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THE NEUROARCHITECTURE OF AIRPORT DESIGN: A STUDY FOCUSED ON TRAVELER WELL-BEING, BEHAVIOR, AND COMFORT AT GATES' WAITING AREAS

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THE NEUROARCHITECTURE OF AIRPORT DESIGN: A STUDY FOCUSED ON TRAVELER WELL-BEING, BEHAVIOR, AND COMFORT AT GATES' WAITING AREAS

A THESIS APPROVED FOR THE
CHRISTOPHER C. GIBBS COLLEGE OF ARCHITECTURE

BY THE COMMITTEE CONSISTING OF

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DEDICATION

So many people supported me during my academic and professional journey.

I first dedicate this to my father, who won't be able to see me as a Master of Interior Design but always supported and believed in me. You were the first person to teach me English, and today, I am able to write a master's thesis in my second language. You put my needs before yours, helping me reach where I am today. You are in the arms of the Father now, and I carry you in my heart.

My loving mother, our companionship is one of my biggest blessings. You supported me and my dreams, even though that meant being away from your daughter. You were always so proud of me and believed in me, especially when I doubted myself. Thank you for being so strong for our family.

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TERMS AND DEFINITIONS

Holdroom: This term is mainly used by aviation designers and architects to describe the waiting areas located by airport gates. These spaces are designed to create a comfortable and convenient space for travelers while they wait for their flights.

Lounges and Clubs: Exclusive rooms located in airports, which are usually benefits granted by credit cards or airline companies to reward premium members. While some lounges and clubs are accessible only through membership programs, many can also be accessed by paying a daily fee – such as hub pay lounges. These spaces provide comfortable seating, relaxing zones, food and beverages, and sometimes showers.

Pain Point: Pain point is a "persistent or recurring problem that frequently inconveniences or annoys customers." (Merriam-Webster Dictionary). In information extracted from the AI tool used to facilitate qualitative analysis, the paint points highlighted which topics were mostly mentioned by online reviewers.

Sentiment: "A view of or attitude toward a situation or event; an opinion." (Oxford Dictionary). Sentiments are described in the circle charts and include the percentage of negative and positive comments.

Themes: Themes were recurring ideas that were recognized through both observations and online review analysis. This paper employed a thematic analysis method in order to investigate design elements that impacted travelers' experience in the airport environment, especially in holdrooms.

Traveler: The user of the space that the research focused on, also referred to as passengers by other researchers. Travelers in airports are in a transitional phase, and their journey from arrival to the gate can affect their mood and behavior.

Trend: "A general direction in which something is developing or changing." (Oxford Dictionary) While themes included the main topics that were mentioned by reviewers, trends display these topics by percentage in bar charts.

Wayfinding: Wayfinding is how humans navigate to reach their destination. In design and architecture, it refers to techniques used to make spaces easier to navigate. This includes using signs, layouts, landmarks, and lighting to guide users on their journey through a space.

ABSTRACT

This research investigates the connection between neuroarchitecture, and the design of airport gate waiting areas, aiming to understand traveler behavior and improve their well-being and comfort. The study examines how key environmental design factors affect travelers' behavior and emotional states, using neuroscience principles to reduce stress and increase cognitive ease. Focusing on sensory perception, managing cognitive load, and emotional regulation, the study aims to apply specific neuroarchitecture concepts to the airport environment, particularly within gate waiting areas. These concepts include brain function, schemas, cognitive maps, sympathetic and parasympathetic nervous systems, the environmental stressor theory, and neuroaesthetics**.** Special attention is given to the design of wayfinding systems, which are critical for improving navigation, reducing stress, and increasing overall travelers' satisfaction.

Employing a multi-method qualitative approach, the study incorporated a literature review, non-participant observations, design analysis, and an examination of online reviews from travelers across various airport contexts. Three airports were selected, considering geographical diversity and their relevance to business and leisure travelers. The airports are in Texas, Illinois, and California. The research also includes a comparative analysis of other terminals, airport lounges, and gate waiting areas to study how different environments influence travelers' comfort and behavior. Through these methods, this thesis identified patterns and design elements that are most impactful in reducing stress and promoting positive emotional responses in high-stress environments like airports. Four design elements stood out after the literature review and the comparison of the observations and online reviews' analysis outcomes: Wayfinding, Ceiling Height, Illumination, and Layout Complexity.

By aligning environmental design strategies with the principles of neuroarchitecture, this research offers empirical recommendations for creating human-centered airport environments. These recommendations aim to inform architects and designers about the most effective ways to enhance the traveler's experience, focusing particularly on reducing stress and improving well-being at airport gate waiting areas.

The study expands the application of neuroarchitecture to public, high-stress environments, providing a foundation for future research on the integration of neuroscience into architectural design practices. Further, the thesis' findings offer actionable insights for improving airport design, which can ultimately contribute to more efficient and enjoyable travel experiences. The results are also intended to support airport designers and other stakeholders in developing spaces that accommodate diverse traveler demographics and needs, ensuring that future airport designs are adaptable and inclusive.

Keywords: Neuroarchitecture, Airports, Holdroom, Gate Waiting Area, Brain Function, Wayfinding.

CHAPTER I: INTRODUCTION

Airports, as hubs of global connectivity, show how contemporary society is in constant movement. Surrounded by so many activities, such as check-ins and security checks, travelers encounter many stressors, including noise, crowding, and overstimulation. Factors like indoor air quality, ventilation, spatial solutions, thermal comfort, and acoustics influence these stressors. This influence is particularly pronounced at airport gate waiting areas, where travelers spend most of their time, since seating by the departure gates reduces the travelers' worry, especially when they have limited time before boarding, according to Boudreau et al. (2016).

Airport lounges emerge as spaces that try to mitigate the evident stress of the airport environment. Various aspects of airport lounges, such as amenities and services, technology and connectivity, crowd and noise management, and safety, enhance traveler comfort and well-being, as Chatterjee et al. (2023) mentioned. How do travelers' experiences differentiate in both spaces? Is it possible for the spaces by departure gates to be as accommodating as lounges? Using club lounges, as well as hub pay lounges, which charge a daily fee, is not always feasible, especially for non-business travelers, according to Boudreau et al. (2016). Traveling can already be expensive, and this extra comfort doesn't always fit within travelers' budgets. The waiting areas by departure gates thus become the focal points where most people are located.

The collaborative field of study bridging architecture and neuroscience, known as neuroarchitecture, offers valuable insights into optimizing built environments for human well-being and comfort. This approach examines how architectural design impacts human cognition and behavior. Ruggles (2017) states, "Humans have evolved sophisticated and automatic response mechanisms that tie our cellular biology to our surroundings" (p.12). By integrating research methods from both neuroscience and architecture, designers can better understand the complex

relationship between spatial design and neurological responses. This interdisciplinary integration contributes to the intentional creation of spaces that promote positive experiences and enhance satisfaction, ultimately improving human well-being and productivity.

Goldhagen (2017) affirms that spaces, whether landscapes or buildings, shape our cognitions, emotions, and actions. The author goes on to say that spaces powerfully influence our well-being. Goldhagen also highlights that positive emotions prolong life and improve its quality, making it imperative to delve deeper into the operations of the mind. In the past two decades, a vast amount of knowledge on this topic has emerged from the sciences and social sciences, even if not specifically focused on architecture. The author emphasizes that people's needs can only be met when the knowledge gained from past experiences and ongoing learning is incorporated into the design and composition process.

This thesis aims to examine travelers' experiences through the lens of neuroarchitecture. It will identify primary environmental factors and patterned behaviors and connect them to principles explored in neuroscience and architecture. The goal is to understand travelers' needs and develop a study highlighting design elements that can improve the travelers' experience and reduce stress. Concepts such as **brain function, schemas, cognitive maps, sympathetic and parasympathetic nervous systems, the environmental stressor theory, and neuroaesthetics** were considered for this study. The priority of this research, however, was to understand how objective points, such as cognition and perception, can be connected to the design elements in airport design. Neuroaesthetics, a more subjective field, will only be introduced without delving deeper into it.

The focus of this research is to explore possibilities in design that can enhance the traveler experience at airport gate waiting areas through the lens of neuroarchitecture and human-centered design. This paper aimed to uncover how these aspects impact travelers' comfort, behavior,

cognitive ease, and satisfaction by examining design factors, such as layout organization, wayfinding systems, and stress-reducing elements. This involved observing airports and connecting to online reviews in order to identify the most valued elements by travelers and create design recommendations that would cater to the airports' specific needs.

This introduction sets the stage for an exploration of neuroarchitecture in airport design, emphasizing the importance of understanding how design elements impact traveler well-being, behavior, and comfort. Through analyzing airport gate waiting areas, this thesis aims to contribute valuable insights to airport design and traveler experience optimization.

Background and Research Problem

This research used qualitative methods to achieve its objectives, chosen for their ability to provide insights into complex phenomena, capturing human behavior and subjective dynamics that are hard to quantify. While quantitative research is valued for its structured approach and statistical analysis, providing objective and generalizable data (Bienkowska & Sikorski, 2024), qualitative research offers different perspectives, uncovering patterns that reveal participants' viewpoints in a more personal way. (Bouncken, 2021).

Analyzing the complexity of the airport is essential to promote evidence-based design. The airport environment is fast-paced and hectic and involves many stressors. According to Kalakou and Moura (2021), the air passenger experience encompasses various activities, crucial to airports influencing people's behavior and satisfaction. The researchers studied how travelers choose activities in airport terminals to better understand their behavior.

Data was collected by Kalakou and Moura (2021) through a combination of revealed and stated preference surveys at the airport, in the area before the security checkpoint. Travelers were

asked about their preferences for different non-aeronautical activities both before and after the security area. The authors used logit models to estimate the influence of many factors on their preferences. The study's findings revealed that the percentage of travelers who checked in online and planned their activities in advance influenced a shift in preferences towards engaging in non-aeronautical activities before the security area. Besides that, the travelers' decisions were also affected by their travel frequency, with occasional travelers preferring to conduct activities only before the security checkpoint.

Topics such as indoor air quality and flow management are widely covered in airport studies. Temperature, ventilation, and air quality are considered ambient stressors; hence, it is essential to examine these topics. Hong and Lin (2019) conducted surveys and experiments on indoor air quality in an airport terminal in China. Li and Gao (2023) used algorithms to predict airport flow and travelers' behavior. Bandarian and Kordani (2022) applied simulations to explore design changes in baggage claim areas to improve efficiency and reduce crowding.

Studies focused on indoor environmental quality, as well as travelers' activities, could be identified in the literature. While the literature has analyzed various aspects of airport environments, there is still a need for a more in-depth exploration of travelers' behaviors and well-being at the gates' waiting areas. Chatterjee and Mandal (2020) researched travelers' preferences from online reviews, examining factors such as travel class, travel goals, and construal level theory influencing preferences and satisfaction. This approach was applied to the latter research to analyze the factors influencing traveler's satisfaction with airport lounges.

According to Chatterjee et al. (2023), their study was only focused on quantitative ratings, which showcases some limitations of their research. The authors emphasized that future research should focus on qualitative data retrieved from customer textual reviews to gain better insights

into travelers' preferences and opinions. Considering these limitations, there is a need to adopt an approach that incorporates qualitative data. While quantitative ratings provide a valuable understanding of the space, delving into qualitative data can offer a different perspective of it and a more personal portrait of travelers' experiences.

According to Bienkowska and Sikorski (2024), quantitative research collects and analyzes data numerically. They affirm that this method is highly valued; it relies on statistical tools to analyze data, which can lead to faster data interpretation. Bienkowska and Sikorski (2024) affirm that a quantitative approach provides structured and standardized results, which are easy to generalize and apply in different research. On the other hand, according to the authors, a qualitative approach focuses on understanding human experiences, behaviors, and motivations. It is an important approach to allow an exploration of complex social interactions. Bienkowska and Sikorski (2024) mention that there is an advocacy to integrate more qualitative research into academia to provide a holistic understanding of different research subjects.

In summary, exploring airports' waiting areas, human behavior, and neuroarchitecture reveals a complex interaction. While existing literature provides some insight, further research is needed to fully grasp the dynamics of the gate waiting areas. As air travel evolves and traveler expectations increase, adopting a multidisciplinary approach that includes qualitative methods becomes valuable for understanding travelers' needs through their personal airport experiences. This approach can lead to the design of airport waiting environments that not only mitigate travel stress but also enhance well-being, satisfaction, and a positive sense of place for diverse ranges of travelers.

Research Goal, Objectives, and Research Questions

This research focuses on proposing solutions to enhance airport gate waiting areas through neuroarchitecture and human-centered design. It examines layout, wayfinding, and stress reduction to improve traveler comfort and satisfaction. The study includes literature reviews, airport observations, and online review analysis to create tailored design recommendations.

The primary goal of this study is to identify key environmental factors that designers should prioritize to enhance travelers' experiences and minimize stress at airport gates. The study also explored how the principles of neuroarchitecture can be applied to airport spaces, with a specific focus on travelers' well-being, behavior, and comfort at the airport gates' waiting areas. This research aimed to identify the critical design elements that contribute to positive traveler experiences, despite the stressors inherent to the airport environment. By understanding these elements, the study seeks to inform the development of effective, human-centered, and evidence-based design strategies that enhance the overall travel experience.

The study aimed to find answers to the following research questions:

1. What key environmental design factors in airport gate waiting areas most effectively enhance travelers' experiences from the perspective of the travelers themselves?
2. How do these design factors align with neuroscience principles to reduce stress and improve well-being in airport gate waiting areas?
3. How can the design of wayfinding systems by airport gate areas improve traveler navigation and overall satisfaction, particularly in reducing stress and enhancing cognitive ease?

To answer the above-mentioned research questions, below are the key objectives of this study.

- Understanding traveler experiences in airport spaces through qualitative analysis.
- Numbering the four most important environmental elements travelers cite in online reviews.
- Listing human-centered design strategies that enhance the overall travel experience through the well-being, behavior, and comfort of travelers in the gate waiting areas.
- Exploring the application of neuroarchitecture principles in airport design
- Identifying critical design elements contributing to positive traveler experiences in airport environments.
- Understanding how the brain can be affected by the design experience and impact travelers' well-being.
- Examining how features, such as clear signs, design elements, color coding, and layout, can make it easier for travelers to make quick and simple decisions.
- Seeing how better wayfinding systems can lower traveler stress by helping them feel more in control and oriented.
- Providing practical recommendations for improving airport environments based on the study's findings.

Research Methodology

This study adopted a qualitative research methodology to explore how the principles of neuroarchitecture can be applied to airport spaces, with a specific focus on travelers' well-being, behavior, and comfort at airport gate waiting areas. This section outlines the methodological approach, including the research design, data collection methods, and data analysis procedures.

Research Design

The research employs a multi-method qualitative design, incorporating a literature review, functional and design analysis, non-participant observations, and data collection from textual online reviews. This approach allows for exploring the critical design elements that contribute to positive airport travel experiences.

Data Collection Methods

1. Literature Review

- A literature review connected the airport environment with behavioral theories and neuroarchitecture principles. This review covered topics such as **brain function, schemas, cognitive maps, sympathetic and parasympathetic nervous systems, environmental stressor theory, and neuroaesthetics.** The goal is to have a theoretical foundation to understand how airport spaces can be designed to enhance traveler experiences.
- Precedent studies of airport designs were analyzed to identify the positive aspects of interior spaces that affect travelers' well-being. Airport terminals and lounges were used as case studies to build a comparative analysis. This analysis included a review of projects of varying sizes and locations to provide a broad perspective on effective design strategies

2. Observations and Design Analysis:

- Nature of Observation: Non-participant observations were conducted at three airport departure gates' waiting areas.
- Scope: Considering variables such as time of day, days of the week, and if the airport is in a touristic location.

- Focus: Observations focused on identifying behaviors, preferences, design elements, and manifestation of stress in the airport gate setting.
- Documentation: Findings were documented using tables and maps to illustrate behaviors and interactions. The names of the airports and the use of pictures were avoided to ensure confidentiality.
- The observations might have been limited to a specific time or group of travelers; online reviews could provide insights from a broader range of passengers over various times and situations.

3. Data Collection from Online Reviews

- Data Sources: To deepen the understanding of travelers' experiences, online reviews were collected from *Yelp, Reddit, Airline Quality*, and *TripAdvisor.* The AI tool *Insight7* was utilized to organize this information and extract key themes and sentiments, helping to identify challenges and propose ideas. Insight7 is known for being user-friendly and effective in summarizing insights from reviews.
- Criteria for Selection: Both negative and positive feedback were analyzed to identify recurring topics and aspects that contribute to travelers' satisfaction or dissatisfaction.
- Thematic Analysis: Common themes and patterns in online reviews were identified, such as amenities, comfort, crowding, lighting, and noise.

Data Analysis Procedure

The data analysis involved identifying recurring patterns and themes across the different data sources. This included:

- Comparative Analysis: Comparing what was noticed during observations with feedback from online reviews to find where they agree or differ in how people feel.
- Pattern Identification: Analyzing observation notes, design analyses, and textual reviews to identify recurring patterns related to well-being, behavior, and comfort.
- Thematic Analysis: Conducting a thematic analysis to categorize and interpret the data, focusing on how different architectural elements impact traveler experiences.

