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EVALUATION OF SPACIOUSNESS IN ISOLATED AND CONFINED ENVIRONMENTS

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EVALUATION OF SPACIOUSNESS IN ISOLATED AND CONFINED ENVIRONMENTS

A Ph.D. Dissertation

by
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ANKARA
December 2023

This thesis is dedicated to those who envision a future beyond our terrestrial borders, where humanity establishes its presence among the stars. In homage to the architects of space settlements, the engineers of extraterrestrial habitats, and the visionaries who see a second home in the cosmos—this work is a tribute to your bold dreams and tireless efforts.

This dedication is an acknowledgment of the collective endeavor to transform the concept of home, extending it from the Earth to the vast expanse of the universe. It is for the astronauts, the researchers, the terraformers, and all who contribute to the ambitious goal of making space a place where humanity not only visits but calls home.

As we gaze toward the prospect of settlements among the stars, may this thesis stand as a small testament to the boundless imagination and determination that propels us toward a future where our species thrives beyond the confines of Earth.

For the settlers, the spacefarers, the dreamers, and all who play a part in the extraordinary vision of living in space—this thesis is dedicated to you.

Ad Astra, towards a new era of human habitation in the cosmos.

EVALUATION OF SPACIOUSNESS
IN ISOLATED AND CONFINED ENVIRONMENTS

The Graduate School of Economics and Social Sciences
of
İhsan Doğramacı Bilkent University

by

BERK DIKER

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THE DEPARTMENT OF
INTERIOR ARCHITECTURE AND ENVIRONMENTAL DESIGN.
İHSAN DOĞRAMACI BİLKENT UNIVERSITY
ANKARA

December 2023

EVALUATION OF SPACIOUSNESS IN ISOLATED AND CONFINED ENVIRONMENTS

By Berk Diker

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Doctor of Philosophy in Interior Architecture and Environmental Design.

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ABSTRACT

EVALUATION OF SPACIOUSNESS IN ISOLATED AND CONFINED ENVIRONMENTS

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December 2023

This thesis explores the adverse psychological effects of Isolated, Confined, and Extreme (ICE) environments, aiming to explore the correlation between these effects and interior architectural elements. In addition, several methods are tested to evaluate interior architectural elements that may directly impact the perceived spaciousness of these environments. The initial phase of the thesis examined the effects of the COVID-19 pandemic on the perception of interior spaces. Individuals who found their living spaces visually appealing, engaged in various activities, expressed satisfaction with their connections to outdoor spaces, encountered less boredom, and displayed fewer signs of anxiety and psychological distress. The following phase explored the effects of furniture, lighting, surface texture, and ceiling height on spaciousness perception and surveyed emotional and aesthetic responses to various design factors. The results indicated that interior architectural elements have a relatively minor impact on individuals' spatial perception within a habitat. Design training is a more significant influencer in all spatial evaluations than interior architectural elements. Although furniture, lighting, and texture have statistically significant effects on spaciousness and aesthetic judgments, design training remains a substantial moderator of these effects. This research contributes substantially to comprehending the complex dynamics between interior architectural design and human perception. The findings underscore the profound influence of design choices on practical functionality and emotional experiences within confined spaces. The study's implications extend to architects, designers, and policymakers, providing valuable insights for enhancing psychological well-being in ICE environments.

Keywords: Confinement, Habitat Design, Isolation, Psychological Well-being, Spaciousness

ÖZET

İZOLE VE KAPALI ORTAMLARDA FERAHЛИĞIN DEĞERLENDİRİLMESİ

Diker, Berk

Doktora, İç Mimarlık ve Çevre Tasarımı Bölümü

Tez Danışmanı: Prof. Dr. Halime Demirkan

Aralık 2023

Bu tez, İzole, Kapalı ve Ekstrem ortamların olumsuz psikolojik etkilerini araştırmakta ve bu etkiler ile iç mimari unsurlar arasındaki ilişkiyi keşfetmeyi amaçlamaktadır. Buna ek olarak, bu ortamların algılanan ferahlığını doğrudan etkileyebilecek iç mimari unsurları değerlendirmek için çeşitli yöntemler test edilmiştir. Tezin ilk aşamasında COVID-19 salgınının iç mekan algısı üzerindeki etkileri incelenmiştir. Yaşam alanlarını görsel olarak çekici bulan, çeşitli faaliyetlerde bulunan, dış mekanlarla olan bağlantılarından memnuniyet duyduklarını ifade eden bireyler; daha az can sıkıntısıyla karşılaşmış ve daha az endişe ve psikolojik sıkıntı belirtisi göstermiştir. Bir sonraki aşamada mobilya, aydınlatma, yüzey dokusu ve tavan yüksekliğinin ferahlık algısı üzerindeki etkileri araştırılmış ve çeşitli tasarım faktörlerine verilen duygusal ve estetik tepkiler incelenmiştir. Sonuçlar, iç mimari unsurların bireylerin bir yaşam alanı içindeki mekânsal algısı üzerinde nispeten küçük bir etkiye sahip olduğunu göstermiştir. Tasarım eğitiminin, tüm mekânsal değerlendirmelerde iç mimari unsurlardan daha önemli bir etken olduğu görülmüştür. Mobilya, aydınlatma ve dokunun ferahlık ve estetik yargılar üzerinde istatistiksel olarak kayda değer etkileri olmasına rağmen, tasarım eğitimi bu etkilerin önemli bir moderatörü olmuştur. Bu araştırma, iç mimari ile insan algısı arasındaki karmaşık dinamiklerin anlaşılmasına önemli ölçüde katkıda bulunmaktadır. Bulgular, tasarım tercihlerinin pratik işlevsellik ve kapalı alanlardaki duygusal deneyimler üzerindeki derin etkisinin altını çizmektedir. Çalışmanın sonuçları mimarlara, tasarımcılara ve karar vericilere hitap etmekte ve bu ortamlarda psikolojik refahın artırılması için faydalı bilgiler sunmaktadır.

Anahtar Kelimeler: Ferahlık, İzolasyon, Kapalılık, Psikolojik Refah, Yaşam Alanı Tasarımı

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LIST OF ABBREVIATIONS

ANOVA: Analysis of Variance

DT: Design Trained

EWB: Eudaimonic Well-Being

HMD: Head Mounted Display

ICE: Isolated, Confined, and Extreme

NDT: Not Design Trained

SCS: Spaciousness and Crampedness Scale

SPES: Spatial Presence Experience Scale

SWB: Subjective Well-Being

VE: Virtual Environment

VR: Virtual Reality

CHAPTER I

INTRODUCTION

In recent years, there has been a resurgence of interest in topics such as lunar and Martian colonization. Conversations and research on the viability of endeavors like lunar and Martian colonization have sparked exploration into new research domains and the reevaluation of existing studies. Initially, spaceflight was measured in hours; later, it became days and months, slowly becoming years. With each successive mission since the first human in space, Yuri Gagarin, humans have spent more and more time in space. The third Skylab crew spent 84 days in low Earth orbit; later, Russian cosmonauts pushed that number up to 438 consecutive days aboard the Mir Station. With the propulsion technologies available today, a round trip to Mars can take up to two years.

Given the extended duration of isolation and confinement required during such space trips, a significant amount of research and development has been directed toward improving crews' living conditions. An existing body of research from experiences in isolated, confined, and extreme environments already present on Earth can be applied to these scenarios. One notable example is the research conducted at Antarctic research stations. There are notable parallels between Antarctic expeditions and space travel, such as the presence of potentially hazardous environments, the lack of indigenous populations, habitats constrained by limited space and resources due to economic and engineering factors, a crew selected for specific tasks, enduring social isolation, and compulsory confinement with a restricted number of individuals. These similarities provide a practical analog for long-term space travel, particularly in studying psychology and behavior and their relationship to the environment. Antarctica served as a valuable model for research in this field before controlled analogs were developed in laboratories.

1.1. Problem Statement

In the early stages of space travel, NASA either ignored or avoided psychological factors affecting their astronauts and, by extension, the missions. Harrison (2001) argued that these issues had much lower priority within NASA, resulting in their delayed consideration compared to physiological aspects of astronaut well-being. Research into behavior and psychology regained focus in the mid-1990s, when long-duration missions and sustained living in space became feasible again with the introduction of Mir (Vakoch, 2011). With data from pre-existing analogs on Earth, it becomes evident that a significant psychological challenge of long-term space travel is associated with isolation and confinement.

Addressing preliminary questions becomes critical to establishing the problem and crafting a research hypothesis. This thesis centers primarily on isolated environments, encompassing arctic stations and habitation modules. The thesis delves into both the immediate and long-term effects of these environments on the psychological well-being of occupants. Furthermore, it aims to tackle human-centered issues observed in isolation and confinement, approaching them from the perspective of an interior architect. The thesis aims to comprehend the design elements affecting spatial cognition within the interiors of such environments, focusing on precise prediction and modeling of spatial properties, including ceiling height, distances, and dimensions. The thesis also aims to provide potential solutions by enhancing the perceived spaciousness through systematically manipulating interior architectural elements. It considers isolation scenarios involving both single individuals and groups. The thesis is built upon the following key questions:

1. How do humans perceive the interior architectural elements of an isolated, confined, and extreme environment?
2. What social, physical, and psychological difficulties come with living in an isolated and confined environment?
3. Which interior architectural elements of an environment have an impact on the perceived spaciousness?

1.2. Aim & Scope

The objective is to explore the connection between psychological issues, understand their intensity, and their association with interior architectural elements. Furthermore, the thesis investigates whether intervening through modifying these design elements can effectively mitigate or eliminate the psychological symptoms of isolation and confinement.

The adverse effects of isolation and confinement can become even more pronounced in environments with highly limited volumes, called Isolated, Confined, and Extreme (ICE) environments. Research has shown that different volumetric geometries, not typically encountered in everyday life, can elicit varying behavioral responses toward an environment (Shemesh et al., 2016). These inclinations can be leveraged to design unconventional yet appealing environments, aligning with people's preference for curved objects and surfaces (Bar & Neta, 2006). Extended periods of confinement could lead to changes in perception of self (psychological) and perception of the environment (physiological). Additionally, several determinants influence an individual's response to the environment.

1.3. Structure of the Thesis

Starting with Chapter II, the fusion of human perception and interior design is explored by investigating the intricate dynamics that define our perception of spaciousness. Beginning with exploring spatial ratios, geometry, and architectural elements' influence, the impact of object density, organization, and lighting is dissected. Important insights unfold regarding the role of clutter and the contrast between object and surface clutter, further explained through empirical studies by researchers.

Moving onward, the significance of openings, particularly windows and doors, in framing our perception of spatial dimensions is explored. Variables such as size, shape, and arrangement are analyzed. Extensive research highlights their impact on perceived spaciousness.

The expedition concludes with examining surface properties, including color, lightness, roughness, and reflectivity. The intricate relations between these surface characteristics and their impact on perceived spaciousness is uncovered. This chapter offers a comprehensive view of the intricate web of elements defining our experience of spatial dimensions and functionality in built environments.

Chapter III examines the complex world of Isolated and Confined Environments (ICE). It begins by exploring the coping strategies used by individuals in ICE environments and the alignment of these strategies with Ryff's model of well-being. The Extreme Environments Questionnaire (ICE-Q), with its four dimensions (social, emotional, occupational, and physical), is introduced, emphasizing their interconnectedness and impact on adaptability. The chapter also unveils the Adaptability Questionnaire (ADQ) model and the Selection of Antarctic Personnel (SOAP) instrument, highlighting "desirable" traits for ICE environments.

It concludes by discussing Virtual reality's role in the ICE environment, including using immersive virtual environments and presence questionnaires to measure immersion and engagement. The advantages of virtual environments over physical ones are considered, focusing on cost-effectiveness and flexibility. The chapter also addresses size estimation discrepancies in virtual environments and identifies critical factors influencing spatial perception. presenting the research methodology, including three experiments exploring interior architectural elements' effects on psychological well-being, perceived spaciousness, and livability in ICE environments.

Chapter IV begins to explore the connection between interior architecture and perceived spaciousness within ICE Environments. How architectural attributes and design choices are investigated for their influence on the perception of space and spaciousness by occupants, particularly in environments closely emulating the conditions of Mars exploration, is being examined. This chapter employs an explanatory analysis, known for its effectiveness in investigating causal relationships between variables, to explore the diverse factors and elements within interior environments that impact psychological well-being. Additionally, the chapter examines the unexpected influence of the COVID-19 pandemic on interior space perception and how it has impacted design considerations.

Examining the previously unforeseen influence of the COVID-19 pandemic on interior space perception shows how the pandemic has reshaped design considerations, spatial requirements, and human perceptions of enclosed environments. This analysis offers unique insights into the evolving dynamics of interior architecture in a post-pandemic world. It identifies four key factors: visual variety, airiness, furniture and clutter, and volume that emerge as critical in shaping a positive and spacious environment in ICE scenarios.

Chapter V builds upon the preceding study by introducing a novel experiment. The chapter initiates with a thorough examination of three distinct analog habitats: the Hawai'i Space Exploration Analog and Simulation (HI-SEAS), the Nazemnyy Eksperimental'nyy Kompleks (NEK), and the Human Exploration Research Analog (HERA). The primary objective of the initial phase of the experiment is to systematically categorize and evaluate the architectural attributes inherent to the selected habitats. This categorization process encompasses four pivotal dimensions: geometry, furniture, lighting, and surface properties (materials). Each habitat undergoes meticulous scrutiny, employing these predefined criteria to discern and assess interior elements recognized for their positive impact on perceived spaciousness. This methodical evaluation constitutes a pivotal stage designed to identify an optimal ICE environment, which will subsequently serve as the experimental setting for testing the hypotheses articulated in this research.

The narrative proceeds to explain the experimental framework further illustrated in Figure 1, with particular attention to the considered factors, including geometry, furniture, lighting, and surface properties. The utilization of the Spaciousness and Crampedness Scale (SCS) and Relative Error in Estimation as assessment tools for evaluating spaciousness is detailed, including their application throughout the study.

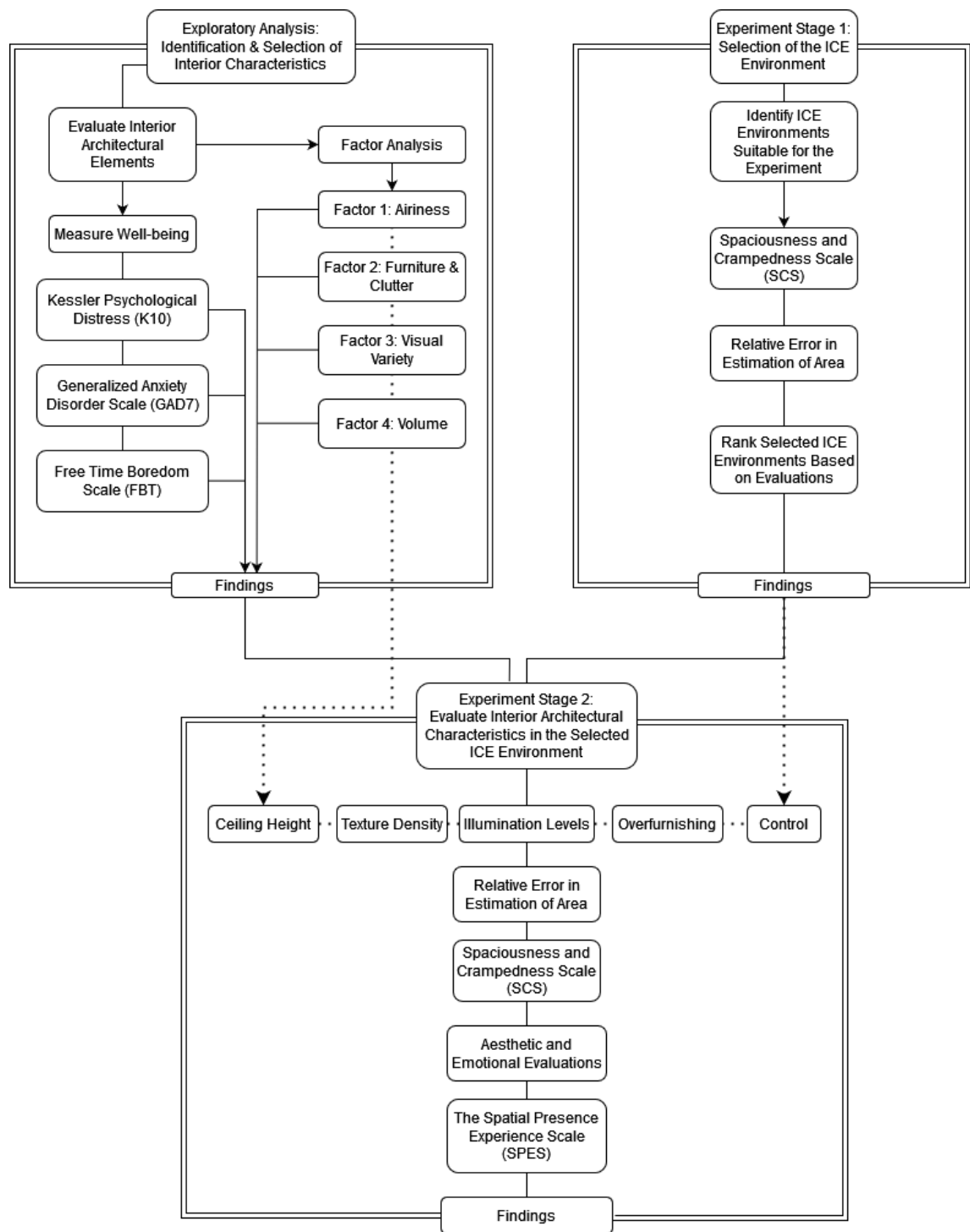


Figure 1. Research road map.

Hereafter, the presentation of experimental results unfolds, shedding light on the effects of various factors—furniture, lighting, surface texture, and ceiling height—on the perception of spaciousness and feelings of confinement. The narrative underscores the role of design training in shaping participants' evaluations and its impact on their emotional and aesthetic responses.

In the closing chapters of this academic work, the reader is afforded an enriched comprehension of the complex interplay between interior architectural design and human perception. How architectural choices can not only influence the pragmatic functionality of a space but also impact emotional and aesthetic experiences within it is unveiled. This chapter offers an illuminating exploration of the profound influence of architectural design on human perceptions and emotions within interior spaces.

Chapter VI summarizes the insights gleaned from a comprehensive exploration into the influence of interior architectural elements on the psychological well-being of individuals residing in ICE environments. The reader is prompted to recognize the crucial role of interior elements in ICE environments, with a particular emphasis on visual variety, airiness, and volume as determinants of creating a positive and spacious environment. The chapter underscores the significance of familiarity as a moderator, primarily influenced by design training, and its integral part in shaping the perception of spaciousness.

Furthermore, the chapter calls attention to the nuanced evaluation of interior environments in ICE conditions, advocating for greater consideration of these aspects by designers and architects. It underscores the responsibility of design professionals to craft interior spaces that promote mental health and well-being.

As a forward-looking chapter, it explores the potential of immersive viewing technologies in furthering our understanding of how occupants perceive spaciousness in various ICE environments. The research reveals the pathways to more effective design solutions for challenging ICE conditions.

CHAPTER II

SPATIAL COGNITION IN INTERIOR ARCHITECTURE

The origins and definitions of architectural spaces and interior environments have deep historical roots dating back centuries to figures like Vitruvius and numerous other scholars. Given the scope of this topic and the need for brevity, we will focus on more contemporary definitions rather than delving into the extensive historical background of interior environment understanding within the realm of architecture.

While the concept of the interior environment holds various meanings and representations in the literature, we can define it as an environment wherein individuals and objects coexist and interact, characterized by their shapes, dimensions, and relationships with one another and with us, as perceived through observation. Such observations become possible through the perception of space and the objects that occupy it (Arnheim, 2007).

Perception and cognition constitute pivotal components of this research, necessitating a brief background contextualization for the ensuing report. Perception and cognition are distinct mental processes that play vital roles in comprehending and engaging with the world around us. They differ in several fundamental ways.

Perception involves recognizing and interpreting sensory information from the environment, starting with the initial reception through the senses (vision, hearing, touch, taste, and smell). This sensory data is then organized and interpreted within the brain. The process of perception is immediate and impacted by elements like attention, motivation, anticipations, and prior experiences.

In contrast, cognition encompasses a broader spectrum of mental processes involved in acquiring, storing, manipulating, and utilizing knowledge and information. These processes encompass perception, attention, memory, language, problem-solving, reasoning, and decision-making. Cognition centers on higher-level mental processes

related to thinking and problem-solving and is influenced by factors such as intelligence, education, and culture (Britannica, n.d.).

Spatial cognition involves acquiring, organizing, utilizing, and revising knowledge related to spatial environments. These cognitive capabilities empower individuals to navigate both basic and complex tasks in their daily lives. Spatial cognition is concerned with understanding how people interact with their surroundings' spatial attributes (Waller & Nadel, 2013).

Spatial environments can be categorized into three scales, each based on the level of actions performed within them rather than their physical size. These categories include small, medium, and large-scale environments.

1. Small-scale environments: These encompass objects or representations such as maps. They are external to the observer and are acted upon rather than being spaces within which an individual operates.
2. Medium-scale environments: These encompass spaces an observer occupies, such as a room, with a limited capacity for movement. In these environments, occupants can interact with local features without requiring extensive cognitive abilities.
3. Large-scale environments: These demand a high degree of cognitive abilities from occupants to perform actions. Examples include towns and buildings, where complex navigation and interaction within the environment are necessary (Waller & Nadel, 2013).

The reliance on spatial cognition in vision is significant, making it essential to understand major theories of visual perception. One common observation in visual perception theories revolves around size constancy—how one can perceive objects of the same size at different distances. The study of modern visual perception traces back to the biological investigations initiated by Kepler in 1604. Following Kepler's description of the development of the retinal image, scientists delved into the anatomy of the eye. These early examinations raised questions about how the eyes process the raw visual data and how perceived objects are interpreted.

It became evident that visual perception information is often inadequate, necessitating a more comprehensive exploration, ranging from the human eye's intricate anatomy to the brain's neurological structure. According to Richard Gregory and Hermann von Helmholtz, visual perception, being inherently limited, prompts the brain to unconsciously rely on prior experiences and memories to form generalized inferences about the immediate environment (Gordon, 2004). These assumptions enhance the apparent environmental input and fill any informational gaps. Their findings highlight the critical role of prior knowledge in the context of visual perception.

This discovery suggests that when we observe an object and discern its particular attributes, there is also a concurrent "anticipation" that it will exhibit certain additional qualities that may not be readily apparent. These anticipations play a substantial role in optical illusions, as inferences at times deviate from the expected visual scene, resulting in discrepancies between what is visually perceived and the actual characteristics (Gordon, 2004, p. 146).

As theories of visual perception evolved, they transitioned from anatomical and biological observations to encompass more psychological and cognitive dimensions. Gibson (1979) articulated a persuasive viewpoint by contending that visual perception does not hinge exclusively on inferential processes, but rather represents a more immediate phenomenon. He underscored the importance of investigating visual perception in controlled laboratory environments and real-world settings. Gibson asserts that the surrounding environment plays a pivotal role in shaping the perception of an object, as it forms an integral part of the perceptual experience. In his theory, the issue of size constancy is resolved not by perceiving the object in isolation but by considering it in conjunction with the background environment, texture, and the presence of a horizon. Following these advancements, the theory of affordances emerged, positing that an object's properties can be directly perceived through the stimulation it offers. This perspective underscores the interplay between the object and its environment, highlighting the importance of context (Gordon, 2004). Nevertheless, it is essential to acknowledge that while Gibson's views have been influential, they may not provide as thorough explanations for optical illusions and deficiencies in visual perception as some alternative theories.

Another prominent theory that emerged during the same period as Gibson's was the Gestalt theory, closely associated with figures such as Max Wertheimer, Wolfgang Köhler, and Kurt Koffka from the Gestalt school of thought. This theory delved into the brain's inclination to group objects based on their perceived properties and how individuals perceive objects regarding figure-ground relationships. At its core, the Gestalt theory focuses on understanding how the simplest elements relate to one another and are recognized across various contexts. The concepts presented in this report draw upon the rich tapestry of visual perception theories mentioned here, incorporating their principles, particularly in visual illusions.

As initially presented by Appleton in 1975, the prospect refuge theory asserts that preferences for particular domains and landscapes are intricately rooted in biological and behavioral mechanisms associated with adaptation. This theory recognizes the crucial role of environmental perception in the adaptation process, asserting that, like many other species, humans have evolved to retain essential survival-related information about their surroundings efficiently. Individuals regard their domain as their habitat, and information about elements carrying potential threats must remain readily accessible to ensure self-preservation.

According to this theory, two primary strategies are employed to accomplish this goal. The first strategy entails maintaining an open awareness of environmental cues through observation and exploration, often referred to as "prospecting." The second strategy involves actively seeking out opportunities for shelter and concealment from the various elements present in the environment, a behavior termed "taking refuge." These fundamental principles underpin the contention that individual preferences for particular environments and habitats are founded upon these adaptive behaviors. Consequently, the theory postulates that environments that effectively facilitate the fulfillment of prospecting and refuge-seeking tendencies are more likely to be favored.

Hildebrand (1999) expanded the scope of the prospect-refuge theory to encompass interior environments, positing its applicability indoors as well. They introduced that interior spaces characterized by narrow dimensions, subdued lighting, and solid walls devoid of openings facilitate refuge-seeking behaviors. In contrast, brighter, more

spacious areas with numerous openings encourage prospecting activities. Hildebrand suggested that transitioning from refuge to prospecting, symbolized by the shift from darkness to light, heightens feelings of security and enjoyment. Moreover, they proposed that interior environments can enhance the comfort and satisfaction of their occupants by incorporating natural materials, landscape vistas, water sights, and ample spatial dimensions.

Nonetheless, Stamps (2006) brought attention to the need for a more rigorous scientific substantiation of these ideas, which, though valuable as architectural critiques, lacked empirical validation. To scrutinize Hildebrand's (1999) theory, Stamps conducted a series of experiments in which participants were exposed to comparable interior environments from diverse perspectives, encompassing shifts from dimly lit to well-lit spaces, changes in height, transitions from compact to expansive areas, and vice versa. These experiments employed computer-generated representations of Japanese-style rooms, a nod to Hildebrand's reference to Frank Lloyd Wright. The first experiment engaged 14 participants, and its results unveiled modest disparities in comfort ratings during transitions between distinct room types, except for a notable distinction occurring when transitioning from a larger room to a smaller one. This outcome ran counter to the originally posited hypothesis.

In a succeeding experiment, images of stone structures, including Roman Baths and Egyptian Tombs akin to the examples cited by Hildebrand (1999) for validating their theory, were employed. The sample size was notably expanded to include 83 participants. Although the observed effects were more pronounced in this larger sample, they remained contradictory to the initial hypotheses. Surprisingly, an opposing pattern emerged, despite the hypothesis that transitioning from smaller, darker, and more enclosed spaces to larger, brighter, and more open environments would lead to enhanced comfort. In light of these findings, Stamps (2006) concluded that further validation might be necessary, employing even larger sample sizes and delving into additional scene properties such as airflow, color schemes, dimensions, shapes, and lighting conditions. In a broader context, a meta-analysis conducted by Dosen and Ostwald (2017) substantiated that quantitative evidence regarding the theory remains inconclusive, implying that the validity of the prospect-refuge theory, especially in interior environments, requires further empirical investigation.

The advancement of computer technologies and the capacity to create various virtual models for real-world phenomena have significantly influenced research in visual perception. Marr's (1982) groundbreaking work on computational approaches to visual perception was aimed at constructing a comprehensive framework for understanding how visual perception operates, achieved through the development of computer models. His research systematically reconstructed the visual perception process by manipulating elements that constitute a visual scene. These elements included geometric attributes, surface properties, lighting conditions, the observer's position, and more. Through this computational approach, Marr mathematically delineated the progression of visual information, starting from the image on the retina and culminating in the perception of a coherent scene within the brain.

Processing sensory information and spatial cognition within the human brain have been examined through diverse theories. An example is the model-based paradigm, where the brain generates a detailed mental 3D model of the surroundings and their arrangement. People thereupon plan their actions by mentally simulating their movements within this cognitive model before physically carrying them out. This approach offers significant advantages by conserving time and energy that might otherwise be expended on potentially unsuccessful attempts. These cognitive models evolve based on internalized assumptions based on experiences and environmental cues (Loomis & Beall, 1998, 2004). The quality of the cognitive model closely determines the accuracy of actions executed in a specific environment.

According to Fajen and Phillips (2013), the relationship between the physical environment and the visual space is somewhat asymmetrical. They propose that actions can be executed with a satisfactory level of accuracy when a cognitive model is "accurate enough." According to their argument, the most critical components of a cognitive model are those directly pertinent to the intended action, drawing upon Gibson's (1979) ecological principles of vision. Warren and Whang's (1987) experiment, illustrating how the presence of eye-height scale information can eliminate the need to depend on knowledge of one's body dimensions when evaluating the navigability of an obstacle, is often cited to support Fajen and Phillips's (2013) theory.

In addition to the model-based approach, the literature extensively explores two other methods of spatial cognition. These methods work in concert to enhance an individual's cognitive model, facilitating comprehension of their position and function within an environment (Kosslyn et al., 1992). These methods include allocentric representations, which rely on maps; they represent locations in reference frames extrinsic to the observer and encompass object-centered (centered on a point of interest) and room/world-centered (environmentally coordinated) frames. Conversely, egocentric representations depict the location and object data relative to the observer within the environment.

Earlier studies (Jager & Postma, 2003; Ruotolo et al., 2011) have recognized various cues inherent to human perception that assist in forming cognitive maps or models of environments. These cues are elements within an environment that prompt responses based on implied information. These cues can be categorized into dynamic and pictorial depth cues (Gibson, 1979; Wallach & O'Connell, 1953).

Pictorial cues encompass a category of cues associated with extracting information from the perspective of visual stimuli. These cues encompass factors regarding the stimuli's relative size and height within the visual field and its ratio to the horizon. They also involve other visual properties, such as occlusions and contours, and visual distortions arising from the interplay of light, including shadows, highlights, and reflections. The human brain amalgamates several of these cues with sensory input from other sensory modalities to gauge and estimate various spatial properties. Significantly, these same perceptual systems play a role in shaping an individual's comfort level within a given environmental context.

Spatial cognition constitutes a cluster of cognitive capabilities encompassing a range of abilities. These capabilities are comprehending geometric relationships between objects, pinpointing specific locations within the surroundings, perceiving depth, ascertaining the direction of lines and objects, and processing motion (Colby, 2009).

As mentioned previously, the human brain relies on the integration of multiple senses to construct a mental model of the environment. While viewing each sense as a distinct contributor may be tempting, such an approach can be misleading (Fodor,

1983). Despite the brain's substantial allocation of neurons, especially in comparison to other senses, to process visual information, it is not infallible and requires input from other sensory modalities to compensate for certain limitations. For instance, the body's vestibular system is responsible for detecting the orientation of the head and any accelerations. This information enables the brain to offset retinal image slip resulting from head rotation (Mohler et al., 2013). Similar instances occur with other sensory organs, although their contributions tend to be more constrained. Theoretically, introducing slight differences in perceived sensory information can result in inaccurate environmental inferences. When coupled with the cognitive model, such false inferences could give rise to negative and positive alterations in the perception of the environment.

Within conventional interior settings, these cues typically manifest themselves through the presence of interior architectural components, including elements such as hued surfaces, windows, lighting installations, and various other design features. While these elements primarily fulfill functional roles in shaping interior spaces, they concurrently contribute to the engagement and stimulation of the individuals inhabiting these environments. In conjunction with its constituent features, the interior space forms an interactive platform through which users engage, thereby serving as the foundation for developing an allocentric representation within the human brain. These interfaces can be objectively measured based on their arrangement, quantity, and capacity to be clearly distinguished (Miniukovich & Angeli, 2014). Disproportionate changes in the number of interactable interfaces can deteriorate performance and overall quality of life (Kersten et al., 2004; Golden et al., 2018; Rosenholtz et al., 2007).

In light of these discoveries, designers and researchers have devised effective strategies, often regarded as ingenious "tricks," routinely harnessed when crafting environments with constrained spatial cognition prospects. These strategies possess the adaptability to instill an illusion of expansiveness or alleviate sensations of confinement, even within the confines of meticulously controlled interior spaces. Simon and Touns (2014) have discerned that such strategies find frequent application in designs for "tiny houses" and are amenable to various ICE environments. These strategies encompass the utilization of clean, unobstructed lines, the reasonable

reduction of clutter above waist level, the optimization of the ratio between ceiling height and room area, the employment of light hues juxtaposed with contrasting darker accents, the maximization of natural or convincingly imitated natural illumination, the incorporation of apertures and windows, and the integration of natural materials and elements evoking the innate affinity.

To comprehensively assess the influence of these strategies on spatial cognition, one can conduct in-depth examinations by drawing insights from existing research and proposing future experiments. To facilitate this exploration, these strategies can be systematically organized according to the individual architectural elements within the interior environment and the particular domains in which they are relevant. This categorization process demonstrates the nuanced, multi-layered approach, encompassing sub-variables associated with each architectural element. This method unfolds from encompassing general environmental attributes to dissecting the impact of precise design elements.

Recognizing the need to accurately assess the influence of different interior architectural elements on spaciousness, Imamoglu (1986) developed the Spaciousness and Crampedness Scale (SCS). The SCS encompasses three factors that pertain to the perception of spaciousness, encompassing appeal, planning, and space freedom. Additionally, it incorporates four factors linked to feelings of crampedness, which encompass planning, physical size, clutter, and appeal. The 'appeal' factor considers elements such as the interior environment's charm, pleasantness, and coziness. At the same time, 'planning' delves into organization, suitability, scale, and coordination within the space. Finally, 'space freedom' assesses the perception of roominess or expansiveness within the environment and the presence or absence of overcrowding or clutter.

