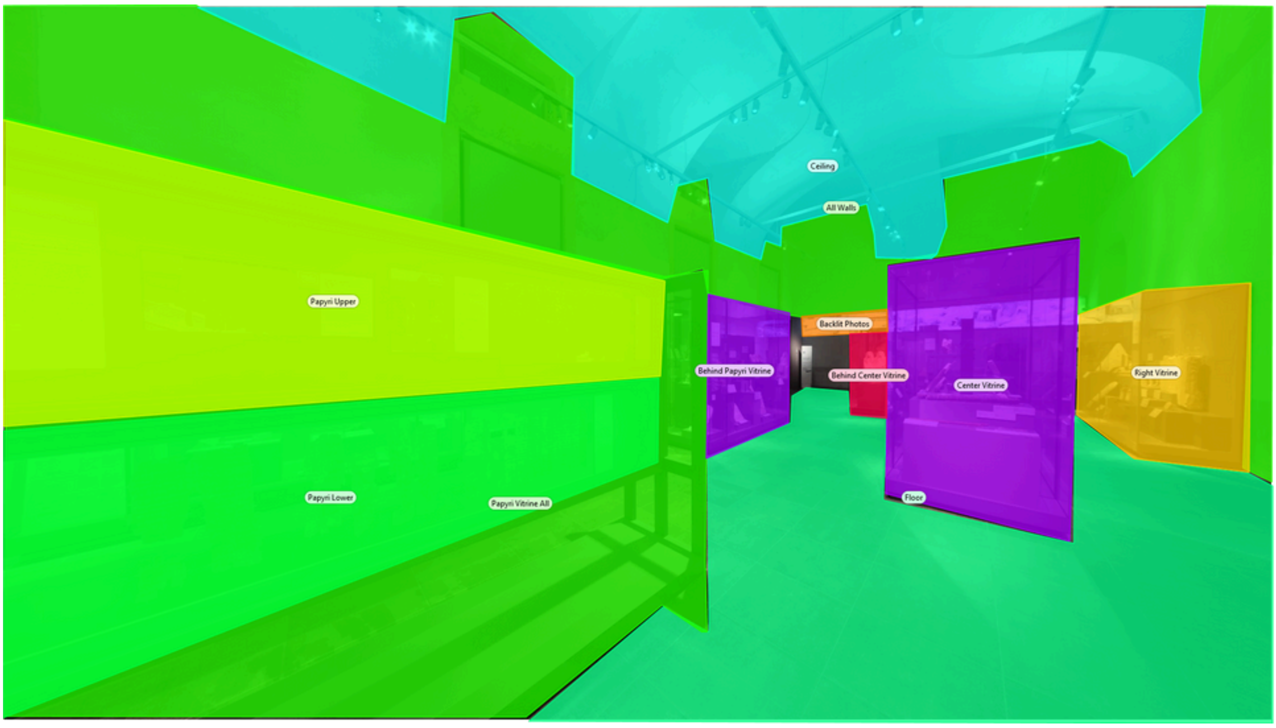
<1.0 = lower than Baseline

Because of this normalization procedure, the Baseline condition does not appear as a separate category in the inferential statistics.

EDA (Shimmer3 GSR+) Processing. Electrodermal Activity (EDA) was recorded using the Shimmer3 GSR+ unit; the signal was acquired at a sampling frequency of 64 Hz. Post-processing was conducted using proprietary laboratory software at Sapienza University of Rome, where the signal was first low-pass filtered with a cut-off frequency of 1 Hz. The signal was then decomposed to estimate the tonic component, known as the Skin Conductance Level (SCL) (Braithwaite et al., 2013). The SCL represents the slow-changing component of the electrodermal signal and was used as the primary index of the participant's overall physiological arousal (Benedek & Kaernbach, 2010).

Eye-Tracking (Tobii Pro X2-30) Processing. Eye-tracking data were calibrated individually before the experiment. The resulting data were analyzed by the Industrial Neuroscience Laboratory, where fixations were mapped onto defined Regions of Interest (ROIs). These included the papyri vitrine (primary artifact), central vitrine, and interpretive graphics (in the Graphics condition). For each ROI, total fixation duration and number of fixations were extracted and averaged per rendering condition.

Figure 12. Regions of Interest (ROIs) polygons on Baseline Image.



Self-Reported Measures. Two types of self-report data were collected:

Interstimulus VAS ratings (ranging from 1 to 7), completed between images, aimed at capturing participants' in-the-moment emotional and cognitive responses.

Post-experiment questionnaire, measuring global impressions of each rendering and participants' familiarity with archaeology and the Museo Egizio.

Self-reported ratings from the Visual Analogue Scales (VAS) were compiled, normalized, and averaged for each stimulus condition.

4.1.2 Data Exclusions

Following data inspection, 2 participants were removed from the dataset due to recording errors. Additionally, GSR data for 2 participants were discarded due to poor signal quality. As a result, physiological data analysis was conducted on the remaining subset of valid recordings (N = 28).

4.2 Descriptive Results

4.2.1 Participant Overview

A total of 28 valid datasets were included in the final analysis. Participants represented a diverse group in terms of age and education level, with the majority expressing familiarity with museum environments and nearly half having visited the Museo Egizio at some point (see Table 7).

Table 7. Participant demographics and background information.

Demographics	Description	Value	Percentage
Education Level	Middle School High School Bachelor's Degree Master's Degree Doctorate	1 3 15 7 4	3.3% 10% 50% 23.3% 13.3%
Museum Visit Frequency	Once a month Several times a year Once a year Never	1 27 1 1	3.3% 90% 3.3% 3.3%
Previously Visited Museo Egizio	Yes No	14 16	46.6% 53.3%

Figure 13. Participant demographics: education level, visualized.

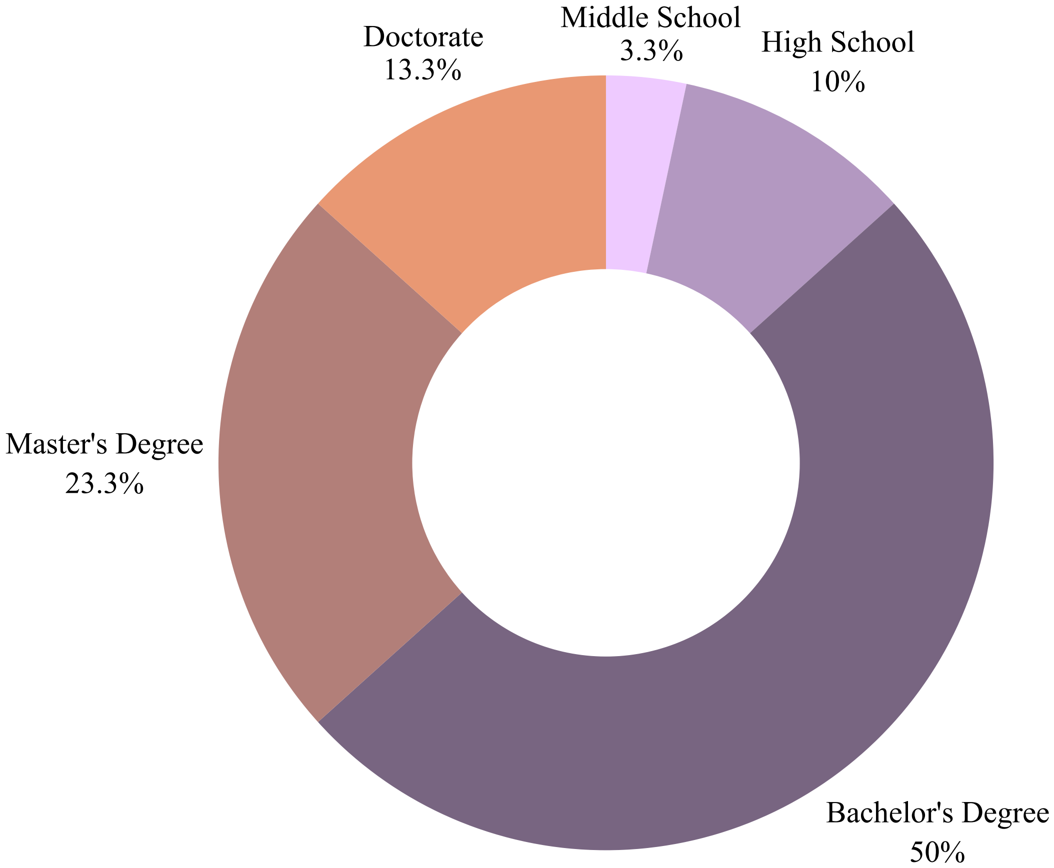


Figure 14. Participant demographics: museum visit frequency, visualized.

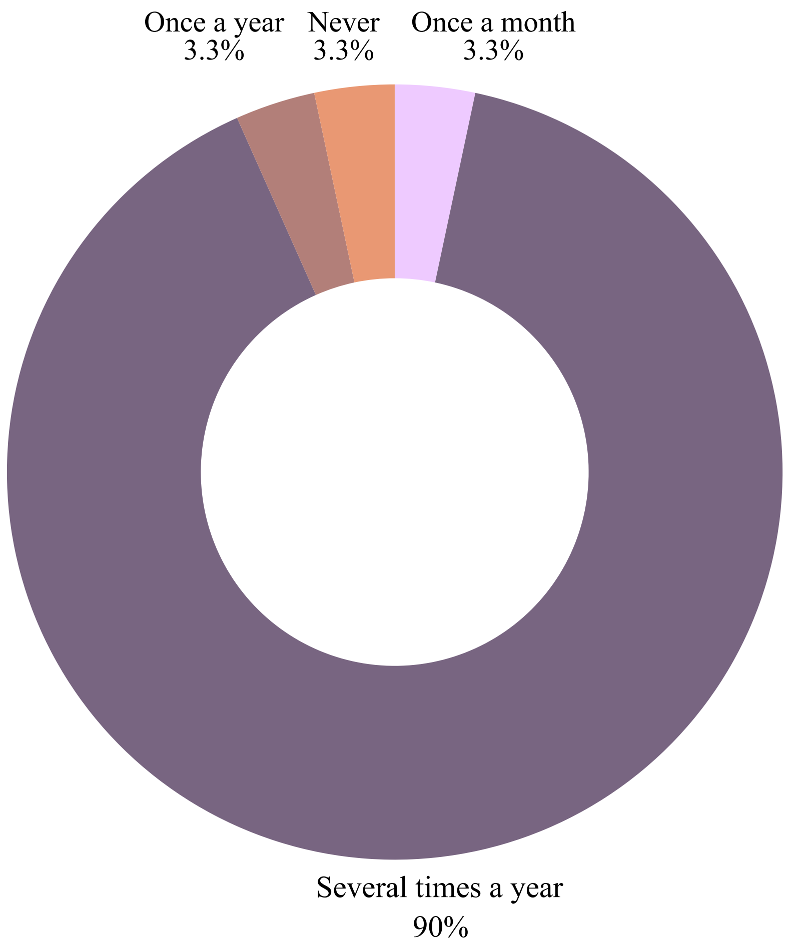


Figure 15. Participant demographics: previously visited Museo Egizio, visualized.