Ethical Consideration

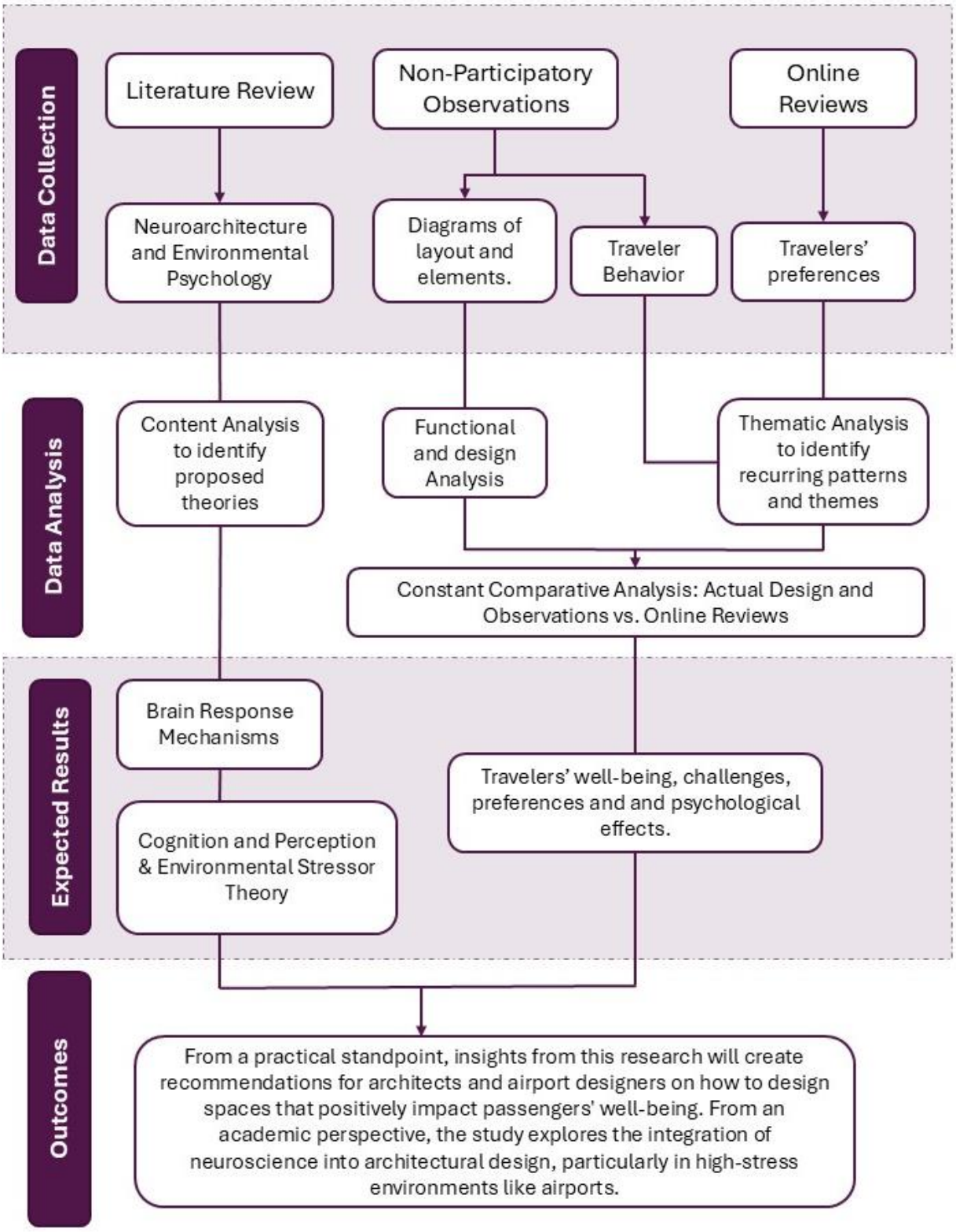
Confidentiality: All data were treated as confidential. The names of the airports and travelers were not disclosed to protect privacy.

By integrating these qualitative methods, this research aimed to showcase which environmental factors are most important to consider for airport gate waiting areas design to improve travelers' experience and reduce stress. It also sought to provide a comprehensive understanding of how neuroarchitecture principles can be applied to airport design, offering valuable insights and practical recommendations for enhancing travelers' experiences.

Figure 1 presents the data collection flowchart to illustrate the research process in order to gather and organize data.

Figure 1

Data Collection Flowchart.



Significance of the Study

The significance of this research is in its potential to enhance airport design practices by focusing on travelers' well-being and satisfaction. As air travel continues to grow and evolve, travel expectations are rising, making airports need to adapt and meet these demands effectively. By identifying and analyzing key neuroarchitecture factors that influence traveler experiences in both airport gate waiting areas and lounges, this study provides useful perspectives that can guide the design of more comfortable, functional, and emotionally supportive environments. This research can benefit travelers by reducing stress and enhancing their travel experience, and it will also assist airport managers and designers in creating spaces that foster positive behaviors and efficient operations.

Furthermore, this study addresses a gap in the current literature by incorporating qualitative methods to gain a deeper understanding of travelers' experiences at airport gate waiting areas. Through observations, functional and design analysis, and the analysis of online reviews, this research will offer an ample view of how different architectural elements impact traveler behavior and satisfaction. The findings will contribute to the fields of neuroarchitecture, and design, offering practical recommendations for improving airport environments and setting a precedent for future studies on the intersection of architecture, human behavior, and well-being.

Limitations

Potential limitations of this study include the following:

1. Restricted Access to Airport Interiors: Due to restricted access to airports, the researcher had limitations in the frequency and timing of visits.

2. Complexity of Neuroarchitecture: Neuroarchitecture is an emerging field, and connecting Neuroscience and Architecture is very challenging. Although the study used neuroarchitecture principles in order to understand travelers and improve airport design, it is difficult to fully understand the complexity of cognitive and emotional responses. It is necessary to have a wider collaboration and integration of different fields due to neuroarchitecture's interdisciplinary quality. This would be beyond the scope of this single study.
3. Sample Diversity: The study's observations and data collection are limited to three airports in the United States, which may not reflect the diverse cultural and demographic factors that influence traveler experiences in different regions of the world. Conducting observations in international airports would provide a better understanding of global traveler behavior and preferences.

By acknowledging these limitations, the study aims to provide a balanced and realistic view of its potential contributions and areas for future research.

Conclusion

This study identified four key environmental factors that influence travelers' experiences in airport gate waiting areas using qualitative methods: **Wayfinding, Ceiling Height, Illumination, and Layout Complexity**. It also explored the application of neuroarchitecture principles to airport designs, focusing specifically on enhancing traveler well-being, behavior, and comfort. This research's intent was to demonstrate how different design elements can significantly impact travelers' experiences, providing crucial insights for optimizing airport environments.

This paper demonstrated the integration of neuroarchitecture principles that can lead to aviation projects that are human-centered and cater to diverse traveler demographics. By focusing on elements such as spatial solutions, seamless navigation, and lighting, airports can create environments that not only reduce stress but also promote positive emotional and social experiences.

In conclusion, this investigation aimed to contribute to the fields of environmental psychology, neuroarchitecture, and airport design, offering practical insights into how airport spaces can be designed to enhance the well-being and comfort of travelers. As air travel continues to increase, the principles mentioned in this study can guide future efforts to create more efficient and enjoyable spaces, promoting a more positive experience for all travelers.

CHAPTER II: LITERATURE REVIEW

Introduction

This literature review sets the foundation of this study by delving into the relationship between neuroscience and architecture, analyzing concepts that affect humans' experience in the interior environment, especially in airports. In order to find books and publications focused on this research's topic, combinations of keywords were used: "airports and interior design", "airport gates' waiting areas and interior design", "holdrooms", "holdrooms and interior design", "neuroscience and architecture", "neuroarchitecture and airports" "architecture, airports, interior design", "airports and wayfinding", using data from the University of Oklahoma's library and Google Scholar. The selection of articles prioritized recent publications, with the majority being within the past decade. When selecting an article, it was assured that they were peer-reviewed. The literature review is organized in two main chapters: Neuroscience and Architecture, to introduce the topic, and Cognition and Perception. Under the second chapter, there are two sub-chapters: Sensory Processes and Wayfinding and Sensory Response to Environmental and Design Elements.

Neuroscience and Architecture

People experience buildings, cities, and places every day during their lives. Brain function and behavior can be strongly affected by the physical environment since there's a cognitive and emotional response from humans to the built environment (Higuera-Trujillo et al., 2021). The authors describe the relationship between neuroscience and architecture using the concept of *Neuroarchitecture*, which integrates insights from neuroscience into architectural design, to address cognitive-emotional dimensions of human experience in built environments. According to

Higuera-Trujillo et al. (2021), Gestalt psychology was one of the theories that influenced this integration, and notable contributions include the architect Richard Neutra, which stated that architecture should satisfy the neurological needs of users, which would only be possible by incorporating neuroscientific research into design.

Gestalt theories developed primarily in the early 20th century, although questioned by some researchers, explain how people perceive and process visual information. Gestalt psychology focuses on understanding how individuals naturally organize visual elements into groups or unified wholes, as mentioned by Kopec (2018) and developed by Wertheimer (1938). Gestalt Laws include the Law of Proximity, Closure, Symmetry, Similarity, Continuity, and Figure Ground. Many of Wertheimer's insights could be applied to airport environments to create a more integrated and pleasant space. Analyzing how design elements like furniture, colors, and materials can create a cohesive ambiance can be connected to *similarity.* Wayfinding can be enhanced by using the *law of continuity*, with continuous lines and direct paths. By using the law of *figure-ground*, designers can increase cognitive clarity by emphasizing key visual elements, such as seating areas or the gates' portals. Wertheimer's theories remain excellent guides in architecture and interior design and continue to be relevant in both academia and the design world today.

Modern research includes investigations and experiments focused on brain function and how it is affected by the environment. Khaleghimoghaddam et al. (2022) explore the connection between neuroscience and architecture by examining the effects of architectural settings on brain activation. Their study conducted neurological experiments using fMRI (Functional Magnetic Resonance Imaging) analysis to assess the emotional-perceptual experience of different architectural settings. According to Kopec (2018), through fMRI, it is possible to visualize the activation of some structures of the brain when a person moves. The study conducted by

Khaleghimoghaddam et al. (2022) suggests that the appearance of an architectural setting can influence the emotional, perceptual, cognitive, and decision-making (behavioral) processes of users. When delving into wayfinding, this paper mentions the study conducted by Liang et al. (2023), which uses fMRI to analyze the parahippocampal cortex and its role in landmark-based distance, making it possible to understand how the use of landmark elements can affect wayfinding perceptions.

Higuera-Trujillo et al. (2021) highlight that although bidirectional human-space influence and its impact on neural activity is not new, the recording of neural activity in physical and simulated environmental situations provides a foundation for future research and design. Mallgrave (2010) emphasizes the fact that newer studies in the field of neuroarchitecture have been making much more progress than the research that has been around for centuries. The author cites the example of the old model of vision; this concept affirms that an image of the world is mechanically impressed on the retinas of our two eyes and then transmitted through the optic nerves to the area at the back of the brain. The new and much more active neurological model challenges this old view; it doesn't separate the act of seeing from the process of understanding, and this has significant implications for architects and designers. (Mallgrave, 2010)

By recognizing that seeing and understanding are not separate processes, designers can create spaces that are intentional, spaces that better engage and stimulate the brain. This means designing buildings that are visually appealing and supportive of cognitive well-being. According to Edelstein and Macagno (2011), neuroscientific investigations offer a higher degree of objectivity, combining both conscious and subconscious responses. The authors emphasize that this is particularly important when studying those unable to understand or explain their perceptions due to various factors, such as dementia.

Building upon this understanding, Albright, Gepshtein, and Macagno (2020) sought an evidence-based approach to design when delving into Visual Neuroscience for Architecture. They mentioned that in the field of architecture, neuroscience is simply a rational, empirical approach to the comprehension of human experiences in spaces. They say, in very broad terms, that basic neuroscience discovery can be the foundation of design inventions that improve human information processing in the built environment. The authors affirm that "viewed in this way, architecture is an applied science of human biology" (Albright, Gepshtein, & Macagno, 2020, p.113) The authors go on to say that design is one of the most effective tools for introducing neuroscience discoveries into human societies when seeking to enhance creativity, promote civility, empathy, compassion, promote health and speed recovery from diseases, among other factors. (Albright, Gepshtein, & Macagno, 2020)

By integrating principles of neuroscience, this research aims to connect neuroarchitecture to airports, more specifically, the departure gates' waiting areas. This chapter will delve into Cognition and Perception, exploring different concepts in neuroarchitecture and environmental psychology that embrace wayfinding and sensory responses to architectural elements. These concepts include **brain function, schemas, cognitive maps, sympathetic and parasympathetic nervous systems, the environmental stressor theory, and neuroaesthetics.** This interdisciplinary approach aims to propose design solutions that are neurologically supportive, leading to healthier and more satisfying environments for users.

Cognition and Perception

The studies on neuroarchitecture have a strong focus on cognition and perception. Goldhagen (2017) emphasizes the importance of considering this factor when studying human

experience in space, affirming that cognition, which includes emotion, is the “realm of the mind.” She affirms that while “experience” might seem “inexpressibly idiosyncratic and amorphous” (Goldhagen, 2017, p.46), cognition is not. About cognition, the author asserts that we have much more than intuitions and hypotheses, we have knowledge.

Kopec describes cognitive processing as “the ability to conceptualize, understand, and interpret incoming stimuli” (Kopec, 2018, p.112). Goldhagen explored a three-way collaboration between *mind, body, and environment; the* author affirms that the processes of the mind are largely shaped by the human body, while human bodies are shaped by the environments in which we live and have evolved. Understanding this relationship can transform our ideas about how humans live in the world.

Eberhard’s (2009) identification of the five critical areas of brain systems research - sensation and perception, learning and memory, decision-making, emotion and affect, and movement - illustrates the complex relationship between various brain functions and our everyday experiences. This intricate relationship suggests that our experiences are not just passive reactions to environmental stimuli but are actively constructed through cognitive processes.

Experiences are composed of identifiable indicators, signals, and stimuli - both rational and emotional - that are registered consciously and unconsciously by the senses. Boudreau et al. (2016) brings the concept of “clues”. The clues evoke the feelings experienced by individuals, shaped by real and perceived stimuli. They are what the traveler sees, smells, tastes, touches, and hears. This aligns with the understanding that human bodies and minds are shaped by the environments in which we live and evolve, as highlighted by Goldhagen (2017). However, the constantly changing nature of customers' expectations, influenced by several factors, adds a layer of complexity to designing spaces that consistently meet these evolving needs, as mentioned by

Boudreau et al. (2016). Understanding the cognitive and perceptual mechanisms underlying these experiences can, therefore, transform our approach to creating environments that resonate with users on both conscious and unconscious levels, accommodating the fluidity of expectations and changes in the broader context.

According to Kopec (2018), perception, the interpretation of sensory information, is influenced by factors such as stimulus type and level, past experiences, attention, readiness to respond, motivation, and emotional state. The author states that research indicates that visual cues heavily influence the perception of distance and movement, often outweighing nonvisual cues. Without visual cues, people misjudge distances, often overestimating short distances and underestimating long ones in large environments like airports. These concepts can be connected to wayfinding. Kopec (2018) highlights that in design, it is important to be careful not to promote cognitive conflict, especially when developing wayfinding signs. “A person could be parked on Level 3 Red, but the sign is written with a green font.” (Kopec, 2018, pp.129-130)

Sensory Processes and Wayfinding

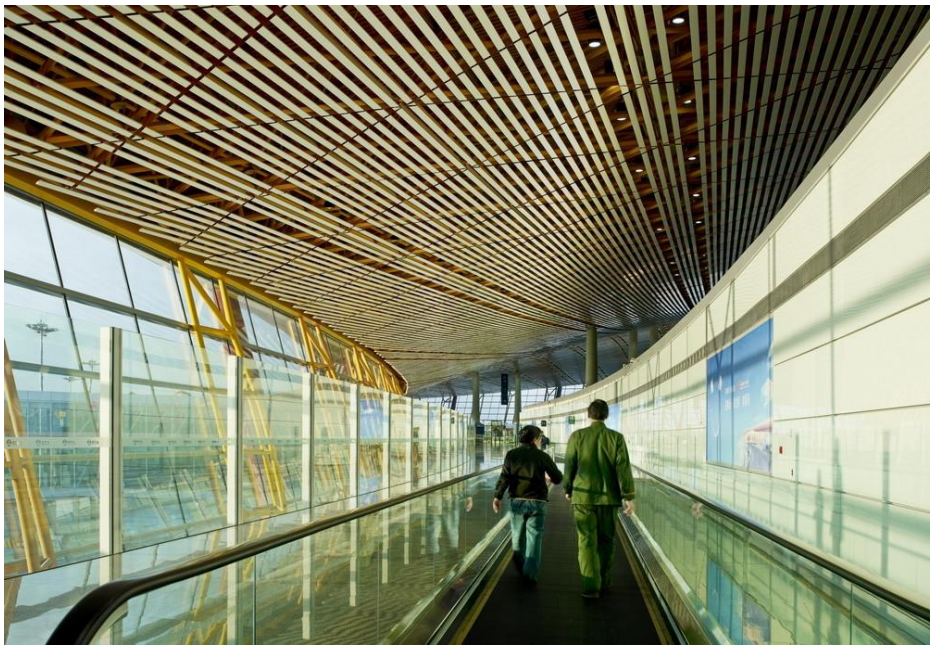
In the studies focused on cognition and perception, wayfinding is a very relevant topic, especially in commercial environments. Hubregtse (2020) asserts that there’s no doubt that airport architects accept that the design and materiality of the buildings have the power to facilitate passenger flow. Besides corridor walls and escalators, materials that operate on a sensory register, visual or auditory, can guide travelers in moving through terminals. Harding et al. (2011), when creating a guide for wayfinding in airport environments, affirm that before determining sign locations, it is important to consider how architectural elements can be used to enhance

wayfinding. Architectural features, for example, can highlight decision points and enhance the wayfinding process.