To create the scale, bipolar adjective pairs that effectively described and represented each factor were employed, with respondents assigning scores ranging from 1 to 7 based on their perceptions. Meanwhile, in their study, von Castell et al. (2014) adopted a different approach to measure perceived spaciousness, utilizing relative estimation error. This measurement was calculated using the following formula:

$$EstError_{rel} = (size_{est}/size_{phys}) - 1$$

In the provided equation, $EstError_{rel}$ signifies the relative estimation error concerning the specific room dimension in question. The variable $size_{est}$ denotes the estimated dimensions of the room, while $size_{phys}$ represents the real value of that dimension. When $EstError_{rel}$ yields values greater than zero, it signifies an overestimation, whereas values below zero indicate an underestimation (von Castell et al., 2014, p. 5).

To conclude, comprehending how individuals perceive spaciousness and confinement within interior environments is critical when assessing the effects of architectural elements on spatial cognition. The methodologies and tools discussed thus far serve as a solid groundwork for delving into the complex relationship between the psychological well-being of occupants and interior architecture across a diverse range of environments. Ongoing investigations into architectural elements and their impact on spatial cognition promise to yield valuable insights, ultimately creating more comfortable and practical spaces within ICE environments.

2.1. Interior Architectural Elements

The physical environment significantly affects its inhabitants' behavior, perception, and psychology (Gifford, 2014). An essential factor in determining the quality of a living environment is the perceived spaciousness, be it in natural or constructed surroundings. In numerous instances, environments perceived as more spacious tend to evoke positive evaluations (Bharucha-Reid & Kiyak, 1982; Herzog, 1985). Various studies have demonstrated This phenomenon by examining housing satisfaction and room/house dimensions, often in conjunction with factors like income and age. These studies have consistently revealed a positive correlation between increased house size and elevated levels of housing satisfaction (Aigbavboa & Thwala, 2016; Zhang et al., 2018).

Moreover, various interior elements can affect the perception of spaciousness, as documented by a large body of research. Figure 2 deconstructs these elements to encompass factors such as furniture density and organization (Bokharaei & Nasar, 2016; Imamoglu, 1973; Kaye & Murray, 1982; von Castell et al., 2014), lighting

quantity and direction (Inui & Miyata, 1973; Kirschbaum & Tonello, 1997; Martyniuk et al., 1973), the application of color and texture (Hidayetoglu et al., 2012; Oberfeld et al., 2010; Oyama & Nanri, 1960; Sundstrom & Sundstrom, 1986), as well as factors like permeability and boundaries (Bokharaei & Nasar, 2016; Franz et al., 2005; Stamps, 2010). These elements collectively contribute to shaping the perception of spaciousness and the overall appeal of interior environments.

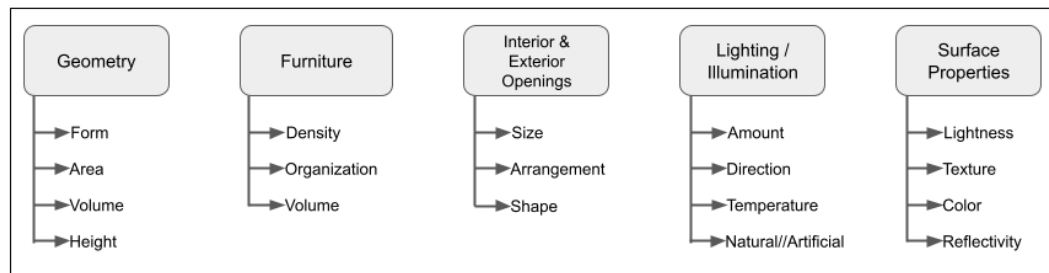


Figure 2. Interior architectural elements encompass a range of components, including their sub-variables.

2.1.1. Geometry

This subject is closely intertwined with interior environments' spatial and architectural characteristics, which encompass variables such as spatial proportions and volume. Key geometric elements within this context encompass the environment's configuration, area, height, and spatial ratio. The spatial ratio primarily indicates the correlation between the ceiling height of a room and its area. Stamps (2013) hypothesized that 'boundaries' delineating the area within which an individual can move freely are closely connected to the perception of spaciousness. Stamps' studies demonstrated that increasing the 'boundary height' was followed by a sense of increased confinement. Particularly, the horizontal area had a more significant impact on the perception of spaciousness than ceiling height. Their experiments, however, were executed within virtual sets, and the applicability of these findings in heavily confined physical environments may differ. Nonetheless, these experiments serve as a valuable illustration of the importance of spatial ratios in shaping our perception of space.

Considerable research has delved into the preferences people exhibit concerning objects and geometric shapes, unveiling a noteworthy propensity for curved objects

and geometries among individuals (Bar & Neta, 2006; Leder et al., 2011; Silvia & Barona, 2009). In the specific context of interior environments, Shemesh et al. (2016) explored the effects of various room shapes (curved, round, square, sharp) on individuals' perceptions. Their findings revealed that curvilinear surfaces held the highest aesthetic appeal within interior spaces. Although these findings may not be directly associated with the perceived spaciousness of an environment, they do illuminate the substantial impact of room geometry on our preferences and our inclination to spend time within particular spaces. This aspect is of noteworthy significance when contemplating the design and attractiveness of interior environments.

An environment is comprehended through its spatial characteristics, which can be broadly categorized into two groups: objects and scene properties. This encompasses attributes such as the size, shape, scale, distance, direction, orientation, and location of objects and elements within the environment (Waller & Nadel, 2013). Furthermore, environmental characteristics play a vital role, including the complexity, geometry, and volume of an interior environment, along with the presence of landmark objects. Additionally, more personal variables come into play, including one's familiarity with the environment, the duration spent within it, the presence of social beings, and individual personality traits (Proulx et al., 2016). These multifaceted variables collectively impact an individual's physical and psychological comfort within a given environment (Blaison & Hess, 2016). Importantly, each person possesses unique preconceptions about these variables, leading to a diverse range of comfort levels (Ritterfield & Cupchik, 1996).

An intriguing area of study, albeit not directly linked to spatial geometries but rather the perception of such geometries by individuals, is the research conducted by Read (2012). In her study, Read compared the use of blur as a visual depth cue to stereo disparity. She investigated how applying blur to 2D images could effectively trick the brain into perceiving them as 3D images, much like the effect achieved through stereo disparity (i.e., the input from both eyes). These cues are grounded in physiological processes and have the potential to be harnessed to manipulate the brain's perception of distances and spatial dimensions. While Read's hypothesis was primarily tested in the context of perceived depth in 2D images, it opens the door to the exploration of

similar principles applied to 3D spaces. This exploration could encompass phenomena like the parallax effect, offering an intriguing avenue for further investigation.

2.1.2. Furniture

Furniture constitutes a critical aspect of interior environments, with key variables encompassing the density, arrangement, and their volume. In confined environments, the concept of obstruction extends beyond physical hindrance to include visual obstruction. This pertains to how architectural features and furnishings either obstruct or facilitate the line of sight. Limited line of sight is a prevalent challenge in confined spaces, imposing significant environmental constraints. Various interior architectural elements can influence the line of sight and the overall design. By extending the visual focal point, these factors significantly contribute to enhancing the perceived spaciousness of confined environments. This exploration, ranging from larger architectural elements to finer details, ultimately leads to a consideration of clutter.

In their study, Imamoglu (1973) conducted assessments on full-scale rooms to investigate three specific parameters related to furniture. The primary research objectives included investigating how furniture density affects the assessment of spaciousness in rooms, evaluating the influence of furniture density on size estimations of the rooms, and indirectly exploring the connection between size estimations and assessments of spaciousness.

For the experiment, three conditions were established: empty, furnished, and over-furnished rooms, along with a control room. The varying factor among these conditions was the number of furniture items within the interior. Participants evaluated spaciousness using an earlier version of the Spaciousness and Crampedness Scale (SCS), while size estimations were determined by calculating magnitude changes, with the control room assigned a reference value of 10.

The results revealed a notable difference in spaciousness evaluations between the 'furnished versus unfurnished' and 'empty versus over-furnished' conditions. Both the empty and over-furnished room conditions received lower spaciousness ratings compared to the furnished room condition. However, no statistical significance

existed between the evaluations of furnished and empty rooms. Notably, Imamoglu observed that, under furnished conditions, the experiment room (which was 20% larger) and the control room received similar spaciousness evaluation scores. This led to the hypothesis that an optimal level of furniture density may exist for interior environments, with deviations from this optimal density level negatively affecting perceived spaciousness. An inverse relationship was identified regarding size estimations, with the empty condition being perceived as the largest and the over-furnished condition as the smallest. In conclusion, Imamoglu suggested that furniture density could exert a more pronounced influence on perceived spaciousness compared to size evaluations.

In a subsequent study, Kaye and Murray (1982) assessed spaciousness in interior spaces, considering variations in furniture density, furniture organization, the presence or absence of windows, and the influence of gender. The study employed watercolor drawings depicting a living room environment, featuring eight distinct conditions.

Among the conditions, two different furniture organization approaches were explored: sociopetal (encouraging social interaction) and sociofugal (discouraging social interaction). To examine the impact of furniture density, the number of items in the environment was increased by three (specifically, additional chairs) in the high-density condition. The assessment of these conditions involved the use of a seven-point unipolar scale comprising 30 items.

Further analysis of the data revealed the emergence of four distinct factors influencing the assessment: social-aesthetic, physical organization, mood, and size. The study revealed that furniture density significantly impacted the factors of size and physical organization within the evaluated environments. In contrast, neither furniture organization nor gender significantly impacted the evaluation of these environments.

Later, Imamoglu (1986) made additional refinements to the SCS and conducted a study investigating the influence of furniture density on perceived spaciousness and estimations of room dimensions in a scaled-down (1/10) conference room. The study included three conditions: empty, normal, and over-furnished.

The study's results unveiled no substantial difference in spaciousness ratings between an empty and a furnished room. In contrast, the over-furnished room received significantly lower ratings regarding spaciousness and appeal, and it was also perceived as considerably more confined when compared to the other two conditions. Notably, these findings closely aligned with the results of Imamoglu's earlier investigations (Imamoglu, 1973) that were conducted in full-scale rooms.

von Castell et al. (2014) conducted a study to investigate how furniture affects the perception of spaciousness in interior environments. Their research was motivated by the need for more empirical studies on spaciousness in interior design. To build on existing knowledge, they analyzed previous studies, aiming to understand and categorize different furniture densities and organization levels. For example, their analysis of Imamoglu's study (1973) revealed that the furnished condition occupied 26% of the room area, while the over-furnished condition occupied 41%. In contrast, the control room had 43% of its area filled with furniture. The study consisted of two separate experiments.

In the first experiment, two true-to-scale (1/10) rooms were created under two conditions: unfurnished and furnished. The researchers aimed to assess how furniture influences a room's perceived spatial dimensions and spaciousness. Parameters such as viewing angle, eye height, luminance, and surface colors were kept constant across the experiments. Furniture pieces were represented as gray cubes, organized based on architectural assumptions. A scaling cue (a person) was presented to half of the participants. All participants evaluated both conditions (furnished and unfurnished), with the viewing order rotated for half of them. Participants were asked to estimate the dimensions of both rooms (depth, width, height) and rate their spaciousness on a 10-point scale ranging from 'Narrow' to 'Spacious.' The results indicated that the amount of furniture influenced the perception of spaciousness and room height. Specifically, the furnished room was perceived as taller but less spacious. However, the error in height estimation was only present when no scale cue was provided. Additionally, the effect of furniture on perceived spaciousness was found to be weak and unaffected by the scaling cue. The authors suggested that the concept of spaciousness in an environment may need to be approached in a more holistic manner.

In the second experiment, the impact of furniture and surface area on perceived spatial dimensions and spaciousness was measured using virtual reality (VR) recreation of a full-scale room. They created a set of fourteen distinct rooms, all sharing a uniform height of 2.7 meters. These rooms varied in surface area, ranging from 16m² to 100m². Two conditions, unfurnished and furnished, were established, with the same cube objects used as in the previous experiment. The quantity of furniture remained constant, resulting in varying furniture density based on the room's area, ranging from 11.89% in the smallest room to 1.89% in the largest room.

Furthermore, the furniture positions were fixed along the walls. During the experiment, participants were presented with these fourteen scenes randomly. They were confined in place during the viewing and had a limited angle of view (162°). Participants were instructed to provide feedback on the room's dimensions and perceived spaciousness during the viewing. Interestingly, the findings of the second experiment did not align with those of the first one. While width and depth estimation errors were reduced in the furnished condition, there was no noticeable change in height estimations.

A more in-depth analysis revealed that the presence of furniture did not significantly affect size estimations or spaciousness evaluations. The authors attributed the disparities between their results and Imamoglu's (1973; 1986) results to differences in the definition of spaciousness. They clarified that they quantified spaciousness using actual room dimensions and the sense of narrowness or wideness, while Imamoglu relied on overall impressions and room characteristics. In addition to these observations, a noteworthy deficiency in the VR environments used in the experiments became evident. These virtual rooms were characterized by blank white and gray surfaces, with black boxes representing furniture. However, there was no realistic representation of lighting in the scenes. While the intention may have been to isolate variables, the interplay between various environmental features, including lighting, might play a significant role, necessitating further analysis and consideration.

Bokharei and Nasar (2016) conducted a study to investigate the impact of six distinct interior characteristics, namely room size, window size, texture, amount of furniture, and wall murals, on both perceived spaciousness and preference within office

environments. To assess these effects, they created twelve desktop virtual reality (VR) environments simulating office spaces, with each interior characteristic tested under two conditions. Specifically, two conditions were manipulated for the amount of furniture: 'lots of furniture/less usable space' and 'not much furniture/more usable space.' These conditions varied in terms of furniture density and organization, resulting in increased or decreased usable space within the room.

To quantify changes in perceived spaciousness, participants were asked to rate their perceptions using three bipolar pairs: 'cramped/roomy,' 'tiny/huge,' and 'small/large.' Additionally, three more bipolar adjectives were employed to assess participants' preferences: 'unpleasant/pleasant,' 'unappealing/appealing,' and 'unattractive/attractive,' with participants providing ratings on a scale from 1 to 10. The study uncovered a statistically significant, medium-sized effect of the quantity of furniture on perceived spaciousness. Specifically, the condition with less furniture was associated with a greater perceived spaciousness compared to the more furnished condition. It is important to note that the effects of furniture quantity on participants' preferences had no statistical significance.

Clutter can be evaluated using different parameters, such as the number of distinct items on a surface, parallel or intersecting borders, and variations in the hues and textures of separate items (Bravo & Farid, 2004). Clutter exerts a direct influence on our perception of space by giving rise to crowding, which manifests as the inability to distinguish objects within a cluttered setting. Our conscious visual perception operates within inherent constraints regarding the number of objects it can effectively process; exceeding this threshold causes us to perceive the environment as cluttered, ultimately leading to feelings of crowding (Whitney & Levi, 2011). This multifaceted phenomenon can be explored through two distinct categories: object clutter and surface clutter.

Object clutter pertains to factors like the abundance of three-dimensional objects within an environment. Skillful organization of objects holds the potential to significantly mitigate object clutter, thereby creating additional physical space for various activities. Furthermore, it can substantially impact our perception of spaciousness and enhance the availability of room for diverse uses. In the absence of

deliberate planning and organization, furniture placement can also contribute to the presence of cluttered objects. For instance, to enhance the sense of spaciousness and impact our perception of clutter, items can be positioned below waist height, such as beneath countertops (Simon & Toups, 2014).

Research unveiled that orderly rooms marked by minimal clutter are often perceived as more spacious than their cluttered and disorganized counterparts (Samuelson & Lindauer, 1976). Intriguingly, even when both rooms contain the same set of objects, the pivotal determinant affecting the perception of spaciousness is the organization of these objects. Samuelson and Lindauer suggested that the perception of spaciousness in well-organized rooms can be attributed to several factors. Firstly, well-organized rooms typically allocate less physical space to objects, creating the impression of more available room. Additionally, these organized spaces generate reduced visual stimulation and diversity, which in turn directs the occupant's attention toward other interior architectural elements, such as the walls. This shift in focus towards architectural elements contributes to the perception of emptiness and larger overall room size.

2.1.3. Interior and exterior openings

Openings provide visual connections between the interior and the exterior and have a direct impact on how we perceive the available space. Windows and doors, in particular, are prominent architectural elements that serve as conduits between an environment's interior and the surrounding exterior (Simon & Toups, 2014).

The presence of openings, such as windows and doors, facilitates an extended line of sight. As previously discussed, an increased line of sight contributes to a heightened sense of spaciousness. Additionally, these openings serve the vital function of delineating the physical boundaries between different rooms within an interior environment. They define what constitutes a confined space versus an open one.

Openings like windows and doors carry substantial psychological and anthropological significance (Vogler et al., 2004). They play a role in humanizing an environment, particularly in extreme or confined settings. The existence of these openings fosters a

connection between the interior and the exterior world, bridging the gap between the two.

Several key variables associated with openings influence the perception of spaciousness within an environment. These variables encompass the quantity and dimension of openings, their shapes, and their arrangement concerning the overall environment. One pivotal factor is the size of these openings, as they exert a direct and quantifiable impact on how spacious an environment is perceived. The research conducted by Bokharaei and Nasar (2016) exemplifies this phenomenon, showing that larger windows enhance the perception of spaciousness. Larger openings, particularly windows, facilitate more natural light into the space and offer unobstructed views of the surroundings, fostering a sense of openness and expansiveness.

It is important to emphasize that numerous confined environments often lack the connection between the interior and the exterior, typically established through windows. Hence, the significance of interior and exterior openings extends beyond their architectural attributes; they also significantly influence our psychological encounter with a space.

2.1.4. Natural and artificial lighting

Light is pivotal in shaping our perception of space, as it stands as a fundamental determinant in our visual understanding and interpretation of our surroundings. Within the area of lighting, three key variables have been recognized as influential factors in altering our perception of spaciousness: the direction of the light (direct or indirect), the quantity of light (in lumens or lux), and the lighting temperature (measured in Kelvin).

Substantial research has been undertaken to investigate how natural and artificial lighting quality affects our perception of an environment. Notably, studies by Kirschbaum and Tonello (1997), Inui and Miyata (1973), and Martyniuk et al. (1973) have contributed valuable insights to this subject.

Manav and Yener (1999) conducted comprehensive room experiments, which unveiled a positive correlation between cove lighting and the perception of spaciousness. Cove lighting contributed to the perception of a larger room and created the illusion of higher ceilings. Notably, cove lighting provided the second-highest overall illumination levels in their study. Following full-scale room investigations by Matusiak (2004) lent further support to these findings. Matusiak's research demonstrated that increased illuminance, achieved through various light sources, both artificial (lamps) and natural (windows), combined with higher surface reflectance, yielded a greater perception of room size. In many cases, a well-lit environment is perceived as more spacious in contrast to a dimly lit one (Bokharaei & Nasar, 2016). The illumination level in a room can be modified by introducing additional light sources, increasing the output of existing sources, or by adjusting the surface properties to enhance their reflectivity, which will be explored in more detail in the next section.

In conclusion, light is a potent and easily modifiable instrument for shaping our perception of spaciousness within an environment. Nevertheless, it necessitates adept handling, for it not only impacts how we perceive space but also substantially influences the well-being and psychology of individuals dwelling in the environment, a facet that becomes particularly crucial in confined spaces.

2.1.5. Color and other surface properties

Interior architects frequently utilize surfaces with distinct characteristics to achieve specific objectives. Surfaces offer a high degree of flexibility due to their diverse range of properties, often determined by material selection. We commonly encounter attributes such as hues and shades, texture, and reflectivity among the vast array of surface properties.

A substantial body of research has been dedicated to color, as it emerges to be the frequently utilized tool by interior architects to influence the perceived size of a space (Oyama & Nanri, 1960; Oberfeld et al., 2010). For instance warmer colors are generally perceived as more aesthetically pleasing than cooler colors and tend to be better retained in the memories of occupants (Hidayetoglu et al., 2012). Cool colors,

characterized by shorter wavelengths of light, encompass violet, blue, and green. In contrast, warm colors, consisting of longer wavelengths of light, encompass yellow, orange, and red. However, the perception of warmth and coolness in colors is not indisputable; it can deviate depending on the properties of the surrounding surfaces (Mikellides, 1990). Although color may be the most common factor, it is not the sole determinant of a given surface's impact on an interior environment. Diverse surface treatments can be implemented within interior spaces to augment the perception of spaciousness. Surface attributes directly impact the level of illumination within an environment, and heightened brightness contributes to an increased sense of spaciousness. Consequently, surfaces that are bright or possess high reflectivity create the illusion of a larger room, surpassing the effect of darker colors (Matusiak, 2004).

Acking and Küller (1972) assert that rooms adorned with lighter colors are typically perceived as more expansive than those adorned with darker colors. Consequently, less saturated colors can be employed to enhance the perceived spaciousness. Similarly, the illusion of surfaces receding from the observer can be triggered by using lighter tones, while the opposite effect can be created by using darker tones (Sundstrom & Sundstrom, 1986). Color within an isolated, confined, and austere (ICE) environment can be categorized into three primary groups (Kozicka, 2008, pp. 243-244):

1. **Backgrounds:** Background hues should be low saturation and light to enhance spaciousness. Oversaturated colors could reduce the legibility of smaller elements and diminish the overall sense of comfort. Pale neutral colors are the preferred choice for backgrounds.
2. **Large Components:** Large components should be more saturated and darker than background colors. This contrast is necessary to distinguish them from the background. Given their substantial size, these components are already quite visible, so there is no need for excessive use of color.
3. **Small Components:** Small components require high contrast and saturated colors to differentiate them from other interior architectural features. However, limiting the selection of colors to just a few options is important to prevent confusion and maintain a sense of order. Overusing these components can make the environment overwhelming and uncomfortable.

Understimulation can manifest when the interior environment lacks a diverse range of hues or when the color choices lead to extreme uniformity in their chromatic values. This condition is often associated with monotony and can result in restlessness, irritation, intense emotional reactions, and difficulties in concentration and task performance (Küller, 1976; Mahnke, 1996).

To mitigate understimulation, various textures and patterns can be introduced into the environment to provide increased visual interest and stimulation. Furthermore, enhancing contrast and saturation between similar colors can help alleviate this issue. However, it's important to strike a balance, as excessive use of different colors and textures can lead to discomfort, restlessness, and tension (Duraó, 2003).

In their research, Wang et al. (2020) employed virtual reality to conduct a series of experiments investigating the impact of textured walls on spatial perception. Their research encompassed three separate experiments, each with a distinct focus. The initial experiment examined how wall texture impacts the perceived spaciousness of an environment. The subsequent experiment delved into the influence of various wall textures on the perception of spaciousness in rooms of different dimensions. The third experiment delved into the impact of associations with texture on individuals' perceptions of spaciousness. Through these experiments, Wang and colleagues sought to gain insights into the role of wall textures in shaping the perception of spatial dimensions.

Their study revealed that rooms featuring textured walls tended to convey a sense of lessened spaciousness compared to rooms with plain white walls of equivalent size. Additionally, perceived spaciousness was significantly influenced by the specific type of texture, and the effects were more pronounced in smaller rooms than in larger ones. This difference was explained by the shorter observation distances in smaller rooms, prompting occupants to focus more on the factual material properties of the materials. Subjective properties of the surfaces, such as aesthetics, significantly influenced the perception of spaciousness in larger room sizes due to decreased observable details. It is essential to acknowledge that utilizing virtual reality (VR) headsets carries limitations when applied to large-scale environments. The technological limitations of head-mounted displays (HMDs), including lower image resolutions in virtual reality

spaces, could impact the perceived sharpness of textured walls in larger rooms during experiments.

A study by von Castell et al. (2020) found that using higher-density striped patterns gave the impression of wider and taller rooms, while lower-density patterns made rooms appear smaller in all dimensions. Notably, pattern density played a more significant role than pattern orientation in influencing perceived spaciousness. Although the effects of pattern orientation yielded inconsistent results regarding its impact on perceptions of room size, it was hypothesized that the dissimilarities between low-density and high-density designs could be attributed to Gibson's (1979) theories. High-density patterns served as a visual cue that made walls appear farther away from the observer.

The research is corroborated by the concept of surface clutter, often connected to the surface properties of objects or architectural elements, including walls decorated with wallpaper. As a two-dimensional effect, surface clutter emerges when materials with conspicuous designs or elements are excessively employed. The repetitive patterns introduce a new scale to the environment, and they can swiftly become overwhelming, overwhelming our perceptual capacities and fostering a feeling of confinement. Conversely, the strategic incorporation of designs on vertical and horizontal axes can create the illusion of a more expansive or taller environment, as emphasized by Simon and Toups (2014).

Surface properties are crucial in specific ICE environments with zero gravity conditions, such as the International Space Station (ISS). Different hues serve as consistent orientation cues within the station modules, differentiating among various components and functions. Surprisingly, providing sufficient differentiation in terms of hues and saturation has often been overlooked in ICE environments like space stations (Durao, 2003).

2.2. Psychological Wellbeing in Interior Environments

Individuals can establish diverse connections to specific settings and situations in interior environments. These connections can be broadly categorized into three distinct dimensions: psycho-sociological, physiological, and psychological.

Psycho-sociological determinants pertain to users' social needs and challenges, encompassing aspects such as communication, interpersonal relationships, and group dynamics. In smaller groups, individual personalities, cultures, and backgrounds can exert influence over other group members.

Physiological determinants are closely tied to users' physical requirements. Architects and designers must consider factors such as functionality, human factors, health, and safety when creating interior spaces.

Psychological determinants revolve around users' psychological needs. The dynamics within an environment can vary significantly among individuals, reflecting their unique psychological states and preferences.

This tripartite framework provides a holistic perspective on how individuals interact with and react to interior environments. The sociological, physiological, and psychological dimensions significantly shape the user experience within these spaces. Before delving further into this topic, it is important to mention Maslow's (1943) hierarchy of needs theory, which elucidates the psychological motivations that drive human actions, spanning from the most fundamental, such as the pursuit of food and shelter, to more intricate endeavors like the creation of art. This theory is often depicted as a pyramid (Figure 3), with the most basic needs forming the pyramid's base and progressively more complex activities ascending as the lower needs are successfully fulfilled. These needs are categorized as basic needs, psychological needs, and self-fulfillment needs, further broken down into physiological, shelter, love/belonging, esteem, and self-actualization.

The first four levels are commonly referred to as deficiency needs, as their fulfillment is considered essential, and their absence motivates individuals to strive for their

satisfaction. In contrast, the top level is known as the growth need. Unlike the preceding levels, growth needs are not rooted in a lack of something but stem from an individual's desires. This level is characterized by an individual's aspiration to expand their horizons, experience diverse aspects of life, and reach their fullest potential, often called self-actualization. The fulfillment of these needs serves as the catalyst for the emergence of ideas, creativity, and innovation.

Soon after, Maslow (1970) developed further models to expand upon the original pyramid concept. These models introduced cognitive needs, reflecting the quest for knowledge, curiosity, and meaning; aesthetic needs, encompassing an appreciation of beauty; and transcendence needs, which go beyond personal motivations, encompassing a desire for novel experiences and a connection with the broader world.

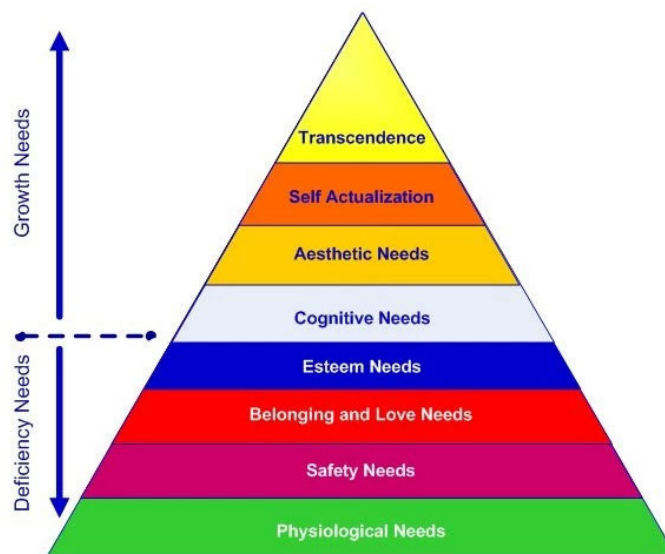


Figure 3. Diagram of Maslow's hierarchy of needs, expanded version (McLeod, 2018).

Maslow's theory sheds light on a crucial aspect of the built environment, emphasizing the expectation that it should fulfill our needs to a certain extent. This approach underscores the fundamental functional requirements the built environment must meet to be considered habitable. These needs include privacy, territoriality, comfort, and functionality. Additionally, individual aesthetic needs, motivations, and self-actualization aspirations are pivotal in shaping preferences for a built environment.

As Banham (1965, p. 70) provocatively questions, "When your house is equipped with such an array of infrastructure, including piping, flues, ducts, wires, lights, inlets, outlets, ovens, sinks, refuse disposers, hi-fi reverberators, antennae, conduits, freezers, and heaters – when it contains so many services that the hardware alone could function independently without any assistance from the house, why have a house to support it?"

The answer to this question can potentially define the status of a built environment, differentiating it as either a mere shelter or a true home. The distinction hinges on the extent to which the environment aligns with the occupants' self-actualization goals. Building upon this notion, exploring the individual needs of occupants is valuable, commencing with the concept of territoriality.

From the perspective of individuals, environmental design encompasses four distinct levels of space on the horizontal plane, as illustrated in Figure 4. These levels are intimately tied to human interaction and comfort, and they include intimate space, personal space, social space, and public space (Hall, 1969).

1. **Intimate Space (0 to 45 cm):** Intimate space represents the zone closest to an individual, extending from 0 to 45 cm. This space is reserved for personal interactions and is typically restricted to individuals with the closest relational ties. Intrusion into this space is often perceived as unacceptable, given its reserved nature.
2. **Personal Space (45 to 120 cm):** Personal space spans from 45 to 120 cm between individuals. It is open to family members and close friends. Charles Hall (1969) defines personal space as the psychological territory that an individual considers their own. Continuous invasion of personal space can lead to discomfort, feelings of territoriality, and even aggression.
3. **Social Space (120 to 370 cm):** Social space, ranging from 120 to 370 cm, is dedicated to interactions between individuals in verbal contact. This level of space accommodates encounters with strangers and acquaintances, fostering social communication without necessitating extreme privacy.
4. **Public Space (370 to 760 cm):** Public space, extending from 370 to 760 cm, is designated for collective activities such as speeches, lectures, and public

events. These spaces are intended for larger gatherings where one-to-one interactions are not the primary focus.

In addition to addressing the need for privacy, it is imperative that the designed environment also meets various psychological needs of individuals. These needs encompass a broad spectrum of psychological states and can vary significantly due to individual differences. Nevertheless, they are commonly discussed under the overarching term of "psychological well-being."

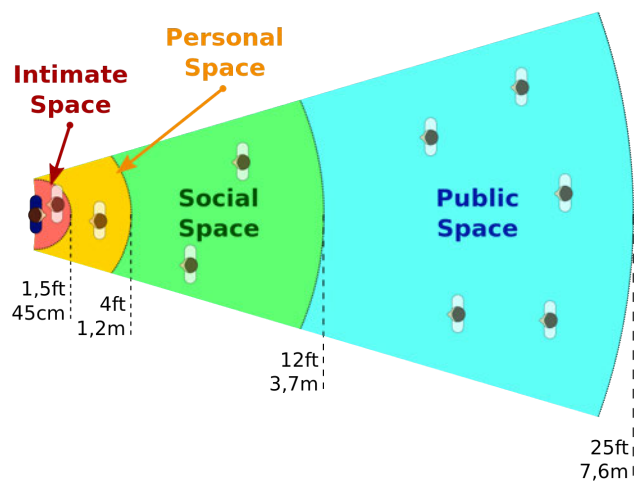


Figure 4. Degrees of personal space (Grall, 2011)

Privacy stands as a pivotal consideration within the realm of environmental design. A fundamental challenge associated with residing in confined environments is the potential scarcity of privacy. Privacy is a fundamental human regulatory process through which individuals determine their accessibility to others (Davis & Palladino, 1997). Striking the right balance in regulating privacy is imperative, as excessive privacy can lead to isolation, while insufficient privacy results in overcrowding—both undesirable states of being (Namazian & Mehdipour, 2013).

Following this perspective, the designed environment should be responsive to the dynamic privacy needs of its occupants. Environmental designers are responsible for ensuring that the environment facilitates varying degrees of privacy, offering options that occupants can control. Failure to do so, leading to the creation of a static and

unchanging environment, can give rise to significant issues among occupants, rendering the space uninhabitable.

A straightforward illustration of this concept can be found in the doors of a room. Occupants can leave the door open, allowing others to enter and exit freely—a signal of accessibility. Conversely, closing the door signifies the occupant's need for heightened privacy, signaling a desire to seclude themselves and avoid disturbances. Well-being denotes the existence of positive developments and expectations in an individual's life, signifying that their lives hold meaning and are advancing positively. Assessing well-being relies on an individual's appraisal of their life satisfaction, considering aspects like feelings of joy or depression (Diener et al., 2004). Well-being is frequently marked by the lack of negative emotions, such as depression and anxiety, as well as the existence of positive emotions, like happiness (Diener, 2000). Researchers have adopted various dimensions to study well-being comprehensively. This chapter explores established models of well-being, shedding light on how these models can enhance our understanding of the psychosocial impacts of ICE environments. Notably, these models and their associated assessments frequently serve as selection criteria for missions in extreme environments (Table 1).