4.2.2 Overview of Interstimulus Questions

Participants were asked to use a VAS to answer 4 short questions between each stimulus (Table 8)

Table 8. Interstimulus questions and targeted measures.

Question	**Translation**	**Measure**
Q1: Quanto ritieni che questo spazio favorisca un'esperienza museale gratificante?	Q1: How much do you think this space fosters a rewarding museum experience?	Emotional valence - how positive/negative the perception is
Q2: Quanto ti senti emotivamente coinvolto/a osservando questa scena?	Q2: How emotionally involved do you feel watching this scene?	Activation/arousal - how intense the response is
Q3: Quanto piacevole trovi questa immagine?	Q3: How pleasant do you find this image?	Aesthetic involvement, how attractive or pleasant the space is
Q4: Quanto hai trovato stancante questa immagine?	Q4: How tiring did you find this image?	Cognitive load

4.3 Comparison Across Experimental Conditions

4.3.1 EEG Measures

Workload

A one-way repeated-measures ANOVA showed a statistically significant effect of the rendering conditions on EEG Workload (p = 0.013).

Table 9. Workload results - within subjects

Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p	ω^2
RENDERING VERSIONS	11.10	3	3.702	3.832	.013	0.124	0.037
Residuals	78.24	81	0.966				

Note. Type III Sum of Squares

Holm-corrected post-hoc comparisons identified two significant contrasts: Cooler Light > Lower Ceiling (p_holm = 0.040) and Lower Ceiling < High Saturation (p_holm = 0.016)

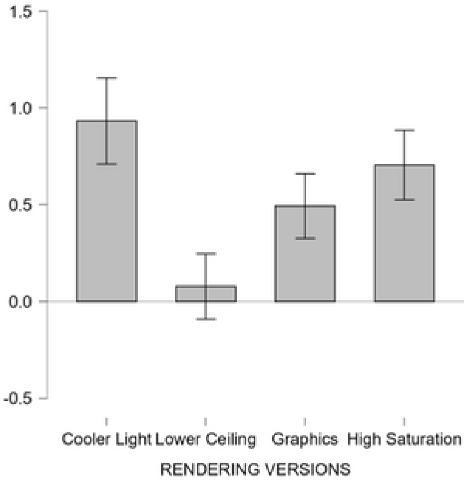
Table 10. Workload results -post hoc comparisons

Post Hoc Comparisons - RENDERING VERSIONS

		Mean Difference	SE	df	t	p_{holm}
Cooler Light	Lower Ceiling	0.855	0.298	27	2.865	.040
	Graphics	0.439	0.245	27	1.793	.336
	High Saturation	0.227	0.320	27	0.711	.810
Lower Ceiling	Graphics	-0.415	0.253	27	-1.641	.337
	High Saturation	-0.628	0.189	27	-3.316	.016
Graphics	High Saturation	-0.212	0.251	27	-0.846	.810

Note. P-value adjusted for comparing a family of 6 estimates.

Figure 16. Workload results visualized



The Lower Ceiling (Figure 12) condition produced the lowest workload scores, with Cooler Light (Figure 12) and High Saturation (Figure 12) produced the highest. This indicates that spatial compression reduced cognitive strain, whereas visually intense or perceptually cooler lit environments produced greater mental effort.

Figure 17. Lower ceiling image, Cooler Light image, High Saturation image, respectively

Approach/Withdrawal (AW norm)

Table 11. AW norm - within subjects

Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p	ω^2
RENDERING VERSIONS	1.188	3	0.396	1.330	.270	0.047	0.005
Residuals	24.109	81	0.298				

Note. Type III Sum of Squares

No significant differences were found. However, correlation analysis between ratings from the interstimulus VASs and neurometrics showed slightly increased approach responses in the Lower Ceiling (Figure 13) condition.

Table 12. AW norm - Pearson's correlations

Pearson's Correlations

			Pearson's r	p
lowerCeiling - Q1	-	lowerCeiling_png_norm_AW_GFP	0.442*	0.019
lowerCeiling - Q2	-	lowerCeiling_png_norm_AW_GFP	0.055	0.781
lowerCeiling - Q3	-	lowerCeiling_png_norm_AW_GFP	0.116	0.557
lowerCeiling - Q4	-	lowerCeiling_png_norm_AW_GFP	-0.234	0.23

* p < .05, ** p < .01, *** p < .001

Figure 18. Lower Ceiling image

Beta/Theta Ratio (Attention)

There are no significant effects, though the High Saturation (Figure 14) condition tended to increase attention activation in descriptive trends.

Table 13. Attention results - within subjects

Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p	ω^2
RENDERING VERSIONS	2.900	3	0.967	1.211	.311	0.043	0.002
Residuals	64.672	81	0.798				

Note. Type III Sum of Squares

Table 14. Attention results - Pearson's correlations

Pearson's Correlations

			Pearson's r	p
hignSaturation - Q1	-	highSaturation_png_norm_BetaTheta_GFP	-0.013	0.947
hignSaturation - Q2	-	highSaturation_png_norm_BetaTheta_GFP	-0.19	0.333
hignSaturation - Q3	-	highSaturation_png_norm_BetaTheta_GFP	0.049	0.804
hignSaturation - Q4	-	highSaturation_png_norm_BetaTheta_GFP	-0.375*	0.049

* p < .05, ** p < .01, *** p < .001

Figure 19. High Saturation image.

Engagement norm

Table 15. Engagement results - within subjects

Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p	ω^2
RENDERING VERSIONS	4.129	3	1.376	2.499	.065	0.085	0.014
Residuals	44.618	81	0.551				

Note. Type III Sum of Squares

Although there is no statistically significant result from the EEG measures, the Holm-corrected post-hoc comparisons suggested higher engagement in the Graphics condition (Figure 16) in comparison to the Lower Ceiling condition (Figure 16).

Table 16. Engagement results - post hoc comparisons

Post Hoc Comparisons - RENDERING VERSIONS

		Mean Difference	SE	df	t	p_{holm}
Cooler Light	Lower Ceiling	0.396	0.196	27	2.015	.270
	Graphics	-0.116	0.165	27	-0.708	.947
	High Saturation	0.159	0.213	27	0.747	.947
Lower Ceiling	Graphics	-0.512	0.151	27	-3.392	.013
	High Saturation	-0.237	0.225	27	-1.054	.947
Graphics	High Saturation	0.275	0.228	27	1.210	.947

Note. P-value adjusted for comparing a family of 6 estimates.

Figure 20. Workload results visualized

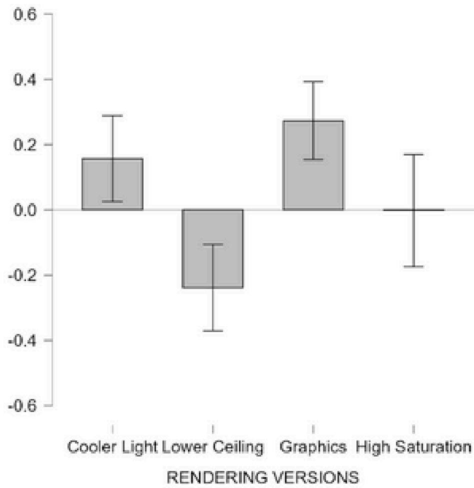


Figure 21. Graphics image, Lower Ceiling image, respectively.

Frontal Theta norm (Mental Effort)

Table 17. Mental Effort results - within subjects

Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p	ω^2
RENDERING VERSIONS	0.278	3	0.093	0.182	.908	0.007	0.000
Residuals	41.138	81	0.508				

Note. Type III Sum of Squares

There are no reliable differences, though Lower Ceiling again trended toward higher cognitive processing (mental effort).

Table 18. Mental Effort results - Pearson's correlations

Pearson's Correlations

			Pearson's r	p
lowerCeiling - Q1	-	lowerCeiling_png_norm_ThetaFront_GFP	-0.159	0.418
lowerCeiling - Q2	-	lowerCeiling_png_norm_ThetaFront_GFP	-0.066	0.739
lowerCeiling - Q3	-	lowerCeiling_png_norm_ThetaFront_GFP	-0.184	0.349
lowerCeiling - Q4	-	lowerCeiling_png_norm_ThetaFront_GFP	0.374	0.05

* p < .05, ** p < .01, *** p < .001

4.3.2 Electrodermal Activity (EDA/GSR norm)

Table 19. GSR norm results - within subjects

Within Subjects Effects

Cases	Sphericity Correction	Sum of Squares	df	Mean Square	F	p	η^2_p	ω^2
RENDERING VERSIONS	None	19152ᵃ	3.000ᵃ	6384ᵃ	0.700ᵃ	.555ᵃ	0.026	0.000
	Greenhouse-Geisser	19152	1.144	16748	0.700	.428	0.026	0.000
Residuals	None	711323	78.000	9120				
	Greenhouse-Geisser	711323	29.733	23924				

Note. Type III Sum of Squares
ᵃ Mauchly's test of sphericity indicates that the assumption of sphericity is violated (p < .05).