Design elements, according to Hubregtse (2020), such as ceiling structures and skylights, are employed in various airports to enhance wayfinding and improve traveler experience. At Beijing's Terminal 3 (See Figure 2), Foster + Partners designed the ceiling with thin slats aligned with the main directional flow, allowing light to shine through skylights without obstruction (Hubregtse, 2020). This design helps guide travelers towards their gates. Similarly, at Heathrow Terminal 5 (see Figure 3), long and narrow skylights in the ceiling emphasize the path through security to the gates. At Toronto Pearson's Terminal 1, designed by Safdie, skylights indicate the main traveler routes. According to Hubregtse (2020), Safdie explained that since airports can be considered very intimidating places, his design aimed to reduce stress and make navigation intuitive by using daylight as a key wayfinding tool.

Figure 2

Beijing Terminal 3.



Note. The photo shows how design elements can direct traveler flow. Source: ArchDaily

Figure 3

London Heathrow Airport – Terminal 5.

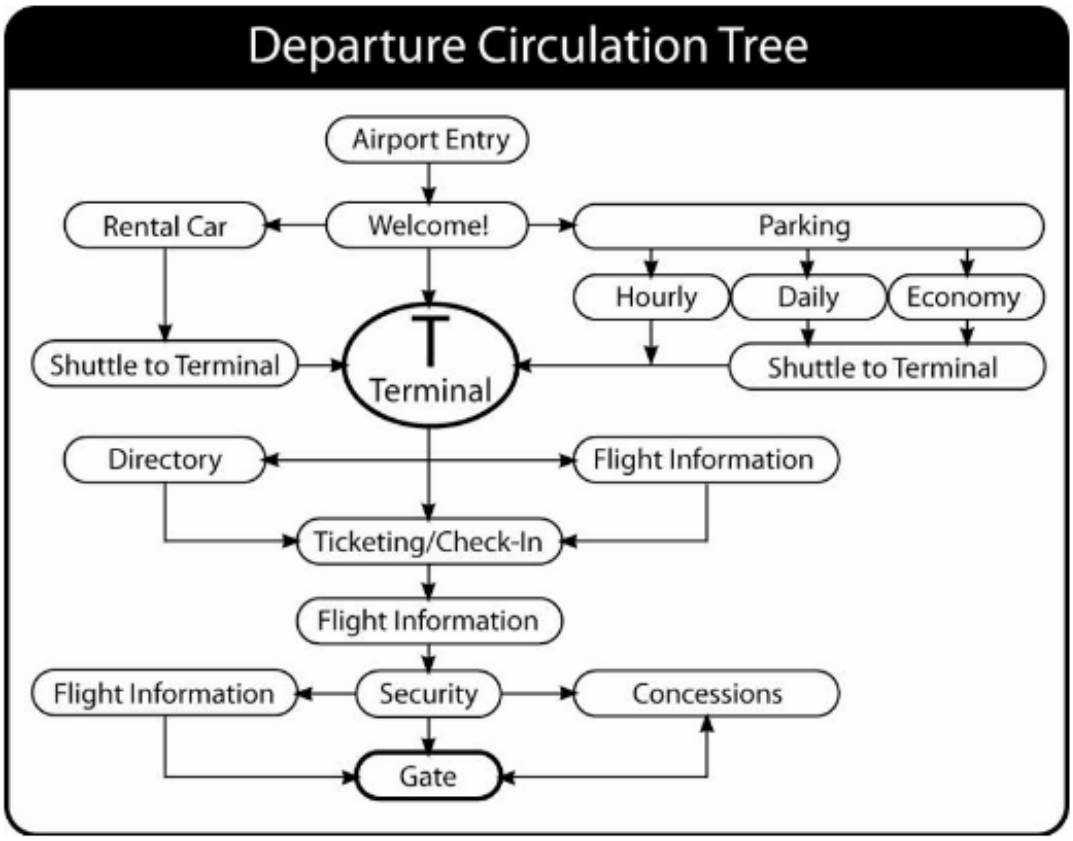
Note. Skylights at Terminal 5. Source: Menno Hubregtse (2013)

Hund (2016) explored the impact of dual-task conditions on wayfinding efficiency. The study found that when participants were engaged in a concurrent visuospatial task, both the accuracy of their wayfinding directions and their speed decreased compared to when they were only focused on wayfinding. Visuospatial working memory, responsible for temporarily holding and manipulating visual and spatial information, was tested using a dual-task paradigm. The results showed that participants in the visuospatial dual-task condition provided less accurate directions and had slower wayfinding times, highlighting the impact of dual-tasking on performance. This is particularly an issue at airports since travelers face numerous activities. A family with children, for example, must juggle several tasks such as locating their gate, keeping an eye on their kids, managing all the family's luggage, and searching for a place to eat, among other responsibilities.

Harding et al. (2011) created a typical circulation tree to showcase the usual airport passenger flow. As shown in Figure 4, travelers have a long journey to arrive at the Gates. All types of stimuli are experienced by them whenever they approach the Gate's holdrooms.

Figure 4

Departure Circulation Tree.



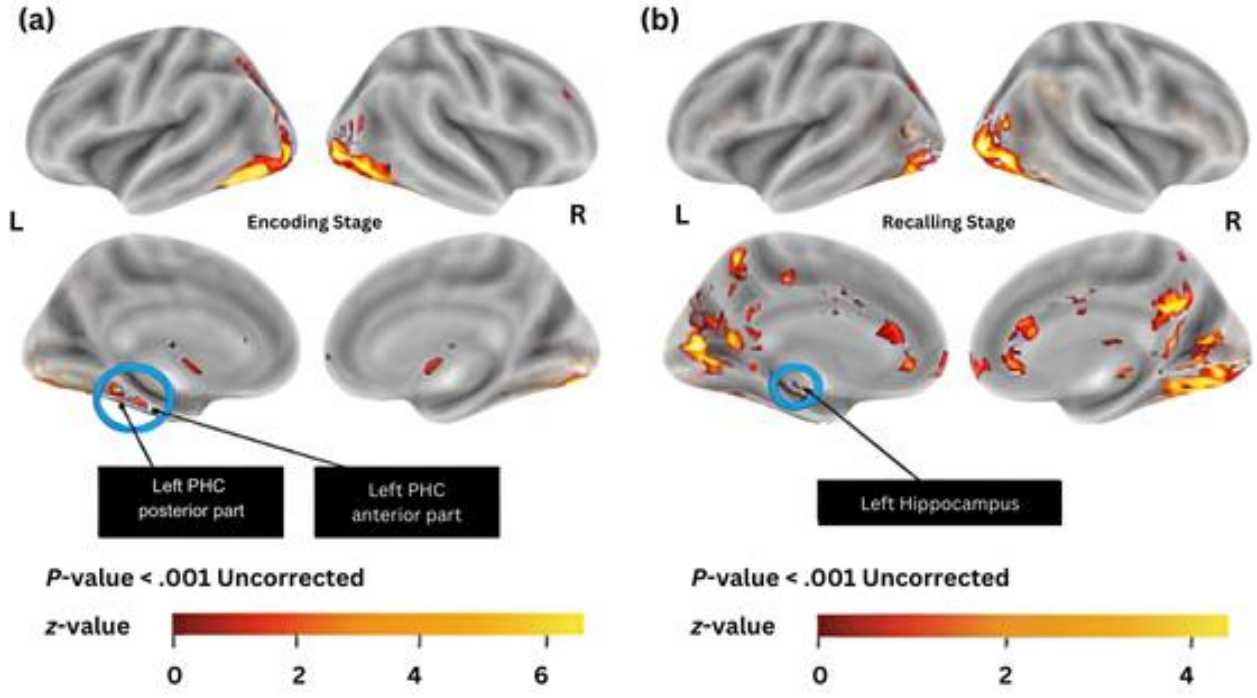
Note. Source: Harding et al., 2011

Liang et al. (2023) study the importance of having landmarks to help wayfinding in a space. The authors used an fMRI experiment to analyze the role of the parahippocampal cortex (PHC) in landmark-based distance estimation. The parahippocampal cortex plays an important role in understanding and remembering places, and in this specific study, by using landmarks. According to Liang et al. (2023), the PHC becomes more active when people see stable landmarks. Stable

landmarks are a prominent and prevailing environmental feature that can serve as a reliable wayfinding reference. The left side of the PHC is more active during the process of remembering, especially when stable landmarks are present, according to the authors. Figure 5 shows the contrast between significant brain areas' activation when having a stable landmark and no landmarks. The contrast is indicated by the blue circles.

Figure 5

Brain Activation



Note. The PHC is more activated when having visually stable landmarks. Source: Liang et al, 2023.

The left part of the brain helps us understand scenes and the context of what we see. It has two main parts: the front part helps with gathering information, and the back part helps with understanding scenes. The PHC has the capability to identify and connect landmarks with the surrounding scene, which helps us remember the context of where things are. (Liang et al., 2023)

This analysis is particularly relevant in airport environments, where the lack of time can become a stressor. Having a landmark can assist travelers in judging distance with more confidence, helping them manage their time in a better way. The PHC is more active when landmarks are present, which helps people judge distances better. The PHC is mainly responsible for encoding information about landmarks rather than storing them, making it a key player in processing and understanding spaces around us.

When developing research focused on wayfinding, Yang et al. (2018) evaluated how moving entities can impact wayfinding performance using virtual environments. The authors used animated human figures like a scientist in a white coat, a man in a blue suit, and a female soldier in uniform. The findings show that the presence of moving elements can reduce wayfinding performance when one is trying to learn the spatial environment for the first time. On the other hand, the authors emphasize that when the participants have already learned the relevant stationary spatial cues, these moving entities do not greatly impact wayfinding. This study supports the importance of using wayfinding elements throughout airport environments. New travelers are going to encounter numerous moving entities, besides other stressors.

Harold M. Proshansky was an important American psychologist known for his contributions to the field of environmental psychology. Proshansky's work focused on the relationship between people and their physical environments, particularly how the built environment influences human behavior and well-being. According to Proshansky (1978), references and wayfinding tools are crucial for building *cognitive maps*, enabling people to plan routes, make decisions on how to reach specific locations, and mentally visualize the layout of their surroundings. These elements are also key in “setting selectability”, as people often select paths based on their design and visibility. (Proshansky, 1978)

When designing spaces, such as airports or public areas, considering the degree of differentiation, visual access, and spatial complexity is crucial for gathering positive place-identity as proposed by Proshansky (1978). These elements can enhance users' ability to navigate and relate to the space, ultimately contributing to their overall well-being and comfort. Spaces that are well-differentiated, provide good visual access, and have a manageable level of complexity are more likely to be perceived positively, helping individuals form connections with their environment and creating positive experiences, as Proshansky (1978) highlighted.

Guelton (2023) features the concepts of cognitive maps and mind maps. Cognitive maps and mind maps differ in their focus and use. *Cognitive maps* are like mental pictures of places you've been to. When moving through a space, our brain creates a map in our mind that helps us remember where things are, like landmarks and streets. These memories are not always perfectly accurate; they may involve distortions or omissions, but they provide a functional understanding of the space. (Guelton, 2023) These maps guide people to find their way around in the real world. On the other hand, *mind maps* (or concept maps) are used to organize and connect ideas. Unlike cognitive maps, mind maps aren't about places; they're about organizing thoughts and information to make them easier to understand and remember. Even for unfamiliar spaces, individuals can apply strategies from both cognitive maps (which represent physical space) and concept maps (which organize abstract ideas). By combining these approaches, they can create a more comprehensive and organized mind map that reflects both the physical layout and the conceptual understanding of the space (Guelton, 2023). The importance of wayfinding in this context is evident. First-time travelers can encounter difficulties when navigating the space, but landmarks and intuitive layout can assist them in connecting spaces.

Guelton (2023) highlights that neural systems are connected to spatial navigation and abstract thinking. The author shows that the brain uses similar mechanisms to handle physical spaces and more complex, non-spatial processes. The cognitive maps, which serve as guides for people to navigate physical spaces, rely on the hippocampus and related areas in the brain. These same brain regions are also involved in more abstract tasks, like organizing concepts and relationships.

Goldhagen (2017) brings the concept of schemas to neuroscience. Schemas refer to mental frameworks or structures that help organize and interpret information based on past experiences and knowledge. The author affirms that they are patterns of association. These patterns link the visual experience, for example, “seeing light flick on with the more abstract notion of a flash of insight” (Goldhagen, 2017, p.50). They serve as cognitive templates that guide perception, thoughts, and behavior, allowing the brain to predict and process incoming stimuli more efficiently. Schemas are essential for understanding complex environments, recognizing patterns, and navigating social and physical spaces.

Schemas are built through experience and learning, and they help the brain quickly categorize and respond to new information by fitting it into pre-existing mental models (Goldhagen, 2017). For example, when entering an airport, a person’s schema might include expectations about checking in, going through security, and finding the gate. In complex environments like airports, schemas can simplify decision-making, reducing cognitive load, which is particularly useful for wayfinding and spatial orientation. The important thing is to create a space that follows travelers' expectations, facilitates their understanding of the space, and creates a seamless experience for them. Having standardized layouts and creating low-complexity spaces can help manage their expectations and stress levels.

A new study led by UCLA Health, published in *Nature*, reveals that repetitive practice improves skills and causes significant changes in the brain's memory pathways. Bellafard et al. (2024) trained mice to recall sequences of odors and observed that, with practice, memory representations in the secondary motor cortex stabilized. Initially unstable, these memory circuits "crystallized" over time, leading to more accurate performance. Using a custom-built microscope, the team simultaneously imaged the neural activity of up to 73,000 neurons, tracking the evolution of working memory circuits. These findings offer insights into learning and memory and may inform treatments for memory-related disorders.

In interior design, according to Ching (2014), repetition involves the consistent use of a particular element, whether it's shape, material, or form. This creates a sense of unity and coherence, reinforcing specific design elements. Repetition can occur at various scales and is not limited to identical elements. Subtle variations can introduce visual interest while maintaining a consistent rhythm (Ching, 2014). Ching emphasizes that repetition can reinforce the hierarchy or importance of architectural components by drawing attention to key elements that are frequently repeated. In airports, elements such as flooring patterns, lighting schemes, or similar signage styles provide users with familiar visual cues, reducing cognitive load and allowing them to focus on their destination rather than deciphering the environment.

In summary, there is an intrinsic connection between wayfinding processes in airport environments and sensory stimuli, spatial cognition, and design. The use of different elements, such as skylights, ceiling elements, and materiality, can play an important role in helping travelers find their final destinations through complex spaces, as highlighted by Hubregtse (2020) and other scholars. Landmarks, repetitions, and visual cues can enhance wayfinding significantly, helping people create cognitive maps and making the experience in a high-pressure environment, such as

airports, less stressful. By reducing cognitive load and improving wayfinding through thoughtful design, architects can improve travelers' functional and emotional experience, allowing them to move through spaces more easily and confidently.