Drawing from the existing literature, this chapter delves into two principal approaches to well-being: the hedonic (subjective) well-being approach and the eudaimonic well-being approach (Vanhove et al., 2015). These approaches offer valuable frameworks for examining and enhancing the well-being of individuals in ICE environments.

Hedonic well-being, often referred to as subjective well-being (SWB), encapsulates the pleasure-driven aspects of well-being, encompassing elements such as happiness, emotions, mood, life satisfaction, and work satisfaction. In contrast, the Self-concordance Model of Goal-striving proposes that eudaimonic well-being (EWB) arises from an individual's realization of their potential and fulfilling personal goals and expressions (Sheldon, 2002).

Table 1. List of models, their main concepts, and dimensions of measurement.

Authors	Concepts			Traits measured	Relevant in ICE Environments	Name of the model/theory	Name of the Instrument
	Subjective well-being (SWB)	Eudaimonic well-being (EWB)	Psychological well-being (PWB)				
Jahoda, 1958			X	Attitudes of an individual toward his own self, Self-actualization, Integration, Autonomy, Perception of reality, Environmental mastery		Ideal Mental Health	
Doll & Gunderson, 1970				Leadership performance, Emotional stability, Task performance, Social compatibility.	X	Clusters of Personality Traits	
Watson and Tellegen, 1985	X			Positive & Negative Affect	X	Consensual Model	Positive Affect Negative Affect Scale (PANAS)
Cazes et al., 1989				Thymic reactions, Social reactions, Somatic reactions, Occupational reactions	X	Four Categories of Adaptation	Adaptability Questionnaire (ADQ)
Antonovsky, 1987			X	Personal growth, Positive emotions, Enriching relationships	X	Salutogenic Model	Sense of Coherence (SoC) Scale
Ryff, 1989			X	Self-acceptance, Positive relation with others, Autonomy, Environmental mastery, Purpose in life, Personal growth.		Six factor model of psychological well-being	Ryff Scale of Measurement
Ryan & Deci, 2001	X	X		Autonomy, Competence, Relatedness		Self Determination Theory	
Sheldon, 2002		X		Adapted Ryan & Deci, 2001		Self-concordance Model of Goal-striving	
Grant et al., 2007	X			Adaptation & Coping	X		Selection of Antarctic Personnel (SOAP)
Nicolas et al., 2019			X	Social, Emotional, Occupational, Physical dimensions	X		Extreme Environments Questionnaire (ICE-Q)

Subjective well-being represents the initial approach to well-being that has undergone extensive systematic and empirical exploration, resulting in the development of comprehensive theories. A defining characteristic of SWB is the identification and measurement of distinct positive and negative emotional states, alongside an individual's overall life satisfaction. One foundational model that has significantly contributed to the understanding of subjective well-being is Watson and Tellegen's (1985) Consensual Model, which has been widely utilized in the literature.

Within this model, the two facets of well-being are examined through the lens of positive and negative emotions. **Positive Affect (PA)** embodies a person's emotions of eagerness, activity, and attention, while **negative affect (NA)** represents experiences of despair and unpleasurable mood states. (Watson et al., 1988; Diener, 2000).

Eudaimonic well-being (EWB) is often linked with performance measures and optimal functioning within an environment. In contrast, the subjective well-being (SWB) approach does not differentiate between the sources of well-being. It primarily measures the level of happiness and satisfaction without differentiating between eudaimonic and hedonic sources (Waterman et al., 2010). SWB tends to view happiness as the ultimate goal, while EWB perceives happiness and satisfaction as byproducts of engaging in actions aligned with personal goals. Contemporary psychologists have varied views on EWB. Some continue to view it primarily as subjective happiness, while others, adopting a more objective standpoint, define it as "flourishing" (Keyes, 2002).

Moreover, Ryan and Deci (2001) have contributed significantly to the field of well-being by developing an approach rooted in the self-determination theory. They identified three fundamental psychological needs essential for optimal functioning: autonomy, competence, and relatedness. Their emphasis centers on individuals' resources for personality development and behavioral regulation, with a focus on both internal and external motivation characteristics. Their theory distinguishes between hedonia and eudaimonia and draws heavily from Ryff's (1989) model of psychological well-being.

The early contemporary investigations into psychological well-being can be traced back to 1958 with Jahoda's clinical studies and her model of ideal health. In her pioneering work, Jahoda identified elements closely associated with positive functioning. These elements included attitudes toward oneself, integration, autonomy, perception of reality, self-actualization, and environmental mastery (Jahoda, 1958).

Building upon the insights of Jahoda and drawing from the works of notable psychologists such as Jung and Maslow, the "Six-factor Model of Psychological Well-being" (Ryff, 1989; Ryff & Keyes, 1995) was developed. This model identifies and measures well-being through six distinct factors, each reflecting a crucial dimension of overall psychological health. These factors are:

1. **Self-acceptance**
2. **Positive relations with others**
3. **Autonomy**
4. **Environmental mastery**
5. **Purpose in life**
6. **Personal growth**

These dimensions were rooted in earlier theories and models from various psychological health studies. Figure 5 (Ryff, 2014) provides an overview of the primary psychological theories and researchers that influenced Ryff's development of her well-being model. Each dimension within this model delves into a different facet of well-being and is further elucidated based on Ryff's original explanations (Ryff, 1989). These explanations draw from a diverse array of theories, as highlighted in Figure 5.

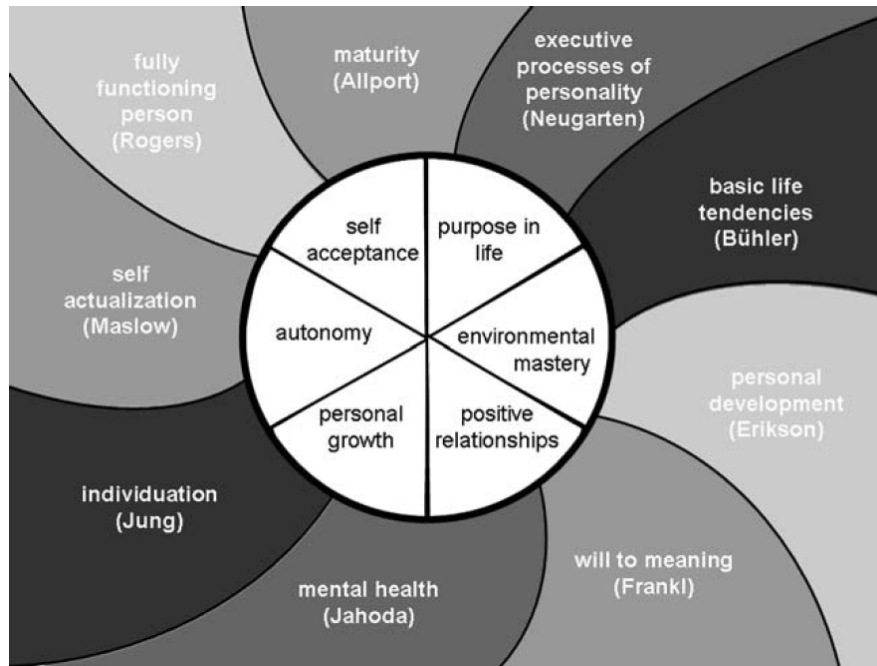


Figure 5. Ryff (2014) identified six core dimensions of psychological well-being, each grounded in theoretical foundations.

Self-acceptance is the capacity to harbor favorable evaluations of oneself and one's life, encompassing achievements and disappointments (Erikson, 1959). It hinges on distinctive individual attributes such as maturity, emotional security, a sense of self-worth, and the recognition of various facets of one's self (Maslow, 1968; Rogers, 1961). This dimension of well-being, rooted in the influential works of psychologists like Erikson, Maslow, and Rogers, holds a profound connection to positive functioning. It involves embracing one's self, acknowledging past experiences, and fostering a healthy self-perception, all of which contribute to a holistic sense of well-being.

Positive relations encompass the capacity to establish trustworthy and warm relationships with others while demonstrating warmth, love, and empathy in appropriate ways (Rogers, 1961; Jahoda, 1958). Those who excel in forming positive relationships tend to exhibit a deeper understanding of interpersonal dynamics and function more effectively within groups (Birren & Renner, 1980).

Autonomy represents an individual's ability to achieve self-actualization and manifests as the capacity to perform or function independently, free from external interference or command (Jahoda, 1958). It is also characterized by resistance to social pressure and a reduced need for external validation due to a strong internal focus on personal valuation. High levels of autonomy empower individuals to act in ways that may deviate from pre-existing societal standards, fears, and beliefs when necessary (Jung, 1933).

Several studies have investigated the factors influencing well-being and their measurable impact on crew members within ICE environments. Kanas et al. (2010) conducted a pilot study within habitat/spacecraft simulation environments to investigate the influence of autonomy on crew members and their interactions with mission control. The subjects completed questionnaires assessing their mood and interpersonal interactions during the study. The experiment was divided into two phases: one with limited autonomy (where mission control controlled duties and scheduling) and another with increased autonomy (where the crew had more control over their schedules and duties). The findings indicated that crew members' mood and well-being improved during the high autonomy phase compared to the earlier stage. Autonomy levels were assessed through self-reporting questionnaires. A subsequent study during the Mars-105 mission yielded consistent results with the pilot study (Kanas et al., 2011).

Environmental mastery pertains to an individual's capacity to exert control over the environment in which they dwell. It is closely intertwined with competence, signifying the ability to adeptly handle various social variables, including personal affairs and family matters, while capitalizing on emerging environmental opportunities (Neugarten, 1973; Buhler, 1935). Notably, the emphasis on environmental mastery often leans toward the social environment rather than the physical surroundings. Environmental mastery, in certain contexts, can be conceptualized as an individual's capacity to create and maintain environments that resonate with their values and principles (Jahoda, 1958).

Purpose is marked by a deep sense of direction and intentionality. Often, individuals uncover their life's purpose by seamlessly integrating various facets of their existence

with their surroundings (Allport, 1961). Jahoda (1958) further defines *integration* as the presence of a unifying perspective that imparts a sense of reason and significance to one's life. This concept is expanded upon by the Sense of Coherence (SoC) Scale developed by Antonovsky (1993), which assesses the comprehensibility, manageability, and meaningfulness of an individual's environment or life. Individuals who experience positive functioning tend to possess clear goals and intentions that contribute to their profound sense of purpose in life.

Personal growth is often seen as the culmination of the preceding dimensions of well-being in a positively functioning individual. Its fundamental premise is that individuals must continually evolve, broaden their horizons, and unlock their inherent potential (Rogers, 1961; Jahoda, 1958). Successful personal growth hinges on the manifestation of the earlier well-being dimensions and serves as the cohesive element that unifies overall functionality.

Ryff's (2014) model sought to delve into deeper and more fundamental aspects of well-being, transcending the surface-level inquiries into an individual's happiness and life satisfaction. This shift in focus aimed to elevate well-being from subjective to objective approaches, bolstering its scientific credibility through rigorous methodologies and quantifying matters that were once within the realm of philosophy. Scales developed based on this model underwent extensive testing and utilization in well-being research.

Over time, some questionnaire scales were streamlined, reducing the number of items from the original 120 (20 items for each of the six dimensions) to as few as 21 items. However, this reduction in scale length posed challenges to the model's reliability. Nevertheless, since its inception, Ryff's model has remained one of the most widely employed frameworks in scientific literature for comprehensively understanding well-being.

Antonovsky (1993) developed the Sense of Coherence (SoC) scale, nearly contemporaneously with Ryff's model, with the aim of elucidating psychological well-being as a lasting attitude characterized by the comprehensibility, manageability, and meaningfulness of life (Huppert & So, 2013). According to Antonovsky (1987),

comprehensibility refers to the structure, predictability, and explainability of stimuli arising from both internal and external environments. Manageability involves having the resources to meet the needs presented by these stimuli, while meaningfulness relates to the value assigned to challenges, promoting engagement and the allocation of resources.

Antonovsky's SoC model was built upon his prior research, particularly the Salutogenic Model of Health (SMH), conceived in 1979 and further expanded in 1987, which became a significant companion to the study of well-being. SMH aimed to shift the understanding of the relationship between stress, coping, and health from a pathogenic orientation to a salutogenic one, focusing on health and well-being factors rather than those causing disease. The salutogenic model advocated for a distinctive approach to stress and coping, emphasizing the inherently positive aspects of circumstances and positive responses to environmental challenges, along with the experience of effectively overcoming difficulties (Palinkas & Suedfeld, 2008).

Subsequent studies applying SMH in polar and Antarctic settings revealed notable enhancements in overall well-being during missions, with enduring effects. These improvements encompassed enhanced health, a sense of personal achievement, courage, resoluteness, indomitability, increased self-esteem, hardiness, heightened individuality, and a strengthened sense of humanity (Suedfeld, 2002). Antonovsky's findings paved the way for the development of methodologies designed to bolster positive outcomes during isolation while mitigating adverse effects.

In his analysis, Waterman (2008, p. 249) scrutinized the strengths and limitations of each well-being approach: SWB (Subjective Well-Being), EWB (Eudaimonic Well-Being), and PWB (Psychological Well-Being). He highlighted the need for greater precision in identifying the role played by the level of analysis in happiness and well-being findings. Additionally, Waterman emphasized the importance of exploring the generalizability of these findings across different levels.

Furthermore, Waterman called for heightened attention to various quantitative outcome measures that can be employed to assess happiness. These measures encompass factors such as intensity, duration, sustainability, predictability, and more.

In essence, Waterman's assessment underscores the necessity for a nuanced and comprehensive understanding of happiness and well-being, urging researchers to consider both the level of analysis and the diverse quantitative measures to enrich the field of well-being psychology.

2.3. Aesthetic Experiences in Interior Environments

Exploring aesthetic experiences within the context of ICE environments, often designed with a utilitarian focus, is a crucial and promising research area. Many studies have emphasized the substantial influence of the aesthetic qualities of architectural spaces on human experiences, including cognitive functioning, psychological well-being, mood, and behavior (Adams, 2014; Cooper et al., 2014; Hartig, 2008; Joye, 2007).

According to Berlyne's arousal theory (Berlyne, 1970), individuals tend to seek stimuli with moderate complexity and novelty in order to achieve optimal levels of arousal and interest. They further reinforce this theory with empirical evidence indicating that both the 'pleasingness' and 'interestingness' of stimuli tend to increase as the level of novelty in the stimuli rises. As the stimuli become repetitive, the attention depicted towards them decreases. However, this reduced attention can be elevated if an opposing stimulation interrupts a monotonous period, albeit The Wundt Curve illustrated in Figure 6 is an interpretation developed by Berlyne, further outlining their theory and the dynamics of arousal.

According to Berlyne's theory of arousal, the most increased positive hedonic value tends to be evoked by stimuli that evoke moderate levels of arousal. However, the hedonic value of the stimulus decreases and trails to negative as the arousal potential of a stimulus rises past a certain degree. Novelty plays a crucial role in this dynamic since stimuli with high levels of novelty are associated with greater arousal potential. As the individual familiarizes themselves with a stimulus, it loses novelty. This progression can be observed in Figure 6 as the curve traverses the X-axis. Moreover, a high novelty and low complexity stimulus falls within moderate initial arousal potential.

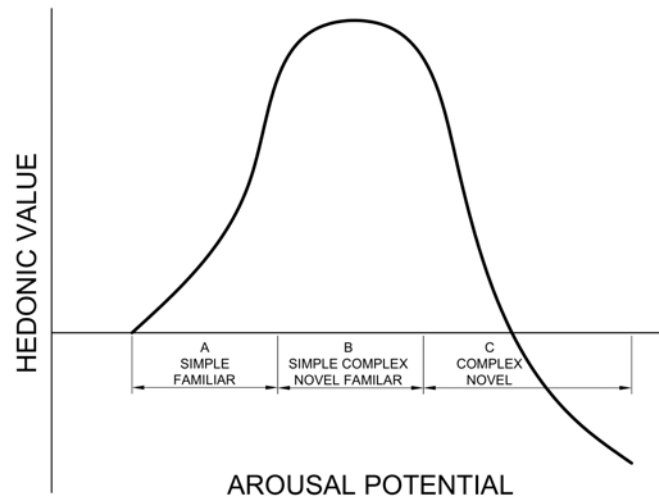


Figure 6. Interpretation of the Wundt Curve by Berlyne (1970, p. 284).

Chatterjee and Vartanian's (2014) framework indicates that aesthetic experiences result from the interplay of three neural systems: sensory-motor, emotion-valuation, and meaning-knowledge. For example, sensory-motor interactions encompass sensory networks, including vestibular systems, somatosensory, olfactory, auditory, visual, and motor responses, such as approach and avoidance (Vartanian et al., 2015).

The interactions between knowledge and meaning in aesthetic experiences are deeply influenced by personal experiences, culture, and education. Furthermore, structures and urban spaces can prompt emotions and feelings; emotion-valuation systems mediate these (Leder et al., 2004).

Coburn et al. (2020) integrated three fundamental parts of knowledge processing to Chatterjee and Vartanian's model to expand upon it. These parts consist of behavior, connected to the sensory-motor element; cognition, connected to the knowledge-meaning element; and emotion, connected to the emotion-valuation element. This comprehensive understanding of aesthetic experiences and their neural foundations holds the potential to provide valuable insights for the design and enhancement of ICE environments. By applying this knowledge, it becomes possible to improve the well-being and experiences of individuals within such environments.

Elver Boz et al. (2022) provide a comprehensive interpretation of how architectural spaces influence human aesthetic experiences. In order to accomplish this, they have

relied on Chatterjee and Vartanian's model and Coburn's interpretation. Their research revealed that human aesthetic experiences could be effectively categorized into three primary dimensions: familiarity, excitement, and fascination. Importantly, these dimensions exhibited differential sensitivity to the various architectural variables, underscoring the unique and nuanced impact that each of these architectural factors can have on shaping the aesthetic experiences of individuals. To test their theory, the researchers controlled several architectural variables in an experiment using VR. These manipulations encompass boundary size, shape, color, texture, and lighting.

Elver Boz et al.'s (2022) study breaks aesthetic experience into familiarity, excitement, and fascination, offering a comprehensive framework for understanding how individuals perceive and respond to architectural spaces. In the familiarity dimension, the study reveals that architectural elements influence not only cognition but also emotions and behaviors. This dimension reflects the cognitive sense of safety, the emotional experience of relaxation, and the behavioral inclination to spend time in a given space. The findings emphasize the importance of size, lighting, color, and boundary orientation in shaping the sense of familiarity. Environments characterized by bigger extents, brighter and cooler lighting, and horizontal boundaries evoke feelings of familiarity, creating a sense of safety, relaxation, and a greater inclination for individuals to spend time in these spaces.

The excitement dimension, centered on emotional responses within architectural spaces, highlights the role of lighting, size, and color's role in evoking excitement or contentment. It demonstrates that the emotional impact of these factors varies, with lighting having a more pronounced effect. Architectural spaces with larger sizes, brighter, warmer lighting, and horizontal boundaries yield higher excitement and positive emotional engagement. Importantly, the orientation of boundaries interacts with lighting intensity, leading to distinct emotional responses based on the boundary's orientation.

In contrast, the fascination dimension, which captures the sense of intrigue and captivation, was not significantly influenced by the architectural variables examined in the study. This suggests that factors contributing to fascination may be more complex or subtle than those directly manipulated in the study. The stimuli employed

in the investigation may not have been captivating enough to evoke a significant sense of fascination.

Overall, this research provides valuable insights for architects and designers, highlighting the importance of carefully considering the design elements that influence occupants' aesthetic experiences. Architects can create environments that promote a sense of safety, relaxation, and positive emotional engagement by understanding how different factors impact familiarity and excitement. Moreover, it is essential to comprehend fascination within architectural spaces in the context of design, requiring further exploration to uncover the nuanced factors contributing to this dimension.

The next chapter explores attitudes and behaviors of crews that spend extended amounts of time in ICE environments. It looks at different coping strategies in ICE and how they connect to well-being. The chapter also discusses the ICE-Q model with its four parts: social, emotional, occupational, and physical, and how they all work together and affect adaptability. The chapter also discusses how virtual reality can be used as an alternative to ICE environments by using immersive virtual spaces and questionnaires to see how engaged people are.

CHAPTER III

ISOLATED, CONFINED, AND EXTREME ENVIRONMENTS

Three distinct features characterize ICE environments. The first characteristic involves the continuous presence of significant bodily risks arising from the external conditions of the surroundings. The second characteristic is associated with physical constraints and strict limitations on mobility due to external environmental conditions. The third characteristic is inadvertent isolation resulting from these conditions, primarily involving the separation of an individual from their usual social surroundings, especially their close social circles, for an extended period. These elements collectively serve as the primary stressors in ICE environments, giving rise to distinctive circumstances and coping strategies (Carrère, 1990).

Given the inherent characteristics of most ICE environments, particularly those in Low Earth Orbit or outer space, research on these matters is typically carried out in analogous settings, such as submarines or Arctic research stations, as seen in Figure 7. Additionally, smaller-scale controlled experiments, like the Mars 500 mission, are employed for investigations. Over nearly six decades, a substantial body of knowledge has been accumulated, primarily emphasizing evaluating the effectiveness of individuals and teams in performing various tasks within these environments. These studies have identified recurring psychological phenomena frequently monitored in parties exposed to ICE environments for extended periods. These phenomena often present significant challenges and constitute central research areas within the ICE studies domain.

These psychological phenomena frequently take on negative characteristics, resulting in a lack of motivation, diminished alertness and cognitive functioning, mood disturbances marked by aggression or depression, social withdrawal, group fragmentation, and polarization among members. Furthermore, biological disruptions such as sleep disturbances have been well-documented in studies (Gunderson, 1963; Natani & Shurley, 1974; Evans et al., 1988; Connors et al., 2005; Suedfeld & Steel,

2000). Nonetheless, there remains a research gap concerning the influence of the built environment on subjective experiences and well-being of individuals within ICE environments.

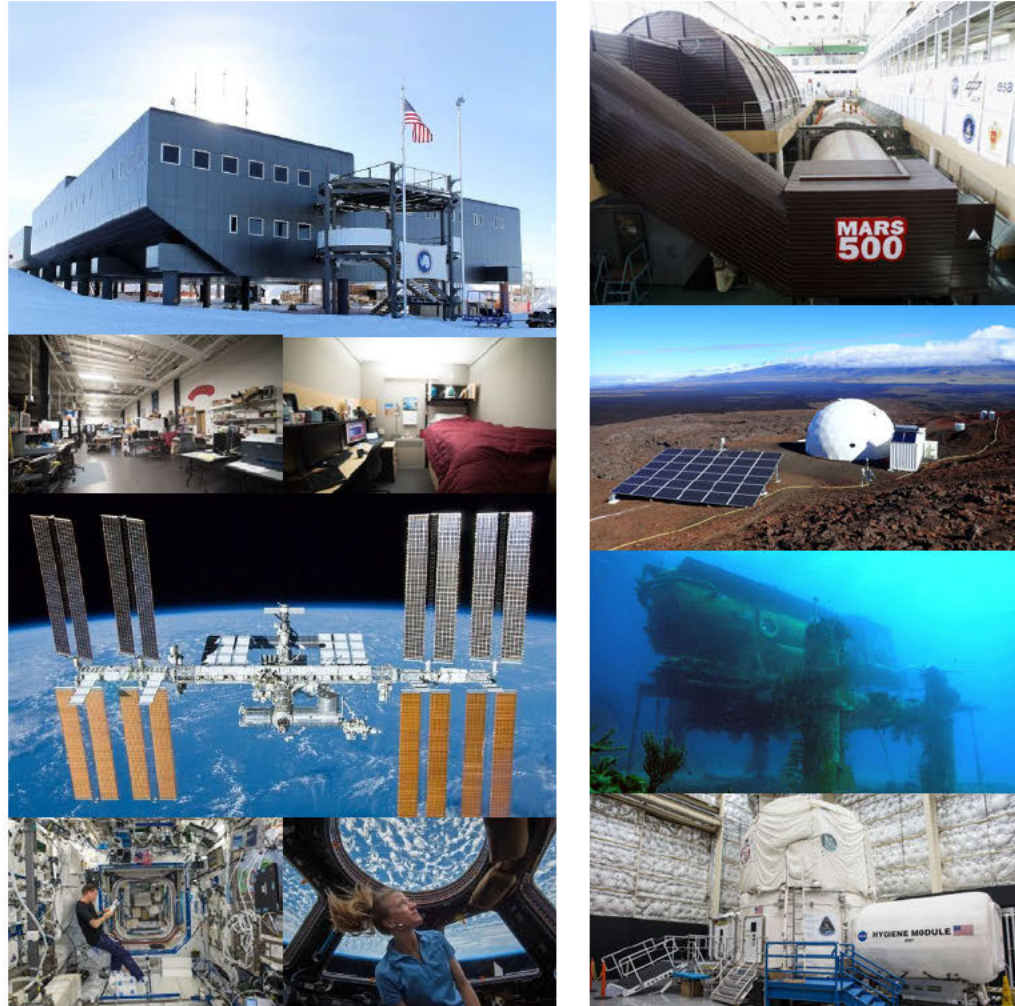


Figure 7. Examples of ICE Environments.

The volume of an environment can significantly influence an individual's choice of reference frames (Presson et al., 1989; Roskos-Ewoldsen et al., 1998). In a small space, individuals new to the environment are less likely to rely on allocentric representations (Proulx et al., 2016). Conducting thorough research and experimentation to gain a comprehensive understanding of these spatial representations can assist designers in creating environments that are inherently livable, safe, and functional for a wide range of occupants. Spatial cognition can have effects that sometimes run counter to conscious preferences and are sometimes implicit.

An individual's environmental perception can be influenced by understanding the utilization of different spatial representation models by providing them with information that may not align with the inherent characteristics of that environment. Applying evidence-based design methods is especially crucial in designing environments that aim to shape perception.

Previous research (Kaplan, 1987; Read, 2012; von Castell et al., 2014; Miniukovich & Angeli, 2014; Shemesh et al., 2016) has identified a set of inherent cues that our brains utilize to calculate the volume of an environment. These cues can also influence an individual's comfort level within that environment. These cues include shading, texture gradients, blur/transparency, perspective, the number of objects, the size of objects, and the orientation of objects. Some of which rely heavily on vision and can be susceptible to deception.

3.1. Studies of Well-being in ICE Environments

A significant body of research has delved into the psychological repercussions of isolation and confinement in extreme environments and conditions (Gunderson, 1963; Natani & Shurley, 1974; Evans et al., 1988; Connors et al., 2005; Suedfeld & Steel, 2000). Extensive observations made at polar research stations have identified three occurrences: the third-quarter phenomenon, the winter-over syndrome, and the polar T3 syndrome. These syndromes are typically noted in crews stationed in polar regions during the winter, where they encounter pronounced confinement and isolation. Although they have been extensively examined in the context of polar station crews, similar symptoms are anticipated in other settings, such as extended space missions.

The third-quarter phenomenon is a unique situation observed by psychiatrists in various crews subjected to isolation and confinement, characterized by a noticeable reduction in cognitive abilities, motivation, and mood after the midpoint of an expedition (Bechtel & Berning, 1991). Repeated studies in ICE environments with varying durations and crews have shown that this phenomenon is consistently present to a certain extent in all cases (Smith & Sandal, 2017). For example, Mullin et al. (1958) conducted experiments at several research stations in Antarctica. After interviewing 85 men following their stay in these stations, it was found that one-third

displayed significant indications of absent-mindedness, lack of attention, a strong desire for stimulation, action, and increased group suggestibility.

The winter-over syndrome was observed in individuals experiencing extended stretches of isolation and confinement while stationed at Antarctic research stations during winter overs, often lasting six to eight months. Depression, irritability, aggressive behavior, sleeplessness, absent-mindedness, lack of concentration, and memory problems were frequently experienced by individuals in these environments (Strange & Youngman, 1971). Similar occurrences of depression and a reduction in cognitive performance have been observed in individuals experiencing polar T3 (triiodothyronine) syndrome, believed to be caused by changes in thyroid hormone functions due to the extreme environment (Palinkas et al., 1995).

Longitudinal studies involving multiple Antarctic expedition crews conducted by Wood et al. (1999; 2005) demonstrated that while the effects of these occurrences were observable, they did not require clinical intervention or disrupt the completion of tasks. Individual adaptation and group relations contributed significantly more to psychological well-being and distress. These studies concluded that specific events influence psychological well-being during an expedition rather than exhibiting a steady decline over time.

According to Kanas (2014), crewmembers of space analogs often begin showing observable changes in psychological well-being after six weeks. These changes are often related to the amount of time remaining rather than the time that has passed. Two studies examining multiple 4 to 7-month missions showed no consistent mood or well-being changes in the time spent in these environments (Kanas et al., 2001; 2007).

As a collaboration between the European Space Agency (ESA) and the Russian Federation, the Mars 500 experiment aimed to replicate a Mars mission by closely monitoring crew members enduring prolonged confinement within a simulated spacecraft. Activities mimicked those of a hypothetical mission to Mars and back. The experiment spanned three phases, with the final stage lasting 520 days between 2010-2011. Some crew members experienced decreased alertness, reduced cognitive functioning, sleep deprivation, and mild depression despite the meticulous selection

and training regimens. Nevertheless, the crew maintained a harmonious atmosphere, and the experiment achieved its objectives without any significant conflicts, demonstrating the crew's effective management of social and emotional isolation (Astrobiology Magazine, 2011).

Prolonged exposure to confined environments has significant implications for the visual perception of space and spatial cognition. Experiments conducted on submariners who spend long durations in confined environments have shown that the average submariner had below-average distance acuity and was more likely to develop conditions such as myopia and esophoria (Kinney et al., 1979). Similar experiments performed on astronauts revealed changes in the accuracy of distance and size estimations of nearby objects after long-duration missions. However, it is important to note that these changes could be related not only to spatial confinement but also to the physiological and postural changes experienced by astronauts in microgravity (Clément et al., 2013).

According to Šikl and Šimeček (2013), a team that spent 500 days in an ICE simulation (Mars-500) showed no significant degradation in their perception of depth or three-dimensional perceptions. Their experiments were conducted multiple times over 500 days, and the results remained reasonably consistent. However, it is worth mentioning that the longest distance the crew members could see during their time in the simulation was limited to 26 meters. Similar experiments have been repeated with conflicting results (Lukavský, 2014; Šikl & Šimeček, 2015). Therefore, the reliability of the results may be affected by increased apathy and fatigue among the participants. Research into confined environments and their influence on spatial cognition remains an evolving field that necessitates further exploration and experimentation.

In numerous ICE environments, the inadequacy of living quarters becomes a substantial stressor and determinant due to individuals' inability to maintain the requisite distance from one another. As discussed earlier, the limited space available leads to a continuous encroachment on each other's personal spaces, often unintentionally. It becomes evident that individuals are territorial by nature, striving to exert control over their surroundings to attain their desired level of privacy. This matter is especially pronounced in such confined environments.

Therefore, promoting a certain degree of ownership of the environment in these confined settings is crucial. Each person's perception of the environment is unique, and allowing for changes in the immediate environment can foster a sense of territoriality. This discovery, in turn, enhances the sense of belonging. Feeling connected to an environment can alleviate sensations of isolation and confinement. Regardless of how small an environment may be, making it 'yours' can help individuals overcome the sense of confinement.

Recent studies on well-being in ICE settings primarily focus on adaptation, coping, and performance (Bartone et al., 2017; John Paul et al., 2010). These dimensions receive more in-depth examination compared to emotional and social dimensions of well-being due to the extreme and intense workloads that accompany living in such environments, alongside the more personal properties of emotions. According to Vanhove et al. (2015), eudaimonic and psychological well-being factors significantly impact long-duration spaceflight due to the motivational, commitment, and functional requirements of groups and individuals participating.

Adaptation is portrayed in this study as a psychological process, distinct from a physical approach like evolution, although the concepts share similarities. An individual is forced to adapt to a new environment to function adequately in it. In the ICE environment, this adaptation occurs due to psychological changes caused by the extreme environment. Another definition of adaptation often used in ICE environments is responding appropriately to various circumstances and adjusting behavior according to different situations or people (VandenBos, 2007). Although changes in the environment require physical adaptation, such occurrences need multiple generations, much more than a single lifetime, of exposure to these conditions to be of any noticeable importance. Grant et al. (2007) identified certain predictors of good adaptation abilities: low defensive hostility, high emotion-focused coping, high openness, high optimism, and a low level of subjective health complaints. According to a review by Bartone et al. (2017), traits such as openness, optimism, control, emotional stability, achievement orientation, hardiness, and ability to cope positively were relevant to high levels of adaptation in individuals within ICE environments.

Coping involves addressing personal and interpersonal problems by investing conscious effort and minimizing or tolerating stress and friction in various situations, as defined by Lazarus and Folkman (1984). Pre-departure examinations assess an individual's ability to cope with the challenges of an ICE environment. Regular examinations conducted throughout periods of isolation seek to gauge how well the individual adapts to extreme conditions and whether there are observable effects on their performance in daily tasks. Individuals employ various coping methods to manage stress, typically categorized into two main types: problem-focused coping and emotion-focused coping (Lazarus & Folkman, 1984).