While the correlation between the renderings and the normalized GSR data did not reach statistical significance (p > 0.05), a trend was observed regarding the Graphics condition (Figure 17). This physiological trend aligns with the EEG findings, which indicated higher engagement levels in the Graphics condition (Figure 17) compared to the Lower Ceiling, suggesting a coherent pattern of activation across measures despite the lack of statistical significance in arousal specifically.

Table 20. GSR norm results - Pearson's correlations

Pearson's Correlations

			Pearson's r	p
graphics - Q1	-	graphics_png_norm_Tonic_GSR	-0.332	0.091
graphics - Q2	-	graphics_png_norm_Tonic_GSR	-0.228	0.252
graphics - Q3	-	graphics_png_norm_Tonic_GSR	-0.21	0.293
graphics - Q4	-	graphics_png_norm_Tonic_GSR	0.377	0.052

* p < .05, ** p < .01, *** p < .001

Figure 22. Graphics image.

4.3.3 Eye-Tracking Results

Fixation on Papyri Vitrine (Primary Artifact)

Data violated assumptions of normality (Shapiro-Wilk), so a Friedman test was used.

Table 21. Eye-tracking primary artifact - Friedman test

Friedman Test

Factor	X^2_F	df	p	Kendall's W
RENDERING VERSIONS	22.31	3	< .001	0.256

This indicates a statistically significant difference ($p < 0.001$) in gaze behavior across conditions.

Holm-corrected post-hoc comparison revealed: Lower Ceiling > All Other Conditions (significant after correction)

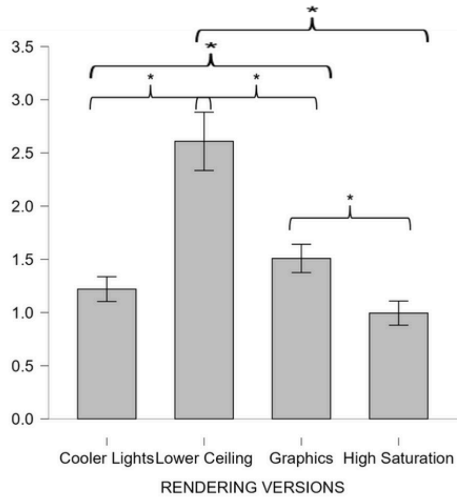
Table 22. Eye-tracking primary artifact - post hoc comparison

Post Hoc Comparisons - RENDERING VERSIONS

		Mean Difference	SE	df	t	p_{holm}
Cooler Lights	Lower Ceiling	-1.389	0.324	28	-4.285	< .001
	Graphics	-0.289	0.109	28	-2.638	.027
	High Saturation	0.226	0.114	28	1.977	.058
Lower Ceiling	Graphics	1.100	0.336	28	3.280	.008
	High Saturation	1.614	0.312	28	5.182	< .001
Graphics	High Saturation	0.514	0.134	28	3.838	.003

Note. P-value adjusted for comparing a family of 6 estimates.

Figure 23. Workload results visualized



On average, the Lower Ceiling condition elicited ~2.5x longer fixation duration on the papyri than any other rendering.

This suggests that spatial compression effectively guided visual attention toward the artifact.

Fixation on Central Vitrines (Secondary ROI)

Again, data violated assumptions of normality (Shapiro-Wilk), so a Friedman test was used.

Table 23. Eye-tracking secondary artifact - Friedman test

Friedman Test

Factor	X^2_F	df	p	Kendall's W
RENDERING VERSIONS	2.770	3	.428	0.032

No significant difference emerged. This indicates the effect of the Lower Ceiling was localized to the primary artifact, not generalized across the room.

Figure 24. Eye-tracking heatmap of Baseline image.

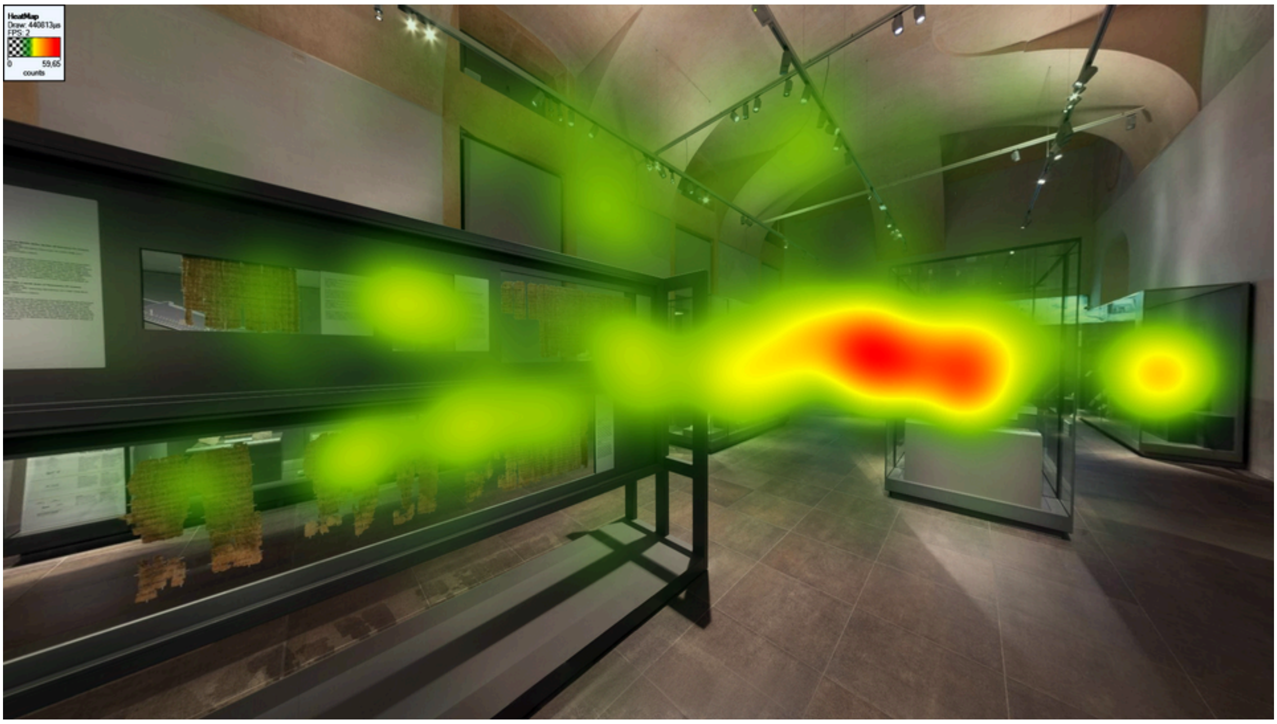
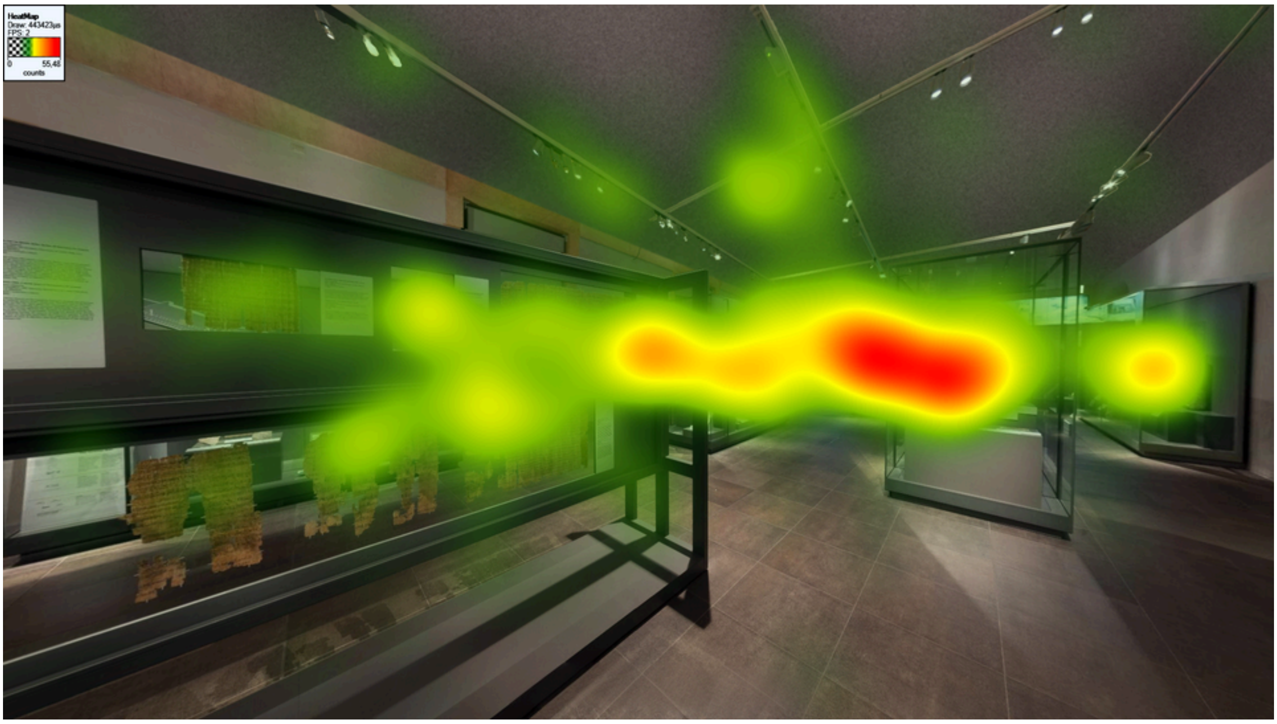


Figure 25. Eye-tracking heatmap of Lower Ceiling image.



4.4 Summary of Findings

Across biometric and behavioral measures, the experiment indicates that architectural interventions can modulate both cognitive load and visual attention within a cultural heritage environment.