Sensory Response to Environmental and Design Elements

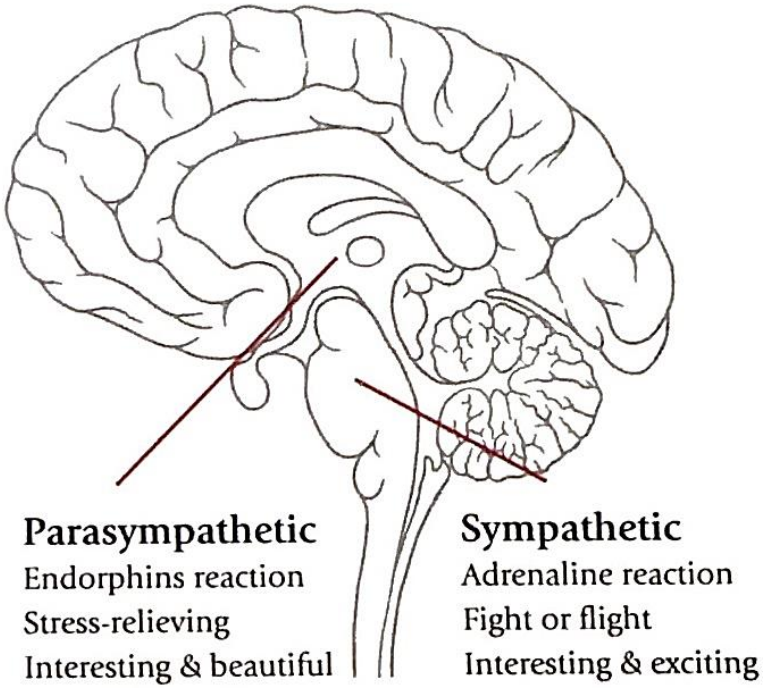
The sensory response to architectural and design elements is an important aspect of how humans interact and experience built spaces. Multiple neuroarchitecture researchers have explored how spatial elements influence our nervous system, emotions, and well-being. In his book, Ruggles (2017) connects the sympathetic and parasympathetic nervous systems to beauty and architecture, as well as the experience the user of a space has in it. The author recalls that humankind is genetically predisposed to seek survival and pleasure, affirming that up to "95 percent of all actions processed by our brains are intuitive and subconscious, and all are geared to survival and pleasure" (Ruggles, 2017, p.9). While the sympathetic nervous system activates the body's resources to handle stressful situations, the parasympathetic nervous system promotes a state of calm and supports functions related to rest and digestion. The exploration of these concepts assists the creation of spaces that can take advantage of design elements that instigate one system or the other. (See Figure 6)

According to Chu et al. (2024), the sympathetic nervous system is activated by stressful situations, triggering an acute stress response called *fight-or-flight* (Figure 6). This response causes a person to either confront the threat or flee the situation. In airport environments, this type of response can lead to increased anxiety and agitation, exacerbating the stress of crowded spaces. It can also impair decision-making and problem-solving skills, resulting in confusion and potential delays. Additionally, it may lead to avoidance behaviors, where travelers, in future trips, choose to

avoid flying or traveling altogether rather than facing the airport experience. Chu et al. (2024) affirm that the adrenal medulla produces a rush of adrenaline and noradrenaline that affects almost all portions of the sympathetic system throughout the body.

Figure 6

Parasympathetic and Sympathetic Nervous Systems.



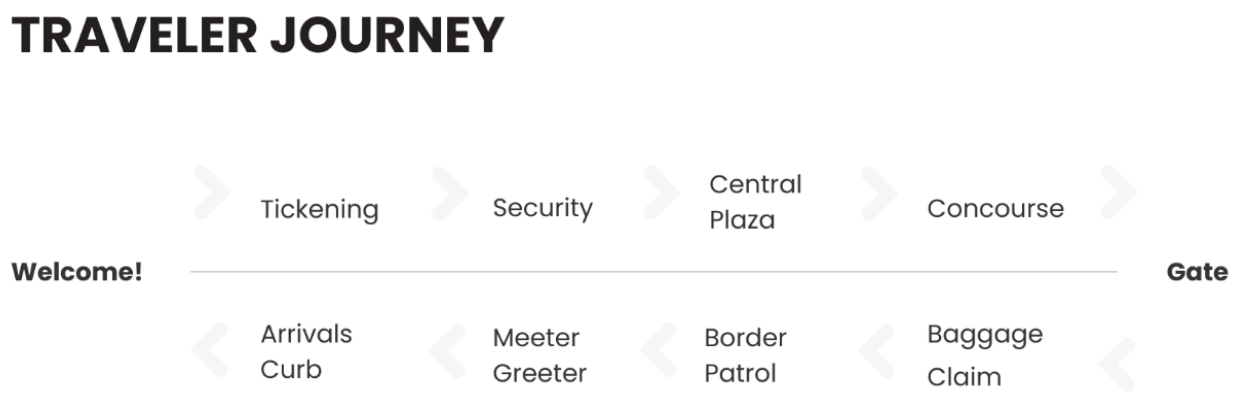
Note. Differences between the parasympathetic and sympathetic nervous systems. Source: Ruggles, 2017.

With a lack of control over delays, missed connections, gate changes, and weather emergencies, there is a high likelihood that travelers will experience activation of their sympathetic nervous system. Chu et al. (2024) highlight that this can affect blood pressure, increase rates of cellular metabolism throughout the body, and heighten mental activity, among other effects. However, how can the environment help create a balance between both nervous systems and enhance travelers' experiences? The authors emphasize that once what was perceived as a "threat"

fades, the body returns to its normal state. After a long journey, gate waiting areas have the potential to become spaces for mental rest, and this is where design plays a critical role in enhancing travelers' well-being. As seen in Figure 7, the traveler's journey can start or end at the boarding gates, making this area particularly significant.

Figure 7

Traveler Journey



Note. Diagram created by M. L. Klem (2024)

In exploring these responses, Goldhagen (2017) emphasizes how overstimulating or understimulating spaces can affect our neurological and psychological well-being. Goldhagen's examples, such as the Chancery Court clerk's cluttered office or a crowded traffic crossing, highlight how overstimulating environments can lead to cognitive exhaustion and stress due to the constant need for vigilance - an instinct likely shaped by our evolutionary history of scanning for threats in the wild. Sun et al. (2004) highlight that when there's an excess of visual elements in a space, humans become less aware of their movements, making it harder to use their other senses to perceive the space. Likewise, understimulating environments, such as the drab suburban development in The Goldfinch or poorly designed school hallways, deprive us of cognitive

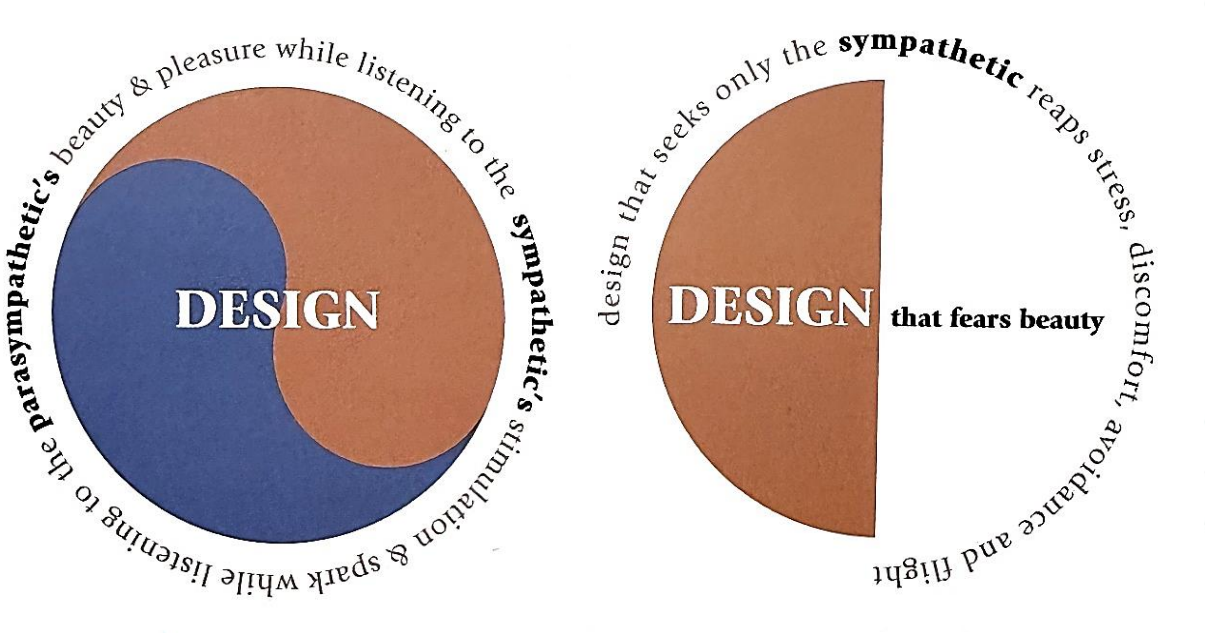
engagement, leading to boredom, stress, and even negative emotional states (Goldhagen, 2017). These concepts can be connected to wayfinding elements. A large number of signs can potentially distract and stress travelers more than guide them. Designing a space with intuitive wayfinding is way more beneficial. At the same time, creating an interesting design with ceiling elements, artwork, and different colors can catch travelers' attention and create an exciting experience.

These ideas are linked to the environmental stressor theory. Kopec (2018) affirms that stress is a psychological and physiological response to a stimulus or stressor. Those can be social, physical, biological, or chemical. Odor, heat, noise, and crowding, according to the author, are considered ambient stressors. When the source of stress is repetitive, it is considered a chronic stressor. A chronic stressor is a persistent, ongoing source of stress that continues over an extended period, typically weeks, months, or even years. Unlike ambient stressors, which are temporary, chronic stressors are long-term and can have significant impacts on an individual's physical and mental health, as mentioned by Kopec (2018).

This idea can be expanded by Ruggles' affirmation that contemporary architecture, often marked by adrenalized designs, contributes to stress. A special emphasis can be put on airports, where so much happens. Ruggles (2017) notes that a better – and healthier – way to create pleasant experiences in spaces would be the utilization of "recognizable, stress-relieving and calming patterns, with an emphasis on beauty for the betterment of all mankind. Concisely: Stress diminishes us. Beauty heals us." (Ruggles, 2017, p.97) What should be taken into account in design, according to Ruggles, is the influence of the autonomic nervous system. He goes on to say that ignoring or resisting the role of beauty decreases a significant portion of the brain's sensory input that comes from the autonomic nervous system. Figure 8 illustrates the concepts explored by Ruggles.

Figure 8

The Learning Continuum of Design & Resistance to Beauty



Note. Source: Ruggles, 2017.

Higuera-Trujillo et al. (2021) identified several key factors influencing environmental psychology, drawing on the work of various scholars and employing an evidence-based approach. Notable among these factors are *ceiling height, the presence of vegetation, spatial complexity, illumination, color, and coherence.* Table 1 in their study provides a detailed overview of these topics. The insights gathered by Higuera-Trujillo et al. (2021) offer a valuable foundation for research in interior design, neuroarchitecture, and environmental psychology, making their findings highly relevant to understanding how built environments impact human behavior and well-being.

Table 1

Design Variables and Effects.

Design Variable	Effect
Ceiling height	High ceilings inspire freedom, low ceilings calm [177].
	High ceilings generate greater creativity and feelings of comfort [178].
	Ceiling height positively affects wayfinding [179]
Presence of vegetation	Vegetation reduces stress and anxiety [4].
	In parks, pleasure increases based on tree density, and arousal with weed density [180].
	Biophilia hypothesis: preference for natural forms [181,182].
	Attention restoration theory: natural environments are restorative. Their restorative characteristics are "fascination," "being away," "coherence," and "compatibility" [183].
Complexity	Preference for moderate levels of complexity, similar to a savannah environment [184].
	Prospect-refuge: preference for natural and built environments, which offer visual control of the environment and places to hide [185–187].
Illumination	Colour temperature and illuminance are interrelated with comfort [188].
	Natural light reduces hospital stays [189].
	Light and form are interrelated: walls and ceilings influence the perception of brightness. A room appears larger when it receives more indirect light [190].
	Mood valence and cognitive performance alter based on light parameters: colour temperature with a less negative effect on mood, improved cognitive performance, the combination of colour temperature, and illuminance with better evaluation in mood, improved cognitive performance [191].
	Emotional states affect the perception of brightness [192].
Colour	Extracted at an early stage of visual processing [193]
	Wide variety of effects on aesthetic preferences [194].
	Hue and saturation are related to the emotional state [195].
	Warm tones have higher arousal values, and colder tones are lower [196].
Use	The use to which a space is put influences its psychological evaluation [197].
Coherence	In natural settings, the coherence of a setting with wooden furniture is significantly greater than a setting with metal furniture, but significantly less than a setting without furniture [198].

Note. Effects generated by variables or aspects of architectural design frequently studied in the environmental psychology and EBD approach. Source: Higuera-Trujillo et al., 2021.

Erkan (2018) conducted experiments using brain imaging with electroencephalography (EEG) using three spaces with different ceiling heights in order to evaluate wayfinding. The results show that the higher the ceiling, the faster it was for the participants to find the exit. More and more often, designers and stakeholders are trying to build airports with higher ceilings, but it is still possible to encounter lower ceilings, especially in older buildings. Other authors also highlight important information about ceiling height. As noted by Vartanian et al. (2015), lower ceilings can

cause the feeling of enclosure, which can be even more intensified with crowding in spaces like airports. The authors go on to say that higher ceilings are perceived as more beautiful and that people are more likely to opt to be in spaces that they find aesthetically pleasing. Therefore, lower ceilings can become an uninviting feature at airport gates' waiting areas.

Figure 9

Bergen Airport / Nordic Office of Architecture

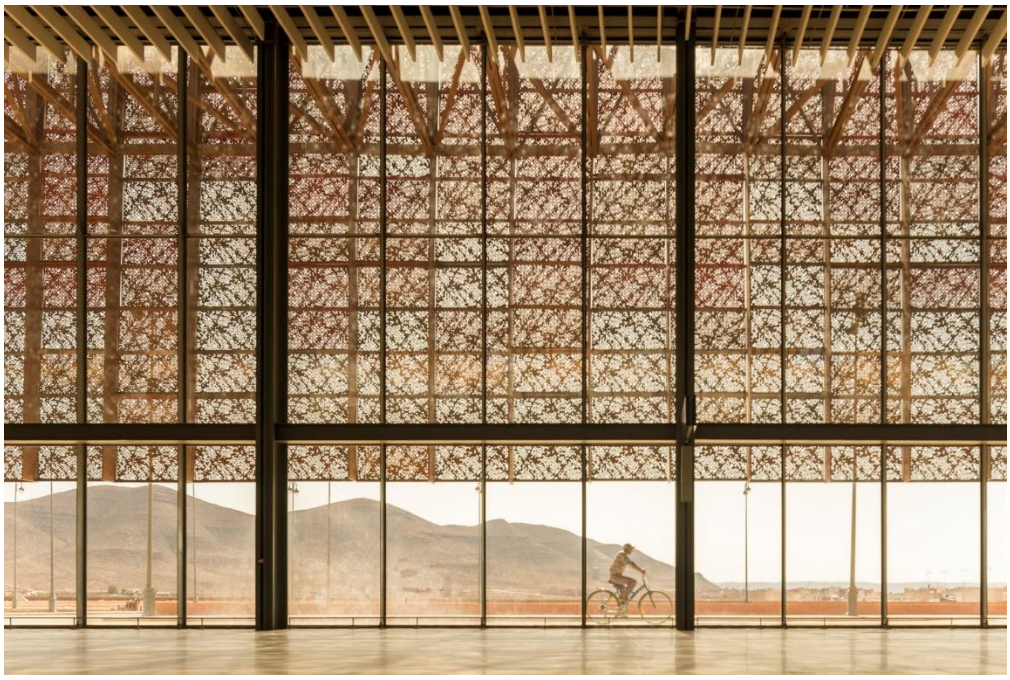
Note. High ceilings at the boarding gate's waiting areas. Source: ArchDaily.

The importance of vegetation and biophilia has been part of scholars' research for a long time. Ulrich (1979) highlights that exposure to nature can significantly positively affect psychological well-being. It promotes the feeling of friendliness and affection and has a calming effect (Ulrich, 1979). Goldhagen (2017) asserts that despite humans' individual differences, such as personality, gender, age, and cultural background, all people have evolved as a biophilic species.

According to the author, this ensures that humans are inherently attracted to nature and seek a connection to it in their homes, offices, or communities (Goldhagen, 2017). How can biophilic design be achieved in airports? Perhaps bigger windows strategically placed by natural views, artwork containing images of nature, or even elements inside the airport that resemble it. Boudreau et al. (2016) highlight that nature scenes can provide a calming scenery in airport environments, positively impacting travelers' experience. Figure 10 shows an image of Guelmim Airport in Morocco, a project developed by Groupe3 Architects.

Figure 10

Guelmim Airport, Morocco



Note. Big windows show the amazing landscape surrounding the airport. Source: ArchDaily.

One of the other elements cited by Higuera-Trujillo et al. (2021) was illumination. Light plays a pivotal role in human mood regulation. Milosavljevic (2019) conducted research on mechanisms connected to the photosensitive retinal ganglion cells (ipRGCs) to understand how

lighting can affect mood. The author emphasizes that it has an impact on circadian rhythms, which are the light-dark cycles of a 24-hour solar day. Shift work changes or altered sleep-wake cycles can have a negative impact on people's moods. These cycles can often be mixed up during long and international trips. Milosavljevic also emphasizes that the light-mood relationship is much more complex, asserting that other factors, such as light's spectral composition, also impact it.