Emotion-focused coping often manifests when coping with outside stressors an individual has no control over. It aims to redefine an individual's approach toward the problem through positive or negative reframing. This is reflected in wishful thinking, praying, meditation, and various other relaxation methods, talking with others, and more destructive strategies such as self-blame, social withdrawal, and substance abuse. Conversely, problem-focused coping involves confronting the stressor to reduce or eliminate its impact. While this is a valid coping strategy, it is less relevant in ICE settings due to the significance of environmental stressors that could not be directly changed (Sandal et al., 1999). Such coping strategies often vary from person to person and are challenging to influence.

Various psychological and demographic factors influence **performance** in ICE environments. Gushin et al. (1997) identified key stressors in ICE environments, including periods of very low-performance demands leading to boredom and monotony and sudden shifts to tasks with intense performance demands. Palinkas et al. (2011) outlined the significant psychological and demographic traits that correlate with performance in ICE environments. Their research categorized these factors into demographic (group) factors such as age, gender, experience, occupation, culture, and psychological (personal) factors, including neuroticism, extroversion, self-control, motivation, and more. They examined the importance of each factor concerning task performance in various ICE missions. Their study primarily focused on identifying preferred psychological traits (personal factors) for high task performance.

The most critical factors for performance were high levels of agreeableness, low neuroticism, extroversion, and openness to novel experiences. The second most significant set of factors was demographic characteristics. Finally, the third most significant factors included a low need for affection, high role clarity, low role conflict, low levels of assertiveness, and a high-perceived fit with the organization.

Vanhove et al. (2015) expanded on these factors affecting performance in ICE environments, including age, experience, strong leadership, effective social skills, maturity, emotional stability, low need for affection, low extraversion, conscientiousness, assertiveness, and the absence of anxiety and depression. These factors collectively contribute to a person's capacity to perform effectively within the demanding conditions of ICE environments.

3.1.1. Importance of Psychological Well-being in ICE Environments

Several of the preferred traits in ICE environments align with those identified in Ryff's (1989) model, which encompasses six dimensions of well-being. Table 2 visually represents how each dimension of Ryff's model relates to individuals' performance, coping, and adaptation in ICE environments through their commonly measured traits.

Table 2. Connections between Ryff's six dimensions of psychological well-being and the main concerns of ICE well-being research.

	Self-acceptance	Positive relations with others	Autonomy	Environmental mastery	Purpose in life	Personal growth
Performance	Maturity, Emotional stability	Low extroversion, low need for affection, Agreeableness	Low conscientiousness	High perceived fit with organization & culture	High role clarity, Low role conflict	Openness to experience
Coping	Hardiness, Resilience			Environmental Control (Withdrawal or confrontation)		
Adaptation		Low defensive hostility	Control		High optimism	

Recent investigations, exemplified by Nicolas et al. (2019), strive to formulate models encompassing a broader spectrum of well-being dimensions, including social, emotional, occupational, and physical facets. Their model introduces a novel measurement approach for evaluating the adaptability and performance of individuals in ICE environments. This model builds upon earlier research, incorporating insights from Cazes et al.'s (1989) findings and Grant et al.'s (2007) SOAP (Selection of Antarctic Personnel) instrument.

Cazes et al. (1989) introduced a set of four categories in their development of the Adaptability Questionnaire and evaluated them as follows: Thymic reactions, which encompass mood, anxiety, and depression. Social reactions include sociability, integration within the group, and irritability. Somatic reactions, covering fatigue, aches, and illnesses. Occupational reactions, focusing on work-related aspects. These categories formed the foundational elements of the model under investigation.

In contrast, the model developed by Grant et al. (2007) is specifically designed for use during the selection of Antarctic exploration crews and is known as the SOAP instrument. This empirical testing tool combines various aspects of subjective and psychological well-being measurements to assess individuals during selection and their performance during missions to Antarctica. The model measures four clusters of behaviors: emotional stability, social compatibility, task performance, and leadership performance.

The basis for these clusters can be traced back to Doll and Gunderson's (1970) studies, which aimed to identify the most critical behaviors for overall group well-being and performance in Antarctic missions. Figure 8 illustrates the perceived importance of each trait, with the radius of the circle representing the importance of each trait. Notably, naval and civilian personnel prioritized different clusters of behavioral traits for overall group performance and well-being. For instance, naval personnel prioritized emotional stability, while civilian personnel valued social compatibility more.

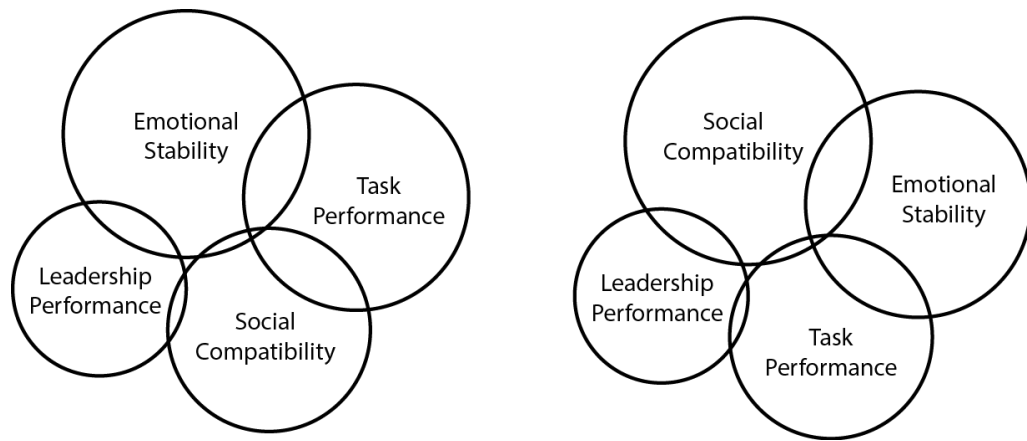


Figure 8. Key behavioral attributes deemed critical for effective functioning and success in U.S. Antarctic Stations, offering a comparative perspective between military (Navy, left) and civilian personnel (right). (Based on Doll & Gunderson, 1970).

The research within these categories has laid the foundation for a behavioral approach to well-being in ICE environments. Qualitative studies have identified specific "desirable" characteristics exhibited by individuals who have previously participated in expeditions and missions in such environments, which can be used to predict psychological well-being. The desired traits for successful performance include self-confidence (minus superiority or arrogance), a team-oriented mindset, social resourcefulness, patience, emotional control, tolerance, likability, a sense of humor, and technical competence (Stuster, 2000). Models like SOAP were explicitly developed to assess and identify these traits in individuals interested in participating in polar expeditions and similar missions.

According to the ICE-Q model developed by Nicolas et al. (2019), there are four key dimensions used to assess the well-being of individuals in ICE environments:

1. **Social Dimension:** This dimension focuses on interpersonal relationships and how individuals perceive group dynamics or crew dynamics. It evaluates the social interactions and group cohesion among the occupants of the ICE environment.
2. **Emotional Dimension:** The emotional dimension assesses the psychological changes in ICE environments. It examines the emotional well-being of

individuals and how they cope with the emotional challenges of living and working in such environments.

3. **Occupational Dimension:** This dimension evaluates task performance and the cognitive capabilities of individuals working in ICE environments. It assesses how well individuals can carry out their responsibilities and tasks in the challenging conditions of these environments.
4. **Physical Dimension:** The physical dimension explores the unique characteristics of the built environment within ICE settings and examines how these environmental factors impact the well-being of the occupants. It includes considerations of space, lighting, temperature, and other physical aspects of the environment.

These four dimensions collectively provide a comprehensive framework for understanding and evaluating the well-being of individuals living and working in ICE environments, considering their psychological and physical experiences.

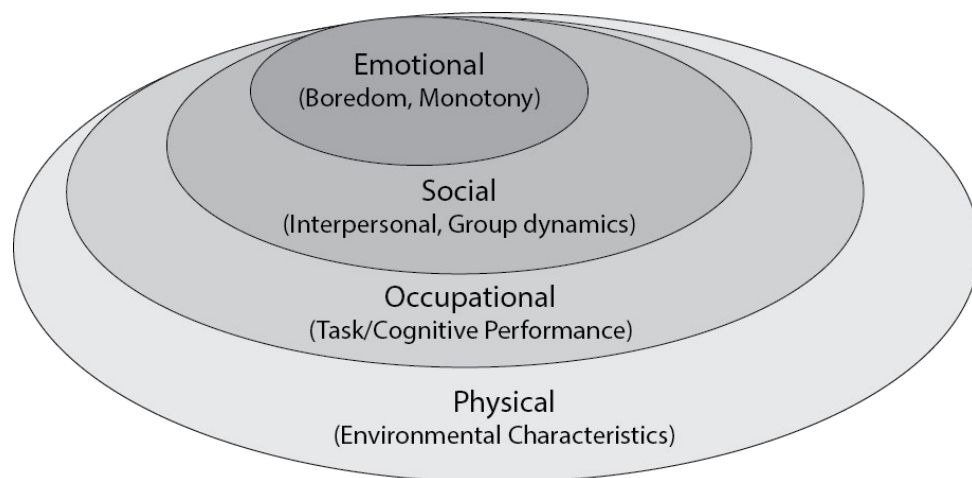


Figure 9. Hierarchy of four categories of well-being adapted from Nicolas et al. (2019).

Figure 9 illustrates the interconnectedness of the four dimensions of well-being in ICE environments and emphasizes the importance of considering them holistically rather than in isolation. Each dimension widens to cover more significant aspects of well-being while narrowing down to become more personal and individualized. This interconnectedness reflects the complex dynamics at play within ICE environments.

In ICE environments, changes or challenges in one dimension can directly impact other dimensions. For example, a decline in emotional well-being can affect an individual's social interactions and ability to perform occupational tasks effectively. Likewise, coping strategies employed by individuals, whether as a group or individually, can influence their overall well-being. It is important to note that some coping strategies, while providing short-term relief, may have negative long-term consequences, such as substance use. These coping mechanisms allow individuals to allocate their cognitive resources across different dimensions to improve their mood and self-preservation.

Environmental characteristics are crucial in influencing an individual's adaptability to ICE environments. Understanding the depth and breadth of this influence is essential for mitigating the cognitive stress experienced by individuals living and working in these challenging environments. By monitoring and measuring coping strategies and well-being over time, researchers can gain valuable insights into how individuals adapt to ICE environments and develop strategies to support their well-being.

Figure 10 provides a comprehensive overview of the relationships and connections between dimensions and outcomes in ICE environments. It is based on a compilation of relevant psychological observations and research conducted in ICE environments over several decades. It serves as a visual representation of the intricate web of factors that impact well-being in these challenging settings. This figure further develops the theories explored in the previous chapter, highlighting the intricate interplay between various elements of life in these environments. The figure is organized into four dimensions, each representing a different aspect of life in ICE environments: physical, emotional, social, and occupational. The dimensions of well-being in ICE environments are interconnected, highlighting the complex nature of individuals' overall well-being in such challenging settings. The physical dimension occupies the left side of the figure and has extensive connections with the other dimensions. This positioning underscores the substantial impact of the physical environment.

The outcomes in the figure are categorized into positive/salutogenic (green) and negative effects (red). Positive effects represent desired outcomes that enhance the

psychological well-being of individuals and groups in ICE environments. In contrast, negative effects denote undesired outcomes that can be detrimental to psychological well-being.

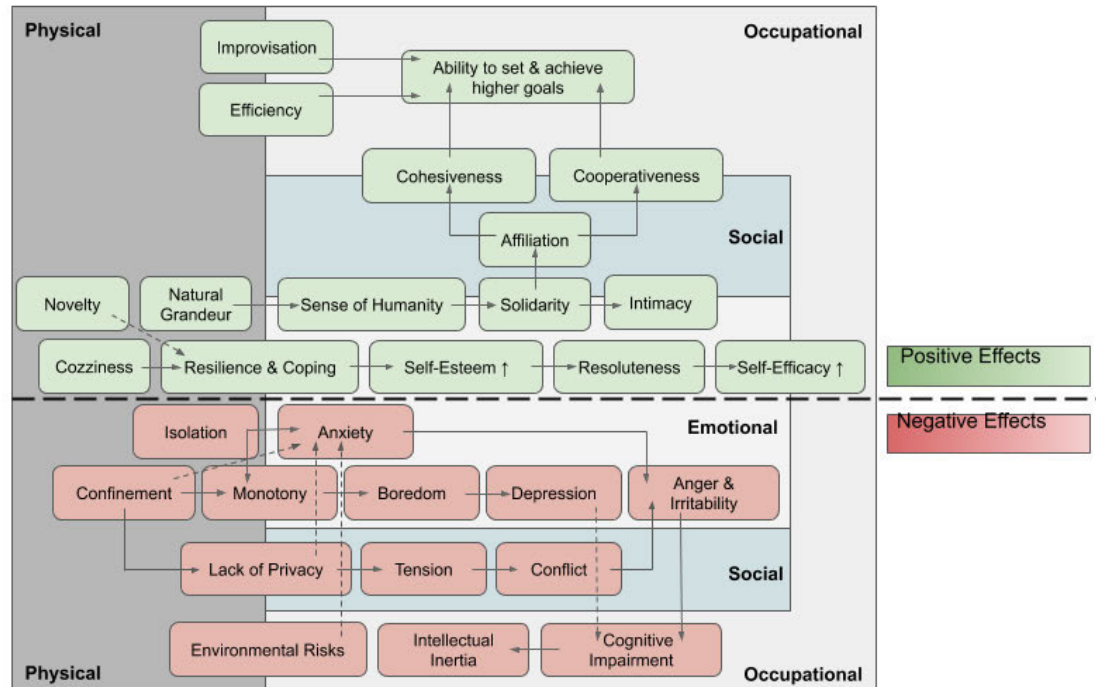


Figure 10. The framework of well-being in ICE environments

Arrows in the diagram depict causation and relationships among different outcomes, explaining how one outcome can pave the way for the emergence of others. For example, the appearance of specific positive outcomes may contribute to improved self-esteem, which can positively affect emotional and social dimensions.

The placement of outcomes within each dimension reflects their connection to that dimension. For instance, self-esteem is primarily an emotional outcome, while intimacy is associated with emotional and social dimensions, indicating shared relevance.

Positioning the physical dimension on the left side of the diagram strategically underscores the crucial role of the physical environment in shaping initial outcomes, which have cascading effects on other dimensions of well-being. This arrangement highlights the idea that the physical properties of the environment, both its internal

and external aspects, lay the foundation for the emergence of other outcomes and dimensions.

In ICE environments, where isolation and confinement are inherent features, addressing the feelings of isolation and confinement is paramount. These two factors often serve as significant challenges to the well-being of individuals and groups in these settings. Therefore, any design or intervention to improve well-being must directly confront and mitigate these inevitable outcomes. Various design techniques and architectural elements have been developed and employed to address these challenges effectively in different environments. These elements are specifically crafted to impact a person's perception under isolation and confinement to alleviate the adverse consequences commonly associated with these conditions. By strategically integrating these design elements, it becomes feasible to establish environments that foster well-being and diminish the psychological repercussions of isolation and confinement. The emphasis on the physical dimension and design considerations in the leftmost position of the figure underscores the importance of proactive and thoughtful design in ICE environments. Such design approaches can profoundly impact the well-being of individuals and groups by shaping their initial experiences and perceptions of the environment.

In addition to mitigating the negative outcomes associated with the physical dimension, the environment's design should also be geared toward fostering positive outcomes. An intelligently crafted environment can generate circumstances where individuals can encounter positive outcomes, improving their psychological well-being and across-the-board functioning.

For instance, a well-thought-out design that combines novelty with comfort and familiarity can contribute to individuals developing greater resilience and coping strategies. It, in turn, can lead to improved psychological well-being and functioning. It highlights the interconnectedness of various outcomes across dimensions, where the physical environment plays a crucial role in enabling or facilitating these outcomes.

To illustrate, outcomes like improvisation and efficiency are closely related to the occupational dimension but depend on the physical environment's design to become

feasible. When the physical environment is conducive to improvisation and efficiency, individuals can more effectively achieve their goals, particularly those related to their occupations. This demonstrates the intricate web of relationships among outcomes, where positive outcomes in one dimension can have ripple effects on other dimensions, ultimately contributing to the overall well-being of individuals and groups in ICE environments.

3.1.2. Measuring Well Being

Psychological well-being is often assessed through self-reported questionnaires, given the personal nature and individual variations. The Positive and Negative Affect Schedule (PANAS) is a frequently used questionnaire (Watson et al., 1988), consisting of ten items each for positive and negative emotions. Examples of emotions include 'interested,' 'excited,' 'upset,' 'strong,' 'irritable,' and 'nervous,' among others. Participants assess their emotional state within a designated timeframe (e.g., right now, the past few days, weeks) by ranking each item on a scale from 1 (very slightly / not at all) to 5 (extremely). Based on Ryff's work (1989; Ryff et al., 1995), the psychological well-being scale encompasses six dimensions, as discussed in the previous section, and assesses these factors using a 42-point scale.

Grant et al.'s (2007) SOAP (Selection of Antarctic Personnel) instrument amalgamates various measurement models for assessing individuals during Antarctic selection processes and missions. This instrument combines elements from several tests, including CES-D (Center for Epidemiologic Studies - Depression) scale, CODE (Coping and Defense), PANAS (Positive and Negative Affect Schedule), DIS (Diagnostic Interview Schedule), LOT (Life Orientation Test), BIC (Battery of Interpersonal Capabilities), ASI (Anxiety Sensitivity Index), NEO-FFI (NEO-Five Factor Inventory), and PCI (Personality Characteristic Inventory). Kanas et al. (2010) utilized self-reported questionnaires. Participants completed assessments of moods using instruments such as the Profile of Mood States (POMS) and interpersonal interactions using the Work Environment Scale (WES) and Group Environment Scale (GES).

Self-reported questionnaires are frequently used to evaluate an individual's well-being, including the General Anxiety Disorder (GAD-7) test (Spitzer et al., 2006) and the Kessler Psychological Distress (K10) test (Andrews & Slade, 2001). The GAD-7 scale is structured to screen for symptoms of general anxiety disorder. The 7-item questionnaire asks how much the participant has experienced nervousness, uncontrollable worrying, excessive worry, difficulty relaxing, restlessness, irritability, and fearfulness (Spitzer et al., 2006). The K10 Scale is designed to assess distress by querying symptoms of anxiety and depression on a 10-item scale. Participants rate the frequency of experiencing symptoms of distress over a specific period, concentrating on recent experiences rather than long-term psychological well-being.

Several self-reported questionnaires also assess the impact of environmental stress on participants. Environmental stress can directly affect individuals' psychological well-being in isolation and confinement settings and in various other environments. It becomes evident when the environmental demands surpass an individual's adaptive capacity (Cohen et al., 2007). Stress levels have been identified as a significant contributor to psychological well-being in ICE environments (Nicolas et al., 2013).

In addition to self-reported questionnaires, methods for measuring stress levels within ICE environments aim to assess psychological well-being by examining the physiological responses of individuals using biometric markers (Arza et al., 2019). The most prevalent biosignals utilized to gauge stress encompass the electroencephalogram (EEG), skin conductance/electrodermal activity (EDA)/galvanic skin response (GSR), respiration rate or volume, blood pressure, blood volume pulse, heart rate variability, skin temperature, and eye blink rates (Goyal et al., 2016). Many of these biosignals are regulated by the autonomic nervous system, making them reliable indicators because individuals have no control over them. They can rapidly detect changes associated with increased stress during monitoring.

3.2. Use of Virtual Environments As an Alternative to Isolated, Confined and Extreme Environments

A new aspect of the interior environment has started making its way into individuals' everyday occurrences with the developments in virtual reality technologies in the last decade; these environments are called immersive virtual environments (VEs) and are digital original creations or replications of real environments. Virtual environments can be encountered through diverse mediums, from computer screens and wall projections to head-mounted displays (HMDs), each offering varying levels of immersion. In the case of immersive virtual reality, the users' physical surroundings are replaced with virtual items convincing enough to suspend the users' disbelief and fully engage with the virtual environment. Elements such as the continuity of surroundings, freedom of movement, interactions, feedback, audio, and narrative are the keys to improving the immersiveness within the virtual environment.

For example, some environments could be static; the participant views a room through the HMD, but the room is frozen and does not react to any input by the respondent. The developer could add pre-recorded sounds externally to increase the level of immersion. Another example is the interactive environments in which the room responds to input by the user, i.e., the user could pick up objects and throw them. Their actions are met with the appropriate feedback, i.e., the sound of an object shattering.

The use of immersive virtual environments comes with its own set of challenges to consider. Questions regarding the users' subjective immersion or *sense of presence*, especially in scenarios where the environment's intractability is crucial, have been brought up. In such cases, the virtual environment's effectiveness is directly related to the user's sense of presence (Witmer & Singer, 1998). *Sense of presence* within a virtual environment can be defined as a combination of perceived realism and the feeling of being there (Weber et al., 2021). Presence questionnaires (PQs) have been developed to measure the sense of presence during VR use.

Barfield and Weghorst (1993) introduced one of the earliest presence tests for virtual environments. Their research developed a 13-item scale to measure presence and

fidelity. Witmer and Singer (1998) later introduced a 32-item Presence Questionnaire (PQ), building upon earlier presence theories in virtual environments. This questionnaire was further subdivided into three subscales. The initial scale, known as the involvement/control scale, evaluated the perceived authority over events within virtual environments, the feedback of the environment to user input, and the level of involvement through visual aspects. The second subscale, termed "natural items," focused on the reality of the virtual environment and whether actions felt genuine and authentic compared to real-life experiences. The third subscale, "interface quality items," pertained to the devices used for experiencing the virtual environment, such as screens and control devices, and assessed whether users could concentrate on a given task without being distracted by these devices. The Presence Questionnaire (PQ) remains one of the most widely cited tools for measuring presence (Witmer & Singer, 1998).

Another significant measure of presence, and the second most referenced questionnaire in this context, is the Slater-Usuh-Steed (SUS) Questionnaire. This questionnaire, developed through a series of studies (Slater et al., 1998; Usuh et al., 1999), assesses presence on three fundamental themes: the degree to which the virtual environment is remembered as a distinct "place," the extent to which the virtual environment surpasses the real world in significance, and the sense of being within the virtual environment. However, later studies by Usuh et al. (2000), seeking to assess whether the PQ and SUS Questionnaire can differentiate between virtual environments and reality, raised concerns about the efficacy of these questionnaires in comparing interactions across conditions such as physical, desktop, and immersive virtual environments. Consequently, some researchers questioned the suitability of post-experience questionnaires for measuring presence in virtual environments and called for developing new strategies incorporating physiological and psychological responses to enhance reliability (Slater, 2004).

Schubert et al. (2001) aimed to identify the cognitive processes involved in constructing a mental-spatial model of a virtual environment, which subsequently contributes to developing the sense of presence. In this context, the researchers identified two crucial cognitive processes: first, the suppression of sensory input that is inconsistent with the virtual environment, and second, the manifestation of physical

actions as conceivable actions within that virtual environment. Their analysis revealed that these two processes were reflected in spatial presence and involvement. Interestingly, a third factor, the 'judgment of realness,' emerged during their experiments. Based on these findings, Schubert et al. (2001) developed a 13-item scale, finalized as the iGroup Presence Questionnaire (IPQ), to assess and measure these factors.

The Spatial Presence Experience Scale (SPES) is another commonly used instrument in VR research to measure the subjective experience of presence, or the sensation of "being there" in a VE (Hartmann et al., 2016). This scale consists of eight items crafted to assess two fundamental components of presence: perceived possible action, evaluating the extent to which participants think they can interact and influence the VE, and self-location, gauging the degree to which participants perceive themselves as physically situated within the VE. Analyzing the answers to the SPES allows researchers to gain practical insights into the degree of engagement and immersion experienced by participants.

Research on VE's and their comparison to real physical counterparts has produced substantial findings. Dunston et al. (2011) state that virtual environments are equally effective as physical mock-ups, particularly in specialized settings such as hospital patient rooms. In these contexts, where the application of evidence-based design techniques and adherence to stringent guidelines are critical, virtual environments have shown their merit. Moreover, they contend that virtual environments offer significant advantages in terms of cost-effectiveness and flexibility during the design phase compared to physical mock-ups.

One early challenge encountered when using virtual environments as alternatives to real environments or physical mock-ups was the issue of discrepancies in the estimation of physical size. Loomis and Knapp (2003) first noted that in virtual reality studies, there tended to be underestimations of visual distances and judgments of egocentric positions compared to real environments. Subsequent studies supported this observation, consistently revealing the underestimation of egocentric distances. However, researchers found that this underestimation was often linear and remained constant (Messing & Durgin, 2005; Murgia & Sharkey, 2009). Notably, the presence

of visual cues significantly reduced the degree of size underestimation (Murgia & Sharkey, 2009).

In an experiment conducted by Interrante et al. (2006) that compared real environments with their identical virtual replicas, participants reported significantly reduced size discrepancies. The researchers suggested that the problem of size estimation might not be intrinsic to HMD and VR technologies but could be linked to higher-level cognitive processes involved in interpreting presented visual stimuli. Additionally, the field of view (FOV) was identified as a factor affecting the perception and judgment of visual distances; participants with a larger FOV (150° versus 60°) within the virtual environment provided more accurate size estimations (Jones et al., 2012).

Renner et al. (2013) reviewed several strategies to mitigate discrepancies in egocentric distance estimations in virtual environments. These strategies involved creating rich virtual environments with uniform textures, utilizing high-quality and high-resolution graphics, incorporating binocular disparity, and prioritizing the user's sense of presence. Furthermore, they categorized the potential sources of these discrepancies into four factors: measurement methods, technical factors, compositional factors, and human factors.

Paes et al. (2017) investigated users' spatial perception in both non-immersive and immersive VE's. The experiment involved a walkthrough of a virtual environment that replicated an existing interior space. The study employed two distinct approaches for users to experience the virtual environment. In the first stage, users engaged with the virtual environment through a non-immersive approach, viewing it via a monitor. The second stage involved an immersive approach, where users experienced the environment through 3D projections within a physical room. The goal was to assess how these different modes of interaction affected users' spatial perception.

The study revealed that users exhibited more accurate spatial perception when utilizing immersive virtual reality systems than non-immersive methods. The immersive experience enhanced users' ability to perceive spatial features within the

virtual environment. Additionally, the study identified significant correlations between different demographic factors and the accuracy of spatial perception in a VE.

Specifically, age, education level, and professional experience were found to be related to users' spatial perception. Participants aged 25 and above tended to demonstrate better spatial perception. Moreover, individuals with undergraduate degrees or higher education performed more accurately than those without such degrees. Furthermore, participants with professional backgrounds in architecture and engineering were also more likely to exhibit precise results. These findings suggest that immersive VR systems offer advantages in enhancing spatial perception, with individual characteristics such as age, education, and professional experience influencing the level of accuracy in spatial perception.

The next chapter examines the complex connection between interior architectural design and how individuals perceive space in ICE environments. Our focus centers on understanding how various architectural attributes and design decisions impact how occupants perceive spaciousness, particularly in settings resembling Mars exploration conditions.

CHAPTER IV

AN EXPLANATORY STUDY ON INTERIOR ELEMENTS AND PSYCHOLOGICAL WELL-BEING DURING LOCKDOWN

Individuals may react differently to specific environmental conditions and situations in ICE environments. Several questions of interest can be outlined to clarify the research problem and guide the main hypotheses' direction. These questions serve as a reference to the problem that the research aims to address. Therefore, the primary research questions can be presented as:

Can the adverse effects of isolation and confinement be mitigated by modifying the environment's interior characteristics?

Since the interior characteristics were previously examined individually, it is beneficial to specify this research question further. This approach will facilitate the formulation of distinct hypotheses for testing various variables and enhance the clarity of the research objectives. Based on this, the overarching question can be refined and divided into five distinct questions:

- 1.1. Can the adverse effects of isolation and confinement be alleviated by manipulating the geometrical properties of the environment?
- 1.2. Can the adverse effects of isolation and confinement be alleviated by manipulating the furnishings within the environment?
- 1.3. Can the adverse effects of isolation and confinement be alleviated by manipulating the interior lighting of the environment?
- 1.4. Can the adverse effects of isolation and confinement be alleviated by manipulating the interior openings within the environment?
- 1.5. Can the adverse effects of isolation and confinement be alleviated by manipulating the interior surfaces of the environment?

However, while these questions clarify the research direction, they need more specificity to formulate precise hypotheses for experimentation and testing. As Figure 2 in Section 2.1 illustrates, each interior characteristic encompasses a list of its variables. The number of potential combinations and variables generated for testing can become extensive. Therefore, a systematic process of elimination is necessary to identify which variables should be manipulated and which should not.

An explanatory analysis has been crafted to delve into the various factors and elements within interior spaces that influence psychological well-being. Explanatory research, well-suited for exploring causal relationships between variables, is the chosen methodology for this examination. The primary objective of this chapter is to solve the causal connections between specific elements within interior environments and the psychological well-being of individuals during periods of prolonged isolation, such as the lockdown. The findings from this explanatory research contribute to a deeper understanding of these relationships and provide crucial insights for the following chapters to identify and manipulate variables for in-depth analysis, ultimately unveiling causation patterns.

4.1. Background

COVID-19 is an infectious disease caused by the SARS-CoV-2 virus, as described by the World Health Organization (2021). In response to the virus's global spread, the initial measures undertaken to reduce and control transmission included the enforcement of lockdowns and social distancing protocols. As a consequence of the unprecedented events driven by the COVID-19 pandemic, many individuals experienced prolonged periods of isolation and confinement within their residences en masse. Furthermore, locations outside these boundaries were characterized as unsafe, severe, and potentially life-threatening (Person et al., 2004; Shultz et al., 2016). As previously observed by Tachibana et al. (2012; 2017), numerous isolation elements stemming from the pandemic response exhibited significant parallels to those customarily linked with isolated and confined environments. Encompassing a broad spectrum ranging from the urban scale to individual experiences, researchers investigated the environmental, behavioral, and attitudinal repercussions of the different measures taken during the pandemic and subsequent lockdowns.

Aljunaidy and Adi (2021) reviewed architecture and design research and its intersection with mental disorders. They observed a trend in the existent literature, where there was a predominant emphasis on conditions such as dementia and autism, while affording sparse attention to other mental health disorders, encompassing depressive disorders, stress-related conditions, anxiety, and schizophrenia. Remarkably, they recognized a notable absence of research on mental disorders outside this spectrum. In their closing remarks, they underscored the significant gap in the architectural research landscape, particularly in its potential to mitigate or prevent symptoms across various mental disorders through environmental design.

The analysis is based on the hypothesis that interior architectural elements can elicit diverse responses from their occupants. Furthermore, it is posited that specific interior environments are more inclined to evoke positive responses compared to others. Expanding upon this premise, the study contends that architectural features within interior environments where individuals are subjected to quarantine have the potential to lessen the negative psychological consequences commonly observed during periods of isolation and confinement. To scrutinize this hypothesis, the researchers employ a battery of self-reported evaluation tools to gauge boredom, psychological distress, and anxiety experienced by individuals while in quarantine. Later, these assessments are correlated with self-assessment statements provided by the respondents, in which they express their perceptions of their immediate interior surroundings.

4.2. Participants

This research, which received approval from the ethics committee at İ.D. Bilkent University (Approval No: 2021_05_24_02; see Appendix H), involved surveying individuals who had experienced lockdowns lasting a minimum of one week during the early stages of the COVID-19 pandemic. To determine the required sample size, an a priori power analysis was conducted using G*Power (Faul et al., 2007). The analysis indicated that a sample size of 98 for each hypothesis was needed to achieve 80% statistical power for detecting a small effect ($d=.2$; Cohen, 1988) at a significance level of $\alpha = .05$. The study employed a convenience sampling method for participant recruitment.

One hundred forty-two participants completed the initial survey containing questions regarding the duration of their lockdown period and the frequency of essential outings to determine the extent of their lockdown experience. All participants were located in Turkey at the time of surveying and were recruited for the study through Bilkent University Administrative Information System. Two participants did not complete the psychometric sections of the questionnaire. As a result, their responses were not included in the analysis of the corresponding sections.

The participant group consisted of 142 individuals, comprising 32 men (22.5%), 105 women (73.6%), and five respondents who did not provide gender information (3.9%). The mean participant age was 38.74 years ($SD = 16.249$), ranging between 15 to 72 years. Concerning educational attainment, 16 participants held high-school degrees (11.3%), 48 participants possessed undergraduate (33.8%), and 78 participants had post-graduate degrees (54.9%).

Among the participants, 84 individuals (59.2%) indicated that they worked from home, while 56 participants (39.4%) did not, and 2 participants did not provide information regarding their work situation (1.4%). The average household size of the participants was 2.91 ($SD = 1.207$); on average, participants spent 8.55 hours daily in a single room ($SD = 6.07$). The period of the lockdown experienced by participants ranged between 10 and 93 days, (Mean = 34.41, $SD = 13.39$).

4.3. Instruments and Procedure

This research investigates the correlation between the interior environment and self-reported alterations in prevalent psychological developments linked to social and physical isolation because of COVID-19. Online surveys were distributed through Google Forms, allowing participants to complete them at their convenience. Responses were automatically gathered and subjected to filtering in line with the criteria predefined by the research team.

The initial survey segment comprised brief demographic inquiries and a questionnaire to obtain insights into the participants' immediate surroundings. Additionally, it sought to understand their perceptions of their primary residences' design and spatial

features. The inquiries in this section aimed to gauge various aspects of the interior setting, encompassing its geometric configuration, lighting conditions, surface attributes, furnishings, clutter, access to external surroundings, and more.

Furthermore, participants were requested to provide specifics about the spatial dimensions, ceiling height, color palettes, lighting setups, and related features. They were also invited to express their opinions on whether they considered their rooms spacious, their contentment with their environment, and their sentiments regarding its potential monotony. Responses to these queries were documented through a 5-point Likert scale, ranging from strong disagreement (1) to strong agreement (5) (see Appendix A).