Key findings from the experiment include that the Lower Ceiling condition consistently altered participant responses, specifically that it reduced cognitive workload and increased fixation on the papyri artifacts. Notably, a significant correlation was found in this condition between Frontal Theta (mental effort) and self-reported effort (Q4). This suggests that the spatial compression may have facilitated a more accurate subjective perception of cognitive effort, whereas other conditions containing distracting features (such as Graphics or High Saturation) may have introduced a bias in the participants' self-evaluation of their effort. The High Saturation and Cooler Lighting conditions generally produced higher workload, suggesting these visually intense manipulations increased cognitive effort, even if not consciously perceived as demanding. The Graphics condition suggested increased engagement, indicating that interpretive overlays modify emotional activation even when they do not recenter gaze on the artifact. Self-report measures showed subtle but consistent differences that aligned directionally with biometric patterns, though physiological effects were stronger. Most neurometrics did not show statistically significant differences, but the directionality across several measures converges to show that spatial compression indicates a deeper engagement with the object, visual intensity (saturation, cooler lighting) indicates higher mental effort from the participant, and added interpretive graphics indicate the potential for higher engagement and emotional arousal but not necessarily better object focus.

Overall, the findings support the central hypothesis that architectural design elements can influence affective and cognitive states, specifically workload, within cultural heritage environments, even when participants are not consciously aware of these changes.

Chapter 5: Discussion

The results of this study highlight a distinct dissociation between cognitive workload and visual attention driven by architectural form. The Lower Ceiling condition emerged as the most impactful intervention, reducing cognitive workload while simultaneously increasing visual fixation on the primary exhibit by over 250%. Conversely, the inclusion of Interpretive Graphics drove marginally higher levels of engagement. These findings suggest that spatial geometry functions as a mechanism, while narrative elements function as engagement drivers.

5.1 Impact of Ceiling Height

The most robust finding of this experiment is the relationship between spatial volume and attention. In the Lower Ceiling condition, participants exhibited a "tunnel vision" effect; their gaze was focused onto the Papyri Vitrine, yet their brain activity showed reduced workload compared to the Cooler Lighting or High Saturation conditions.

By lowering the ceiling, the visual volume of the room was reduced, effectively removing some visual noise from the periphery. The architecture performed a filtering function for the participant, allowing them to focus on the object without exerting high cognitive effort. It should be noted, however, that participants did self-report that this condition required more mental effort on their part. This indicates that the Lower Ceiling condition, despite inducing lower workload, would enable participants to clearly rate their effort as opposed to the other rendering conditions

This creates a compelling paradox for design: a smaller space (lower ceiling) did not induce claustrophobia or negative affect (as AW and GSR remained stable), but rather facilitated a state of focus, a state ideal for deep object contemplation. It should be noted, however, that participants did self-report that this condition required more mental effort on their part.

5.2 Narrative vs. Architecture: The Engagement Gap

While the Lower Ceiling optimized focus, it did not optimize engagement. The Graphics condition elicited higher engagement scores than the lowered ceiling.

This distinction is critical. "Focus" (looking at an object) is not the same as "Engagement" (processing its meaning). The presence of contextual graphics likely triggered narrative processing, or what Keen describes as narrative empathy (Keen, 2006). This requires more active cognitive participation than the passive focus induced by the ceiling. This supports the museological argument that while architecture sets the mood (Böhme, 1993), narrative elements are required to sustain active interest (Falk & Storksdieck, 2005).

5.3 Conscious and Unconscious Alignment

The correlation analysis offers insight into the reliability of neurometrics in this context. In the Lower Ceiling condition, the physiological signals for effort (Frontal Theta) correlated significantly with self-reported mental effort. This validation suggests that participants were accurately perceiving their own internal states in the compressed space. However the lack of significant arousal (GSR) differences across the board suggests that 2D static stimuli may not be immersive enough to trigger the autonomic nervous system's response or strong emotional arousal mechanisms, even if they successfully modulate cognitive attention.

5.4 Implications for Design

Based on the multimodal physiological and eye-tracking data, this research proposes a specific design grammar for cultural heritage spaces.

> For points to be highlighted, use spatial compression (lower ceilings or dropped canopies) to reduce visitor cognitive load and passively force focus onto the artifact or point of interest.
>
> For complex narratives, rely on graphic and textual interventions to drive active engagement, as architecture alone may create opportunities for focus but not necessarily deep engagement.

Variations in color saturation and lighting can be employed to intentionally modulate the visitor's emotional tone and preparatory attention. Although not reaching statistical significance for general arousal, the non-neutral lighting and color conditions showed trends in workload and fixation, and previous studies demonstrate their role in affecting mood. These variables act as affective tuning devices, setting the perceptual context that can either amplify or dampen the effects of the spatial and narrative interventions.

5.5 Limitations and Conclusion

While the experimental design ensured control and replicability, it also introduced limitations.

The use of 2D image stimuli cannot fully replicate the embodied and multisensory experience of a real museum environment.

Additionally, the sample size of 28 participants limits the generalizability of the findings.

Future studies could extend this work by employing immersive virtual 3D environments or in-situ measurements with larger and more diverse samples.

A key limitation in the results is the lack of significant variation in arousal (GSR). This is likely due to the use of static 2D images on a screen. As noted in the literature review, embodied simulation relies on proprioception and movement in a space (Mallgrave, 2013).

Future research using VR or physical environments would likely yield stronger arousal responses. Additionally, future investigations might explore how multisensory cues (sound, temperature, scent) further influence emotional response, or how these effects differ across cultural backgrounds. However, the significant findings regarding workload and gaze behavior confirm that even in static viewing, subtle variations in architectural design can alter how the brain allocates attention in a space. By combining multimodal physiological and self-reported data, the research provides empirical support for design strategies that prioritize emotional resonance and experiential depth in cultural heritage settings.

Chapter 6: Conclusion

6.1 Summary of Research

This thesis set out to investigate the invisible dialogue between the visitor and the architectural environment. By isolating and manipulating four distinct variables, lighting, ceiling height, color saturation, and graphics, within the context of the Museo Egizio, this study sought to quantify how space shapes experience.

The results revealed a dissociation between cognitive focus and narrative engagement. The most robust finding was the impact of spatial compression; lowering the ceiling acted as a powerful mechanism for attention guidance, significantly increasing fixation on the primary artifact while simultaneously reducing cognitive workload. Conversely, the introduction of interpretive graphics drove marginally higher levels of engagement but dispersed visual attention. These findings suggest that architecture and scenography perform distinct, complementary roles: architecture facilitates the state of looking (focus), while narrative elements facilitate the meaning of what is seen (engagement).

6.2 Theoretical Implications

Theoretically, this work supports the embodied cognition framework proposed by Mallgrave (2013) and Jelić et al. (2016), confirming that the body and brain respond to spatial cues pre-reflectively. The study validates the phenomenological assertion that "atmosphere" is not merely a poetic metaphor but a measurable physiological state. Specifically, the correlation between spatial volume and cognitive load provides empirical weight to the architectural intuition that intimate spaces foster contemplation.

However, the study also highlights the complexity of immersion. The lack of significant electrodermal arousal (GSR) suggests that while visual attention can be captured through static spatial manipulation, the deeper visceral feeling of experiencing spaces likely relies on the full sensorimotor experience that 2D representations cannot fully replicate such as proprioception, acoustics, and movement.

6.3 Implications for Architectural Practice

For architects and museum curators, this research offers a preliminary evidence-based guide for exhibition design that prioritizes the visitor's cognitive economy. To highlight specific artifacts without inducing fatigue, reducing the vertical scale of the space proves to be a more effective strategy than merely increasing visual intensity. Consequently, designers must distinguish between their communicative goals: if the objective is deep visual inspection, minimizing the spatial volume is optimal, whereas if the goal is contextual understanding or empathy, graphic narratives should be utilized. Furthermore, regarding the management of cognitive load, since high saturation and cooler lighting demonstrated a trend toward higher cognitive workload, neutralizing the architectural container in complex exhibitions effectively preserves the visitor's cognitive energy for the artifacts themselves.

6.4 Limitations and Future Directions

The primary limitation of this study was the reliance on static, screen-based stimuli. While this medium was sufficient for measuring attention and cognitive load, it likely dampened the physiological arousal responses that would naturally occur within a physical space. Future research should aim to bridge this gap by utilizing Virtual Reality (VR) to reintroduce the elements of immersion and scale while maintaining experimental control, as well as conducting in-situ mobile EEG studies within physical museums to validate these laboratory findings against real-world visitor behavior. Additionally, future investigations should extend to cross-cultural analyses to determine whether the observed "tunnel vision" effect of spatial compression is a universal human response or a culturally conditioned phenomenon.

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Annex

Annex 1. Slide deck from the Laboratory of Industrial Neuroscience at Sapienza University of Rome with physiological measure results.