Research on the spectrum of light has shown how lighting temperature can affect people's moods. Shahidi et al. (2021) affirm that warm light creates a more calming and relaxing environment, reducing confusion and inducing feelings of warmth and comfort. In contrast, cool light tends to enhance brightness perception, which can lead to increased alertness. Another thing to take into consideration, according to Kopec (2017), is that besides boosting attention, colder lights can also disrupt the body's circadian rhythms.

Since airport environments require a certain level of alertness, using indirect lighting may promote this feeling without being too overwhelming. Perhaps using neutral or warmer tones at the boarding gate's waiting areas can create a respite for travelers after their long journey through the airport. In a perfect scenario, dynamic lighting systems that adjust throughout the day, mimicking natural daylighting, can support a balance that would positively affect travelers' moods. Using a combination of white color and warm light or blue color with cool light has also been shown to have a more positive effect on visual perception and mood, according to Shahidi et al. (2021).

A more modern approach to humans' perception of visual information has been explored by different scholars. The emerging discipline called *Neuroaesthetics*, which explores 'beauty' through cognitive Neuroscience, is more subjective and involves appraisals of natural objects, artifacts, and environments, according to Chatterjee and Vartanian (2014). The authors affirm that

aesthetic experiences include emotions, valuation, and action. The evaluation of emotions could introduce some skepticism toward Neuroaesthetics among researchers, as Pearce et al. (2024) highlighted. However, when analyzing the studies of emotions, the authors affirm that even though people differ greatly on what it means to experience happiness, for example, or what it is like to be in love or feel rejected, scholars still study emotions. (Chatterjee & Vartanian, 2014) These differences in perception only mean that scientific research on emotion, more specifically focused on aesthetic experiences, must determine which aspects clarify the differences among individuals.

According to Boudreau et al. (2016), the newest trend in terminal design is hospitality which is very connected with the aesthetic experience. Hospitality has been an important element of airport lounges, which are more exclusive, for a significant amount of time. However, looking for practicality, the departing gate waiting areas many times lack this concept. What Boudreau et al. affirm is that the "future terminal will require less processing and more passenger-centric services" (Boudreau et al. 2016, p.99). Figure 11 showcases Jackson Hole Airport with a "lodge-type" terminal.

Figure 11

Jackson Hole Airport – New Terminal

Note. Gensler; image credit: Matthew Millman. Source: Boudreau et al. 2016, p.100

To complement these perspectives, it is essential to understand that the perception of aesthetics in terminal design can significantly impact travelers' emotional well-being and overall satisfaction. A thoughtfully designed terminal that considers aesthetics more than mere decoration can promote a sense of calm and tranquility amid the typically stressful experience of air travel. As Boudreau et al. (2016) suggest, the future of terminal design is moving towards a more hospitality-oriented approach, where traveler comfort and experience are prioritized. This change integrates aesthetic principles that make the environment more inviting and human-centered, contributing to a positive emotional response. The use of natural materials, warm lighting, and spatial layouts that promote relaxation – elements seen in examples such as Jackson Hole Airport – illustrate how aesthetics can transform functional spaces into areas that promote well-being. By aligning with neuroaesthetic principles, these designs not only satisfy practical needs but also create an emotional connection, increasing traveler satisfaction and making the airport experience more enjoyable.

In conclusion, the sensory response to architectural and design elements influences how people experience built environments, particularly in high-stress areas such as airports. By understanding the connection between design elements and nervous systems, designers and stakeholders can create spaces that balance the activation of the sympathetic and parasympathetic systems, promoting alertness and relaxation. Biophilic design, appropriate lighting, and intuitive wayfinding can be incorporated into the design in order to reduce environmental stressors, improve well-being, and improve overall user satisfaction. Ultimately, a thoughtful design that is not only functional but creates an aesthetic experience can promote calmness, comfort, and a positive emotional experience.

CHAPTER III: METHODS

Introduction

To reach the expected results for this research, the chosen methodology included qualitative research. Quantitative research is typically strongly structured and is assumed to provide objective and generalizable results (Bienkowska & Sikorski 2024). The authors highlight that it is highly regarded in the scientific community, as it provides well-defined data. While quantitative research collects and analyzes data in a numerical form, which can be statistically examined (Bienkowska & Sikorski, 2024), qualitative research provides deep insights into complex phenomena, capturing human behavior and their dynamics in a more personal approach as described by Bouncken (2021). The qualitative approach was chosen because it helps find patterns and connections that are hard to measure with numbers, making it easier to understand the subject's perspective.

Maguire and Delahunt (2017) affirm that the data collected through qualitative methods, such as interviews and observations, are deep and nuanced, which creates a comprehensive understanding of themes. It prioritizes the perspectives of a specific group, utilizing their perceptions and viewpoints.

The research methods adopted for this study were chosen to be able to demonstrate the social phenomena that occur in airports, especially surrounding the airport gates. **Employing a multi-method qualitative approach, this study incorporates non-participant observations, design analysis, and an examination of online reviews from travelers across various airport contexts.** The multiple methods of qualitative approach were adopted to attain a more broad understanding of the research objectives by collecting data from different perspectives, contexts, or sources.

The study objectives include:

- Understanding traveler experiences in airport spaces through qualitative analysis.
- Numbering the four most important environmental elements travelers cite in online reviews.
- Listing human-centered design strategies that enhance the overall travel experience through the well-being, behavior, and comfort of travelers in the gate waiting areas.
- Exploring the application of neuroarchitecture principles in airport design
- Identifying critical design elements contributing to positive traveler experiences in airport environments.
- Understanding how the brain can be affected by the design experience and impact travelers' well-being.
- Examining how features, such as clear signs, design elements, color coding, and layout, can make it easier for travelers to make quick and simple decisions.
- Seeing how better wayfinding systems can lower traveler stress by helping them feel more in control and oriented.
- Providing practical recommendations for improving airport environments based on the study's findings.

Each method usually looks at different parts of the topic being studied, giving deeper and more detailed understanding. To reduce bias and compensate for the limitations of individual methods, this paper used two different data sets: observations and online review analysis that were tied together with a literature review. The use of two or more methods to explore a third phenomenon is called triangulation, according to Gorard and Taylor (2004). Triangulation in

research refers to the use of multiple methods, typically combining quantitative and qualitative approaches, to increase the reliability of results. (Gorard & Taylor, 2004)

This study also included a comparative analysis of airport lounges and gate waiting areas to understand how different environments influence travelers' comfort and behavior. Through these methods, the paper identified patterns and design elements that are most impactful in reducing stress and promoting positive emotional responses in high-stress environments like airports. Observing the behaviors and travelers' reviews made it possible to connect human behavior and interaction with space to neuroarchitecture concepts. The aim of this connection is to be able to better comprehend travelers' needs and challenges.

Observations

Non-participant observations were conducted during personal travels to collect data about three different airports in the United States. According to Ostrower (1998), non-participant observation is connected to qualitative research. It involves researchers observing a group or situation without actively participating in it. (Ostrower, 1998) The data is gathered and analyzed by observing behaviors, interactions, and contexts without influencing the subjects being studied, according to Ostrower. As a traveler, it was also possible to experience all the activities involved in the boarding process. It was taken into consideration stressors that could be involved during different travelers' journeys: business and leisure travelers, different age groups, as well as individual or group travelers. During the observation period, the following elements and factors were considered:

- Spatial layout and proximity of seating to the boarding gate and how it influences travelers' flow and behavior.

- Availability and accessibility of amenities (e.g., charging stations, food outlets) and how they impacted travelers' comfort and convenience.
- The impact of crowding on traveler behavior, including how it influences their movement patterns, stress levels, and decisions regarding where to sit or stand. Visual and acoustic stimuli (e.g., noise levels, lighting quality)
- Traveler behavior during different phases of waiting (e.g., checking phones, conversing, moving around)

Data was recorded through detailed notes and photographs. Photos containing names and people were not used in this paper.

The non-participant observation method was chosen because it allows researchers to see how people behave and interact naturally in the airport setting. This method helps understand how the design of the airport gate impacts travelers. It is important in qualitative research because it lets researchers watch and analyze behaviors and interactions without changing or affecting the environment, as explained by Ostrower. This approach is especially helpful for understanding social actions, cultural habits, and how organizations work. (Ostrower, 1998)

In this research, data was provided on how travelers navigated the airport space, dealt with crowds, and reacted to elements such as lighting, noise levels, and seating availability. These observations were crucial in establishing a connection between neuroarchitecture concepts, including brain function, schemas, cognitive maps, the sympathetic and parasympathetic nervous systems, the environmental stressor theory, and neuroaesthetics. They highlight how the design of spaces influences mental and emotional responses as well as the experiences of travelers. Through direct observation, the researcher can document elements such as travelers' behavior, the use of space, crowding levels, lighting conditions, seating availability, and noise levels.

Data Source

The criterion for selection was picking out airports that were located in places that could be a destination for both business and leisure travelers. Even though the study was restricted to the US, the diversity of locations was also prioritized. For this reason, the chosen airports are in different regions of the United States. Three airports were selected, airport A in Texas, airport B in Illinois, and airport C in California. Each observation lasted from 30 – 90 minutes, focusing on peak travel times, which were early morning, noon, and late afternoon.

Steps to Perform Observations

1. Airport Selection: Three airports were chosen based on their relevance to both business and leisure travelers. The airports are located in different regions (Texas, Illinois, and California) to ensure geographical diversity. After conducting the literature review, it was evident that design elements can significantly influence traveler's experience in built environments. Key concepts from the literature review include wayfinding, its effects on the brain, and how design variables such as ceiling height, illumination, and design complexity can impact travelers' journeys in airports. For this reason, when selecting the airports that would be included in this study, the spaces that may present challenges in navigation related to the identified concepts listed above were chosen. This approach allowed the researcher to not only identify the issues but also understand travelers' perspectives by examining their online reviews.

2. Timing and Observation Conditions: Observations were conducted at various times of the day, including early morning, midday, and late afternoon, with each session ranging from

30 to 90 minutes. This approach enabled a good understanding of how traveler behaviors and airport traffic patterns change throughout the day. By observing during peak and off-peak periods, such as rush hours and quieter times, a bigger range of interactions with the space could be documented. This variation in time also provided insights into how different factors, such as fatigue, time pressure, or changes in daylight, can influence travelers' responses to crowding, spatial layout, and other environmental conditions. These time-based observations were important for identifying patterns in how travelers navigate, use, and experience airport gate areas under different conditions.

3. Documenting the Data: Detailed notes were taken throughout the observation sessions, and photographs of the space were captured, ensuring that no identifiable images of individuals were included. Key environmental factors, such as crowding levels, ambient noise, and lighting conditions, were documented alongside traveler behaviors. This documentation provided a set of data to analyze how passengers interacted with the space, allowing for a more detailed understanding of the influence of environmental variables on their choices, movements, and overall comfort within the airport's boarding areas.

4. Analysis: The data was analyzed by looking for patterns that could explain how environmental stressors, such as crowding, poor lighting, or insufficient seating, influenced travelers' well-being and behavior.

Expected Outcome

By conducting these observations, the intention is to identify relationships between the design of waiting areas at airport doors and travelers' behavior. Specifically, the goal is to

understand how elements such as seating arrangement, lighting, crowding, and noise impact comfort, stress, and overall well-being. This information will be connected to neuroarchitecture principles and strengthened by the analysis of online reviews, which can be used to comprehend airport design in order to create more comfortable and stress-reducing experiences for travelers.

Online Reviews Analysis

To be able to deepen the understanding of travelers' experiences, online reviews were gathered and organized. The online review platforms that were used were *Yelp, Reddit, Airline Quality, and TripAdvisor.* To be able to organize all the information, and create insights that highlighted different themes and sentiments, Insight7, which is an AI tool focused on research and data collection, was used. Insight7, as described by the developers, is user-friendly and extracts key themes, summaries, and insights from interviews or reviews to identify challenges or difficulties and propose ideas. The verbiage used by Insigsht7 includes terms such as *pain points, sentiments, themes, and trends.* Paint points are "persistent or recurring problem that frequently inconveniences or annoys customers." (Merriam-Webster Dictionary). Sentiments are described in the circle charts and include the percentage of negative and positive comments. Themes include the main topics that were mentioned by reviewers, while trends display these topics by percentage in bar charts.

According to Morgan (2023), AI tools offer numerous benefits for qualitative research, including automated transcription and organization of data from interviews or observations, which saves researchers time and effort. Sentiment analysis enables AI to evaluate the emotional tone of textual data, providing insights into participants' attitudes and experiences. Insight7 can also enhance data analysis by identifying key patterns, themes, and topics through Natural Language

Processing (NLP) while supporting the creation of effective data visualizations such as word clouds or interactive dashboards, according to its developers. By automating tasks such as transcription and data organization, AI helps reduce researcher bias and significantly reduces time and costs, although it is essential that these tools complement, rather than replace, human experience and interpretation (Morgan, 2023).

Because Insight7 is an AI tool focused on qualitative research, it is more reliable than other AI platforms for this type of content analysis. The purpose of it is specifically to create reports including insights and uncover detailed patterns in use behavior. Insight7, according to its developers, helps businesses refine marketing strategies and create better campaigns. In the field of architecture and interior design, it can also be a useful tool for helping designers and other stakeholders to understand through the perspective of the users of the space, what they are looking for. In this research, the focus is to comprehend, using the lens of neuroarchitecture, how different environmental elements can affect well-being and satisfaction.

Data Source

In order to strengthen the insights from the observations and connect the data, the airports and gate waiting areas selected for the online reviews were the same ones visited during observations. Keywords, including the names of the airports, terminal letters, and gate numbers, were used to filter the comments and gather those related to the correct spaces. Since airports have different terminals with unique features, it would be challenging to evaluate the pain points affecting satisfaction by only selecting reviews that mention the airport in general. Some comments even compared different terminals, making it possible to assess which features were most valued by travelers and why one terminal was preferred over another.

Steps to Develop Online Review Analysis

1. Airport Selection: The same criteria were applied for the online review analysis method. Three airports were chosen based on their relevance to both business and leisure travelers. The airports are located in different regions (Texas, Illinois, and California) to ensure geographical diversity.
2. The online reviews were gathered from *Yelp, Reddit, Airline Quality, and TripAdvisor.* They were organized in a *Word* document. As mentioned, the reviews were selected using keywords, including the names of the airports, terminal letters, and gate numbers.
3. The *Word* document was uploaded into Insight7, and the AI tool was able to organize the information and create graphics and tables to better display the insights extracted from travelers' comments.
4. Analysis: After Insight7 created an automated analysis by highlighting *pain points, sentiments, themes, and trends,* it was possible to connect the findings to the observations and evidence the design elements and behavior patterns noted. This process strengthened the understanding of which design elements are most relevant when creating a space that promotes well-being and satisfaction.

Expected Outcome

The expected outcome of this online review analysis is to uncover key pain points and patterns in travelers' experiences in specific waiting areas at airport gates while also strengthening the observational method by providing additional layers of knowledge. By analyzing feedback using Insight7, it was possible to connect these questions to the principles of neuroarchitecture,

offering a deeper understanding of how environmental elements such as lighting, acoustics, spatial layout, and furniture design affect travelers' well-being and satisfaction. This analysis, combined with observational data, will guide the development of actionable design recommendations to mitigate discomfort and stress, ultimately improving the overall travelers' experience. The goal is to produce data-driven insights that complement observational findings, leading to more effective, user-centered design strategies for airport spaces.

Literature Review

In order to connect all the data gathered from both observations and online review analysis, a literature review was conducted to present the results. Grounding the research into reliable sources is essential to ensure their credibility. According to Snyder (2019), a literature review is relevant for research because it helps synthesize and assess the collective evidence in a particular area, providing a firm foundation for advancing knowledge and facilitating theory development. It integrates findings and perspectives from multiple studies, addressing research questions with a power that no single study can achieve. Additionally, it offers an overview of contrasting and interdisciplinary research areas, identifies gaps where more research is needed, and helps build theoretical frameworks and conceptual models. (Snyder, 2019)

This literature review links neuroarchitecture, spatial design, and its impact on human behavior, explaining their connection to travelers' concerns and experiences in the studied airports.

Steps to Develop Literature Review

1. Targeted keywords were used, such as neuroarchitecture, airport design, well-being, and wayfinding.
2. Databases and academic sources were used, selecting high-quality, peer-reviewed studies that align with the research goals.
3. The findings from observations and online reviews were complemented by connecting them to the neuroarchitecture concepts that were analyzed in the previous literature review.

Expected Outcome

The expected outcome of the literature review is to present the results of this investigation, integrating knowledge from the observations and analysis of the online review, using reliable previous studies as the foundation to support and validate the conclusions. By grounding the research in established knowledge, the literature review aims to contextualize the results within broader discussions in neuroarchitecture and spatial design. This ensures that recommendations drawn from the study are not only evidence-based but also aligned with best practices and principles from previous research. Additionally, the literature review will highlight any gaps or new insights this research contributes to the field, particularly regarding the impact of airport gates' waiting areas design on traveler behavior and well-being.