Following that, the questionnaire gathered responses on how the increased availability of leisure time, a consequence of restricted mobility and shifts in daily routines (such as the inability to commute to regular workplaces) during the lockdown, impacted individuals' susceptibility to boredom. To gauge this, participants were presented with a condensed version of the Free Time Boredom Scale (FTB) (Ragheb & Merydith, 2001; Appendix B). Compelling evidence suggests that in ICE environments, a scarcity of environmental stimuli can result in elevated levels of boredom, which, if not mitigated, can further compromise individuals' well-being; the assessment of this aspect was considered significant.

The FTB scale begins by stating, 'During my free time.' It consists of 20 items strategically crafted to assess boredom across four distinct subscales: the absence of meaningful involvement, the absence of mental engagement, the perception of time passing slowly, and the lack of physical engagement. A higher FTB score signifies a lower susceptibility to experiencing boredom during one's leisure time.

The third segment of the survey was devised to identify psychological challenges that are prevalent outcomes of extended periods of isolation and confinement. A pair of standardized assessments by Andrews and Slade (2001) and Spitzer et al. (2006) were distributed to evaluate participants' psychological well-being. These assessments were the Kessler Psychological Distress (K10) test (Appendix C) and the General Anxiety Disorder (GAD-7) test (Appendix D).

4.4. Statistical Analysis

The initial questionnaire section employed exploratory factor analysis to pinpoint the primary factors associated with interior assessments. In the course of this procedure, 7 out of 21 questions were identified as redundant and subsequently excluded. These questions pertained to factors such as wall colors, the number of lamps and mirrors, the presence of habitable outdoor areas, the participant's satisfaction with artificial light sources, and the level of satisfaction when spending time in their environment.

With 14 questions left, a principal component analysis (PCA) employing both Varimax and Oblimin rotations was performed. The Oblimin rotation, accommodating non-orthogonal elements, yielded four factors collectively explaining 55.69% of the shared variance with a statistically significant KMO measure of sampling adequacy at .713 and Bartlett's test of sphericity ($\chi^2(91)=412.59$, $p<.01$). The statistically significant relationship among the factors demonstrated the dataset's fitness for analysis.

Four distinguishable factors were determined based on the distribution of the items: Airiness, Furniture and Clutter, Visual Variety, and Volume. Each factor accentuates a unique facet of the interior environment. Cronbach's Alpha coefficients were computed for each identified factor to assess their reliability. Resulting alpha values resided within satisfactory ranges: .708 for Airiness (3 items), .626 for Furniture and Clutter (4 items), .622 for Visual Variety (4 items), and .578 for Volume (3 items). Removing additional items from any of the scales would not have resulted in substantial enhancements in alpha values. The factors and their items are outlined in Table 3, alongside their corresponding loadings.

The scoring for the assessment entailed calculating the mean of items primarily linked to each respective factor. Higher scores in the Airiness factor signify an environment perceived as more expansive, characterized by abundant natural light, pleasing connections to the external surroundings, and an overall sense of permeability. In contrast, a lower score implies discontent with the degree of permeability in the environment. Higher scores in the Furniture and Clutter factor suggest an increased probability that the environment is perceived as overwhelming, disorganized, and

cluttered. Higher Visual Variety scores represent a greater diversity of observable environmental stimuli, encompassing a spectrum of surfaces, hues and shades, and natural materials. Lower scores in this factor signify a monotonous and uninspiring environment. Additionally, their negative loadings indicate the inverse relationship between certain items in the Visual Variety factor. Lastly, higher scores in Volume indicate that the respondent's quarantine took place in a more spacious physical environment.

Table 3. Factor loadings determined through a PCA with Oblimin rotation for the 14 items (n=142).

Item	Item Name	Factor 1	Factor 2	Factor 3	Factor 4	Communalities
1	My room receives plenty of natural light	0.834				0.699
2	My room has large windows.	0.794				0.670
3	I am satisfied with the scenery outside my room	0.524				0.490
4	I have large/heavy pieces of furniture in my room.		0.760			0.613
5	I have a hard time keeping my room clean.		0.721			0.623
6	My room is cluttered most of the time.		0.668			0.460
7	There is a lot of furniture in my room.		0.549			0.513
8	There are patterned surfaces in my room.			-0.738		0.551
9	There are surfaces with natural materials in my room.			-0.721		0.571
10	I find my room to be monotonous.			0.668		0.638
11	There are plenty of natural objects in my room.			-0.445		0.410
12	My room's ceiling is high.				0.705	0.545
13	How big is the room you are currently staying in?				0.608	0.587
14	My room feels spacious.				0.478	0.427
	Eigenvalue	3.489	1.880	1.266	1.162	
	% of Common Variance	24.921	13.431	9.041	8.298	
	Cumulative %	24.921	38.352	47.392	55.690	
Factor 1: Airiness, Factor 2: Furniture and Clutter, Factor 3: Visual Variety, Factor 4: Volume						

Source: Diker & Demirkan, 2022a, p.748.

Pearson's correlation coefficients provided a way to examine potential significant correlations among factors and psychological assessments. Henceforth, a stepwise multiple regression analysis was conducted. This approach allowed the identification

of factors that serve as significant forecasters that can demonstrate a strong fit in a model.

4.5. Results

4.5.1. Influence on Psychological Distress

One hundred forty participants completed the K10 evaluation. Results revealed that 19.2% of respondents (n=27) indicated a low degree of psychological distress, 27.9% (n=39) reported a medium degree, 27.9% (n=39) displayed high degrees, and 25.0% of participants (n=35) exhibited very high degrees of psychological distress. As depicted in Table 4, K10 scores correlated negatively with Airiness [$r(138)=-0.28$, $p<.01$], Visual Variety [$r(138)=-0.30$, $p<.01$] and Volume factors [$r(138)=-0.29$, $p<.01$] at weak but statistically significant levels.

Table 4. To analyze the relationship between interior spaciousness factors and K10 evaluations, Pearson's correlation was computed using data from 140 participants.

	1	2	3	4	5
1 K10 - Total Score	-				
2 Airiness	-.276**	-			
3 Furniture & Clutter	0.122	-0.142	-		
4 Visual Variety	-.302**	.380**	-0.135	-	
5 Volume	-.294**	.431**	-.188*	.398**	-
** Correlation is significant at the 0.01 level (2-tailed).					
* Correlation is significant at the 0.05 level (2-tailed).					

A stepwise multiple regression analysis provided a sufficient model to predict psychological distress. Findings revealed that the Volume factor ($\beta=-2.88$, $SE=1.14$, $p=.012$) and the Visual Variety factor ($\beta=-1.78$, $SE=.88$, $p=.045$) were statistically significant predictors. In contrast, neither the Airiness factor nor the Furniture and Clutter factor contributed substantially to predicting psychological distress. Based on this, the following regression model was formed;

$$K10\ Score = 34.32 - 2.88 * (Volume) - 1.78 * (Visual\ Variety)$$

The regression model demonstrated statistical significance [$F(2, 138)=9.95, p<.0005, R^2=.127$].

4.5.2. Influence on Anxiety

One hundred forty participants completed the GAD-7 assessment, yielding the following results: 41.4% ($n = 58$) demonstrated minimal indications of anxiety, 29.3% ($n = 41$) presented mild indications, 15.7% ($n = 22$) exhibited moderate indications, and 13.6% of the participants ($n = 19$) displayed severe indications of generalized anxiety disorder. As demonstrated in Table 5, GAD-7 scores correlated positively with Furniture and Clutter [$r(138)=0.18, p<.05$], and correlated negatively with Airiness [$r(138)= -.27, p<.01$], Visual Variety [$r(138)= -.28, p<.01$], and Volume factors [$r(138)= -.24, p<.01$] at weak but statistically significant levels.

Table 5. To analyze the relationship between interior spaciousness factors and GAD-7 evaluations, Pearson's correlation was computed using data from 140 participants.

	1	2	3	4	5
1 GAD7 Scores	-				
2 Airiness	-.271**	-			
3 Furniture & Clutter	.179*	-0.142	-		
4 Visual Variety	-.279**	.380**	-0.135	-	
5 Volume	-.241**	.431**	-.188*	.398**	-
** Correlation is significant at the 0.01 level (2-tailed).					
* Correlation is significant at the 0.05 level (2-tailed).					

Visual Variety ($\beta= -1.25, SE=.59, p=.037$) and Airiness ($\beta= -1.39, SE=.646, p=.032$) factors were effective predictors of anxiety experienced during lockdown. The fitted regression model is expressed as follows:

$$GAD7\ Score = 14.41 - 1.39 * (Airiness) - 1.25 * (Visual\ Variety)$$

The regression was statistically significant [$F(2, 137)=8.44, p<.0005, R^2=.11$], suggesting that higher ratings of Airiness and Visual Variety are more likely to correspond to milder symptoms of anxiety.

4.5.3. Influence on Boredom

Each subcomponent of the Free Time Boredom (FTB) scale was individually juxtaposed with the four dimensions of interior spaciousness. Table 6 examines the four FTB subscales and the four dimensions of interior spaciousness. An additional examination was conducted between the factors and the comprehensive FTB scores. Significant correlations, denoted with an asterisk, instigated succeeding investigations.

Table 6. To analyze the relationship between interior spaciousness factors and FTB sub-scales, Pearson's correlation was computed using data from 141 participants.

	Airiness	Furniture and Clutter	Visual Variety	Volume
Physical Involvement	0.198*	-0.142	0.139	0.243**
Mental Involvement	0.165	-0.064	0.266**	0.169*
Meaningfulness	0.284**	-0.188*	0.374**	0.347**
Speed of Time	0.239**	0.048	0.060	0.132
**Correlation is significant at the 0.01 level (2-tailed).				
*Correlation is significant at the 0.05 level (2-tailed).				

Only the Volume ($\beta=1.20$, $SE=.40$, $p=.003$) factor was a statistically significant forecaster to the degree of physical engagement [$F(1, 140)=8.70$, $p=.004$, $R^2=.059$]. This implies that individuals tend to engage in more physical activities when they have a larger space available within their living environment. This finding aligns with expectations, especially considering the limitations imposed by lockdown. Individuals with greater space in their living environments are more inclined to engage in physical activities. However, it is worth noting that while a significant relationship was observed, the predictive power of the Volume factor in explaining physical involvement is relatively modest, with a small effect size.

Regarding mental engagement, the Visual Variety ($\beta=.21$, $SE=.069$, $p=.002$) emerged as a noteworthy factor [$F(1, 140)=10.60$, $p=.001$, $R^2=.071$]. The obtained result indicates that a higher level of visual variety is associated with increased mental engagement, emotional involvement, and a heightened sense of connection.

Comparable to the earlier dimension of FTB, it is logical to infer that a visually diverse interior setting provides a wider array of surroundings, increased visual stimuli, and an improved connection to that environment.

Regarding a lack of meaningful involvement, both the Visual Variety factor ($\beta=.29$, $SE=.09$, $p=.002$) and the Volume factor ($\beta=.35$, $SE=.12$, $p=.004$) emerged as significant predictors [$F(2, 140)=15.83$, $p<.0005$, $R^2=.187$]. The findings confirm the observed patterns in the earlier dimensions. People with access to more spacious living environments with greater variety within those spaces report an enhanced sense of purpose and meaning in their activities. Additionally, they tend to experience improved engagement and reduced irritability, and they are less likely to suffer from feelings of aimlessness while undergoing lockdowns.

Perceive the speed of time was significantly influenced by the Airiness factor ($\beta=.206$, $SE=.07$, $p=.004$), [$F(2, 140)=8.39$, $p=.004$, $R^2=.057$]. It is essential to acknowledge that this connection seems relatively modest in strength. This finding indicates that participants who expressed greater contentment with their environment's links to the external surroundings and had increased prospects for observation were more inclined to perceive their time as passing quickly.

4.5.4. Other Influences

Furthermore, this study explored the connections between demographic factors and lockdown conditions to identify potentially valuable correlations for future research. The analysis of bivariate correlations unveiled significant associations between age, the duration of lockdown, and the amount of time spent in a single room with psychological distress and anxiety ($p < .01$). Nevertheless, no significant correlations were found regarding the level of boredom, except for age ($p < .05$). Additional information on these correlation coefficients can be found in Table 7.

The findings from the analysis suggest that age exhibited the most pronounced correlation with the overall psychological well-being of participants. Younger individuals tended to experience more severe symptoms of stress, anxiety, and boredom during the lockdown. Furthermore, spending more time in lockdown and

within a single room was associated with increased stress and anxiety levels. At the same time, these factors did not show a significant correlation with boredom. Lastly, no noteworthy relationship was identified between household size and psychological well-being.

Table 7. Correlation between Demographic Variables and Psychological Assessments using Pearson's Coefficient (n=140).

	K10	GAD-7	FTB
Age	-0.506**	-0.558**	0.178*
Household population	-0.127	-0.86	-0.006
Lockdown duration	0.313**	0.384**	-0.064
Time spent in a single room	0.272**	0.281**	-0.068
**Correlation is significant at the 0.01 level (2-tailed).			
*Correlation is significant at the 0.05 level (2-tailed).			

A one-way multivariate analysis of variance (one-way MANOVA) was utilized to explore potential differences in stress, anxiety, and boredom levels based on gender, education levels, and work from home (WFH) status. The results indicated no significant differences in stress, anxiety, or boredom levels related to gender. However, distinctions emerged concerning participants' education levels and WFH status.

Specifically, a statistically significant difference was observed in psychological distress, anxiety, and boredom levels based on education level [$F(6, 266)=2.224$, $p=.041$; Wilk's $\lambda=.907$, $\eta^2p=.048$]. Individuals with advanced degrees were less likely to report severe psychological distress, anxiety, or boredom.

Similarly, a significant difference was found in psychological distress, anxiety, and boredom levels based on whether participants worked from home or not [$F(3, 132)=3.437$, $p=.019$; Wilk's $\lambda=.928$, $\eta^2p=.072$]. Participants who worked from home tended to exhibit more severe signs of psychological distress and anxiety. However, they reported lower boredom levels than those who did not work from home.

4.6. Discussion

The objective of this study was to investigate the relationship between individuals' psychological well-being during the COVID-19 pandemic lockdowns and the characteristics of their indoor living environments. A web-based survey revealed four key factors crucial in categorizing and understanding individuals' perceptions of indoor spaces during the lockdown. It aimed to determine which specific elements within these spaces were associated with higher levels of psychological well-being.

According to the study's findings, higher ratings of psychological well-being can be attributed to higher scores in the Airiness, Visual Variety, and Volume factors. In essence, those who found their living spaces visually appealing had more room for living and engaging in various activities. They reported satisfaction with their connections to the outdoors, experienced less boredom, and exhibited fewer signs of anxiety and psychological distress during lockdown.

Amerio et al. (2020) and Fornara et al. (2022) conducted studies in Italy during the COVID-19 lockdowns to assess the correlation between housing satisfaction, dwelling size, crowding, and mental health. In their investigation, Amerio et al. (2020) employed online surveys, utilizing five distinct assessment instruments to identify quality of life (The Short Form 12-Item Health Survey, SF-12), depression (Patient Health Questionnaire, PHQ-9), impulsivity (Barratt Impulsiveness Scale-11, BIS-11), sleep-related symptoms (Insomnia Severity Index, ISI) and anxiety (Generalized Anxiety Disorder scale, GAD-7). Their results indicated that individuals expressing discontent with the quality of their indoor environment, encompassing factors such as lighting, acoustics, temperature, and other elements, and residing in apartments smaller than 60 square meters, were significantly more prone to manifest moderate-severe and severe symptoms of depression.

Fornara et al. (2022) conducted a study to explore how both subjective and objective aspects of the built environments, which included factors like home crowding and residential satisfaction, influenced individuals' levels of perceived stress during lockdown. Perceived stress assessments using the Perceived Stress Scale (PSS) did not show a direct correlation with home crowding. However, the link between home

crowding and perceived stress was moderated by residential satisfaction. Specifically, individuals satisfied with the spaciousness of their homes tended to report lower levels of perceived stress.

The COVID-19 pandemic and the consequent lockdown efforts necessitated adjustments and transformations in the built environment, particularly interior environments, to cater to its inhabitants' operational and behavioral requirements. Al Waer et al. (2021) emphasized the complexity of directly attributing the impact of the built environment, particularly at an urban scale, on cognitive and physical well-being. They argued against oversimplifying these intricate interactions by attributing them solely to design and planning, advocating instead for a more interdisciplinary approach to creating habitation spaces.

During the pandemic, there was a growing demand for flexible designs, secure outdoor spaces, and private areas (Abd Elrahman, 2021). Abusaada and Elshater (2022a; 2022b) proposed the adoption of new design paradigms to accommodate the changing needs of the post-pandemic era. They outlined three principles for addressing post-pandemic boredom within urban studies. These principles involve strategies such as promoting diversity to enable urban transformation, vigilantly monitoring shifts in public life dynamics, and adapting to the digital environment during uncertain times to address both evident and concealed expressions of boredom.

Although studies by Amerio et al. (2020) and Fornara et al. (2022) explore the connections between attitudes toward housing characteristics and their effects on mental well-being, there is a gap in dedicated research specifically investigating the direct influence of interior architectural attributes on an individual's psychological well-being.

Concerning psychological distress, the findings indicate that a larger living space and a greater variety of things or elements within the interior environment were linked to decreased levels of psychological distress. This observation aligns with Fornara et al.'s (2022) findings, indicating that the size of the rooms and satisfaction contributed to a reduction in perceived stress levels. Furthermore, as was the case in Fornara et al.'s study (2022), no significant connection was found between household crowding

and the perception of stress. This study did not identify a significant correlation between psychological distress and increased furniture and clutter.

Airiness and Visual Variety factors significantly influenced the emergence of generalized anxiety disorder symptoms. People residing in environments characterized by a diverse array of items and qualities, as well as those who found pleasure in pleasant outdoor connections, were less likely to display symptoms of generalized anxiety disorder. These findings echo the findings of Amerio et al. (2020), where enjoyable outdoor links were associated with a decreased likelihood of severe depression. It is important to highlight a significant distinction regarding the pleasantness of outdoor links. This study centered on the permeability of the interior, encompassing elements such as windows and the presence of natural light, as well as the participants' contentment with their scenery, irrespective of their specifics. On the other hand, Amerio et al. (2020) concentrated on factors like the topography, accessibility, and subjective quality of sceneries. Nevertheless, factors such as restricted available space or abundant things within the interior (clutter) did not substantially contribute to anxiety.

Concerning free time boredom, the study revealed that the availability of living space had a modest impact on physical involvement, suggesting that individuals with larger living areas might have increased opportunities for physical activities, potentially reducing their experiences of boredom during isolation. Likewise, mental engagement was significantly related to the degree of visual variety within indoor spaces. Individuals residing in environments characterized by a broader range of elements experienced heightened mental stimulation. This finding closely aligns with previous research on how environmental stimulation can influence levels of boredom (Mikulas & Vodanovich, 1993).

Consistent with the trends noticed in other FTB subscales, visual variety and volume impacted the sense of meaningful engagement. Consistent with the trends noticed in other FTB subscales, visual variety and volume impacted the sense of meaningful engagement. This suggests that providing more room for activities, opportunities for interaction with the surroundings, and exposure to adequate stimuli may help individuals derive more meaning from their activities during a lockdown.

This discovery reflects the findings by Wessels et al. (2022), who explored boredom levels and the perception of the passage of time (PPT) among people staying in lockdown during COVID-19. According to them, participants experienced a high degree of boredom and perceived time as passing slowly during the initial phases of a lockdown. However, as individuals adapted to the lockdown conditions and adjusted their expectations, their reported levels of boredom decreased. This congruence underscores that individuals may feel that time passes more swiftly when they have pleasant outdoor connections. Even if direct access to the outdoors is limited, the ability to observe it may increase arousal levels and induce a meditative mental state. Figure 11 presents a brief visual representation, highlighting the factors that demonstrate influences on psychological effects and illustrating the connections discussed throughout the study.

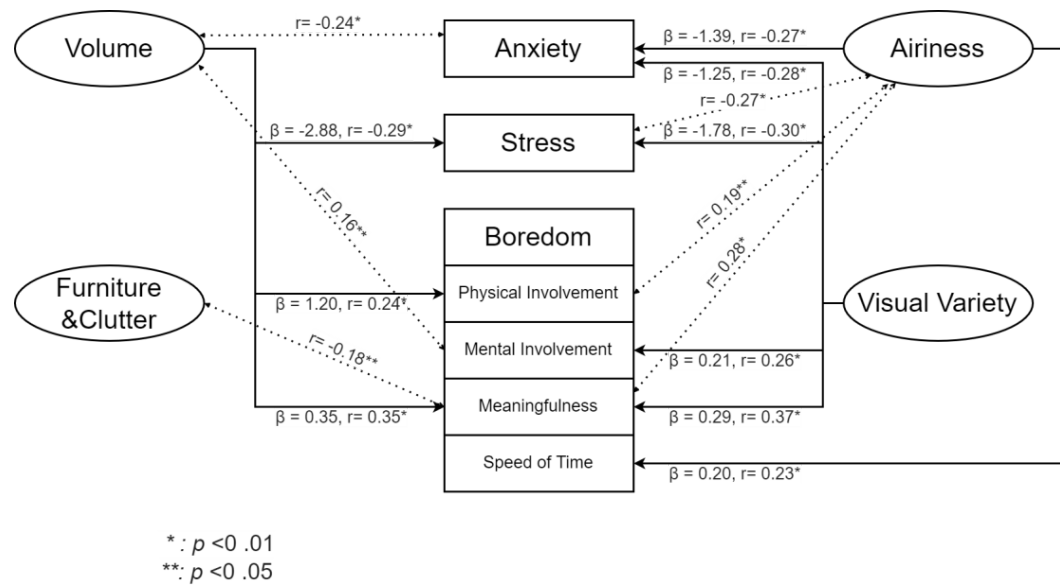


Figure 11. Factors affecting stress, anxiety, and boredom (Diker & Demirkan, 2023, p. 753).

The findings emphasize the substantial role that interior environments can play in influencing the psychological well-being of individuals, especially when they experience prolonged periods of isolation and confinement. Therefore, interior architects must acknowledge the potential impact of their design decisions on how occupants experience psychological distress, anxiety, and boredom. When devising interior spaces for individuals facing isolation or confinement due to unexpected or

extreme situations, interior architects should prioritize integrating diverse architectural elements. Furthermore, they should be cautious about incorporating features that could contribute to a monotonous environment. In addition, designers should consider how the interior environment connects with the outside and how creating a perception of spaciousness within confined spaces can contribute to stress alleviation.

CHAPTER V

COMPREHENSIVE ANALYSIS OF INTERIOR ARCHITECTURAL ELEMENTS IN ICE ENVIRONMENTS

In the context of this study, it is essential to note that two variables, namely geometry and interior/exterior openings, will not be considered. This decision is based on the fact that, in many ICE environments, the shape and dimensional properties of the interior space have limited flexibility. Operational and physical constraints within the environment often determine these properties. The construction methods and resulting geometrical characteristics are typically influenced by the technological and engineering limitations of the era in which the environment is constructed. During the design phase of such environments, the primary emphasis is placed on the structure's functionality and ability to withstand external conditions. These external conditions are crucial in determining whether the interior space will have curved or angular features.

Similarly, including windows and other openings in the environment is often constrained by external factors that the building is designed to shield occupants. In pressurized interior spaces, such as those found underwater or in space, incorporating multiple exterior openings becomes less practical due to safety and structural considerations. Conversely, in Arctic stations, windows may serve little purpose due to the absence of daylight during extended periods of darkness. As a result, three of the five primary interior characteristics are excluded from consideration.

5.1. Experiment Stage 1: Assessing Interior Architectural Elements that Influence Perception of Spaciousness in ICE Environments

This step, illustrated in Figure 12, seeks to align the findings of existing publications with the interior architecture of ICE environments. The primary goal is to uncover the association between interior architectural elements and the perceived spaciousness of these ICE environments. It is hypothesized that the presence and alterations of interior

architectural elements influence the perception of spaciousness in an ICE environment. To achieve this, the study employs a mixed-method approach, encompassing qualitative and quantitative data analyses, to scrutinize the design of habitats utilized in ICE environments.

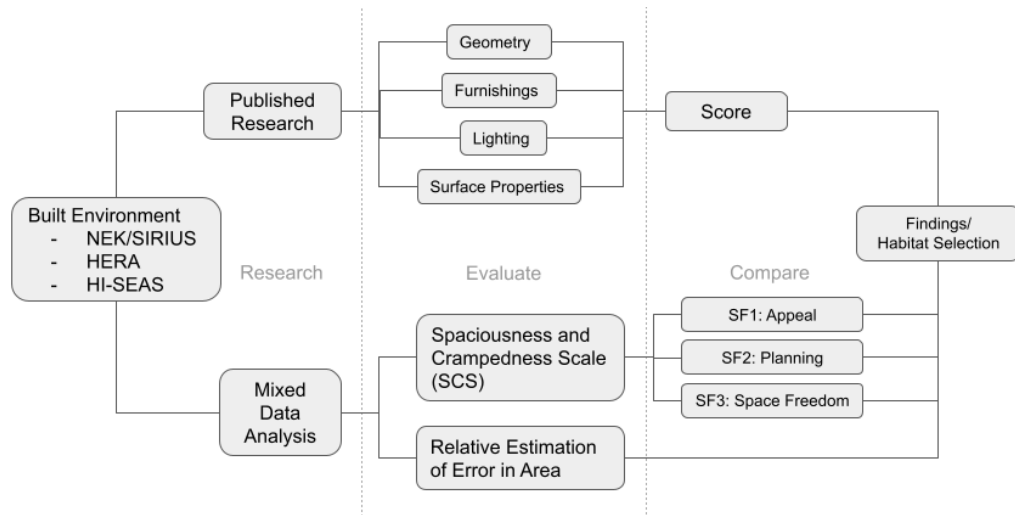


Figure 12. Experiment Stage 1 Procedure

5.1.1. Instruments and Procedure

Three simulation habitats, displayed in Figure 13, were chosen to assess their interior architecture. The expected operational similarities demonstrated by these environments served as the basis of their selection. Each of the three settings functioned as analogs for potential extreme environments, closely mirroring the conditions of habitats that would be found on Mars. Within these habitats, crews engage in highly faithful simulations of various scenarios.

The Hawai'i Space Exploration Analog and Simulation (HI-SEAS) is a habitat used for simulating life during off-world missions. The volcanic terrain of Mauna Loa, where the habitat is located, closely replicates the harsh conditions of Mars, making it suitable for performing high-fidelity exploration scenarios. The habitat is a semi-portable domed facility that accommodates six crews for up to eight months. The interior of the dome contains two levels. The ground level accommodates common spaces, the galley and dining area, laboratories, a bathroom, and workspaces. The top level contains personal chambers for six crew members and an additional

restroom. It is worth noting that the dome's design enables a taller canopy height within the habitat (Haeuplik-Meusburger et al., 2017).



Figure 13. Interiors of the chosen habitats (Top to Bottom: HI-SEAS, HERA, SIRIUS/NEK Module EU-100)

The Human Exploration Research Analog (HERA) Facility at NASA's Johnson Space Center in Houston, Texas, US, simulates ICE environments in exploration scenarios in

missions lasting up to 45 days. It is a three-story habitat housing crews of up to four. The first floor comprises an airlock serving as the entry/exit, a hygiene module serving as a bathroom, and a central space for conducting aviation simulations, day-to-day duties, and experiments. The second floor contains a galley area for food preparation and additional room for recreational activities. The third floor contains individual sleeping quarters for the crew (NASA, 2019).

Situated at the Institute of Biomedical Problems in Moscow, Russia, The Nazemnyy Eksperimental'nyy Kompleks (NEK) Habitat has a lengthy record dating back to the 1960s. This facility, equipped with five interconnected modules, simulates isolation, confinement, and exploration scenarios in extreme environments while accommodating crews of up to 8 individuals for over a year. Module EU-100, which is equipped for conducting medical and psychological experiments in simulated scenarios, was selected for this study. It features two-person living quarters, a galley, a toilet, and additional workspaces with medical tools (Belakovsky et al., 2019).

The interior architectural features of the habitats were grouped into four categories: geometry, furniture, lighting, and surface properties. This experiment did not consider external openings, as they were absent in the chosen habitats. The habitats underwent assessment according to the criteria summarized in Table 8. Moreover, particular interior architectural elements were highlighted, with desired and undesired values. The highlighted elements are likelier to impact the perceived spaciousness, presenting the likelihood that habitats with desired characteristics have the potential to acquire increased ratings of spaciousness.

Fourteen interior architects participated in the experiment, and they were instructed to conduct evaluations by examining carefully chosen photographs of each habitat displayed on a computer monitor. The order in which they viewed the environments was systematically rotated to mitigate potential viewing biases. Upon inspecting each environment, participants were asked to gauge the square meter of the area depicted in the photographs. This estimation was employed to calculate the relative error of estimation in habitat areas, following the method outlined by von Castell et al. (2014). The relative error in estimation assesses spaciousness by calculating the extent of discrepancy between estimated versus actual areas of the habitats.

Afterward, they completed the Spaciousness and Crampedness Scale (SCS) (Imamoglu, 1986; Appendix E). This scale comprises 16 bipolar adjectives rated on a 7-point scale. The assessments derived from the SCS were categorized into three distinct factors: appeal (SF1), planning (SF2), and space freedom (SF3). Mean scores for each factor were used to gauge spaciousness through a range of positive and negative adjective pairs. Higher scores on SCS suggested that the habitat was perceived as more comfortable, emotionally satisfying, and functional. The correlation between evaluations of interior spaces and SCS scores, as well as area estimations, was measured by aligning the obtained metrics independently.

Table 8. Selected Habitats and Their Interior Characteristics (Diker & Demirkan, 2022).

		NEK/SIRIUS: Module EU-100	HERA (Core)	HI-SEAS
Geometry	Form	Horizontal Cylinder	Vertical Cylinder	Domed
	Area	35 m ²	27.34 m ²	26.8 m ²
	Ratio (Area:Height)	17.272:1	12.716:1	4.872:1
	Height	2.40 m (d)	2.15 m (d)	5.5m at top(d=11m)
Lighting	Type	Downlight	Downlights + Task Lights	Downlights + Indirect Lighting
	Temperature	4000K-6000K (White)	4000K-6000K (White)	3000K-4000K (Warm White)
	Natural/Artificial	Artificial	Artificial	Artificial + Natural
Furniture	Type	Built-in + freestanding	Custom Built-in	Freestanding
	Organization	Linear	Central	Central
	Density	Dense	Very Dense	Light
Surfaces	Type	Wood Planks	Metal	Carpet, Gypsum, Plastic
	Texture	Wood Grain	Flat	Flat
	Color	Light Brown	Grey, White, Black	White, Grey

As presented in Table 8, the common area of HI-SEAS contained most of the features known to influence perceived spaciousness positively. The habitat's footprint is the smallest, despite having the tallest ceiling and largest volume. In contrast, the NEK Module EU-100 provided the biggest area. However, the excessive wood texture on its vertical and horizontal surfaces and the brown hues due to the material selection

likely contribute negatively to spaciousness perception. Additionally, the horizontal cylindrical form significantly limits the line of sight, diminishing the perceived spaciousness. Similarly, HERA's perceived spaciousness is adversely affected by its cluttered interior and a significant limitation in the field of vision due to the presence of an elevator/ladder.

5.1.2. Results

The mean scores of SCS were calculated for each habitat, as illustrated in Figure 14. These scores were then utilized in a One-Way Multivariate Analysis of Variance (MANOVA) test conducted using IBM SPSS. The purpose of this test was to compare the assessments of spaciousness for each habitat. Three variables, namely appeal (SF1), planning(SF2), and Space Freedom (SF3) were measured.

The analysis uncovered a statistically significant disparity in mean SCS scores across the habitats [$F(6, 74)=16.96, p<.005$, Wilk's $\lambda=.177, \eta^2p=.579$]. Additional examinations revealed that the specific type of habitat had a statistically significant effect on the assessments related to appeal (SF1) [$F(2, 39)=17.9, p<.005, \eta^2p=.48$] and space freedom (SF3) [$F(2, 39)=74.34, p<.005, \eta^2p=.79$]. Bonferroni Post Hoc tests unveiled a notable distinction in mean Appeal and Space Freedom scores of the HI-SEAS compared to the HERA and SIRIUS/NEK ($p<.005$). In contrast, no noteworthy distinction was detected in mean Planning scores.

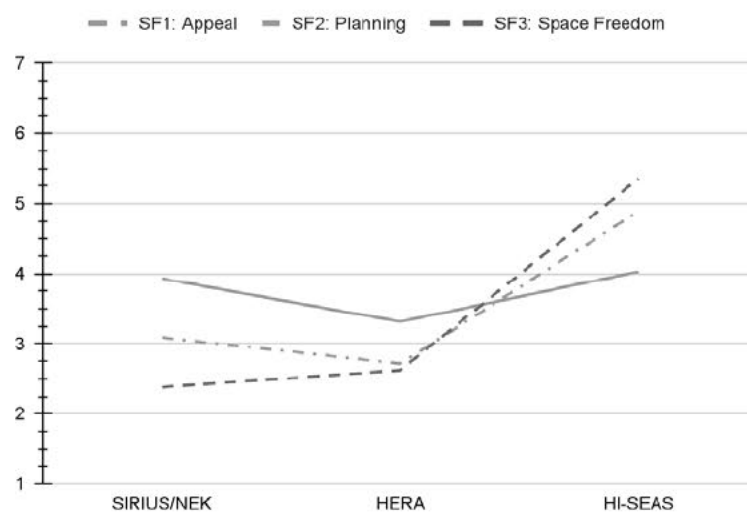


Figure 14. Mean SCS ratings for each habitat.