AW norm : comparison among renderings 1/2

Within Subjects Effects

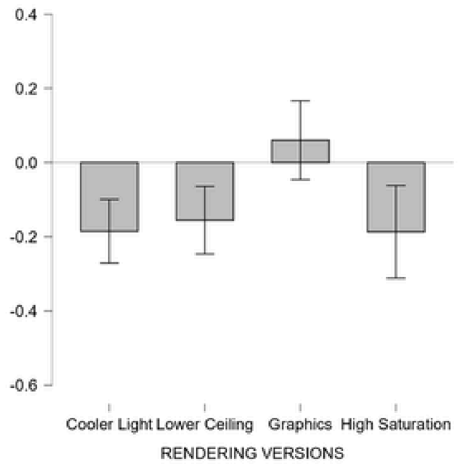
Cases	Sum of Squares	df	Mean Square	F	p	η^2_p	ω^2
RENDERING VERSIONS	1.188	3	0.396	1.330	.270	0.047	0.005
Residuals	24.109	81	0.298				

Note. Type III Sum of Squares

Friedman Test

Factor	X^2_F	df	p	Kendall's W
RENDERING VERSIONS	3.300	3	.348	0.039

AW norm : comparison among renderings 2/2



Beta/Theta norm : comparison among renderings 1/2

Within Subjects Effects

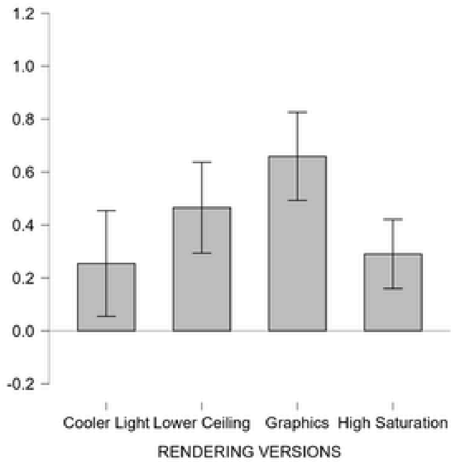
Cases	Sum of Squares	df	Mean Square	F	p	η^2_p	ω^2
RENDERING VERSIONS	2.900	3	0.967	1.211	.311	0.043	0.002
Residuals	64.672	81	0.798				

Note. Type III Sum of Squares

Friedman Test

Factor	X^2_F	df	p	Kendall's W
RENDERING VERSIONS	3.900	3	.272	0.046

Beta/Theta norm : comparison among renderings 2/2



Engagement norm : comparison among renderings 1/2

Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p	ω^2
RENDERING VERSIONS	4.129	3	1.376	2.499	.065	0.085	0.014
Residuals	44.618	81	0.551				

Note. Type III Sum of Squares

Friedman Test

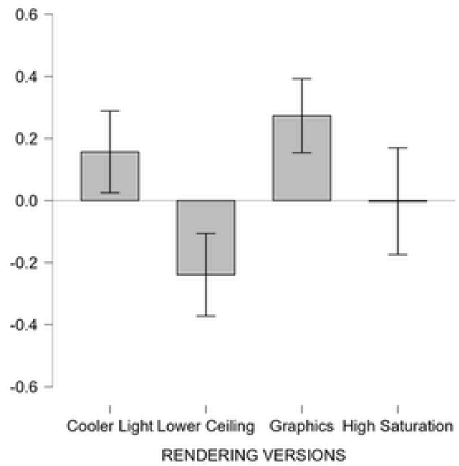
Factor	X^2_F	df	p	Kendall's W
RENDERING VERSIONS	7.371	3	.061	0.088

Engagement norm : comparison among renderings 2/2

Post Hoc Comparisons - RENDERING VERSIONS

		Mean Difference	SE	df	t	p_{holm}
Cooler Light	Lower Ceiling	0.396	0.196	27	2.015	.270
	Graphics	-0.116	0.165	27	-0.708	.947
	High Saturation	0.159	0.213	27	0.747	.947
Lower Ceiling	Graphics	-0.512	0.151	27	-3.392	.013
	High Saturation	-0.237	0.225	27	-1.054	.947
Graphics	High Saturation	0.275	0.228	27	1.210	.947

Note. P-value adjusted for comparing a family of 6 estimates.



Theta frontal norm : comparison among renderings 1/2

Within Subjects Effects

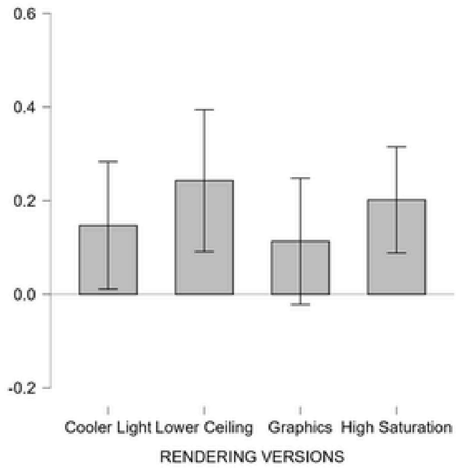
Cases	Sum of Squares	df	Mean Square	F	p	η^2_p	ω^2
RENDERING VERSIONS	0.278	3	0.093	0.182	.908	0.007	0.000
Residuals	41.138	81	0.508				

Note. Type III Sum of Squares

Friedman Test

Factor	X^2_F	df	p	Kendall's W
RENDERING VERSIONS	0.771	3	.856	0.009

Theta frontal norm : comparison among renderings 2/2



GSR norm : comparison among renderings 1/2

Within Subjects Effects

Cases	Sphericity Correction	Sum of Squares	df	Mean Square	F	p	η^2_p	ω^2
RENDERING VERSIONS	None	19152[a]	3.000[a]	6384[a]	0.700[a]	.555[a]	0.026	0.000
	Greenhouse-Geisser	19152	1.144	16748	0.700	.428	0.026	0.000
Residuals	None	711323	78.000	9120				
	Greenhouse-Geisser	711323	29.733	23924				

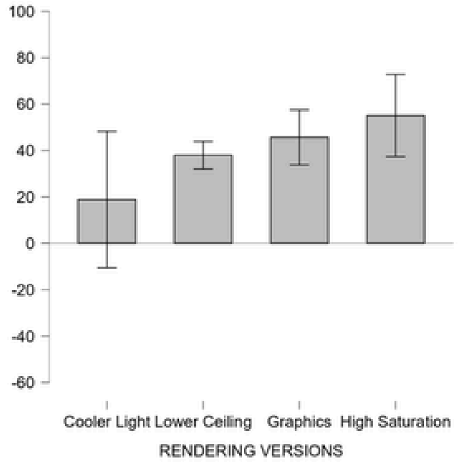
Note. Type III Sum of Squares

[a] Mauchly's test of sphericity indicates that the assumption of sphericity is violated (p < .05).

Friedman Test

Factor	X^2_F	df	p	Kendall's W
RENDERING VERSIONS	2.378	3	.498	0.029

GSR norm : comparison among renderings 2/2



WorkLoad norm : comparison among renderings 1/2

Within Subjects Effects

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p	ω^2
RENDERING VERSIONS	11.10	3	3.702	3.832	.013	0.124	0.037
Residuals	78.24	81	0.966				

Note. Type III Sum of Squares

Friedman Test

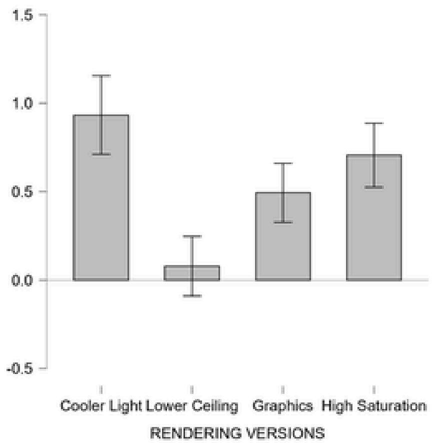
Factor	X^2_F	df	p	Kendall's W
RENDERING VERSIONS	8.357	3	.039	0.099

WorkLoad norm : comparison among renderings 2/2

Post Hoc Comparisons - RENDERING VERSIONS

		Mean Difference	SE	df	t	p_{holm}
Cooler Light	Lower Ceiling	0.855	0.298	27	2.865	.040
	Graphics	0.439	0.245	27	1.793	.336
	High Saturation	0.227	0.320	27	0.711	.810
Lower Ceiling	Graphics	-0.415	0.253	27	-1.641	.337
	High Saturation	-0.628	0.189	27	-3.316	.016
Graphics	High Saturation	-0.212	0.251	27	-0.846	.810

Note. P-value adjusted for comparing a family of 6 estimates.



Correlation between **lower ceiling** and AW

1. Valenza emotiva
2. Attivazione/arousal
3. Coinvolgimento estetico
4. Carico cognitivo (WL)

Pearson's Correlations

			Pearson's r	p
lowerCeiling - Q1	-	lowerCeiling_png_norm_AW_GFP	0.442*	0.019
lowerCeiling - Q2	-	lowerCeiling_png_norm_AW_GFP	0.055	0.781
lowerCeiling - Q3	-	lowerCeiling_png_norm_AW_GFP	0.116	0.557
lowerCeiling - Q4	-	lowerCeiling_png_norm_AW_GFP	-0.234	0.23

* p < .05, ** p < .01, *** p < .001

Correlation between **high saturation** and BetaTheta

1. Valenza emotiva
2. Attivazione/arousal
3. Coinvolgimento estetico
4. Carico cognitivo (WL)

Pearson's Correlations

			Pearson's r	p
hignSaturation - Q1	-	highSaturation_png_norm_BetaTheta_GFP	-0.013	0.947
hignSaturation - Q2	-	highSaturation_png_norm_BetaTheta_GFP	-0.19	0.333
hignSaturation - Q3	-	highSaturation_png_norm_BetaTheta_GFP	0.049	0.804
hignSaturation - Q4	-	highSaturation_png_norm_BetaTheta_GFP	-0.375*	0.049

* p < .05, ** p < .01, *** p < .001

Correlation between **lower ceiling** and Theta frontal

1. Valenza emotiva
2. Attivazione/arousal
3. Coinvolgimento estetico
4. Carico cognitivo (WL)

Pearson's Correlations

			Pearson's r	p
lowerCeiling - Q1	-	lowerCeiling_png_norm_ThetaFront_GFP	-0.159	0.418
lowerCeiling - Q2	-	lowerCeiling_png_norm_ThetaFront_GFP	-0.066	0.739
lowerCeiling - Q3	-	lowerCeiling_png_norm_ThetaFront_GFP	-0.184	0.349
lowerCeiling - Q4	-	lowerCeiling_png_norm_ThetaFront_GFP	0.374	0.05

* p < .05, ** p < .01, *** p < .001

1. Valenza emotiva
2. Attivazione/arousal
3. Coinvolgimento estetico
4. Carico cognitivo (WL)

Correlation between **graphics** and **GSR**

Pearson's Correlations

			Pearson's r	p
graphics - Q1	-	graphics_png_norm_Tonic_GSR	-0.332	0.091
graphics - Q2	-	graphics_png_norm_Tonic_GSR	-0.228	0.252
graphics - Q3	-	graphics_png_norm_Tonic_GSR	-0.21	0.293
graphics - Q4	-	graphics_png_norm_Tonic_GSR	0.377	0.052

* p < .05, ** p < .01, *** p < .001

ROI 'Papyri Vitrine All' : comparison among renderings 1/3

It is not possible to perform ANOVA because the Shapiro-Wilk test shows that the distribution is not normal.