Data Analysis

The data collected through non-participant observations and online reviews and synthesized with the literature review was analyzed to identify key patterns and insights that relate to the research questions:

1. What key environmental design factors in airport gate waiting areas most effectively enhance travelers' experiences from the perspective of the travelers themselves?
2. How do these design factors align with neuroscience principles to reduce stress and improve well-being in airport waiting areas?
3. How can the design of wayfinding systems in airport gate areas improve traveler navigation and overall satisfaction, particularly by reducing stress and enhancing cognitive ease?

Each method offers a unique perspective on travelers' behaviors and experiences. The purpose of this analysis is to integrate these different viewpoints to form a comprehensive understanding of how the design of airport gate waiting areas can impact travelers' experiences and satisfaction.

To achieve the desired results, the **thematic data analysis** method was utilized. Nowell et al. (2017) provide an overview of thematic analysis, which is a qualitative research method used for identifying, analyzing, organizing, describing, and reporting themes within a data set. The authors outline the steps for conducting a thematic analysis, beginning with familiarization with the data, during which the researchers immerse themselves in the topic. The literature review greatly facilitated this step, revealing themes related to both neuroarchitecture and airport environments, with the aim of gaining deeper insight into the subject before commencing observations and online review analysis.

Subsequently, initial codes were generated. In this case, keywords such as comfort, wayfinding, well-being, acoustics, lighting, and stressors were listed to help connect with the data gathered from observations and online reviews. After data collection, the gathered information was synthesized, and themes were developed. These themes systematically explored how various spatial elements - such as lighting, furniture, and acoustics - affect travelers' well-being.

Thematic analysis is praised for its flexibility, as noted by Nowell et al. (2017). Researchers can adapt the analysis process based on the needs and nature of the study. This adaptability allows for developing themes that are meaningful to the research.

Themes Development

The notes and photographs from the observations were reviewed to identify people's behaviors and design elements that affect the overall airport experience. Key behaviors, such as moving patterns, responses to stressors, and interactions with the provided amenities, were categorized to highlight common trends when compared to online reviews. These elements were connected to neuroarchitecture principles to understand, through empirical data, why these components affect their behavior and comfort.

The online reviews were analyzed with the insights, graphs and numbers extracted from Insight7. The software automatically extracted *key themes* that included pain points and sentiments from users' reviews. By comparing reviews across the same three airports that were observed, patterns were identified to determine which design factors consistently influenced traveler satisfaction and well-being. The online reviews are tools to complement the data gathered from the observations in order to reduce bias. Using an AI tool helps with the bias factor since it is generated, and the researchers' personal opinions and experiences don't influence the results.

A comparative analysis was conducted by examining observational data and online reviews to identify consistencies or discrepancies in traveler experiences. For example, if environmental factors such as crowding or noise are emphasized in both data sets, this strengthens the conclusions. This analysis also aligned with neuroarchitecture principles, specifically on how design elements influence stress levels and cognitive ease. To build up the analysis, results from

literature reviews were integrated, providing a theoretical framework that connects environmental design, neuroarchitecture concepts, and traveler experiences. Previous studies were used to contextualize the identified patterns, highlight any gaps, and ensure that the investigation builds on established knowledge. This combined approach, also called triangulation, deepened the understanding of the relationship between airport design and traveler behavior, offering a valuable perspective on the topic.

Tables, diagrams, and maps were created to synthesize the gathered information and facilitate the understanding and visualization of the results. The objective is to make this study comprehensive and easy to follow.

CHAPTER IV – RESULTS AND ANALYSIS

Introduction

This section includes data collected from non-participant observations and online reviews using insight7. These methods were chosen to be able to evidence the social phenomena that occur in airports, especially surrounding the airport gates. Through observing the behaviors and travelers' reviews, it will be possible to connect human behavior and interaction with the environment to the neuroarchitecture concepts explored that include **brain function, schemas, cognitive maps, sympathetic and parasympathetic nervous systems, the environmental stressor theory, and neuroaesthetics.** The aim of this connection is to be able to better comprehend travelers' needs and challenges.

In order to create a richer connection, the results from both methods were tied with a literature review and design analysis of lounges and other departure gates' waiting areas. During the observation period, the following elements and factors were considered:

- Spatial layout and proximity of seating to the boarding gate and how it influences travelers' flow and behavior.
- Availability and accessibility of amenities (e.g., charging stations, food outlets) and how they impacted travelers' comfort and convenience.
- The impact of crowding on traveler behavior, including how it influences their movement patterns, stress levels, and decisions regarding where to sit or stand. Visual and acoustic stimuli (e.g., noise levels, lighting quality)
- Traveler behavior during different phases of waiting (e.g., checking phones, conversing, moving around)

Observations

Non-participant observations were conducted during personal travels to collect data about three different airports in the United States.

Airport A – Texas

The observations at Airport A were conducted at the same gate waiting area location on three different days, which made it possible to assess elements, such as lighting, at different times of the day. The busyness of these gates varies depending on the day of the week and the time of day:

- 3/21 - Thursday / 6 AM: The space was moderately crowded, especially in the corridors. Most travelers were either sleeping or using electronic devices. The TSA checkpoint was in front of the gate, which complicated traffic flow and increased noise levels.
- 3/31 - Easter Sunday / 3 PM: The space was significantly more crowded, likely due to the holiday. There was a noticeable diversity in the types of travelers, including families, couples, and business travelers.
- 7/17 - 2 PM: The gates were not very crowded, which helped with the overall organization of the space.

Spatial Organization and Layout

The organization of the gates presented some challenges, particularly affecting traffic flow:

- Low Ceilings and Limited Windows: The low ceilings and the limited number of windows contributed to a darker environment, which might impact travelers' spatial perception.

- TSA Placement: The TSA security checkpoint was positioned directly in front of the gates, creating congestion and noise, affecting traffic flow and acoustic comfort in the area. These activities generated constant noise since there was no separation from that area to the gate.
- Crowd Noise: The high volume of travelers in transit added to the noise levels, making it harder for travelers to hear announcements or concentrate.

Lighting and Ambiance

The lighting conditions had a direct impact on the ambiance and traveler comfort:

- 3/21 - 6 AM: In the absence of natural lighting, artificial lighting was assessed. The gate area had colder lighting. The uniform lighting across the space contributed to the darker atmosphere.
- 3/31 - 3 PM: The area received more natural light despite the limited windows, but the exterior views remained restricted. The dark flooring contributed to a compressed and heavier visual weight.

Furniture and Amenities

There was a limited variety, and the availability of seating options impacted on traveler comfort, with only one table with outlets available for three gates. This limited variety can:

- Restrict travelers' comfort choices.
- Lead to congestion and overcrowding in certain areas.
- Reduce accessibility for travelers with specific mobility needs.
- Offer inadequate personal space or privacy.

- Create uneven distribution of amenities, particularly charging stations and work areas.

Something interesting that could be noticed was that a few gates at the end of the terminal had their holdrooms renovated. This part had higher ceilings, lighting variety, new flooring, bigger windows, and different seating options. The difference between this area and the waiting areas that were analyzed was noticeable. It would be a positive - and very exciting project - to extend the renovations to the other spaces in the terminal.

Airport B – Illinois

8/18 - Sunday / 8:05 PM: Due to arriving early at the gate, many people were still boarding the previous flight. It was necessary to stand while waiting for travelers to board. Afterward, it was noticeable that people would approach the gate and find another place to wait since there was no designated holdroom and limited seating options. Approaching the flight time, the number of people by the gate increased, and travelers mostly sat on the floor or stood.

Spatial Organization and Layout

The gate design at this airport deviated from the typical layout seen in most American airports:

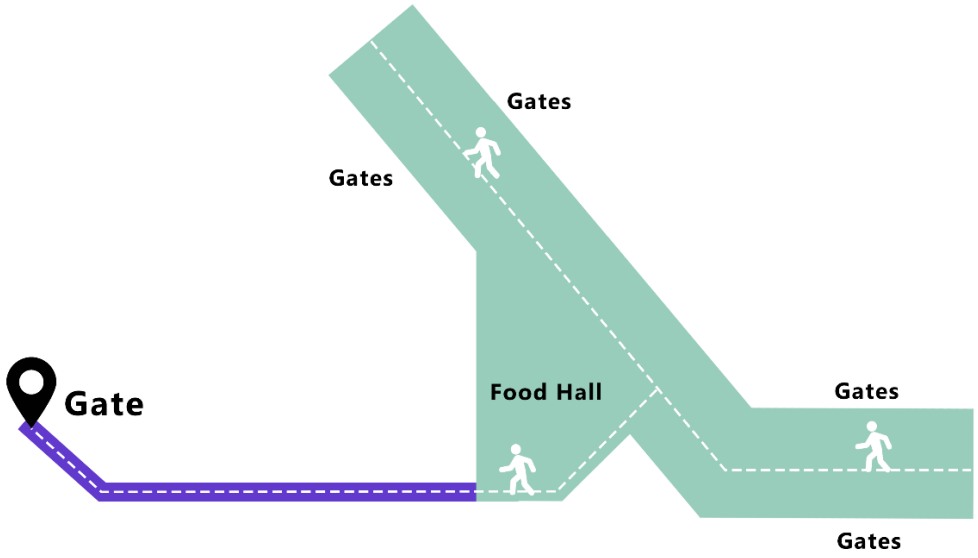
- Non-conventional Gate Placement: Unlike traditional gate areas, the gate was placed at the end of a long corridor, which had small windows, and lacked natural lighting, as shown in figure 13.
- Confusing Walkway: The pathway leading to the gate was confusing for travelers, contributing to disorientation.

- Longer Walk: The distance to the gate required a longer walk, which could add to traveler fatigue, especially for those with mobility challenges.

  Figure 12 illustrates the traveler flow in that area of the airport.

Figure 12

Flow Diagram – Airport B.



Note. Diagram by M. L. Klem (2024)

Lighting and Ambiance

- Having small windows and little natural lighting contributed to a darker, less inviting environment, potentially affecting travelers' moods and well-being.

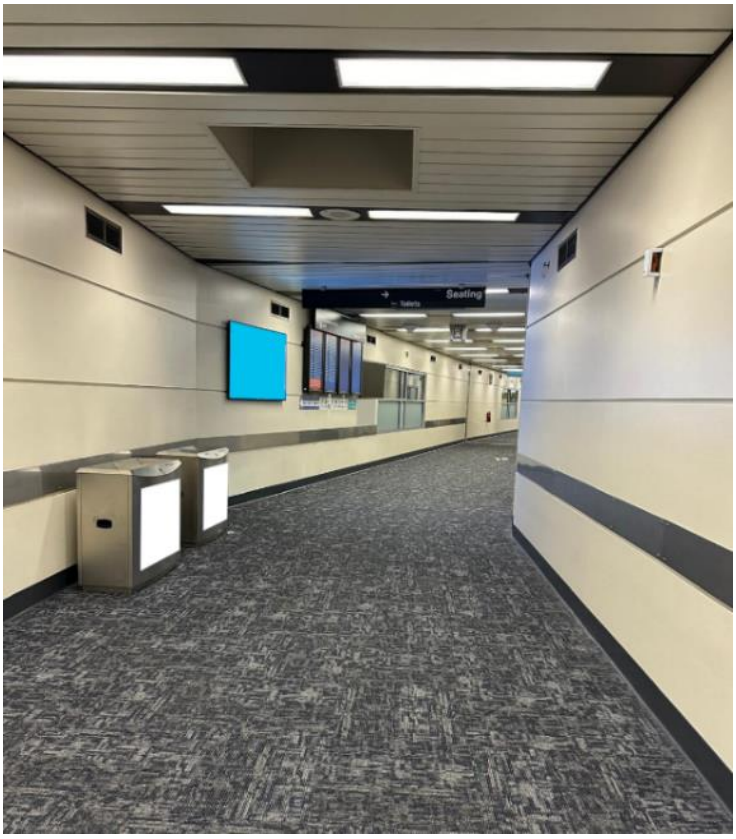
Furniture and Amenities

- No Designated Waiting Area: There was no dedicated Holdroom for travelers to wait near the gate.
- Limited Seating: Only four seats were available at the gate, forcing many travelers to either sit on the floor or wait in other areas that were not close to the gate itself.

- Small Screen with Flight Information: The flight information was displayed on a small screen, which may have been difficult for travelers to see from different areas.
- Small Number of Windows and Natural Lighting: The small number of windows contributed to a darker atmosphere, affecting the overall ambiance.

Figure 13

The Corridor Leading to the Gate – Airport B.



Note. Photo taken and edited by M. L. Klem (2024)

Traveler Behavior

- The unconventional location of the gate at the end of a long corridor with small windows and a long walkway created challenges in navigation and accessibility for travelers.

- The absence of a holdroom required travelers to wait in further locations or sit on the floor, reducing comfort and convenience.

Airport C – California

3/23 - Saturday / 2:30 PM: The space was crowded, particularly in the corridors. Most travelers were eating, standing, or sitting on the floor. There were many kids.

Spatial Organization and Layout

- The terminal layout was not organized linearly, which could impact travelers' wayfinding experience.
- The designated holdroom for the observed gates appeared to be small for the boarding demand.

Lighting and Ambiance

- The lighting conditions were consistent throughout the area but there was no variation in lighting, and the space remained darker overall, possibly affecting travelers' mood and perception of the space

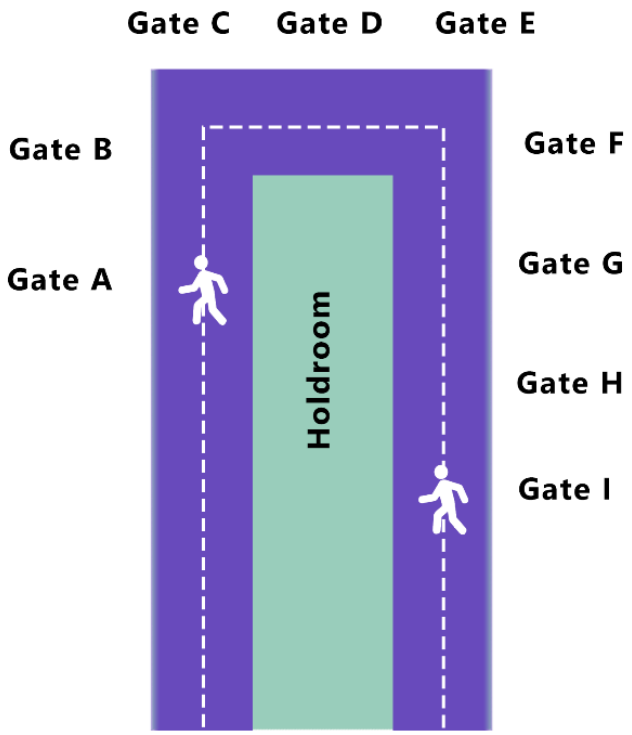
Furniture and Amenities

- Noisy Environment: The gate area was filled with people talking, contributing to elevated noise levels that may have disrupted relaxation or focus.

- A few seats were available for travelers at Gates A-I, as shown in Figure 7, forcing many travelers to sit or lie on the floor. Families with small children were observed lying on the floor with their bags spread around.

Figure 14

Flow Diagram – Airport C.



Note. Diagram by M. L. Klem (2024)

Traveler Behavior

Travelers' behaviors might have reflected the discomfort caused by the space limitations:

- Sleeping and Laying on the Floor: Many travelers were observed sleeping or laying on the floor, particularly families with children.
- Standing by Outlets: Travelers frequently stood by outlets due to limited seating options and a lack of accessible charging stations.

- Walking Back and Forth: Some travelers were pacing, walking from side to side, possibly due to a lack of comfortable waiting spaces or as a way to pass the time.
- Behavior in Line: When one person in line stood up, others followed, even when it wasn't time to board, indicating a heightened sense of readiness or anxiety among travelers.

Because there were a large number of travelers in the area, it was possible to observe various people's behaviors near the boarding gate. Noticing these behavioral patterns was an interesting experience. Terminals are spaces where all different types of people can be found, and how they react to the environment can be quite revealing, reflecting diverse emotional states, stress levels, and coping mechanisms during travel.

Online Reviews Analysis

The sample online reviews from three geographically diverse airports (Texas, Illinois, and California) revealed key *pain points* related to spatial amenities, stressors, and layout issues. These were collected for each airport from at least three of the selected review websites: *Yelp, Reddit, Airline Quality, and Trip Advisor.* Using Insight7, data was automated into graphs and diagrams, highlighting recurring issues such as overcrowded spaces and inadequate wayfinding. Understanding travelers' perspectives makes creating spaces that adequately embrace functionality and user satisfaction possible.

The verbiage used by Insight7 includes terms such as *pain points, sentiments, themes, and trends.* Paint points are "persistent or recurring problem that frequently inconveniences or annoys customers." (Merriam-Webster Dictionary). Sentiments are described in the circle charts and include the percentage of negative and positive comments. Themes include the main topics that were mentioned by reviewers, while trends display these topics by percentage in bar charts.