The difference in the mean SCS scores for the selected habitats was statistically significant. Most meaningful insights were drawn from the Appeal (SF1) and Space Freedom (SF3) factors, whereas the Planning (SF2) factor did not differ significantly. This is likely due to the distinguishing features of such habitats, where the primary emphasis is placed on comprehensive planning and functionality, given the constraints of limited resources, space, and stringent mission prerequisites.

Participants made estimations of the areas for each habitat, which were employed to calculate relative errors. The relative errors were determined by comparing participants' estimates to the actual areas of the habitats. Mean scores are illustrated in Figure 15 to provide a visual illustration of the data. HI-SEAS habitat's area was perceived to be 49.5% larger, representing the highest rate of error in comparison to NEK Module EU-100 (42.9% underestimation) and HERA (3.8% underestimation).

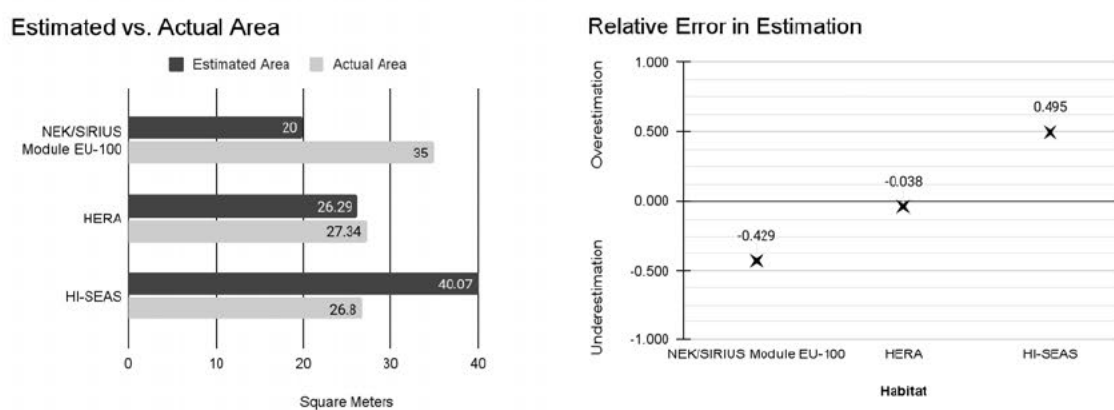


Figure 15. Comparison between estimated and actual areas of the habitats, along with the calculation of relative estimation errors.

5.1.3. Discussion

The HI-SEAS habitat, which featured a larger volume, better lighting, lower density of furniture, and minimal use of hues and texture, received the highest ratings for both Appeal (SF1) and Space Freedom (SF3). These results indicate that it was the most spacious habitat among the three and was perceived to offer the most living space. In contrast, the SIRIUS/NEK habitat received the lowest scores for Space Freedom

(SF3) despite having a larger area than other habitats. Differences in habitat geometry and material selection likely cause this disparity.

The influence of the line of sight was expected to be a more prominent contributor to the perception of spaciousness. Despite a vertical shaft in the center, which obstructs vision at the eye level for occupants, HERA's evaluations suggested greater space freedom scores than the SIRIUS/NEK habitat. The vertical cylindrical shape of SIRIUS/NEK affords a narrower field of vision but a more distant horizon than HERA's horizontal cylindrical structure. Interestingly, HERA received the lowest ratings for appeal among the three, likely due to its mechanical and industrial appearance and lower overall brightness.

HI-SEAS was deemed the most spacious and livable habitat, while SIRIUS/NEK was the least. With the most minor relative error observed, assessing spaciousness for the HERA habitat produced unexpected findings. This initial contradiction becomes more apparent when considering that it received the lowest overall score in the SCS evaluations. However, an examination of the Space Freedom (SF3) scores showed that the HERA habitat ranked second. This finding suggests that Space Freedom (SF3) may strongly correlate with area estimations and their relative error. The remaining estimation results aligned with expectations.

5.2. Experiment Stage 2: Assessment of Perceived Spaciousness in Virtually Simulated Isolated and Confined Environments.

This experiment seeks to expand upon the preceding two phases, emphasizing the marked disparity in spaciousness assessments and perceptions, particularly for the NEK/SIRIUS habitat's Module EU-100, which exhibited a 42.9% underestimation. The experiment investigated the ensuing theories:

1. An increase in furniture density is associated with a negative impact on perceived spaciousness.
2. Enhancing the all-around illumination level has a positive effect on perceived spaciousness.
3. Reducing surface texture density is linked to a positive effect on perceived spaciousness.

4. Raising the ceiling height has a positive effect on perceived spaciousness.

Apart from the primary hypotheses, assessing additional factors associated with the perception and evaluation of interior spaces is important. These factors include whether participants have received formal education and training in design principles and their aesthetic and emotional responses to a given interior environment. Based on these considerations, the following additional hypotheses are tested:

1. Participants' evaluation of spaciousness is influenced by their design training.
2. Participants' evaluation of spaciousness is influenced by their aesthetic and emotional responses.
3. Perceived familiarity positively influences perceived spaciousness.
4. Perceived excitement positively influences perceived spaciousness.
5. Perceived fascination positively influences perceived spaciousness.

5.2.1. Setting

Given the severe resource and accessibility limitations of ICE environments, testing the hypotheses necessitated a resourceful approach. A tactic for balancing the compromise between authenticity and experimental precision entails the utilization of virtual reality, simulations, and immersive media technologies. Although the firsthand experience within a genuine ICE environment is noteworthy, virtual environments offer an intermediary solution by bridging the authenticity of a real atmosphere with the controlled, albeit artificial, conditions of a research laboratory. As a result, VR was selected to evaluate each variable using HMD's comprehensively.

The module EU-100 was virtually reconstructed as an equal representation of the real habitat using 3DS Max for initial 3D modeling and Lumion 11 for crafting final stereoscopic images, with Figure 16 serving as a valuable reference for the process. Following this, the environment was rendered to enable static viewing through an HTC Vive. Participants were limited to observing the surroundings from an egocentric perspective and were not able to interact with the environment. The interior architectural elements selected for modification, were then adjusted to create distinct variations of the habitat.

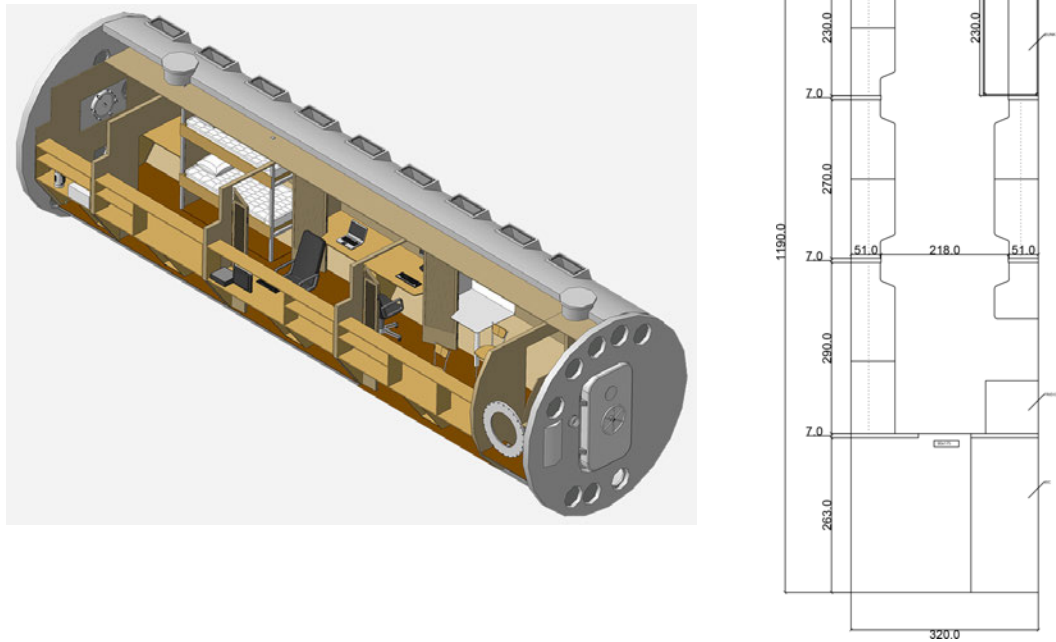


Figure 16. Isometric projection and plan view of Module EU-100.
(<http://mars500.imbp.ru/en/nek.html>)

Following this, eight distinct alternative virtual scenes were created, incorporating interior architectural elements that had previously connected significantly with anxiety, psychological distress, and boredom. The experiments were carried out at two distinct locations, specifically selected to involve participants with and without training in design. Participants with design training were recruited from İ.D. Bilkent University, FB building, whereas participants with no design training were gathered at Ankara City Hospital. Throughout the experiment, only one participant occupied the room.

5.2.2. Participants

The experiment received approval from the İ.D. Bilkent University ethics committee and enrolled participants aged 18 to 64 using cluster sampling for selection. Participants were categorized into two groups to overcome potential biases from design training: those with formal design training and those without design training. Furthermore, each participant underwent a comprehensive briefing regarding the experimental process and scenario. They were also informed of the option to pause or

stop the study and withdraw if they encountered discomfort related to the HMD at any time.

The study involved 81 participants, comprising 29 men (35.8%) and 52 women (64.2%). The average age of participants was 29.8 years, with a standard deviation of 10.01. Within the participant group, 44 (54.3%) did not receive design training, while 37 (45.7%) did. In terms of education, the participants were distributed as follows: 23 (28.4%) had high school degrees, 7 (8.6%) had associate degrees, 15 (18.5%) possessed bachelor's degrees, and 36 (44.5%) held post-graduate degrees.

5.2.3. Stimuli

Control—Hypothesis H_0

The control scene was created as an exact one-to-one replica of the NEK/SIRIUS Module EU-100, utilizing the information in Figure 17. The control scene underwent the same treatment as the experimental scenes, except for the interior architectural elements being tested. Including a control scene is essential to validate that any observed effects result from the tested variable, not other extraneous factors. The presence of a control scene helps ensure that changes are genuinely attributed to the tested variable rather than occurring by chance or due to unrelated factors.



Figure 17. View of the original habitat (Control).

Effects of Furniture Density on Spaciousness in ICE Environments—Hypothesis 1

A single scene was created to examine the influence of furniture density on spaciousness. The alterations in furniture density were designed with considerations from both an architectural and usability perspective. The variations were crafted following a similar approach to that proposed by Imamoglu (1973), resulting in two scenarios: one with standard furnishing (control, Figure 17) and another with an excess of furniture (Figure 18). Acknowledging the importance of adopting a comprehensive perspective when assessing spaciousness and furniture density, as advocated by von Castell (2014), it was deemed essential to maintain consistency in other architectural attributes. Therefore, both scenes retained uniform color, texture, and lighting characteristics.



Figure 18. View of the habitat, over furnished.

Effects of Illumination on Spaciousness in ICE Environments—Hypothesis 2

Two scenes were created to evaluate the impact of lighting on spaciousness. In one scene, the overall illuminance levels were doubled (Figure 19), while in the other, they were halved (Figure 20). It is worth noting that the direction and color temperature of the lighting remained consistent across both scenes. The additional lights were introduced solely to augment the overall illuminance level within the environment.



Figure 19. View of the habitat with increased illuminance.



Figure 20. View of the habitat with decreased illuminance.

Effects of Texture on Spaciousness in ICE Environments—Hypothesis 3

Two scenes were created to assess the changes to perception caused by surface texture. In one visualization, the surface texture was eliminated and substituted with non-textured surfaces of the same color (Figure 21). In the other scene, the texture density on surfaces was doubled (Figure 22).



Figure 21. View of the habitat with no surface texture.



Figure 22. View of the habitat with increased surface texture.

Effects of Ceiling Height on Spaciousness in ICE Environments—Hypothesis 4

Two scenes were created to assess the effects of ceiling height. In the first scene, the ceiling height was reduced to a minimum of 220 cm (Figure 23), while in the second scene, it was increased to 260 cm (Figure 24).



Figure 23. View of the habitat with a lower ceiling.



Figure 24. View of the habitat with a higher ceiling.

5.2.4. Instruments and Procedure

Participants were presented with one of the eight scenes and evaluated using the aforementioned tools. This random assignment was implemented to prevent biases and viewing effects. Each participant viewed only one of the eight environments. Similar to the prior experiment, the SCS scores were calculated to categorize and

evaluate the different variations, aiding in identifying the most and least substantial alterations. Participants were asked to gauge the dimensions of the surroundings (length, width, and height) while viewing them. The remaining evaluations were conducted after the participants had finished viewing the scenes. Figure 25 provides an overview of the entire procedure during this stage.

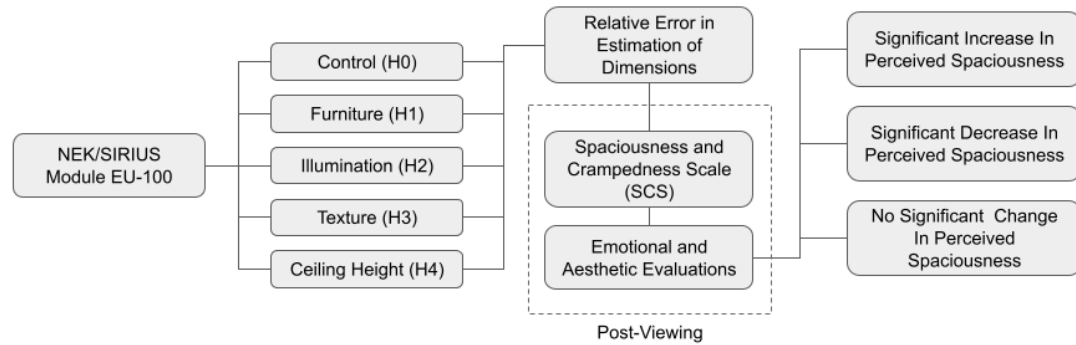


Figure 25. Experiment Stage 2 Procedure

After viewing the environments and estimating their square footage, the participants completed the SCS (Imamoglu, 1986) (see Appendix E). The estimates for height, width, and length were used to calculate the relative error in size estimations (von Castell et al., 2015).

In addition to the spaciousness measures, participants' emotional and aesthetic responses were assessed using the Aesthetic Experience Scale (Elver et al., 2022; see Appendix G). This scale assessed participants' aesthetic and emotional responses to the habitat. Within the familiarity and excitement components, participants rated the viewed interior environment using 21 bipolar adjective pairs on a 5-point scale. These adjectives were specifically designed to gauge participants' emotional and aesthetic responses, such as whether they found the environment calming or stimulating, pleasant or unpleasant. The fascination component comprised four items on a 5-point scale, measuring participants' intentions to engage in specific behaviors within the environment.

The Spatial Presence Experience Scale (SPES) used to filter participants that did not showcase a strong sense of presence within the virtual environment (see Appendix F). This 8-item scale assesses the sense of presence across various media presentations

and encompasses two dimensions: self-location and perceived possible action (Hartmann et al., 2016).

5.2.5. Results

SPES responses revealed that 100% of participants showed satisfactory presence within the environments, and all responses were included in the subsequent analyses. Participants rated perceived possible actions slightly lower ($M=3.96$, $SD=0.92$) than self-location within the environment ($M=4.28$, $SD = 0.64$). This disparity can be attributed to the static qualities of the scenes.

The impact of individual scenes was assessed by independently comparing each of them to the control scene. The significance of differences in perceptions between distinct sample groups, design trained (DT) and not design trained (NDT), were analyzed using Two-way ANOVA. The effect size, indicating the magnitude of the difference, was determined using eta-squared (η^2). An effect size of $\eta^2 = .01$ is considered small, $\eta^2 = .25$ is considered medium, and $\eta^2 = .4$ is considered large. The significance of the effects identified in the experiment can be contextualized using these values. In summary, the results of the Two-way ANOVA provide valuable insights into the significant differences in perceptions among the two participant groups and the eight scenes.

Evaluations Using Spaciousness and Crampedness Scale

The comparison between control and over-furnished scenes highlighted significant effects influenced by participants' design training. These effects were of medium size on the Appeal (SF1) factor [$F(1, 17)=9.57$, $p=.007$, $\eta^2p=.360$], and of large size on the Space Freedom (SF3) factor [$F(1, 17)=17.86$, $p=.001$, $\eta^2p=.512$], as well as the Planning (CF2) factor [$F(1, 17)=33.32$, $p<.001$, $\eta^2p=.662$]. As illustrated in Figure 26, a medium-sized interaction effect of design training and over-furnishing was observed on the Space Freedom (SF3) [$F(1, 17)=9.43$, $p=.007$, $\eta^2p=.357$] and Physical Space (CF2) [$F(1, 17)=6.38$, $p=.022$, $\eta^2p=.273$] factors. Additionally, a small-sized interaction effect was noted on the Clutteredness (CF3) [$F(1, 17)=5.47$, $p=.032$,

$\eta^2p=.032$] factor. No significant differences among groups were observed in the Appeal (CF4) factor.

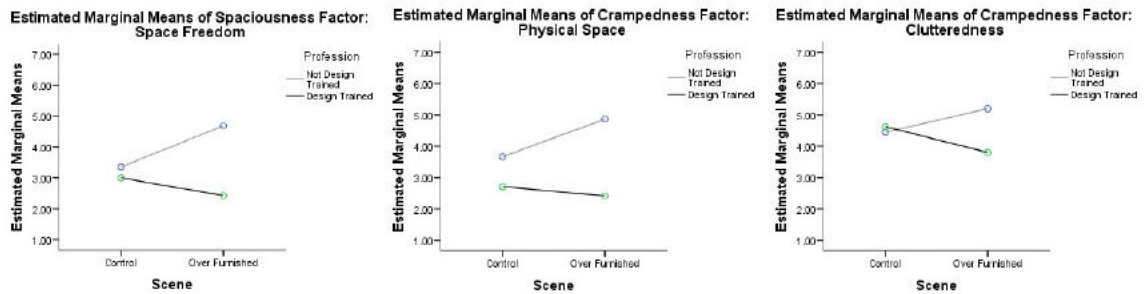


Figure 26. Estimated marginal means of SF3, CF2 and CF3 of control and over furnished scenes.

Increasing illumination levels did not have any direct effect on evaluations. However, as depicted in Figure 27, design training significantly influenced the Appeal (SF1), Space Freedom (SF3), and Physical Space (CF2) factors compared to the control scene. The observed effect sizes were medium; $[F(1, 18)=5.03, p=.038, \eta^2p=.218]$, $[F(1, 18)=5.46, p=.031, \eta^2p=.233]$, $[F(1, 18)=5.67, p=.028, \eta^2p=.240]$, respectively.

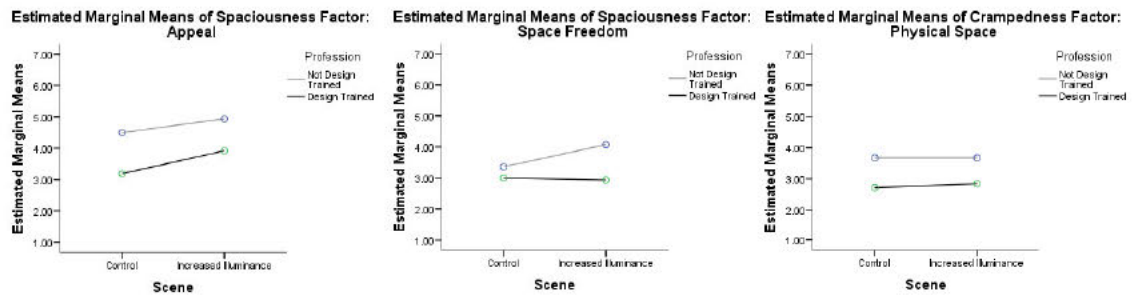


Figure 27. Estimated marginal means of SF1, SF3, and CF2 of control and increased illumination scenes.

Unlike the previous scene, reducing illumination levels and design training exhibited a significant interaction effect of medium size on the Appeal (SF1) $[F(1, 18)=4.88, p=.040, \eta^2p=.213]$ and Planning (SF2) $[F(1, 18)=6.51, p=.020, \eta^2p=.266]$ factors. Additionally, design training was a main effect $[F(1, 18)=5.02, p=.038, \eta^2p=.218]$ on the Physical Space (CF2) evaluations. The effects are illustrated in Figure 28.

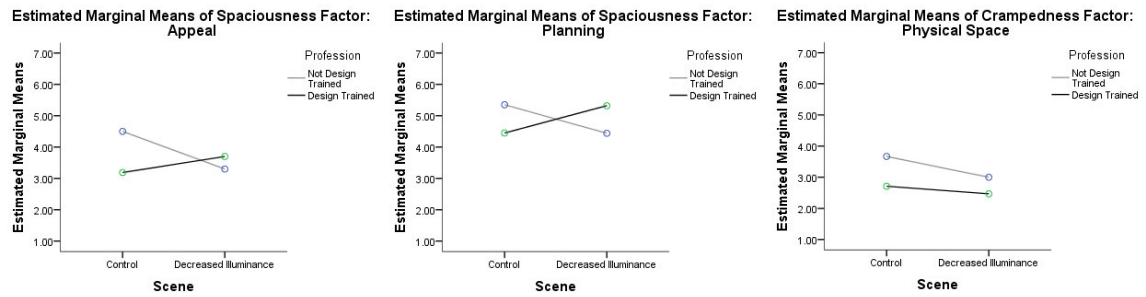


Figure 28. Estimated marginal means of SF1, SF2, and CF2 of control and decreased illumination scenes.

Upon examining the increased texture scene, design training exerted a notable influence on two components associated with crampedness: the Planning (CF1) [$F(1, 17)=4.49$, $p=.049$, $\eta^2p=.209$] and Physical Space (CF2) [$F(1, 17)=7.06$, $p=.017$, $\eta^2p=.294$] factors, as illustrated in Figure 29. This observation indicates that design training elicited a distinct response to the increased texture within the habitat. Furthermore, the effect size observed in both cases, depicting the relationship between design training and increased texture, was of medium magnitude.

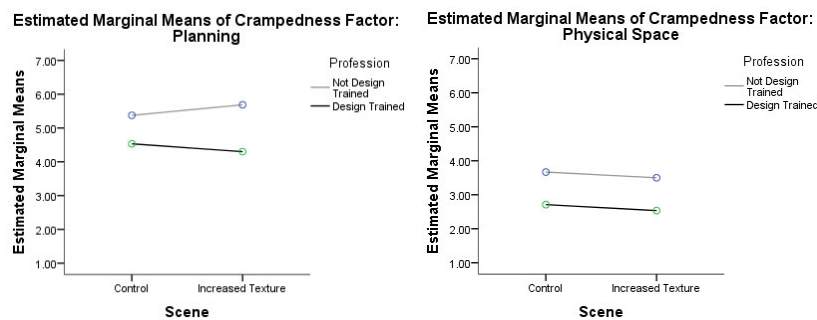


Figure 29. Estimated marginal means of CF1 and CF2 of control and increased texture scenes.

In contrast, when examining the decreased texture scene, it became evident that design training [$F(1, 18)=4.65$, $p=.045$, $\eta^2p=.283$] and the absence of texture [$F(1, 18)=7.09$, $p=.016$, $\eta^2p=.206$] played distinctive and significant roles in shaping perceptions of the Planning (SF2) factor. These individual main effects were characterized by a medium effect size, emphasizing their significance in influencing

how participants evaluated spaciousness within environments with reduced texture, as illustrated in Figure 30. Additionally, the absence of texture emerged as a main effect in the Planning (CF1) [$F(1, 18)=5.34, p=.033, \eta^2p=.229$] factor, further highlighting its relevance in shaping the perceived constraints within such spaces.

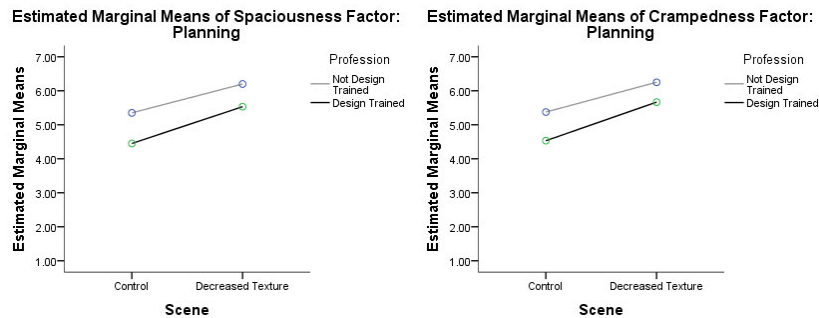


Figure 30. Estimated marginal means of SF2 and CF1 of control and decreased texture scenes.

The manipulation of ceiling height, whether increasing or decreasing, yielded no notable mean differences in the evaluations, according to the SCS. These results imply that components like furniture, illumination, and texture, rather than ceiling height, have a meaningful function in shaping the perception of spaciousness and crampedness. Moreover, design training may affect these perceptions, indicating the multifaceted nature of how interior architectural elements interact with individual backgrounds and training in shaping the experience of built environments. Table 9 summarizes the results of SCS evaluations for each scene that were analyzed to investigate how each element and design training influenced the perceived spaciousness of the habitat.

Table 9. Summary of the Main and Interaction Effects for SCS Evaluations Based on the Results of the Two-way ANOVA.

Control x Over Furnished	SF1: Appeal	SF2: Planning	SF3: Space Freedom	CF1: Planning	CF2: Physical Space	CF3: Clutteredness	CF4: Appeal
Scene	F(1, 17) = 2.30, p = .147	F(1, 17) = 1.27, p = .276	F(1, 17) = 1.50, p = .239	F(1, 17) = 1.71, p = .208	F(1, 17) = 2.35, p = .143	F(1, 17) = 0.01, p = .913	F(1, 17) = 1.92, p = .183
Profession	F(1, 17) = 9.57, p = .007, η^2 p = .360	F(1, 17) = 3.44, p = .081	F(1, 17) = 17.86, p = .001, η^2 p = .512	F(1, 17) = 2.85, p = .109	F(1, 17) = 33.32, p < .001, η^2 p = .662	F(1, 17) = 3.30, p = .087	F(1, 17) = 4.13, p = .058
Scene*Profession	F(1, 17) = .007, p = .933	F(1, 17) = .000, p = .984	F(1, 17) = 9.43, p = .007, η^2 p = .357	F(1, 17) = .001, p = .975	F(1, 17) = 6.38, p = .022, η^2 p = .273	F(1, 17) = 5.47, p = .032, η^2 p = .032	F(1, 17) = .230, p = .637
Control x Increased Illuminance							
Scene	F(1, 18) = 1.25, p = .277	F(1, 18) = 2.15, p = .159	F(1, 18) = 1.01, p = .328	F(1, 18) = 1.95, p = .180	F(1, 18) = .026, p = .873	F(1, 18) = 1.74, p = .203	F(1, 18) = .514, p = .482
Profession	F(1, 18) = 5.03, p = .038, η^2 p = .218	F(1, 18) = 2.26, p = .150	F(1, 18) = 5.46, p = .031, η^2 p = .233	F(1, 18) = 3.01, p = .099	F(1, 18) = 5.67, p = .028, η^2 p = .240	F(1, 18) = .107, p = .748	F(1, 18) = 4.15, p = .056
Profession*Scene	F(1, 18) = .079, p = .782	F(1, 18) = .166, p = .689	F(1, 18) = 1.49, p = .237	F(1, 18) = .000, p = .992	F(1, 18) = .026, p = .873	F(1, 18) = .766, p = .393	F(1, 18) = .024, p = .880
Control x Decreased Illuminance							
Scene	F(1, 18) = .787, p = .387	F(1, 18) = .003, p = .955	F(1, 18) = .577, p = .457	F(1, 18) = .062, p = .806	F(1, 18) = 1.87, p = .188	F(1, 18) = 1.13, p = .301	F(1, 18) = 1.25, p = .278
Profession	F(1, 18) = 1.38, p = .254	F(1, 18) = .001, p = .977	F(1, 18) = 1.27, p = .274	F(1, 18) = .034, p = .855	F(1, 18) = 5.02, p = .038, η^2 p = .218	F(1, 18) = .022, p = .883	F(1, 18) = .756, p = .396
Profession*Scene	F(1, 18) = 4.88, p = .040, η^2 p = .213	F(1, 18) = 6.51, p = .020, η^2 p = .266	F(1, 18) = .000, p = .980	F(1, 18) = 3.95, p = .062	F(1, 18) = .410, p = .530	F(1, 18) = .162, p = .692	F(1, 18) = 4.38, p = .051

Table 9. Summary of the Main and Interaction Effects for SCS Evaluations Based on the Results of the Two-way ANOVA (cont.).

Control x Increased Texture	SF1: Appeal	SF2: Planning	SF3: Space Freedom	CF1: Planning	CF2: Physical Space	CF3: Clutteredness	CF4: Appeal
Scene	F(1, 17) = .103, p = .753	F(1, 17) = .011, p = .918	F(1, 17) = .057, p = .814	F(1, 17) = .006, p = .939	F(1, 17) = .225, p = .641	F(1, 17) = .200, p = .660	F(1, 17) = .018, p = .894
Profession	F(1, 17) = 3.45, p = .080	F(1, 17) = 4.33, p = .053	F(1, 17) = 2.33, p = .145	F(1, 17) = 4.49, p = .049, η^2 p = .209	F(1, 17) = 7.06, p = .017, η^2 p = .294	F(1, 17) = .001, p = .973	F(1, 17) = 2.65, p = .122
Profession*Scene	F(1, 17) = .694, p = .416	F(1, 17) = .043, p = .838	F(1, 17) = .176, p = .680	F(1, 17) = .267, p = .612	F(1, 17) = .000, p = .991	F(1, 17) = .267, p = .612	F(1, 17) = .652, p = .430
Control x Decreased Texture							
Scene	F(1, 18) = 1.40, p = .251	F(1, 18) = 7.09, p = .016, η^2 p = .206	F(1, 18) = 2.26, p = .150	F(1, 18) = 5.34, p = .033, η^2 p = .229	F(1, 18) = .624, p = .440	F(1, 18) = .519, p = .481	F(1, 18) = .766, p = .393
Profession	F(1, 18) = 3.90, p = .064	F(1, 18) = 4.65, p = .045, η^2 p = .283	F(1, 18) = 1.09, p = .310	F(1, 18) = 2.69, p = .118	F(1, 18) = 1.78, p = .199	F(1, 18) = .134, p = .719	F(1, 18) = 2.21, p = .154
Profession*Scene	F(1, 18) = .624, p = .440	F(1, 18) = .103, p = .752	F(1, 18) = .004, p = .949	F(1, 18) = .090, p = .768	F(1, 18) = .981, p = .335	F(1, 18) = .017, p = .898	F(1, 18) = .766, p = .393
Control x Increased Height							
Scene	F(1, 18) = 2.50, p = .131	F(1, 18) = .185, p = .672	F(1, 18) = 1.57, p = .226	F(1, 18) = .056, p = .815	F(1, 18) = .098, p = .758	F(1, 18) = .441, p = .515	F(1, 18) = 1.27, p = .274
Profession	F(1, 18) = 2.50, p = .131	F(1, 18) = 3.75, p = .069	F(1, 18) = .290, p = .597	F(1, 18) = 3.72, p = .070	F(1, 18) = 1.72, p = .249	F(1, 18) = .044, p = .836	F(1, 18) = 2.38, p = .140
Profession*Scene	F(1, 18) = 1.29, p = .269	F(1, 18) = .279, p = .604	F(1, 18) = .084, p = .776	F(1, 18) = .026, p = .874	F(1, 18) = .476, p = .499	F(1, 18) = .547, p = .469,	F(1, 18) = .743, p = .131
Control x Decreased Height							
Scene	t(21) = -.683, p = .502	t(21) = -1.30, p = .205	t(21) = -.700, p = .491	t(21) = -1.64, p = .116	t(21) = -.076, p = .940	t(21) = -.360, p = .722	t(21) = -.360, p = .722

Evaluations Using Aesthetic and Emotional Responses

Similar to the previous section, the results are derived from a two-way analysis that evaluated participants' aesthetic and emotional reactions to the habitat's interior based on five elements (furniture, illumination, texture, ceiling height, and design training). These reactions were measured using the Emotional Aesthetic Experience Scale, and its three components: Familiarity, Excitement, and Fascination.

Comparisons between over-furnished and control scenes did not reveal any substantial disparity in the emotions of excitement and fascination. However, the familiarity factor approached significance ($p = .059$), suggesting that participants in the over-furnished group felt a slightly higher sense of familiarity with the habitat interior compared to the control group as depicted in Figure 31.

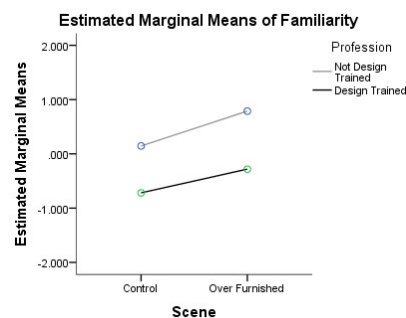


Figure 31. Comparison of estimated marginal means of familiarity between control and over-furnished scenes.

As depicted in Figure 32, the increase in illuminance did not significantly impact any components of EAS. Nevertheless, design training exhibited a significant main effect on ratings of familiarity [$F(1, 17)=6.13$, $p=.024$, $\eta^2p=.265$] and fascination [$F(1, 17)=5.04$, $p=.038$, $\eta^2p=.229$]. NDT participants rated the habitat as significantly more familiar and fascinating than DT participants.