For this reason, the non-parametric Friedman test was performed.

Friedman Test

Factor	X^2_F	df	p	Kendall's W
RENDERING VERSIONS	22.31	3	< .001	0.256

ROI 'Papyri Vitrine All' : comparison among renderings 2/3

Post Hoc Comparisons - RENDERING VERSIONS

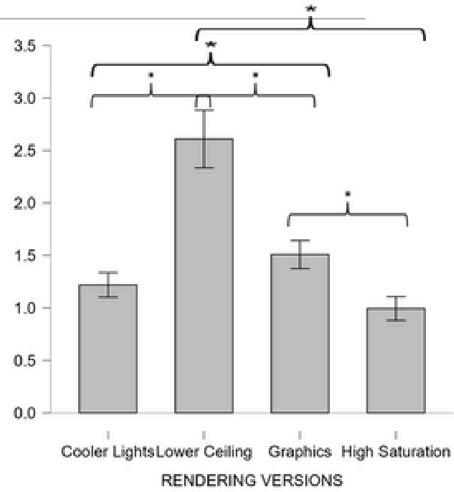
		Mean Difference	SE	df	t	p_{holm}
Cooler Lights	Lower Ceiling	-1.389	0.324	28	-4.285	< .001
	Graphics	-0.289	0.109	28	-2.638	.027
	High Saturation	0.226	0.114	28	1.977	.058
Lower Ceiling	Graphics	1.100	0.336	28	3.280	.008
	High Saturation	1.614	0.312	28	5.182	< .001
Graphics	High Saturation	0.514	0.134	28	3.838	.003

Note. P-value adjusted for comparing a family of 6 estimates.

ROI 'Papyri Vitrine All' : comparison among renderings 3/3

RESULTS:

- In the lower ceiling rendering condition, the time spent on the papyri vitrine is higher than the other conditions (all $p < 0.05$). More than 2.5 times the time spent in the actual conditon (baseline).
- Cooler lights and High saturation conditions, even if they are almost significantly different ($p = 0.058$), are the conditions more similar to the actual condition.
- These results are possibly due to the lower ceiling that guides the gaze toward the papyri vitrine.



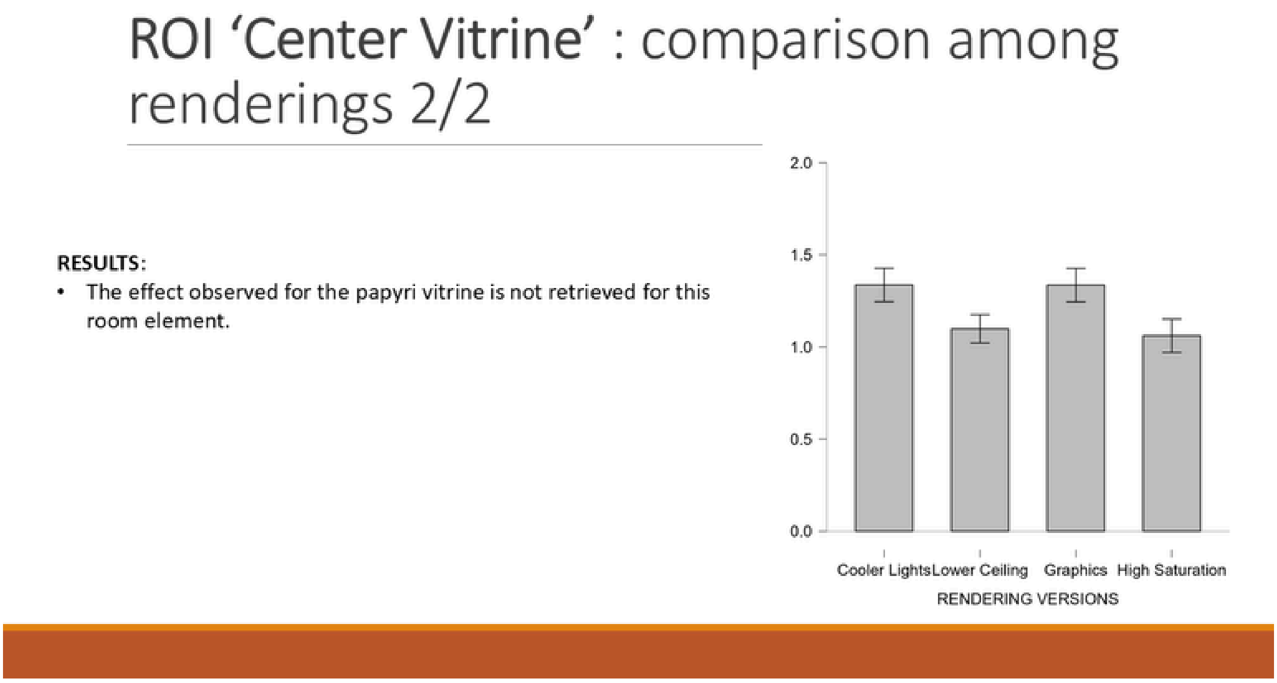
ROI 'Center Vitrine' : comparison among renderings 1/2

It is not possible to perform ANOVA because the Shapiro-Wilk test shows that the distribution is not normal.

For this reason, the non-parametric Friedman test was performed.

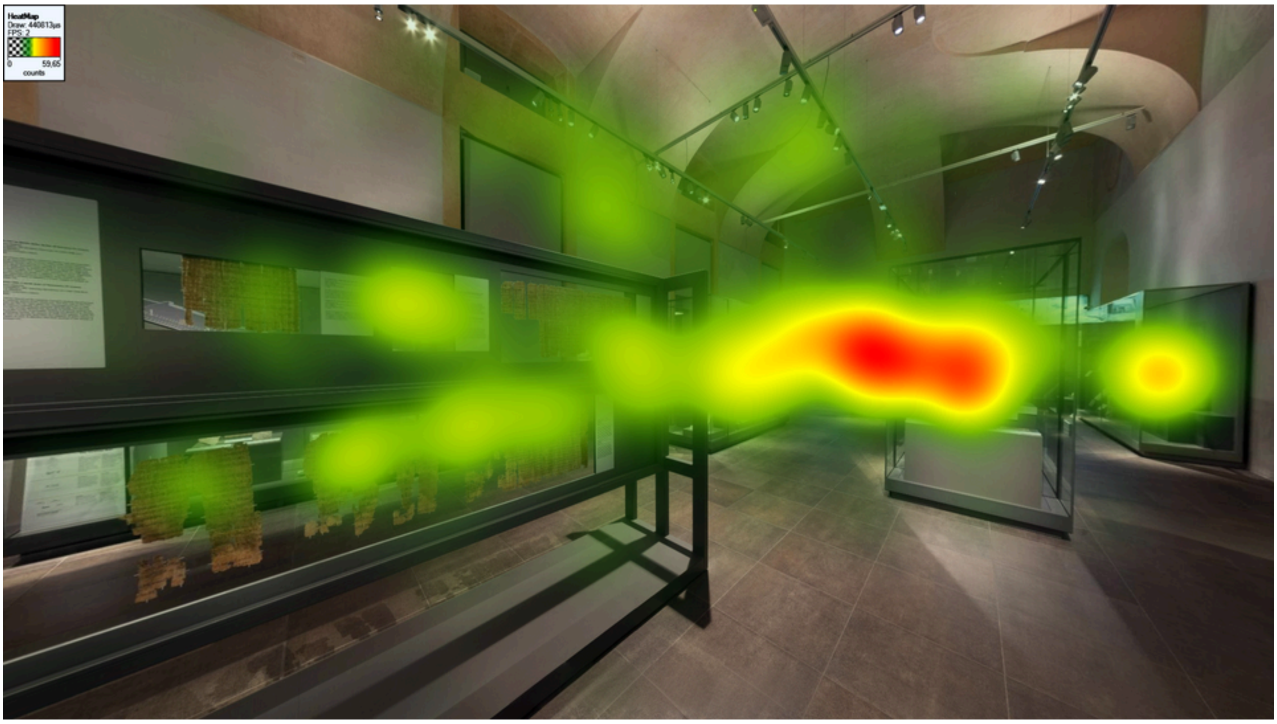
Friedman Test

Factor	X^2_F	df	p	Kendall's W
RENDERING VERSIONS	2.770	3	.428	0.032

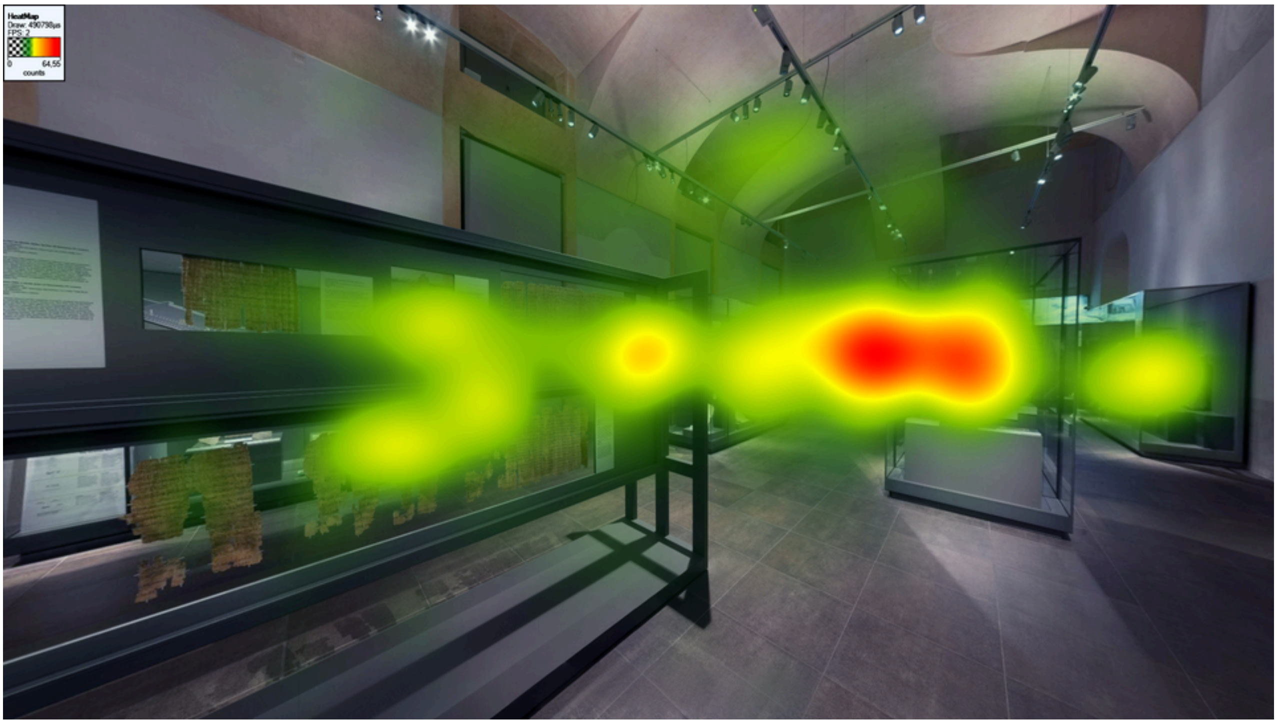


Annex 2. Eye-tracking heatmaps from the Laboratory of Industrial Neuroscience at Sapienza University of Rome.