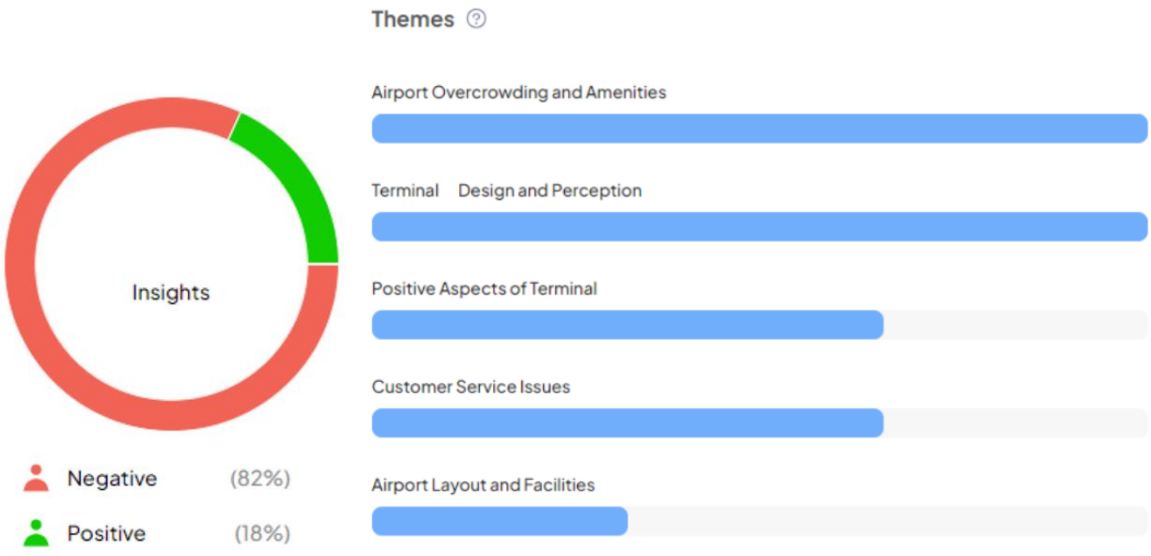
Reviews were selected using specific keywords, including airport names, terminal letters, and gate numbers. Airports A and C had more generalized reviews, with most comments focused on the terminal. In contrast, for Airport B, using the gate number allowed for finding many reviews, enabling a more focused examination.

Airport A – Texas

Airport A's reviews display some travelers' concerns. The results from Insight7 highlight that the chosen terminal for the study is criticized for being **crowded, outdated, and having poor customer service.** Besides that, travelers report long lines, rude staff, and limited food options. The reviewers affirm that the layout is confusing due to its **outdated design, low ceiling heights, and the gates being "spread out."** Some users appreciate the cleanliness and the area with recently renovated holdrooms. Figure 15 shows the sentiments and themes that were extracted from the comments.

Figure 15

Sentiments and Themes – Airport A.

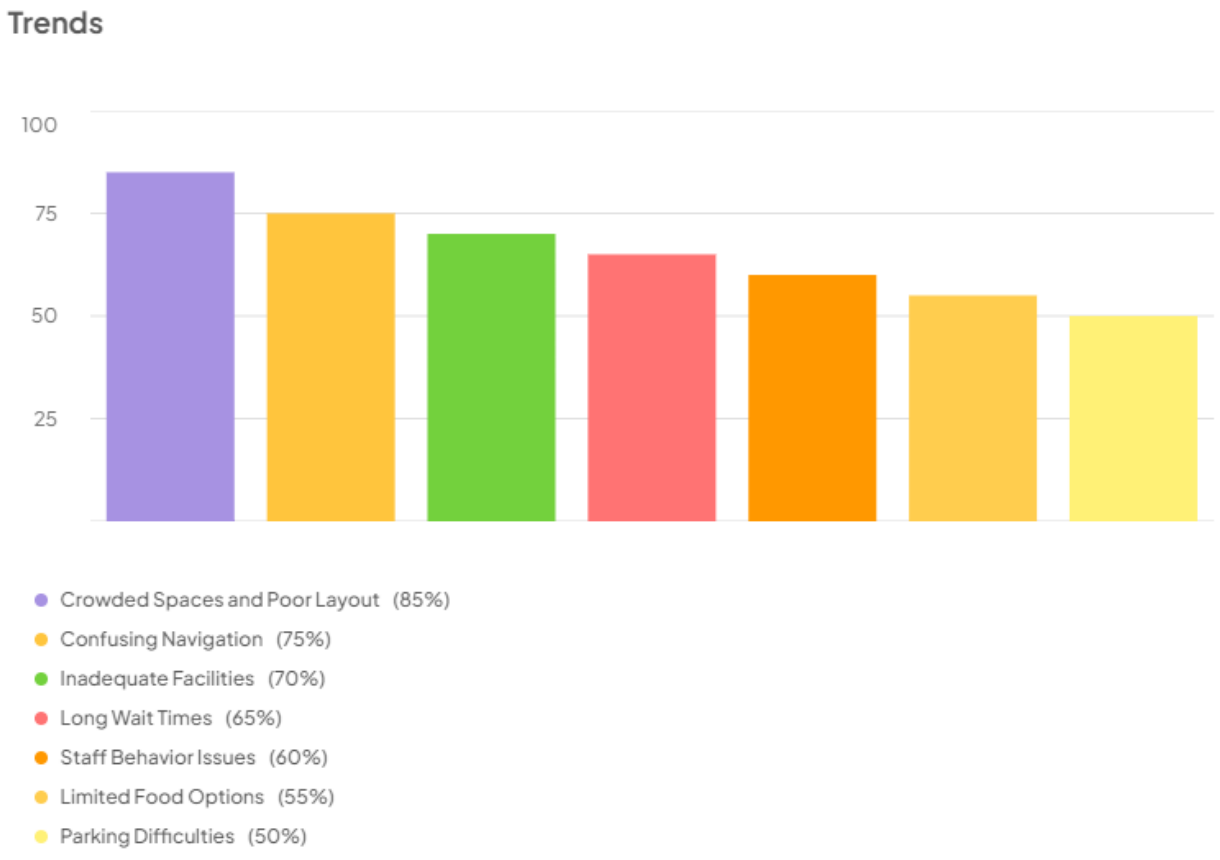


Note. Extracted from Insight7.

The trends graph (figure 16) points out the main topics and the percentage of comments that mentioned them. It is possible to notice that **crowding**, which is considered an external stressor, as cited by Kopec (2018), is the number one concern among travelers. According to the reviews, **confusing navigation**, which is affected by poor wayfinding, is the second biggest concern. Chapter II explored how to recognize patterns from elements that impact human perception and behavior, and this analytical approach made it possible to discover some of these underlying issues as observed in the travelers' reviews.

Figure 16

Trends – Airport A.



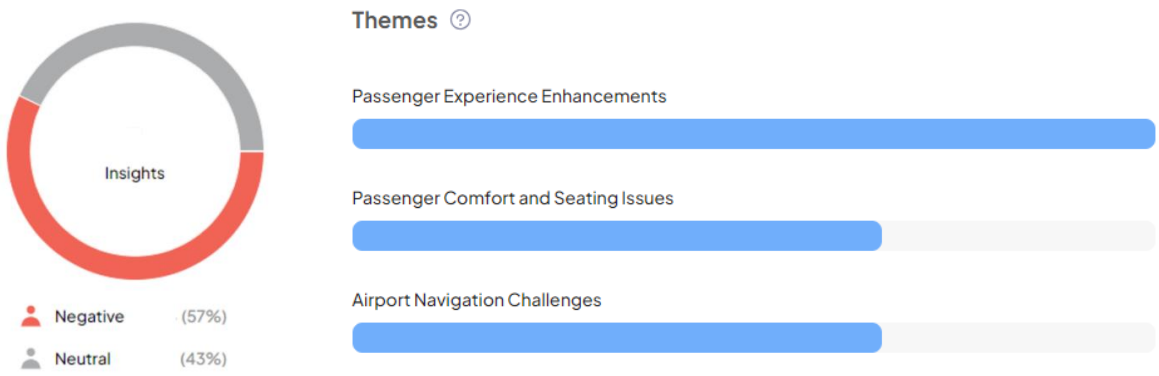
Note. Extracted from Insight7.

Airport B – Illinois

The concerns expressed by travelers related to Airport B focused on **orientation, wayfinding, and general layout.** Reviewers related difficulties locating the gates that were analyzed through observations. The comments feature **long corridors** and **confusing signage.** Reviews highlight the fact that the airport's design requires **long walks** to reach the gate, which can be tiring, especially when services like seating and concessions are limited around the boarding area. Other comments emphasized **crowding** and **noise**. Something noteworthy about Airport B's online reviews is the ability to find specific comments related to the observed gate, allowing for more precise insights into the area. Figure 17 showcases the sentiments and themes extracted from Insight7.

Figure 17

Sentiments and Themes – Airport B.

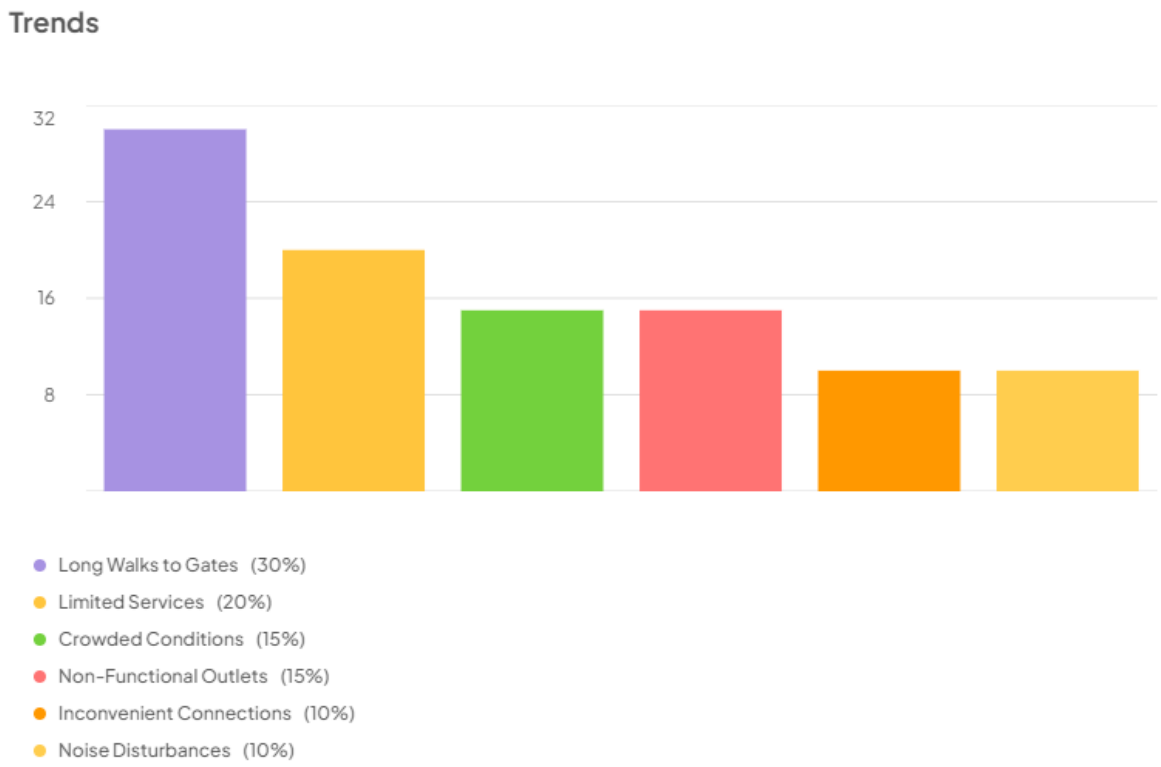


Note. Extracted from Insight7.

Figure 18 portrays the current trends at Airport B and showcases the most prevalent topics discussed among travelers. The primary concern among travelers is the **long walks to the gate** (30%), closely followed by the **limited availability of services** (20%) and the **crowded conditions** within the airport. (15%)

Figure 18

Trends – Airport B.



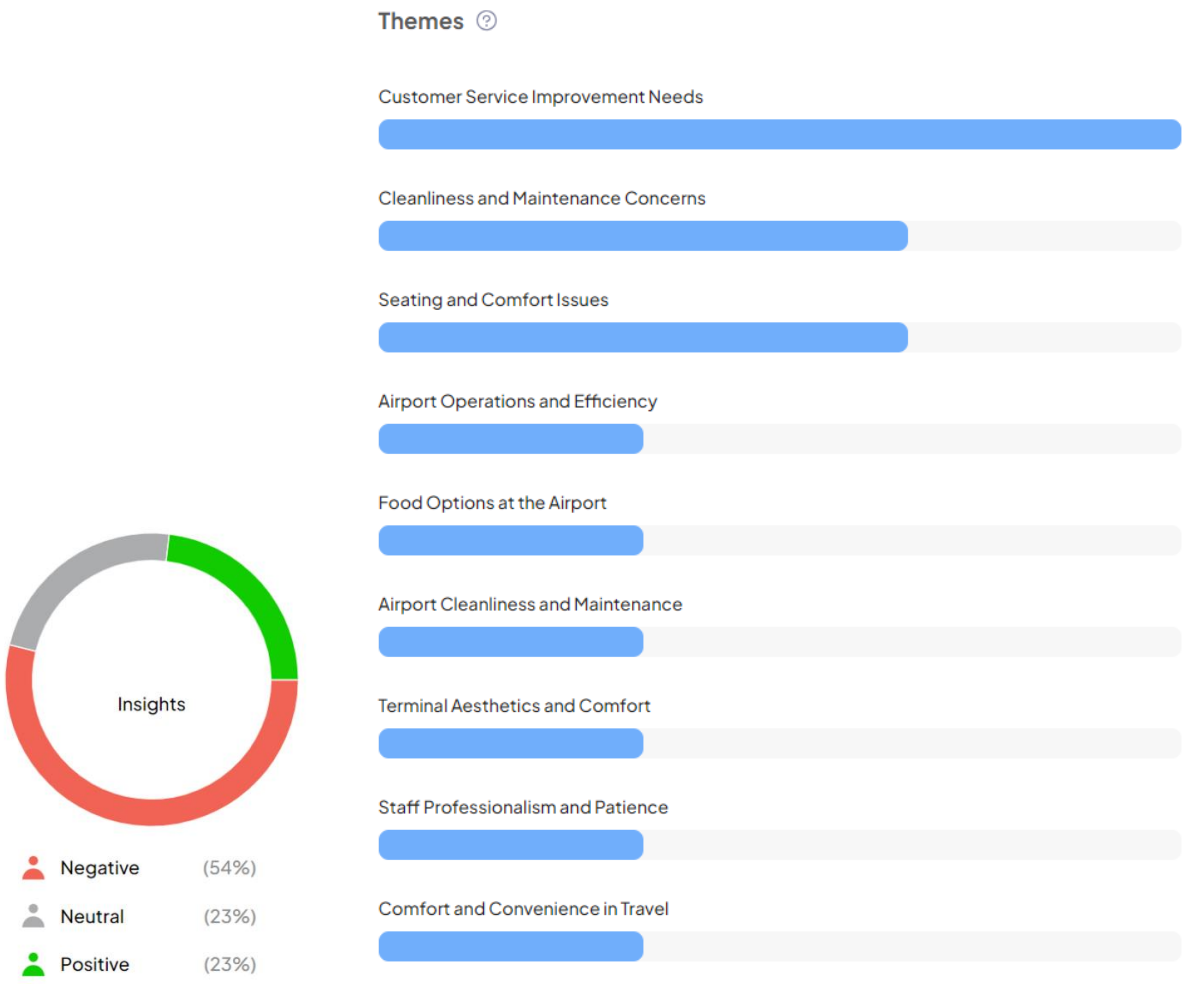
Note. Extracted from Insight7.

Airport C – California

According to the reviews gathered, Airport C is currently undergoing renovations and presents negative, neutral, and positive insights. Key issues **include overcrowding, insufficient seating,** and limited, overpriced food options. Travelers also highlighted positive aspects, **including cleanliness and friendly staff.** Figure 19 showcases the sentiments and themes extracted from reviews.

Figure 19

Sentiments and Themes – Airport C.