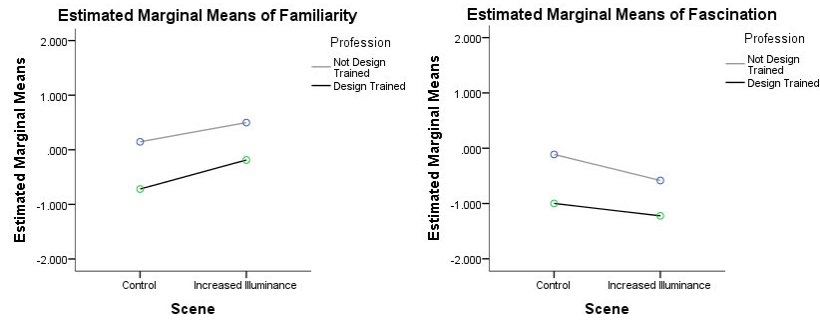


Figure 32. Comparison of estimated marginal means of familiarity and fascination between control and increased illumination scene.

Analysis of the decreased illuminance group revealed a significant interaction effect with design training on familiarity evaluations, suggesting that the familiarity of the decreased illumination scene depended on participants' design training [$F(1, 17)=5.75$, $p=.028$, $\eta^2p=.253$]. This interaction is visually depicted in Figure 33.

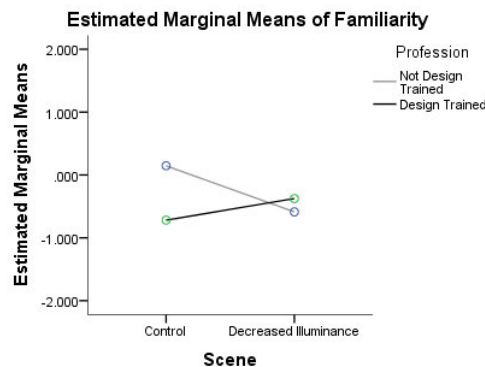


Figure 33. Comparison of estimated marginal means of familiarity between the control and decreased illumination scene.

Analysis of the increased texture scene revealed that it did not significantly impact any of the components. However, an interaction effect was observed between design training and increased texture on the fascination component [$F(1, 16)=6.75$, $p=.019$, $\eta^2p=.297$], indicating that DT participants found the habitat with increased texture density more fascinating compared to NDT participants. This interaction is visualized in Figure 34. Additionally, design training significantly influenced familiarity [$F(1, 16)=6.39$, $p=.022$, $\eta^2p=.286$].

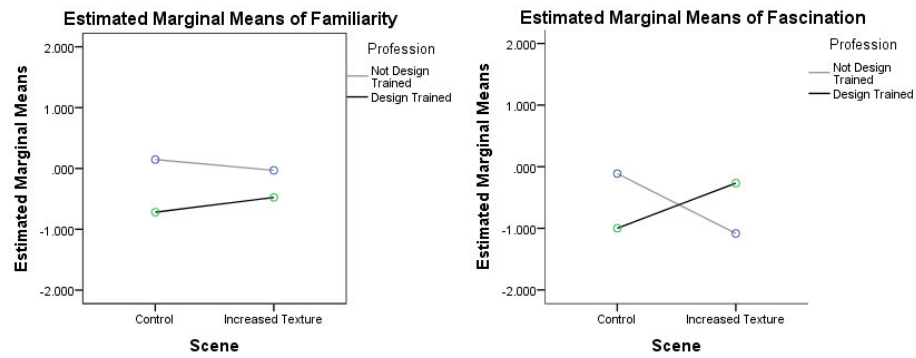


Figure 34. Comparison of estimated marginal means of familiarity and fascination between control and increased texture scene.

Analysis of the decreased texture group revealed that the absence of texture did not significantly impact any components. However, as visualized in Figure 35, design training was a main effect of familiarity [$F(1, 17)=6.18, p=.024, \eta^2p=.267$] and fascination [$F(1, 17)=6.23, p=.023, \eta^2p=.268$] components, indicating that scenes featuring habitats with absent texture were reported to be more familiar and fascinating by DT participants compared to NDT participants.

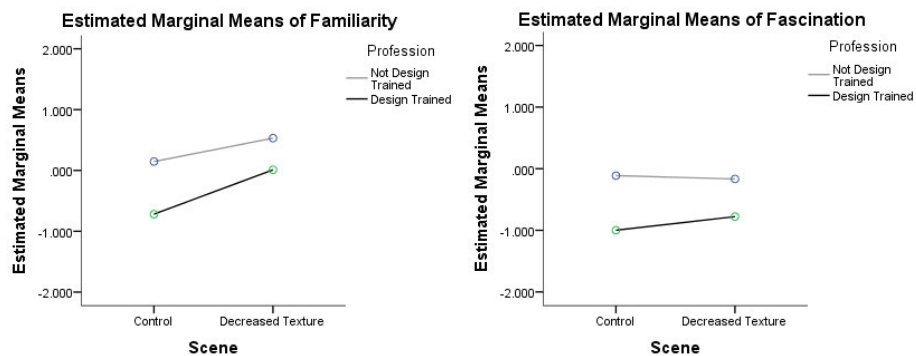


Figure 35. Comparison of estimated marginal means of familiarity and fascination between control and decreased texture scene.

No statistically significant main or interaction effects were observed for any of the components when analyzing the increased height scene, except for design training having a significant effect on the fascination component [$F(1, 17)=5.87, p=.027, \eta^2p=.257$]. Similarly, the decreased height scene did not demonstrate any significant main or interaction effects. However, it's important to note that additional effects may

be uncovered with a larger sample size, as the p-value for the familiarity component is close to 0.05. Table 10 summarizes the results discussed in this section.

Table 10. The summary of main and interaction effects for EAS evaluations resulting from a two-way ANOVA analysis.

Control x Over Furnished	Familiarity	Excitement	Fascination
Scene	F(1, 16) = 4.14, p = .059 F(1, 16) = 13.30, p = .002, $\eta^2 p = .454$	F(1, 16) = 1.06, p = .318	F(1, 16) = 1.90, p = .186
Profession		F(1, 16) = 1.50, p = .237	F(1, 16) = 4.09, p = .060
Profession*Scene	F(1, 16) = .149, p = .702	F(1, 16) = .190, p = .669	F(1, 16) = .706, p = .413
Control x Increased Illuminance			
Scene	F(1, 17) = 1.99, p = .176 F(1, 17) = 6.13, p = .024, $\eta^2 p = .265$	F(1, 17) = 1.29, p = .271	F(1, 17) = 1.04, p = .321 F(1, 17) = 5.04, p = .038, $\eta^2 p = .229$
Profession		F(1, 17) = 2.91, p = .106	
Profession*Scene	F(1, 17) = .036, p = .779	F(1, 17) = .899, p = .356	F(1, 17) = 5.04, p = .720
Control x Decreased Illuminance			
Scene	F(1, 17) = .751, p = .398	F(1, 17) = .059, p = .811	F(1, 17) = .342, p = .566
Profession	F(1, 17) = 2.10, p = .165 F(1, 17) = 5.75, p = .028, $\eta^2 p = .253$	F(1, 17) = .370, p = .551	F(1, 17) = 4.28, p = .052 F(1, 17) = 4.23, p = .524
Profession*Scene			
Control x Increased Texture			
Scene	F(1, 16) = .016, p = .900 F(1, 16) = 6.39, p = .022, $\eta^2 p = .286$	F(1, 16) = .030, p = .864	F(1, 16) = .133, p = .720
Profession		F(1, 16) = .325, p = .577	F(1, 16) = .011, p = .916 F(1, 16) = 6.75, p = .019, $\eta^2 p = .297$
Profession*Scene	F(1, 16) = .657, p = .429	F(1, 16) = .177, p = .679	
Control x Decreased Texture			
Scene	F(1, 17) = 4.00, p = .062 F(1, 17) = 6.18, p = .024, $\eta^2 p = .267$	F(1, 17) = 1.70, p = .209	F(1, 17) = .077, p = .784 F(1, 17) = 6.23, p = .023, $\eta^2 p = .268$
Profession		F(1, 17) = .917, p = .352	
Profession*Scene	F(1, 17) = .384, p = .544	F(1, 17) = .001, p = .977	F(1, 17) = .211, p = .652
Control x Increased Height			
Scene	F(1, 17) = 1.47, p = .242	F(1, 17) = 2.48, p = .134	F(1, 17) = .026, p = .873 F(1, 17) = 5.87, p = .027, $\eta^2 p = .257$
Profession	F(1, 17) = 2.33, p = .145	F(1, 17) = .000, p = 1.00	
Profession*Scene	F(1, 17) = 1.17, p = .293	F(1, 17) = 1.10, p = .308	F(1, 17) = .348, p = .563
Control x Decreased Height			
Scene	t(20) = -1.93, p = .068	t(20) = -1.20, p = .242	t(20) = -.971, p = .343

Evaluations by Calculating Relative Error in Estimated Dimensions

The means of each dimension (height, length, width) were calculated, and the relative error in the estimated dimensions was determined using von Castell's formula. The results of these calculations are presented in Figure 36 through Figure 38.

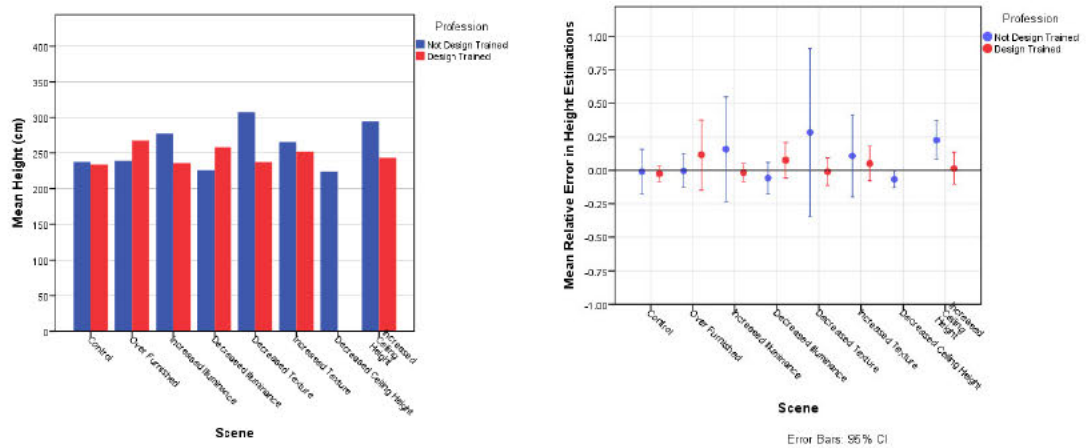


Figure 36. Mean height estimates and relative error in estimation for each scene, grouped based on design training.

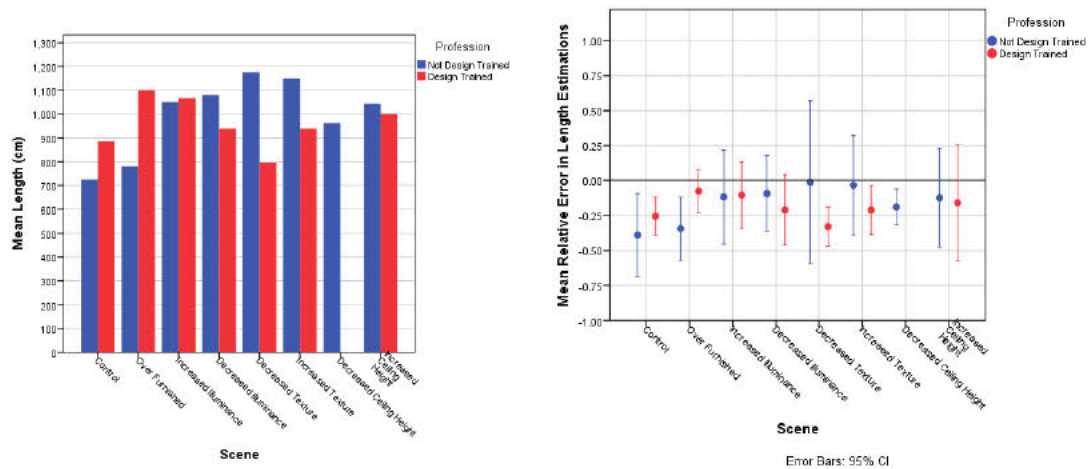


Figure 37. Mean length estimates and relative error in estimation for each scene, grouped based on design training.

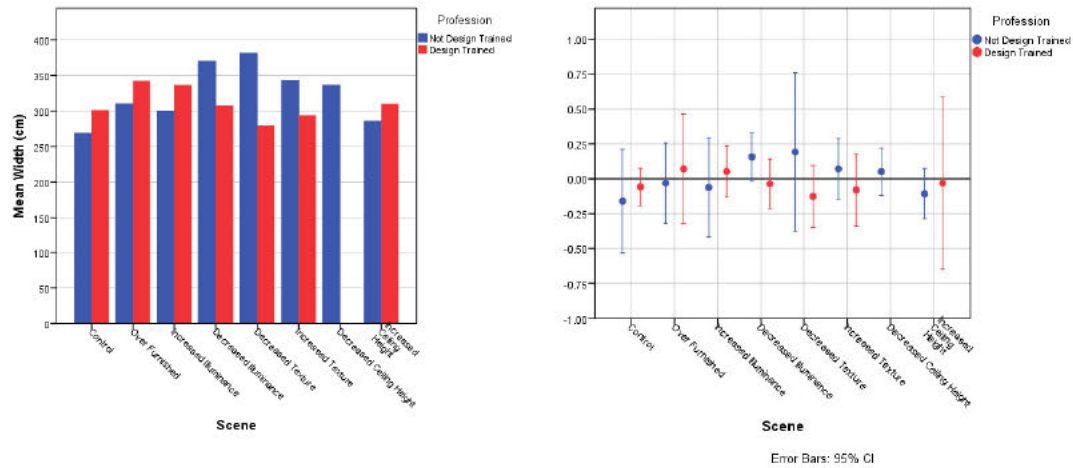


Figure 38. Mean width estimates and relative error in estimation for each scene, grouped based on design training.

The impact of furniture, illumination, texture density, ceiling height, and design training on the accuracy of height, length, and width estimations were analyzed using two-way ANOVA. Increasing texture density and illumination levels had a medium effect on length estimations of the habitat ($\eta^2p=.275$ and $\eta^2p=.252$, respectively). On the other hand, a decrease in illumination significantly affected width estimations ($F(1, 18)=5.26$, $p=.034$, $\eta^2p=.226$), underscoring the importance of lightning for accurate size estimations. Decreasing texture exhibited an interaction effect ($\eta^2p=.251$) with design training in length estimations, suggesting a higher accuracy for DT participants. Design training was a main effect for height estimations when ceiling height was increased [$F(1, 18) = 4.71$, $p = .043$, $\eta^2p = .208$]. Table 11 summarizes the results of relative error in size estimation results for each scene that were analyzed to investigate how interior architectural elements influenced the height, length, and width estimates of the habitat.

Table 11. The summary of main and interaction effects for relative error in estimated dimensions resulting from a two-way ANOVA analysis.

Control x Over Furnished	Height	Length	Width
Scene	F(1, 17) =2.33, p = .145	F(1, 17) =2.32, p = .146	F(1, 17) =1.85, p = .191
Profession	F(1, 17) =1.15, p = .298	F(1, 17) =7.56, p = .014, $\eta^2 p = .308$	F(1, 17) =1.15, p = .298
Profession*Scene	F(1, 17) =1.95, p = .180	F(1, 17) =.806, p = .382	F(1, 17) =.000, p = .000
Control x Increased Illuminance			
Scene	F(1, 18) =2.58, p = .125	F(1, 18) =6.05, p = .024, $\eta^2 p = .252$	F(1, 18) =1.54, p = .230
Profession	F(1, 18) =3.01, p = .100	F(1, 18) =.765, p = .393	F(1, 18) =1.66, p = .214
Profession*Scene	F(1, 18) =2.10, p = .164	F(1, 18) =.507, p = .486	F(1, 18) =.006, p = .939
Control x Decreased Illuminance			
Scene	F(1, 18) =.436, p = .517	F(1, 18) =4.25, p = .054	F(1, 18) =5.26, p = .034, $\eta^2 p = .226$
Profession	F(1, 18) =2.14, p = .161	F(1, 18) =.013, p = .911	F(1, 18) =.393, p = .539
Profession*Scene	F(1, 18) =3.42, p = .081	F(1, 18) =2.34, p = .143	F(1, 18) =4.02, p = .060
Control x Increased Texture			
Scene	F(1, 17) =3.44, p = .081	F(1, 17) =6.45, p = .021, $\eta^2 p = .275$	F(1, 17) =1.56, p = .229
Profession	F(1, 17) =.480, p = .498	F(1, 17) =.064, p = .804	F(1, 17) =.090, p = .767
Profession*Scene	F(1, 17) =.153, p = .700	F(1, 17) =3.92, p = .064	F(1, 17) =2.31, p = .147
Control x Decreased Texture			
Scene	F(1, 18) =3.69, p = .071	F(1, 18) =2.66, p = .120	F(1, 18) =1.92, p = .182
Profession	F(1, 18) =3.72, p = .069	F(1, 18) =.961, p = .340	F(1, 18) =1.12, p = .303
Profession*Scene	F(1, 18) =3.01, p = .100	F(1, 18) =6.03, p = .024, $\eta^2 p = .251$	F(1, 18) =4.22, p = .055
Control x Increased Height			
Scene	F(1, 18) =1.14, p = .299	F(1, 18) =2.27, p = .149	F(1, 18) =.196, p = .663
Profession	F(1, 18) =4.71, p = .043, $\eta^2 p = .208$	F(1, 18) =.176, p = .680	F(1, 18) =.958, p = .341
Profession*Scene	F(1, 18) =3.42, p = .081	F(1, 18) =.517, p = .481	F(1, 18) =.020, p = .889

5.2.6. Discussion

This study demonstrated that interior architectural elements had a relatively minor impact on individuals' spatial perception within a habitat. Compared to the interior architectural elements, design training was a more substantial influencer in all spatial evaluations. As illustrated in Table 12 and Table 13, furniture, lighting, and texture exhibited statistically significant effects on spaciousness and aesthetic judgements; however, design training was still a substantial moderator of these effects.

Table 12. Summary of SCS and Relative Error in Estimated Dimension Findings.

	Spaciousness and Crampedness Scale							Relative Error in Estimated Dimensions		
	Spaciousness			Crampedness						
	Appeal (SF1)	Planning (SF2)	Space Freedom (SF3)	Planning (CF1)	Physical Space (CF2)	Clutteredness (CF3)	Appeal (CF4)	Length	Width	Height
Over Furnished	Blue		Orange		Orange	Orange				
Increased Illuminance	Blue		Blue		Blue			Green		
Decreased Illuminance	Orange	Orange			Blue				Green	
Increased Texture				Blue	Blue			Green		
Decreased Texture		Green	Blue	Green				Orange		
Increased Height										
Decreased Height										
	Orange	Interaction Effect Design Training x Scene Type		Green	Main Effect—Scene Type		Blue	Main Effect—Design Training		

Table 13. Summary of Aesthetic and Emotional Evaluation Findings

	Aesthetic and Emotional Evaluations		
	Familiarity	Excitement	Fascination
Over Furnished			
Increased Illuminance			
Decreased Illuminance			
Increased Texture			
Decreased Texture			
Increased Height			
Decreased height			

In terms of furniture, noteworthy distinctions were observed in the assessments of participants with design training compared to those without. NDT participants assigned higher SCS scores to the over-furnished scene. In contrast, DT participants exhibited the opposing tendency, indicating that design training may cause participants to become more sensitive to the impact of excessive furniture and perceive it negatively in the context of spaciousness. Contrarily, those without design training may exhibit a higher tolerance for or even a preference for cluttered environments. The length estimations of the scene exhibited substantial variations between the two groups. NDT participants perceived the habitat to be shorter when it was over-furnished. In contrast, increasing the furniture amount increased the accuracy of length estimations for DT participants. Consistent with von Castel et al.'s (2014) breakdown, the over-furnished scene was reported as having a taller ceiling. However, this difference was only noticeable in DT participants and too slight to achieve statistical significance with the existing sample size. DT participants demonstrated lower estimation errors compared to their NDT counterparts.

In terms of aesthetic and emotional evaluations, both participant groups assigned higher familiarity scores to the over-furnished scene compared to the control. However, the increase in NDT participants' familiarity scores was more substantial. This difference may indicate that the elevated sense of familiarity among NDT participants might further correlate with their spatial perception. Additional analysis uncovered a strong positive correlation between physical space (CF2) evaluations of the over-furnished scene [$r = .743$, $n=9$, $p=.022$] and the familiarity ratings of all participants.

Observations revealed that a reduction in illumination levels had a noticeable impact on participants' responses to the SCS, noticeable in the Appeal (SF1) and Planning (SF2) factors. Much like the results for the over-furnished scene, DT and NDT participants displayed significant dissimilarities in their evaluations. Furthermore, familiarity evaluations displayed robust positive correlations with Appeal (SF1) [$r=.647$, $p=.043$] and Planning (CF2) [$r=.815$, $p=.004$] scores regardless of design training. The habitat was perceived to be wider when illumination levels were decreased, and this trend remained consistent among both groups. Likewise, DT participants maintained a higher accuracy level in their size estimations. On the other hand, increasing illumination led to a significant increase in the accuracy of length estimations for both groups while maintaining similar responses to SCS and aesthetic evaluations. Texture changes demonstrated similar results to illumination levels. Eliminating texture affected both planning factors of SCS evaluations. Both groups demonstrated the effects, indicating that texture may be a more versatile tool for manipulating spaciousness in ICE environments. Moreover, either change in surface texture density strongly impacted length estimations. The increased texture was the main effect of relative error; the same effect was modulated by design training in the decreased texture scene.

The results of this experiment suggest that familiarity may be a pivotal characteristic in shaping spatial perception of the environment. The observations on familiarity are consistent with the conclusions of Elver Boz et al. (2022); regardless, design training is influential in moderating this outcome. A deeper understanding of the correlations and causation between spaciousness and familiarity in ICE environments could be uncovered through further research.

The next chapter summarizes the findings concerning how the well-being of individuals in ICE environments is affected by the design of interior spaces. The chapter highlights the implications of these findings for designers and architects, advocating for more comfortable and functional spaces to promote psychological well-being in ICE environments. It also acknowledges the limitations and recommends future research using electroencephalography to understand the neural correlates of perceived spaciousness on cognition, ultimately informing interventions and treatments for those in high-stress environments.

CHAPTER VI

CONCLUSION

Three experiments were conducted to investigate the influence of perceived spaciousness on psychological well-being within ICE environments and to examine the role of different interior architectural elements. The first experiment explored the built environment's impact on occupants' well-being during COVID-19 lockdowns. A web-based questionnaire identified four crucial factors for further exploration: Airiness, Furniture and Clutter, Visual Variety, and Volume. It was discovered that Airiness, Visual Variety, and Volume were linked to psychological well-being. Participants who found their indoor spaces attractive, spacious, and well-connected to the outdoors reported fewer symptoms of boredom, psychological distress, and anxiety.

The second experiment aimed to illuminate the elements impacting the spaciousness of ICE environments. It involved an evaluation of three simulated habitats by fourteen design professionals and identifying critical contributors to positive and negative changes in spaciousness measured by the Spaciousness and Crampedness Scale. Results indicated that lighting, texture, geometry, and color greatly affected perceived spaciousness. Notably, habitats with higher ceilings and abundant light were perceived as more spacious than habitats with greater area but lacking in effective use of color and texture.

The findings from the first two experiments were combined in the third experiment to investigate how interior architectural elements affect spaciousness in ICE environments. This experiment revealed that a design background and familiarity with the environment shaped their perception of spaciousness when it was over-furnished, inadequately illuminated, or absent of texture. Additionally, the experiment demonstrated that several elements influenced participants' accuracy in size estimations. The experiment concluded that interior architectural elements can profoundly impact spaciousness perception in ICE environments, and design training

and familiarity are pivotal factors in this perception. Nonetheless, it emphasized the need for further research to establish causal relationships between appraisals of familiarity and spaciousness and to pinpoint the specific elements that significantly affect measurements of spaciousness.

6.1. Implications of Findings on Interior Architectural Design Process

Overall, the experiments discussed in this report suggest that interior architectural elements greatly influence the psychological well-being and perception of spaciousness. In particular, the studies highlight the importance of visual variety, airiness, and volume in creating a positive and spacious environment for individuals in ICE environments. Furthermore, the impact of design training is highlighted by its moderation on spaciousness and familiarity evaluations. These findings highlight the need for more nuanced evaluations of interior environments in ICE situations and provide valuable insights for designers and architects.

By incorporating these insights into their designs, they can create more comfortable and functional interior spaces that promote better mental health and well-being. Additionally, advanced immersive viewing technologies have the potential to deliver more precise data and comprehensive insights into how occupants perceive spaciousness across a diverse range of environments. This, in turn, can contribute to developing enhanced design solutions for challenging situations.

6.2. Limitations of the Study

This thesis has several limitations to consider. Regarding the initial experiment, it is essential to acknowledge that numerous intractable inner and outer variables affect the mental conditions discussed. The changes in isolation periods and the frequency of outings introduce a degree of uncertainty in the results dependability and interpretability, highlighting the experiment's consequential constraints. Due to this, the surveyed results may be less prevailing or even non-existent in numerous scenarios. Given the participants' personal experiences, prospective investigations should aim to evaluate these conditions with immaculate acuity.

It is essential to acknowledge that the exploratory analysis in Chapter IV specifically investigated the impact of interior environments on anxiety, psychological distress, and boredom. Nevertheless, these mental states are shaped by many internal and external factors, frequently beyond one's control. Factors such as variations in the duration of isolation and the frequency of outdoor excursions introduced additional complexity to the data, underscoring a limitation of this research. Consequently, while this study offers valuable insights into the potential influence of interior design, it is crucial to recognize that the observed effects may vary or not be applicable in all circumstances.

Due to the subjective nature of individuals' experiences, future research endeavors should strive for more precise and nuanced measurements of these mental states. Investigating aspects such as place attachment may provide valuable insights into living under comparable conditions. While the extensive lockdowns during the pandemic were exceptional, the findings may have broader relevance, particularly in other instances of isolation and confinement. Subsequent research and studies will be indispensable in establishing more definitive and generalizable outcomes. Likewise, a noteworthy limitation surfaced as the study unfolded was the influence of participants' familiarity with the environment and its connection to the perception of spaciousness. The experiences of participants subjected to lockdown within familiar surroundings may differ from those in unfamiliar environments. This substantial variance significantly restricts the generalizability of the analysis.

Also, 'place attachment' was a worthwhile pointer that was not included in the scope of the experiment but may prove to be a fruitful exploration in the future, particularly when examining living conditions under comparable circumstances. Further examinations and analysis will be necessary for more definitive outcomes and results relevant to a wider spectrum of scenarios.

In the final experiment, several limitations need consideration. First, the sample size could be bigger, which raises concerns about the representativeness of the findings for the general population. The study was limited to participants who were available and willing to participate, potentially introducing bias into the sample. Furthermore, the study only examined a limited number of factors that could impact the perception of

spaciousness in ICE environments. Factors such as color, materials, and openings were not investigated, leaving their potential influence on participants' perceptions unknown.

Additionally, this experiment focused exclusively on one type of ICE environment, specifically virtual representations of analogous environments. Therefore, the findings may not apply to other types of ICE environments. The study did not control for participants' prior experiences with virtual reality technology, which might have influenced their evaluations of spaciousness in the virtual environment.

Finally, the study did not explore the long-term effects of exposure to ICE environments on participants' perceptions of spaciousness. It remains unclear whether repeated exposure to ICE environments can lead to habituation or desensitization regarding perceived spaciousness.

6.3. Suggestions for Future Studies

Building on previous experiments, further studies could explore the impact of perceived spaciousness on psychological well-being in virtual environments. One proposed approach involves incorporating electroencephalography (EEG) to investigate the neural correlates of participants' responses. Advanced signal processing techniques can analyze EEG data to develop predictive models for stress levels, cognitive workload, and task performance. Machine learning algorithms could be trained on this data, enabling predictions about the impact of perceived spaciousness on psychological well-being and functioning in real-world scenarios. This research could inform interventions and treatments for individuals exposed to high-stress environments, such as long-term isolation and confinement.

However, it is important to acknowledge some limitations. EEG has limitations and may not detect subtle changes in response to virtual environments. Small sample sizes could limit the generalizability of findings, and it is worth noting that the study focuses solely on perceived spaciousness, without accounting for other factors that affect well-being in isolated and confined environments, such as social isolation and lack of privacy.

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APPENDICES

Appendix A: Understanding Perception Under Quarantine

1. Age: _____

2. Gender

☐ Female ☐ Male ☐ Prefer not to say ☐ Other:

3. What is your highest level of education?

☐ Secondary education (high school)

☐ Undergraduate university education

☐ Postgraduate education (masters or doctorate)

4. How many members are present in your household including yourself? _____

5. How many days have you been living under quarantine? _____

6. Are you working from home on a day to day basis?

☐ Yes ☐ No

7. How often (if at all) do you go out for necessities? (Groceries etc.) _____

Please take into consideration the room you spend the most time in when you are under quarantine while answering the next set of questions:

1. My room feels spacious

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

2. How big is the room you are currently staying in?

☐ Very Big (50+ Square Meters)

☐ Big (30-49 Square Meters)

☐ Medium (20-29 Square Meters)

☐ Small (10-19 Square Meters)

☐ Very Small (5-9 Square Meters)

3. My room receives plenty of natural light

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

4. My room has lightly colored walls.

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

5. There are similar colors (tones) on surfaces and furniture.

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

6. My room has large windows.

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

7. My room has direct access to the outdoors. (private balcony, porch, etc.)

☐ Yes ☐ No

8. There are plenty of natural objects in my room (Plants, flowers, etc.)

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

9. There are surfaces with natural materials in my room (wood grain etc.)

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

10. There are patterned surfaces in my room.

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

11. There mirrors in my room

0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

12. My room's ceiling is...

☐ Very high (4+ meters)

☐ High (3-4 meters)

☐ Standard (2.7 - 3 meters)

☐ Low (2.4 - 2.7 meters)

☐ Very low (less than 2.4 meters)

13. There are lamps in the room.

0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐

14. There is a lot of furniture in my room

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

15. My room is cluttered most of the time.

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

16. I have large/heavy pieces of furniture in my room

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

17. My room is well lit during the night

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

18. I'm satisfied with the scenery outside my room

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

19. I find my room to be monotonous

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

20. I enjoy spending time in my room

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

21. I have a hard time keeping my room clean.

Strongly Disagree ☐ ☐ ☐ ☐ ☐ Strongly Agree

Appendix B: Free Time Boredom Scale

Rate the following items from 1 to 5 according to the extent to which you agree. A rating of "1" indicates that you strongly disagree and a rating of "5" indicates that you strongly agree.

During my free time...

1. _____ I feel that my surroundings are dull and "blah".
2. _____ I tend to be busy with meaningless things.
3. _____ I am without focus.
4. _____ I feel excited.
5. _____ New ideas are stimulated.
6. _____ I have a variety of places to go to.
7. _____ I usually have something to do.
8. _____ I feel empty.
9. _____ I am provided with many experiences.
10. _____ It seems like I am wasting my time.
11. _____ I want it to last longer.
12. _____ The time flies while I'm in my room.
13. _____ I wish I had more of it.
14. _____ It feels that time stands still.
15. _____ My physical abilities are challenged.
16. _____ I enjoy getting my body built up.
17. _____ I do not use a lot of my physical skills.
18. _____ I am physically energetic.
19. _____ I do things below my physical ability level.

Appendix C: Kessler Psychological Distress Scale (K10)

These questions concern how you have been feeling over the past 30 days. Tick a box below each question that best represents how you have been .

1. I often feel tired out for no good reason.

☐ None of the time ☐ A little of the time ☐ Some of the time ☐ Most of the time
☐ All of the time

2. I often feel nervous.

☐ None of the time ☐ A little of the time ☐ Some of the time ☐ Most of the time
☐ All of the time

3. I feel so nervous that nothing can calm me down.

☐ None of the time ☐ A little of the time ☐ Some of the time ☐ Most of the time
☐ All of the time

4. I often feel hopeless.

☐ None of the time ☐ A little of the time ☐ Some of the time ☐ Most of the time
☐ All of the time

5. I often feel restless or impatient.

☐ None of the time ☐ A little of the time ☐ Some of the time ☐ Most of the time
☐ All of the time

6. I feel so restless that I can not sit still.

☐ None of the time ☐ A little of the time ☐ Some of the time ☐ Most of the time
☐ All of the time

7. I often feel depressed.

☐ None of the time ☐ A little of the time ☐ Some of the time ☐ Most of the time
☐ All of the time

8. I often feel that everything is an effort.

☐ None of the time ☐ A little of the time ☐ Some of the time ☐ Most of the time
☐ All of the time

9. I often feel so sad that nothing can cheer me up.

☐ None of the time ☐ A little of the time ☐ Some of the time ☐ Most of the time
☐ All of the time

10. I often feel worthless.

☐ None of the time ☐ A little of the time ☐ Some of the time ☐ Most of the time
☐ All of the time

Appendix D: The Generalized Anxiety Disorder 7 (GAD-7)

Over the last two weeks, how often have you been bothered by the following problems?