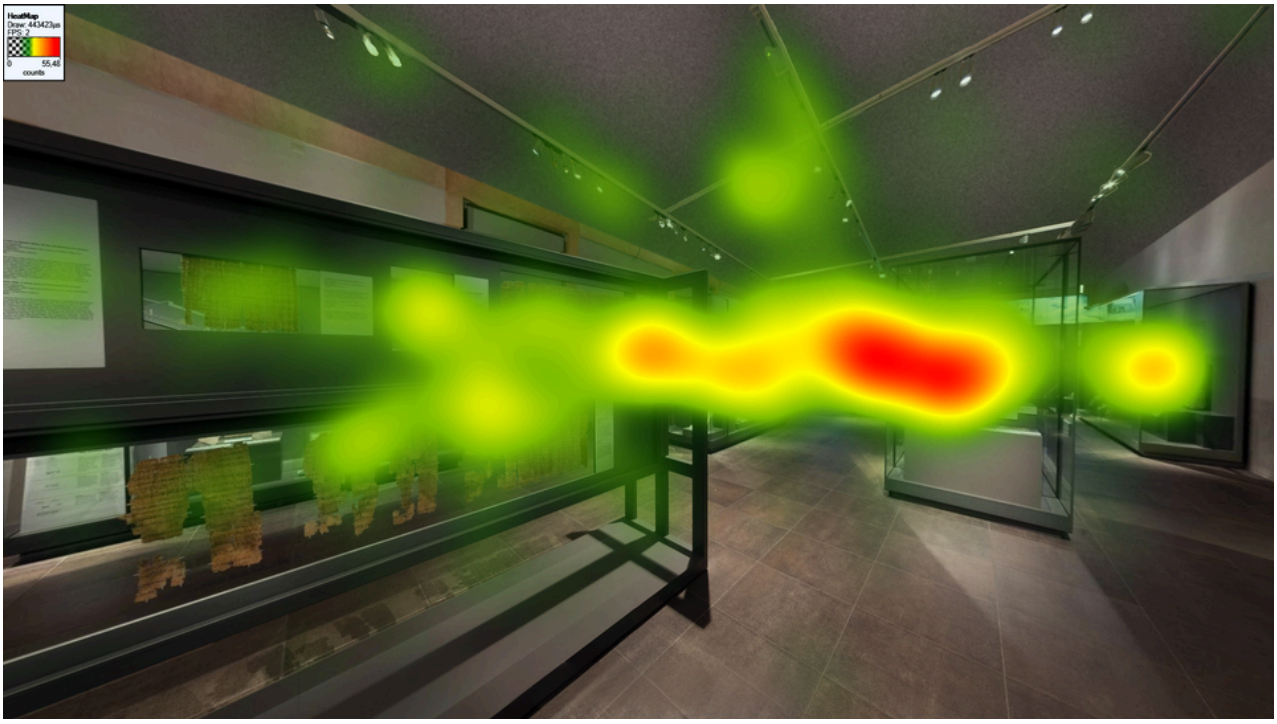
Baseline Image



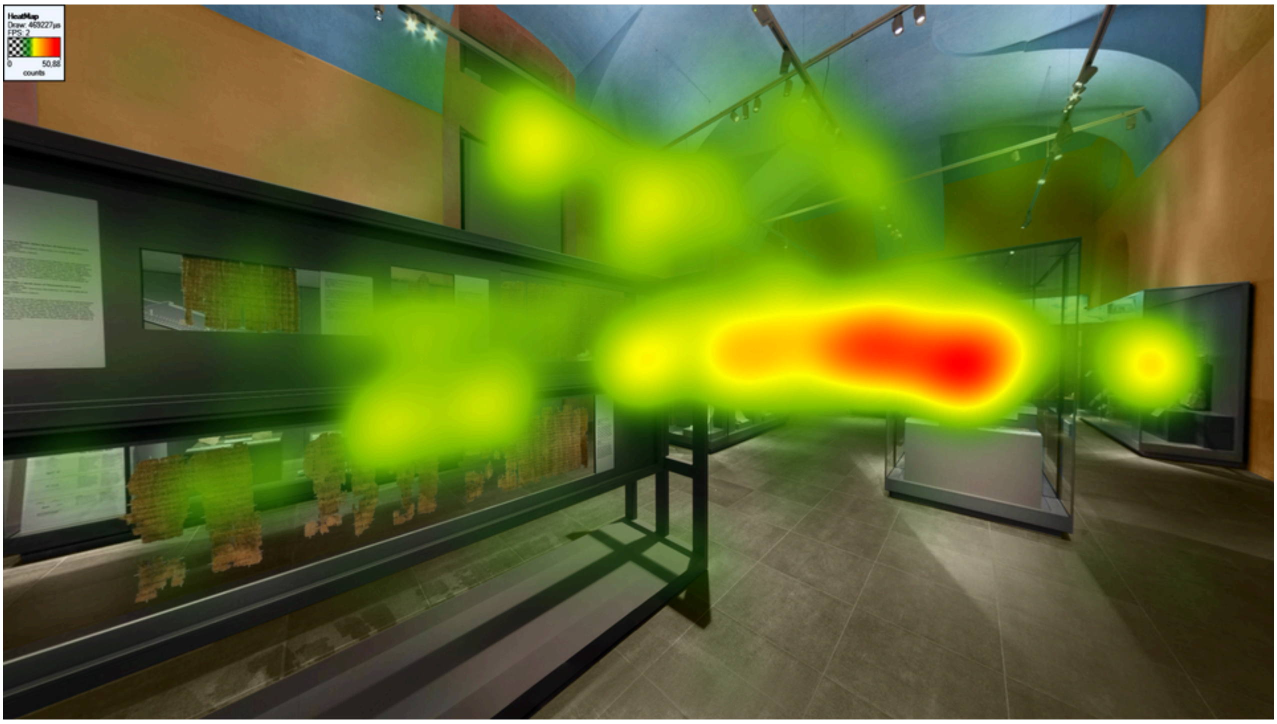
Cooler Lights image



Lower Ceiling image



High Saturation image



Graphics image

Annex 3. Interstimulus questionnaire document that was printed and filled out by each participant during the experiment

Ripensando all'immagine appena vista, **indica come ti ha fatto sentire** su una scala da 1 a 7 (1=Per niente, 7=Molto).

1)

Quanto ritieni che questo spazio favorisca un'esperienza museale gratificante?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○
Quanto ti senti emotivamente coinvolto/a osservando questa scena?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○
Quanto piacevole trovi questa immagine?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○
Quanta hai trovato stancante questa immagine?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○

2)

Quanto ritieni che questo spazio favorisca un'esperienza museale gratificante?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○
Quanto ti senti emotivamente coinvolto/a osservando questa scena?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○
Quanto piacevole trovi questa immagine?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○
Quanta hai trovato stancante questa immagine?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○

3)

Quanto ritieni che questo spazio favorisca un'esperienza museale gratificante?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○
Quanto ti senti emotivamente coinvolto/a osservando questa scena?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○
Quanto piacevole trovi questa immagine?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○
Quanta hai trovato stancante questa immagine?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○

ID: ___________________ R: ______

Ripensando all'immagine appena vista, **indica come ti ha fatto sentire** su una scala da 1 a 7 (1=Per niente, 7=Molto).

4)

Quanto ritieni che questo spazio favorisca un'esperienza museale gratificante?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○
Quanto ti senti emotivamente coinvolto/a osservando questa scena?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○
Quanto piacevole trovi questa immagine?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○
Quanta hai trovato stancante questa immagine?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○

5)

Quanto ritieni che questo spazio favorisca un'esperienza museale gratificante?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○
Quanto ti senti emotivamente coinvolto/a osservando questa scena?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○
Quanto piacevole trovi questa immagine?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○
Quanta hai trovato stancante questa immagine?						
1 = Per niente	2	3	4	5	6	7 = Molto
○	○	○	○	○	○	○

ID: ____________________ R: ______

Annex 4. Post-experiment questionnaire that was filled out by each participant after the physiological data collection was concluded.

META-MUSEUM_OTT25_ROMA

Cisono 18 domande in questaindagine.

Inserisci il tuo ID: *

Scrivere la propria risposta qui:

Inserisci la tua età (in anni): *

Scrivere la propria risposta qui:

Indica il tuo genere: *

Scegliere solo una delle seguenti voci
Scegli **solo una** delle seguenti:

- ◯ Maschio
- ◯ Femmina
- ◯ Preferisco non dichiarare

Indica il tuo titolo di studio: *

Scegliere solo una delle seguenti voci
Scegli **solo una** delle seguenti:

- ◯ Licenza elementare
- ◯ Licenza media
- ◯ Diploma di maturità
- ◯ Laurea triennale
- ◯ Laurea magistrale
- ◯ Dottorato
- ◯ Master o Specializzazione

Su una scala da 1 a 7 (1= Per niente, 7= Moltissimo), in generale, quanto sei interessato/a alla storia e all'archeologia? *

Scegliere la risposta appropriata per ciascun elemento:

	1	2	3	4	5	6	7
	◯	◯	◯	◯	◯	◯	◯

Con quale frequenza visiti musei o istituzioni culturali?

*

Scegliere solo una delle seguenti voci
Scegli **solo una** delle seguenti:

- ◯ Mai
- ◯ Una volta all'anno
- ◯ Alcune volte all'anno
- ◯ Una volta al mese
- ◯ Più di una volta al mese

Su una scala da 1 a 7 (1= Per niente, 7= Moltissimo), quanto sei interessato/a in particolare all’Antico Egitto? *

Scegliere la risposta appropriata per ciascun elemento:

	1	2	3	4	5	6	7
	◯	◯	◯	◯	◯	◯	◯

Hai mai visitato il Museo Egizio di Torino?
*
Scegliere solo una delle seguenti voci
Scegli **solo una** delle seguenti:

◯ Sì
◯ No

ANTICO EGITTO

Su una scala da 1 a 7 (1= Per niente, 7= Moltissimo), indica il tuo livello di familiarità con i seguenti reperti e argomenti dell’Antico Egitto:
*
Scegliere la risposta appropriata per ciascun elemento:

	1	2	3	4	5	6	7
Mummie, sarcofagi e tombe	◯	◯	◯	◯	◯	◯	◯
Faraoni e regine	◯	◯	◯	◯	◯	◯	◯
Dei e religione	◯	◯	◯	◯	◯	◯	◯
Oggetti della vita quotidiana (es. strumenti, mobili, gioielli)	◯	◯	◯	◯	◯	◯	◯
Scrittura geroglifica	◯	◯	◯	◯	◯	◯	◯

Quando pensi all'"Antico Egitto", quali emozioni o sentimenti ti vengono in mente? (Puoi selezionare più opzioni) *

Selezionaretutte quellechecorrispondono
Scegliere **tutte** le corrispondenti:

- [ ] Stupore
- [ ] Fascinazione
- [ ] Curiosità
- [ ] Ammirazione
- [ ] Orgoglio
- [ ] Sicurezza / Fiducia in sé
- [ ] Determinazione
- [ ] Ispirazione
- [ ] Entusiasmo
- [ ] Attenzione / Interesse
- [ ] Malinconia
- [ ] Senso di disagio / Inquietudine
- [ ] Nervosismo
- [ ] Paura
- [ ] Indifferenza

Su una scala da 1 a 7 (1= Per niente, 7= Moltissimo), indica quanto associ l'Antico Egitto ai seguenti aggettivi: *

Scegliere la risposta appropriata per ciascun elemento:

	1	2	3	4	5	6	7
Misterioso	○	○	○	○	○	○	○
Grandioso / Monumentale	○	○	○	○	○	○	○
Lontano / Irrilevante	○	○	○	○	○	○	○
Ispiratore	○	○	○	○	○	○	○
Cupo / Macabro	○	○	○	○	○	○	○
Complesso	○	○	○	○	○	○	○
Riconoscibile / Facile da comprendere	○	○	○	○	○	○	○

IMMAGINI

Guardando questa immagine, quali emozioni o sentimenti ti vengono in mente? (Puoi selezionare più opzioni)

*

Selezionaretutte quellechecorrispondono

Scegliere **tutte** le corrispondenti:

- [ ] Stupore
- [ ] Fascinazione
- [ ] Curiosità
- [ ] Ammirazione
- [ ] Orgoglio
- [ ] Sicurezza / Fiducia in sé
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- [ ] Ispirazione
- [ ] Entusiasmo
- [ ] Attenzione / Interesse
- [ ] Malinconia
- [ ] Senso di disagio / Inquietudine
- [ ] Nervosismo
- [ ] Paura
- [ ] Indifferenza

Guardando questa immagine, quali emozioni o sentimenti ti vengono in mente? (Puoi selezionare più opzioni)

*

Selezionaretutte quellechecorrispondono

Scegliere **tutte** le corrispondenti:

- ☐ Stupore
- ☐ Fascinazione
- ☐ Curiosità
- ☐ Ammirazione
- ☐ Orgoglio
- ☐ Sicurezza / Fiducia in sé
- ☐ Determinazione
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- ☐ Entusiasmo
- ☐ Attenzione / Interesse
- ☐ Malinconia
- ☐ Senso di disagio / Inquietudine
- ☐ Nervosismo
- ☐ Paura
- ☐ Indifferenza

Guardando questa immagine, quali emozioni o sentimenti ti vengono in mente? (Puoi selezionare più opzioni)

*

Selezionaretutte quellechecorrispondono

Scegliere **tutte** le corrispondenti:

- [ ] Stupore
- [ ] Fascinazione
- [ ] Curiosità
- [ ] Ammirazione
- [ ] Orgoglio
- [ ] Sicurezza / Fiducia in sé
- [ ] Determinazione
- [ ] Ispirazione
- [ ] Entusiasmo
- [ ] Attenzione / Interesse
- [ ] Malinconia
- [ ] Senso di disagio / Inquietudine
- [ ] Nervosismo
- [ ] Paura
- [ ] Indifferenza

Guardando questa immagine, quali emozioni o sentimenti ti vengono in mente? (Puoi selezionare più opzioni)

*

Selezionaretutte quellechecorrispondono

Scegliere **tutte** le corrispondenti:

- [ ] Stupore
- [ ] Fascinazione
- [ ] Curiosità
- [ ] Ammirazione
- [ ] Orgoglio
- [ ] Sicurezza / Fiducia in sé
- [ ] Determinazione
- [ ] Ispirazione
- [ ] Entusiasmo
- [ ] Attenzione / Interesse
- [ ] Malinconia
- [ ] Senso di disagio / Inquietudine
- [ ] Nervosismo
- [ ] Paura
- [ ] Indifferenza

Guardando questa immagine, quali emozioni o sentimenti ti vengono in mente? (Puoi selezionare più opzioni)

*

Selezionaretutte quellechecorrispondono

Scegliere **tutte** le corrispondenti:

- [ ] Stupore
- [ ] Fascinazione
- [ ] Curiosità
- [ ] Ammirazione
- [ ] Orgoglio
- [ ] Sicurezza / Fiducia in sé
- [ ] Determinazione
- [ ] Ispirazione
- [ ] Entusiasmo
- [ ] Attenzione / Interesse
- [ ] Malinconia
- [ ] Senso di disagio / Inquietudine
- [ ] Nervosismo
- [ ] Paura
- [ ] Indifferenza

SENSAZIONI

Su una scala da 1 a 5 (1=Per niente d'accordo, 5= Del tutto d'accordo), indica quanto sei d’accordo con ciascuna delle seguenti affermazioni: *

Scegliere la risposta appropriata per ciascun elemento:

	1	2	3	4	5
Spesso sono confuso/a circa le emozioni che provo	○	○	○	○	○
Mi è difficile trovare le parole giuste per esprimere i miei sentimenti	○	○	○	○	○
Provo delle sensazioni fisiche che neanche i medici capiscono	○	○	○	○	○
Riesco facilmente a descrivere i miei sentimenti	○	○	○	○	○
Preferisco approfondire i miei problemi piuttosto che descriverli semplicemente	○	○	○	○	○
Quando sono sconvolto/a non so se sono triste, spaventato/a o arrabbiato/a	○	○	○	○	○
Sono spesso disorientato dalle sensazioni che provo nel mio corpo	○	○	○	○	○
Preferisco lasciare che le cose seguano il loro corso piuttosto che capire perché sono andate in quel modo	○	○	○	○	○
Provo sentimenti che non riesco proprio ad identificare	○	○	○	○	○
È essenziale conoscere le proprie emozioni	○	○	○	○	○
Mi è difficile descrivere ciò che provo per gli altri	○	○	○	○	○
Gli altri mi chiedono di parlare di più dei miei sentimenti	○	○	○	○	○
Non capisco cosa stia accadendo dentro di me	○	○	○	○	○
Spesso non so perché mi arrabbio	○	○	○	○	○
Con le persone preferisco parlare di cose di tutti i giorni piuttosto che delle loro emozioni	○	○	○	○	○
Preferisco vedere spettacoli leggeri, piuttosto che spettacoli a sfondo psicologico	○	○	○	○	○

	1	2	3	4	5
Mi è difficile rivelare i sentimenti più profondi anche ad amici più intimi	◯	◯	◯	◯	◯
Riesco a sentirmi vicino ad una persona, anche se ci capita di stare in silenzio	◯	◯	◯	◯	◯
Trovo che l'esame dei miei sentimenti mi serve a risolvere i miei problemi personali	◯	◯	◯	◯	◯
Cercare significati nascosti in film o commedie distoglie dal piacere dello spettacolo	◯	◯	◯	◯	◯

Big5

Su una scala da 1 a 5 (1=Per niente d'accordo, 5= Del tutto d'accordo), indica il tuo grado di accordo rispetto alle seguenti affermazioni. Mi vedo come una persona che... *

Scegliere la risposta appropriata per ciascun elemento:

	1	2	3	4	5
...è riservata	◯	◯	◯	◯	◯
...generalmente si fida	◯	◯	◯	◯	◯
...tende ad essere pigra	◯	◯	◯	◯	◯
...è rilassata, sopporta bene lo stress	◯	◯	◯	◯	◯
...ha pochi interessi artistici	◯	◯	◯	◯	◯
...è spigliata, socievole	◯	◯	◯	◯	◯
...tende a trovare i difetti negli altri	◯	◯	◯	◯	◯
...è coscienziosa nel lavoro	◯	◯	◯	◯	◯
...si agita facilmente	◯	◯	◯	◯	◯
...ha una fervida immaginazione	◯	◯	◯	◯	◯

Inviare l'indagine.
Grazie per aver completato il questionario.