1. Feeling nervous, anxious, or on edge.
☐ Not at all ☐ Several days ☐ Over half the days ☐ Over half the days
2. Not being able to stop or control worrying.
☐ Not at all ☐ Several days ☐ Over half the days ☐ Over half the days
3. Worrying too much about different things.
☐ Not at all ☐ Several days ☐ Over half the days ☐ Over half the days
4. Trouble relaxing.
☐ Not at all ☐ Several days ☐ Over half the days ☐ Over half the days
5. Being so restless that it's hard to sit still.
☐ Not at all ☐ Several days ☐ Over half the days ☐ Over half the days
6. Becoming easily annoyed or irritable.
☐ Not at all ☐ Several days ☐ Over half the days ☐ Over half the days
7. Feeling afraid as if something awful might happen.
☐ Not at all ☐ Several days ☐ Over half the days ☐ Over half the days

Appendix E: Spaciousness and Crampedness Scale

Please evaluate the environment you are provided with using the list below. The list consists of 19 adjective pairs alongside 7 boxes in between them. Please select one for each adjective pair, and do not leave any blanks.

	Very	A lot	Somewhat	Undecided	Somewhat	A lot	Very	
Cluttered	☐	☐	☐	☐	☐	☐	☐	Uncluttered
Well Planned	☐	☐	☐	☐	☐	☐	☐	Poorly Planned
Tiny	☐	☐	☐	☐	☐	☐	☐	Huge
Inviting	☐	☐	☐	☐	☐	☐	☐	Repelling
Inadequate Size	☐	☐	☐	☐	☐	☐	☐	Adequate Size
Poorly Balanced	☐	☐	☐	☐	☐	☐	☐	Well Balanced
Uncoordinated	☐	☐	☐	☐	☐	☐	☐	Coordinated
Large	☐	☐	☐	☐	☐	☐	☐	Small
Livable	☐	☐	☐	☐	☐	☐	☐	Unlivable
Narrow	☐	☐	☐	☐	☐	☐	☐	Wide
Poorly Organized	☐	☐	☐	☐	☐	☐	☐	Well Organized
Closed	☐	☐	☐	☐	☐	☐	☐	Open
Empty	☐	☐	☐	☐	☐	☐	☐	Full
Restful	☐	☐	☐	☐	☐	☐	☐	Disturbing
Uncomfortable	☐	☐	☐	☐	☐	☐	☐	Comfortable
Roomy	☐	☐	☐	☐	☐	☐	☐	Cramped
Uncrowded	☐	☐	☐	☐	☐	☐	☐	Crowded
Well Scaled	☐	☐	☐	☐	☐	☐	☐	Poorly Scaled
Restricted Space	☐	☐	☐	☐	☐	☐	☐	Free Space

Appendix F: The Spatial Presence Experience Scale (SPES)

1. I felt like I was actually there in the environment of the presentation (SL1).

I do not agree at all ☐ ☐ ☐ ☐ ☐ I totally agree

2. It seemed as though I actually took part in the action of the presentation (SL2).

I do not agree at all ☐ ☐ ☐ ☐ ☐ I totally agree

3. It was as though my true location had shifted into the environment in the presentation (SL3).

I do not agree at all ☐ ☐ ☐ ☐ ☐ I totally agree

4. I felt as though I was physically present in the environment of the presentation (SL4).

I do not agree at all ☐ ☐ ☐ ☐ ☐ I totally agree

5. The objects in the presentation gave me the feeling that I could do things with them (PA1).

I do not agree at all ☐ ☐ ☐ ☐ ☐ I totally agree

6. I had the impression that I could be active in the environment of the presentation (PA2).

I do not agree at all ☐ ☐ ☐ ☐ ☐ I totally agree

7. I felt like I could move around among the objects in the presentation (PA3).

I do not agree at all ☐ ☐ ☐ ☐ ☐ I totally agree

8. It seemed to me that I could do whatever I wanted in the environment of the presentation (PA4).

I do not agree at all ☐ ☐ ☐ ☐ ☐ I totally agree

Appendix G: Emotional and Aesthetic Evaluation

How does this architectural environment look?

Sleepy	☐	☐	☐	☐	☐	Arousing
Unpleasant	☐	☐	☐	☐	☐	Pleasant
Gloomy	☐	☐	☐	☐	☐	Exciting
Distressing	☐	☐	☐	☐	☐	Relaxing
Simple	☐	☐	☐	☐	☐	Complex
Incoherent	☐	☐	☐	☐	☐	Coherent
Unsafe	☐	☐	☐	☐	☐	Safe
Not Mysterious	☐	☐	☐	☐	☐	Mysterious
Masculine	☐	☐	☐	☐	☐	Feminine

How does this architectural environment make you feel?

Annoyed	☐	☐	☐	☐	☐	Pleased
Unhappy	☐	☐	☐	☐	☐	Happy
Bored	☐	☐	☐	☐	☐	Relaxed
Unsatisfied	☐	☐	☐	☐	☐	Satisfied
Melancholic	☐	☐	☐	☐	☐	Contented
Despairing	☐	☐	☐	☐	☐	Hopeful
Unaroused	☐	☐	☐	☐	☐	Aroused
Calm	☐	☐	☐	☐	☐	Excited
Sluggish	☐	☐	☐	☐	☐	Frenzied
Dull	☐	☐	☐	☐	☐	Jittery
Sleepy	☐	☐	☐	☐	☐	Wideawake
Relaxed	☐	☐	☐	☐	☐	Stimulated

How much would you prefer to live this place?

Never	☐	☐	☐	☐	☐	Very much
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How much time would like to spend in this space?

Never	☐	☐	☐	☐	☐	Very much
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How much would you enjoy exploring this space?

Never	☐	☐	☐	☐	☐	Very much
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To what extend does this place make you feel friendly and talkative to a stranger who happens to be near you?

Never	☐	☐	☐	☐	☐	Very much
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Appendix H



Bilkent Üniversitesi

Akademik İşler Rektör Yardımcılığı

Tarih : 24 Mayıs 2021

Gönderilen : Berk Diker

Tez Danışmanı : Halime Demirkan

Gönderen : H. Altay Güvenir
İnsan Araştırmaları Etik Kurulu Başkanı

Konu : “*Stress, anxiety, ...*” çalışması etik kurul onayı

Üniversitemiz İnsan Araştırmaları Etik Kurulu, 24 Mayıs 2021 tarihli görüşme sonucu, “*Stress, anxiety, boredom, and their relation to the interior environment under quarantine*” isimli çalışmanız kapsamında yapmayı önerdiğiniz etkinlik için etik onay vermiş bulunmaktadır. Onay, ekte verilmiş olan çalışma önerisi, çalışma yürütücüleri ve bilgilendirme formu için geçerlidir.

Bu onay, yapmayı önerdiğiniz çalışmanın genel bilim etiği açısından bir değerlendirmedir. Çalışmanızda, kurumumuzun değerlendirmesi dışında kalabilen özel etik ve yasal sınırlamalara uymakla ayrıca yükümlü olursunuz.

Kovid-19 salgını nedeniyle konulmuş olan kısıtlamaların yürürlükte olduğu süre içinde, tüm komite toplantıları elektronik ortamda yapılmaktadır; aşağıda isimleri bulunan Bilkent Üniversitesi Etik Kurulu Üyeleri adına bu yazıyı imzalama yetkisi kurul başkanındadır.

Etik Kurul Üyeleri:

Ünvan / İsim	Bölüm / Uzmanlık	
Prof.Dr. H. Altay Güvenir	Bilgisayar Mühendisliği	Başkan
Prof.Dr. Erdal Onar	Hukuk	Üye
Prof.Dr. Haldun Özakaş	Elektrik ve Elektronik Müh.	Üye
Doç.Dr. Işık Yuluğ	Moleküler Biyoloji ve Genetik	Üye
Dr. Öğr. Üyesi Burcu Ayşen Ürgen	Psikoloji	Üye
Doç.Dr. Çiğdem Gündüz Demir	Bilgisayar Mühendisliği	Yedek Üye
Dr. Öğr. Üyesi A.Bariş Özbilen	Hukuk	Yedek Üye

Kurul karar/toplantı No: 2021_05_24_02

Appendix I



Bilkent Üniversitesi

Akademik İşler Rektör Yardımcılığı

Tarih : 8 Mayıs 2022

Gönderilen : Berk Diker

Tez Danışmanı : Halime Demirkan

Gönderen : H. Altay Güvenir
İnsan Araştırmaları Etik Kurulu Başkanı

Konu : "Evaluation of ..." çalışması etik kurul onayı

Üniversitemiz İnsan Araştırmaları Etik Kurulu, 8 Mayıs 2022 tarihli görüşme sonucu, "Evaluation of Spaciousness in Virtually Simulated Isolated and Confined Environments (ICE)" isimli çalışmanız kapsamında yapmayı önerdiğiniz etkinlik için etik onay vermiş bulunmaktadır. Onay, ekte verilmiş olan çalışma önerisi, çalışma yürütücüler ve bilgilendirme formu için geçerlidir.

Bu onay, yapmayı önerdiğiniz çalışmanın genel bilim etiği açısından bir değerlendirmedir. Çalışmanızda, kurumumuzun değerlendirmesi dışında kalabilen özel etik ve yasal sınırlamalara uymakla ayrıca yükümlüsünüz.

Kovid-19 salgını nedeniyle konulmuş olan kısıtlamaların yürürlükte olduğu süre içinde, tüm komite toplantıları elektronik ortamda yapılmaktadır; aşağıda isimleri bulunan Bilkent Üniversitesi Etik Kurulu Üyeleri adına bu yazıyı imzalama yetkisi kurul başkanındadır.

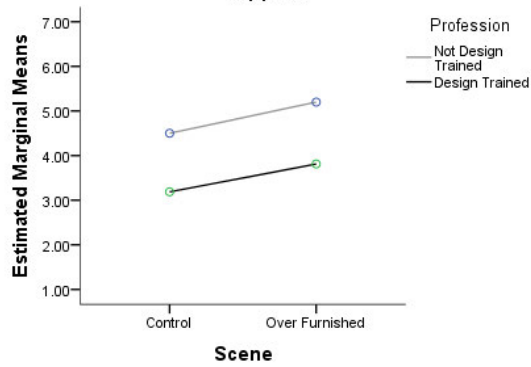
Etik Kurul Üyeleri:

Ünvan / İsim	Bölüm / Uzmanlık	
Prof.Dr. H. Altay Güvenir	Bilgisayar Mühendisliği	Başkan
Prof.Dr. Erdal Onar	Hukuk	Üye
Prof.Dr. Haldun Özaktaş	Elektrik ve Elektronik Müh.	Üye
Doç.Dr. Işık Yuluğ	Moleküler Biyoloji ve Genetik	Üye
Dr. Öğr. Üyesi Burcu Ayşen Ürgen	Psikoloji	Üye
Dr. Öğr. Üyesi Didem Özkul McGeoch	İletişim ve Tasarımı	Yedek Üye
Dr. Öğr. Üyesi A.Barış Özbilen	Hukuk	Yedek Üye

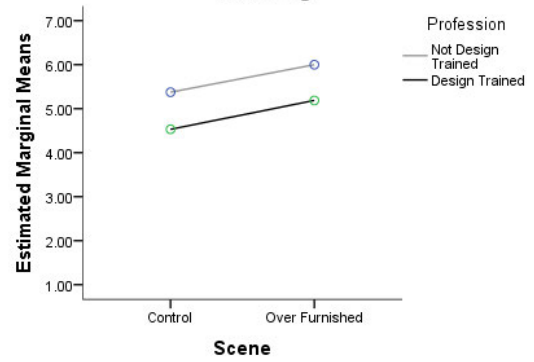
Kurul karar/toplantı No: 2022_05_08_01

Appendix J

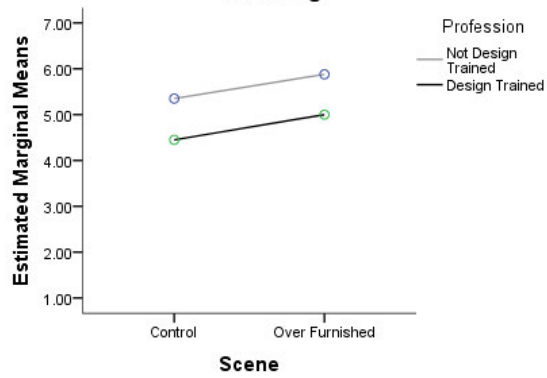
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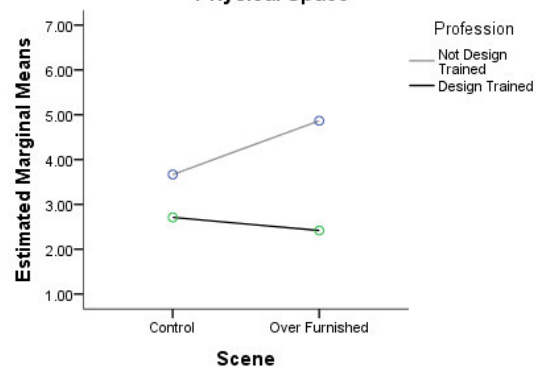
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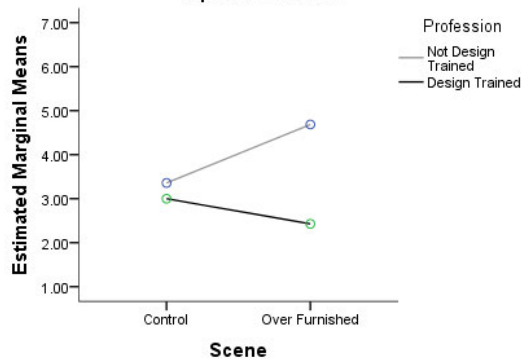
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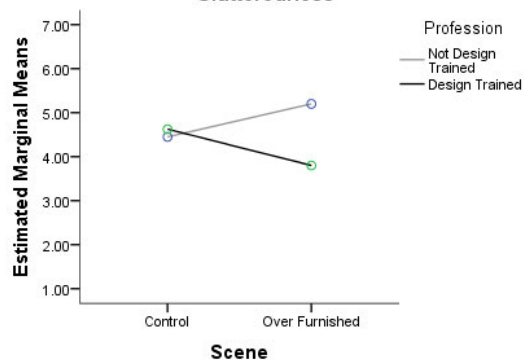
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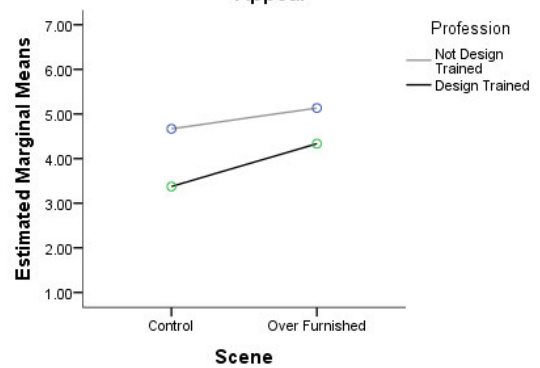
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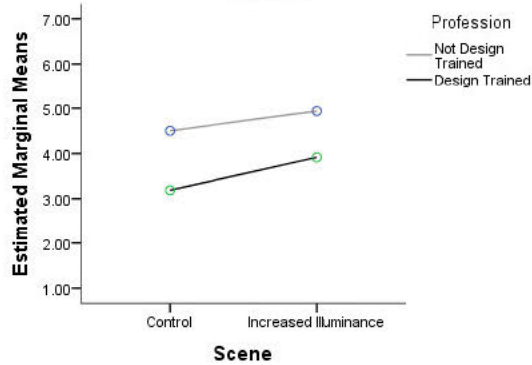
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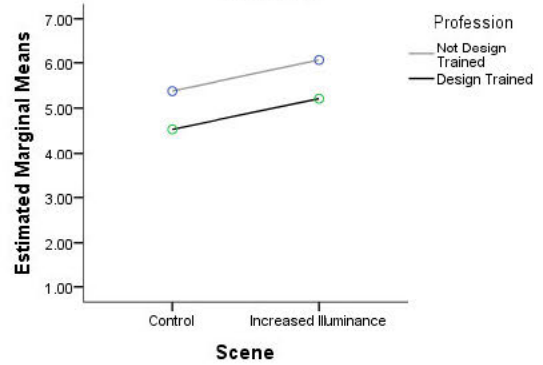
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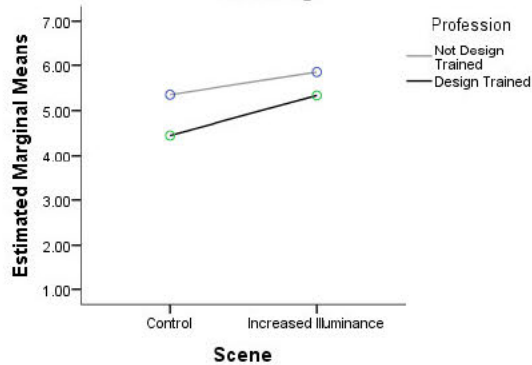
**Estimated Marginal Means of Spaciousness Factor:
Appeal**



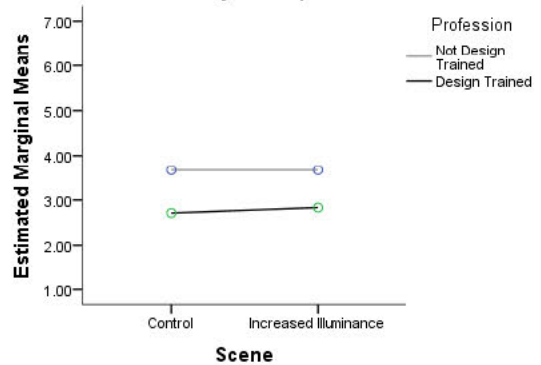
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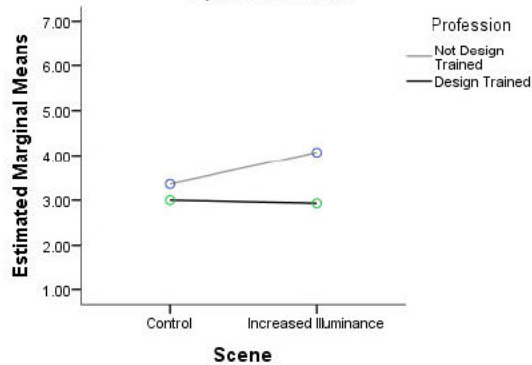
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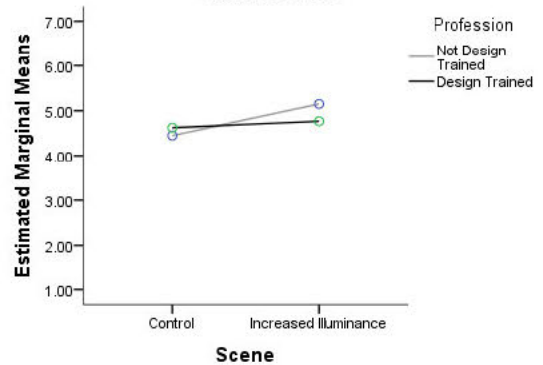
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Physical Space**



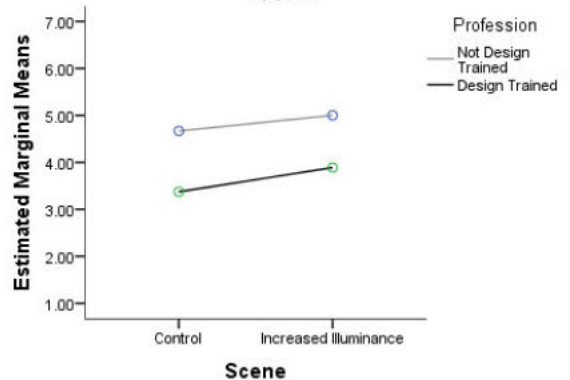
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Space Freedom**



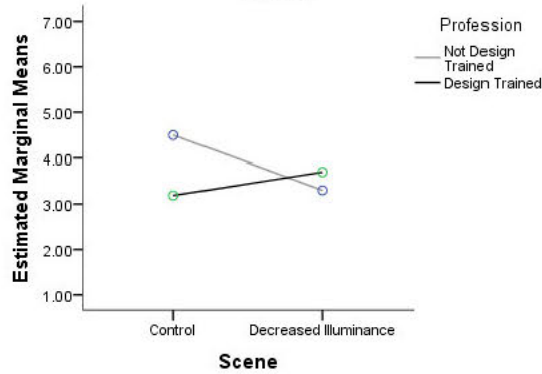
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Clutteredness**



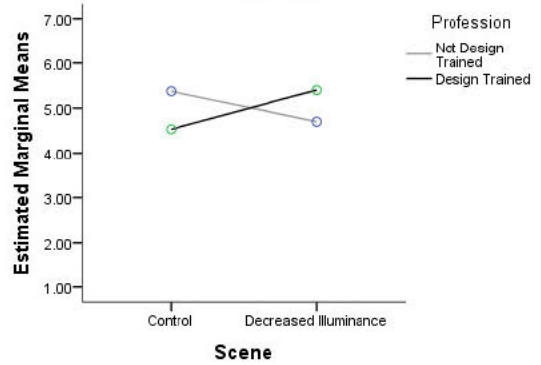
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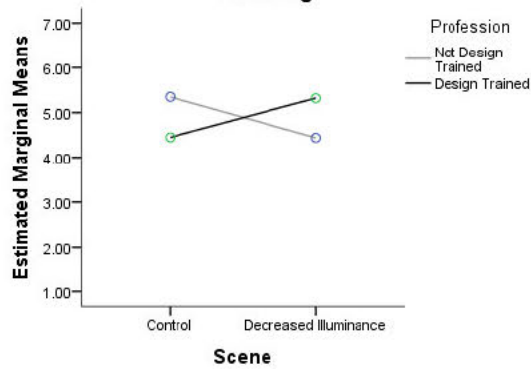
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Appeal**



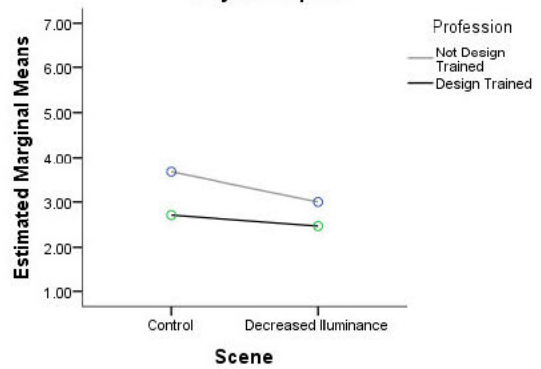
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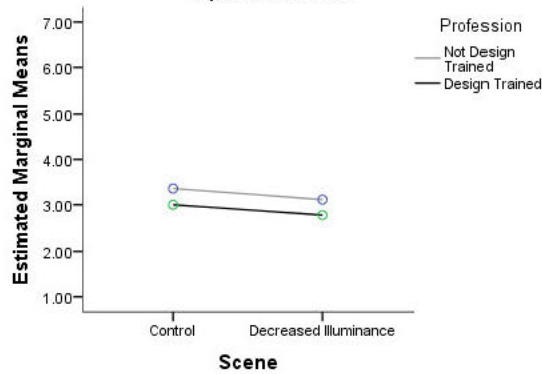
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Planning**



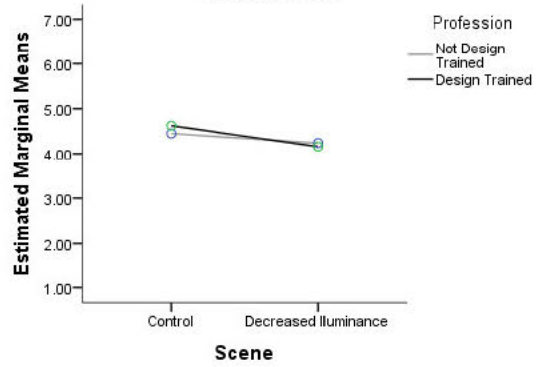
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Physical Space**



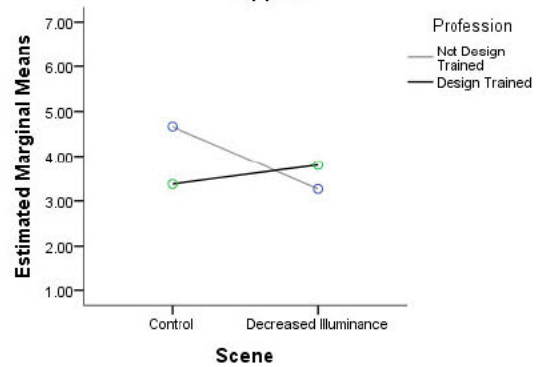
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Space Freedom**



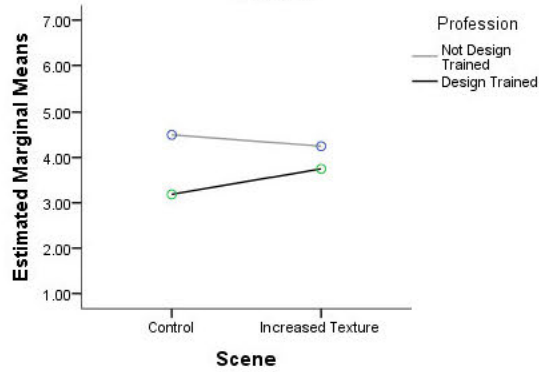
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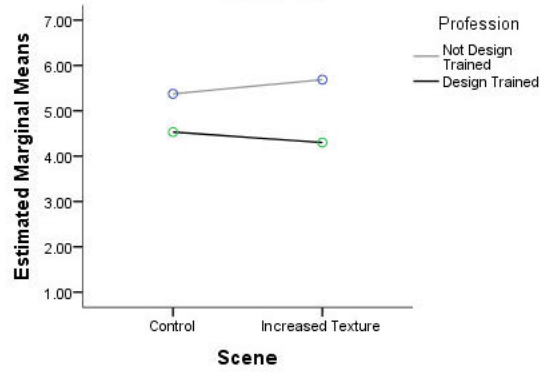
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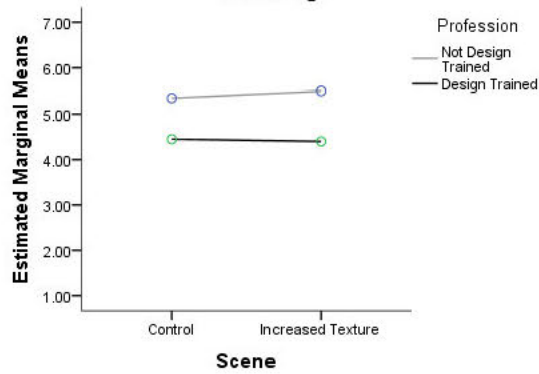
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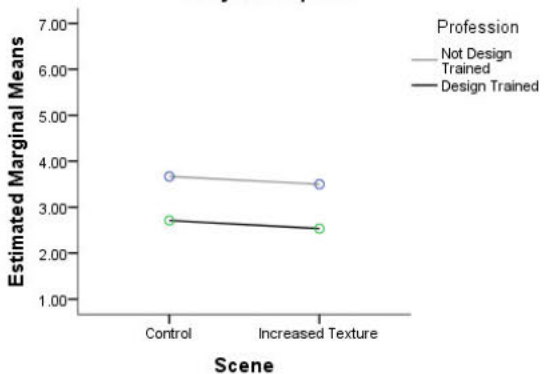
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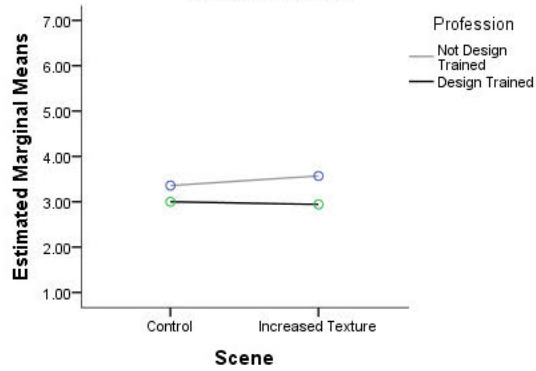
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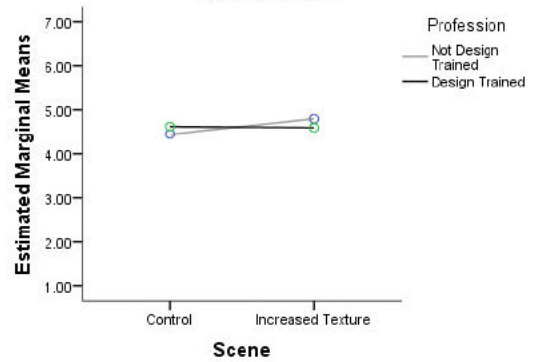
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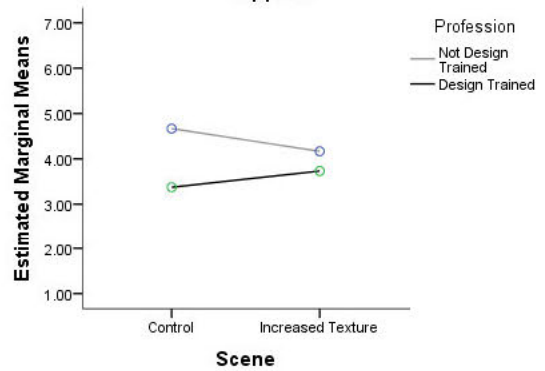
Estimated Marginal Means of Spaciousness Factor: Space Freedom



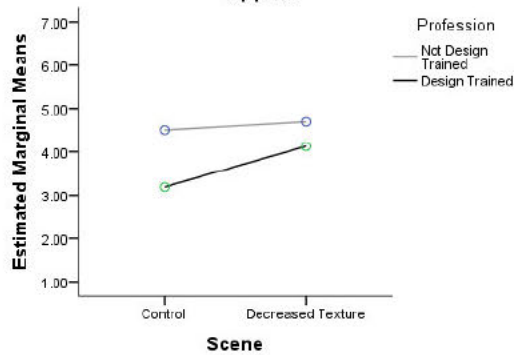
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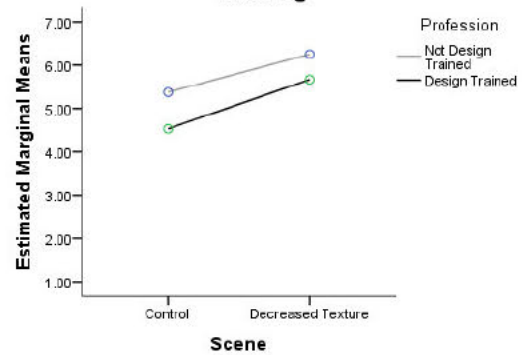
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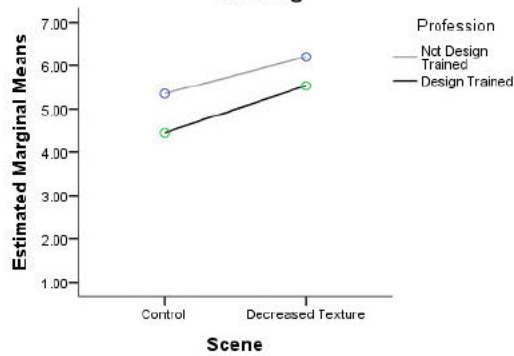
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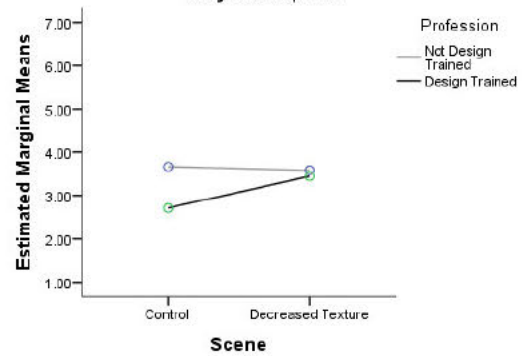
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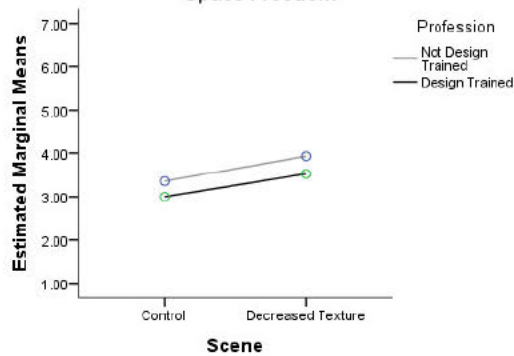
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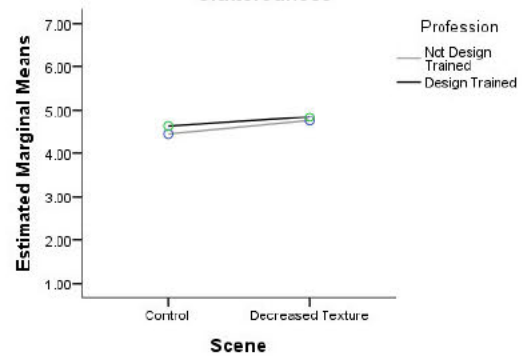
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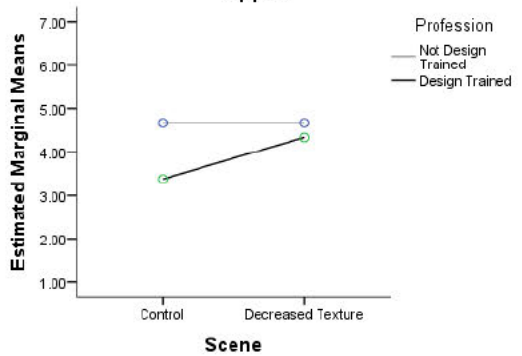
**Estimated Marginal Means of Spaciousness Factor:
Space Freedom**



**Estimated Marginal Means of Crampedness Factor:
Clutteredness**



**Estimated Marginal Means of Crampedness Factor:
Appeal**



Appendix K