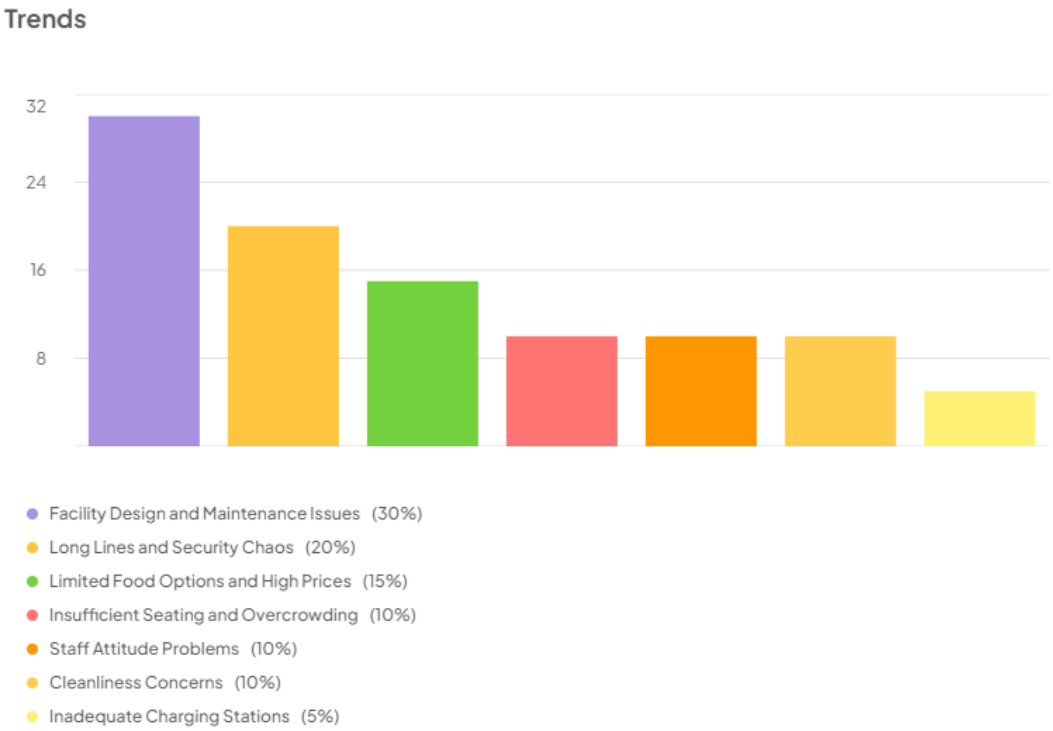


Note. Extracted from Insight7.

Figure 20 contains the chart that illustrates the top *pain points* faced by travelers in Airport C, with facility **design and maintenance issues** being the biggest concern, accounting for 30% of reported issues. **Long lines and chaotic security processes** are the second most significant problem, accounting for 20% of complaints. Other notable challenges include **limited food options and high prices** (15%), **insufficient seating and overcrowding** (10%), as well as **employee attitude issues** (10%) and **cleanliness concerns** (10%).

Figure 20

Trends – Airport C.



Note. Extracted from Insight7.

Analysis

After conducting observations and extracting data from Insight7, an AI tool focused on qualitative research; an analysis was undertaken to compile the information gathered. Matching the observations with the automated info from Insight7 helped reduce observational bias and organize the data. While AI tools assist in structuring research and generating graphs and diagrams for easier visualization, reviewing the data to ensure coherence is important. For this reason, tables were created to summarize the main themes from observations and online reviews. The tables include **insights, design factors, perception, and highlights.** Insights relate to the topics mentioned in the reviews, while design factors list the design elements that could impact the travel

experience. The perception column contains the topics related to their interaction with the space, and highlights include the actual reviews with airport and terminal names omitted for privacy. The key highlights are valuable, as they include direct quotes from online reviews, providing genuine reflections of the travelers' sentiments and thoughts.

Airport A – Texas

Table 2

Themes & Insights – Airport A

AIRPORT A - TEXAS			
Insight	**Design Factors**	**Perception**	**Highlight**
The airport is experiencing overcrowding, leading to long lines and inadequate service access.	Flow Layout Efficiency	User Experience Customer Interaction Overcrowding	*"[…]is now approaching **overcrowded stage**. **Long lines**, **poor service** […], **inept gate personnel** […]"*
Due to design factors, such as low ceiling height and layout efficiency, thermal comfort can be affected, and negative feelings towards crowding can be exacerbated.	Ceiling Height Thermal Control Flow Layout Efficiency	Comfort Sense of Confinement Overcrowding	*"It's **tight** and **crowded** with **super low ceilings**, always so **hot**."*
Outdated design that was not focused on creating spaces that accommodated all kinds of travelers is now facing challenges related to overcrowding, and it affects travelers' satisfaction.	Flow Layout Efficiency	Overcrowding	*"They were never designed to **be hub & spoke airports** or to handle the **crowds** that fly now."*

Layout and spatial issues can impact seating availability, which affects travelers' comfort.	Seating Availability Layout Efficiency	Overcrowding Comfort	*"The concourse was very **crowded** and there was a **lack of seating at the gate area**."*
The terminal is widely regarded as outdated. Lower ceilings and, consequently, smaller windows impact travelers' perception of the space.	Lighting Design Natural Light Availability Outdated Design	Comfort Sense of Gloominess	*"[...] ** **terminal is dark** and should be [...] **rebuilt**.*
The airport is perceived as outdated, with old flooring and walls and low ceilings.	Outdated design Ceiling Height Materiality	Comfort	*"As for terminals,[...] are all **aging** and look **ready for a big update. The flooring, walls, ceilings, ... it's all outdated"***
Travelers highlight the fact that the terminal has many service options.	Layout Efficiency	User Experience	*"There are **lots of shops** and eateries in **the gate areas**"*
Certain areas of the airport, particularly near the recently renovated holdrooms, are noted for their brightness and modern design, contrasting with the overall perception of the terminal.	New Design Lighting Design Natural Light Availability	User Experience Comfort	*"If you go down towards Gate **, it **feels like a completely different airport.** They're **SO NICE**. Hopefully, they'll turn the entire terminal into gates like those."*
The recently renovated holdrooms are considered a standard for the other departure gates' areas to follow.	New Design Lighting Design Natural Light Availability	User Experience Comfort	*"Any amount of work and effort to improve ** **with the exception of ** gates**."*

Spaces such as lounges that prioritize hospitality are well-regarded by travelers.	Layout Efficiency Flow	User Experience Sense of Place Hospitality	*"The old school **Admiral's Club** is **classic**. A bit musty but **spacious** […] It was the first one I ever visited; good times."*
Having a challenging navigation system can lead to the need for interactions with staff who do not always have the ability to deal with a large number of travelers.	Layout Efficiency Flow	User Experience Customer Interaction	*[…] **Rude workers can definitely ruin a travel experience** when an airport is already **stressful enough**!"*
The airport layout is confusing, with the bathrooms being inadequately distributed relative to the number of gates, causing inconvenience for travelers.	Layout Efficiency Navigation	User Experience	*"**Bathrooms are spread out** […] All of their gates **are so spread out and the layout makes no sense at all**."*

It was interesting to note that some reviewers highlighted how the recently renovated gates offered a completely different experience for the users of the space. Through observations, it was evident that this area features higher ceilings, ample natural light, and various seating options. New lighting elements contribute to intuitive wayfinding and create an engaging environment. Another positive comment mentioned the Admiral's Club lounge, emphasizing the value travelers place on comfort - particularly as lounges prioritize hospitality- and the sense of place, as one traveler expressed a nostalgic feeling the space evoked in them.

Airport B – Illinois

Table 3

Themes & Insights – Airport B

AIRPORT B - ILLINOIS			
Insight	**Design Factors**	**Perception**	**Highlight**
Travelers have noted that the security line is often short, and there is a variety of shops, which is a positive aspect of the airport experience.	Layout Efficiency Navigation	User Experience	*"[...] there was **hardly a line** at all to get through security. **There's lots of shops** [...]*
Travelers appreciate the quiet atmosphere at the concourse, which lacks loud TVs or music, emphasizing that travelers aim for spaces that promote a calm experience by the gate's waiting areas.		User Experience Comfort	*"I like that the gates where I as at [...] there were **no loud TVs or music playing**. **Travelling is loud enough**. [...]*
The seating arrangement at the Concourse is cramped, making it difficult for travelers to find comfortable spots to sit. The comment also highlights the importance of having charging stations.	Seating Comfort Seating Variation Charging Stations	User Experience Comfort	*"[...] **Seating is stacked** in such a way that you have to shimmy to get a seat. **Many outlets don't work**."*
The long walk to the Gate is exhausting, especially with limited seating and no concessions available at the end.	Seating Availability Layout Efficiency Navigation	User Experience Comfort	*"[The gates have] **No concessions** at the end of **an endless walk** with not **enough seating**"*

The airport layout can be confusing, particularly with the long jet bridge and the distance between gates.	Layout Efficiency Navigation	User Experience Comfort	*"[...] Thats a **confusing** [...] gate to find. [...] **long walk and no "services" nearby**."*
The long corridor to the gate, which only has a small number of windows, can contribute to an even more negative experience for travelers.	Lighting Design Natural Light Availability Outdated Design	Comfort Sense of Gloominess	*"[...] Heart of **Darkness** facilities [...].*

While looking for reviews focused on this specific airport and gate, comments from 21 years ago were found on *airliners.net*, expressing the same concerns. Although these were not considered in the insights, comparing the newer comments with the older ones was very thought-provoking. It was interesting to notice that not much has been updated in the area, and comments expressed the same concerns. Below are two of the comments that were found on this website.

"After sitting in quite possibly the most uncomfortable seat for over two hours, I felt truly "honored" to have to walk down a corridor for my connecting flight to DFW that had to have been at least 200 yards long with my 60 LB carry-on. Some sort of makeshift pre-fab tunnel that had absolutely nothing but two gates at the end of it."

*"Sorry you had to walk thru that long walkway with no windows. I have seen that tunnel. It runs along *** avenue. That tunnel is temporary, won't be there much longer. Once the constrution on concorse ** is done they will go on and finish concorse **. And you won't be using that tunnel anymore."*

Even with concerns expressed years ago, the space continued to be used for the same purpose without updates. It is evident that the long runway, confusing layout, and lack of natural lighting were and continue to be a complaint from travelers. This emphasizes the importance of valuing users' reviews, as it showcases the issues and needs of the space that can be mitigated.

Airport C – California

Table 4

Themes & Insights – Airport C

AIRPORT C - CALIFORNIA			
Insight	**Design Factors**	**Perception**	**Highlight**
Having a challenging navigation system can lead to the need for interactions with staff who do not always have the ability to deal with a large number of travelers.	Layout Efficiency Navigation	User Experience Customer Interaction	*"[…]* ***security was not helpful****... […]* ***great way to start a trip.****"*
Capacity, convenience, and comfort impact travelers' journeys.	Layout Efficiency Seating Availability Seating Variation	Comfort Sense of Confinement Overcrowding	*"So* ***cramped****, so* ***crowded****, only one bathroom on each side of the terminal resulting in* ***long lines****, very limited food options, nowhere near* ***enough seats.****"*

Even though the referred area is large, the space planning could have been improved to enhance layout efficiency and consequently cater to diverse travelers' needs.	Layout Efficiency Seating Availability Seating Variation	Comfort	*"[...] This* ***terminal has space****, but there is such a* ***lack of chairs*** *that* ***most of the space is wasted****. I have witnessed professional* ***** goers bring beach towels so they can lay down on the floor and relax****."*
Travelers have noted that the terminal has an outdated design. They also described not having a good aesthetic experience. Travelers Complain about comfort and seating availability.	Layout Efficiency Seating Variation Seating Availability Seating Comfort Outdated Design	Comfort	*"The* ***seats are uncomfortable****, the* ***space it's not utilized as good as it could have been****. I almost feel like it has a* ***bad 80's vibe*** *[...]"*
Some reviews affirm that the staff at the airport are demonstrating patience and professionalism, which positively impacts travelers' experiences during busy times.		User Experience Customer Interaction	*"The employees are* ***being patient, calm, and redirecting lost travelers into the correct lines […]*** *one counter person gave me a* ***positive sign*** *of things to come today****, which was relieving."***
Travelers appreciate the availability of power outlets in seating areas, enhancing their comfort and convenience while waiting.	Charging Stations New Design Layout Efficiency	User Experience Comfort	*"The best part is the seating/waiting areas, where* ***there is power for USB or standard plugs at every seat.*** *Also, the* ***bathrooms are brand new with very wide stalls*** *[...]"*

In summary, the feedback from travelers highlights several observations, concerns, and compliments about the airport terminal experience. **Confusing layout, insufficient seating, and maintenance** were relevant topics in the comments. While some reviewers mentioned that they had a bad experience with personnel, others expressed appreciation for the professionalism of other staff members. One interesting thing to be highlighted from one of the comments that praised the customer service is that after emphasizing that the employees were being patient and redirecting people who were lost, they said: *"One counter person gave me a positive sign of things to come today, which was relieving."* Comments like this make us realize that travelers are already anxious about the travel journey, and any little help that can make it less stressful is already appreciated.

Conclusion

The design and spatial conditions of airport terminals can significantly impact travelers' comfort and satisfaction, as demonstrated by the experiences observed at the airports and analyzed through online reviews**.** In **Airport A**, overcrowding was the biggest concern among travelers in the specific terminal. Observations highlighted that the low ceiling and limited windows contributed to a darker, more compressed environment, which affected travelers' spatial perception and comfort (Vartanian et al., 2015). Through both observations and online reviews, it was possible to notice a lack of seating variation and limited charging stations that can induce crowding in certain areas of the airport, where outlets can be found. Overcrowding is an ambient stressor (Kopec, 2018), increasing anxiety and discomfort, activating the sympathetic nervous system, and increasing stress levels (Ruggles, 2017; Chu et al., 2024). The feeling of enclosure and a cluttered environment are further examples of how overstimulation, as Goldhagen (2017) noted, can lead to cognitive exhaustion, emphasizing the need for spaces that minimize stress and support well-being.

Observations and online reviews complemented each other, as it was possible to understand comments by experiencing the space. Seeing the gates' waiting areas complimented by reviewers at **Airport A**, for instance, made it possible to evidence the aspects that travelers value without even realizing. In contrast with most parts of the terminal, the space has higher ceilings, bigger windows, and ceiling elements that help with noise and intuitive wayfinding. Research conducted by Erkan (2018) highlights that the height of the ceiling directly impacts the time it takes for individuals to navigate through a space. Specifically, lower ceiling heights can lead to increased time spent searching for their destinations since they cause the feeling of confinement and interfere with the formation of cognitive maps (Proshansky, 1978; Guelton, 2023). This means that the wayfinding experience is not only affected by a lack of design variation but also by ceiling heights and openness.

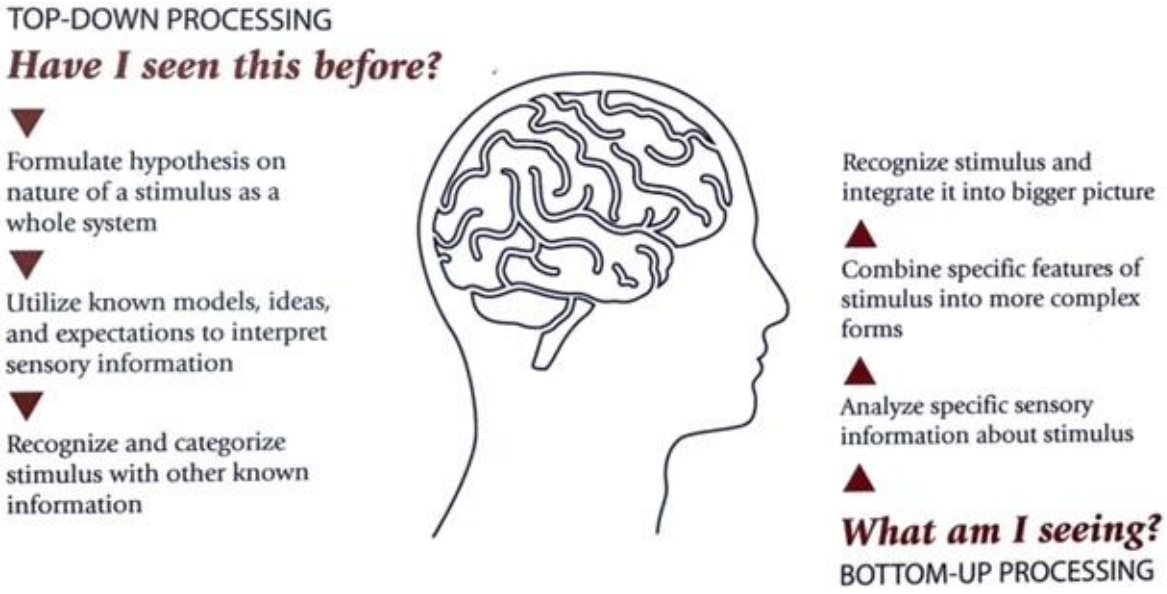
As mentioned in Chapter II, mental representations of the space, also called cognitive maps, are subject to many distortions and omissions (Guelton, 2023). These maps are not continuous but patchworks of models, memories, and expectations influenced by the design and layout of the space (Guelton, 2023; Ruggles, 2017). Ruggles (2017) mentions Hermann Von Helmhotlz, when bringing up the "bottom-up" and "top-down" processes to talk about how people read environments. The author explains the difference between both processes by saying that "Top-down refers to cognitive influences and higher-order mental functions such as expectations, attention, imagery and learned visual associations" (Ruggles, 2017, p.83). He highlights that the brain is analyzing stored knowledge to understand the emotion that is being felt. This type of processing helps to clear up confusion; when the brain only partially recognizes something, it uses this mental process to fill in gaps and missing details for the information being processed to make sense. On the other hand, "the bottom-up processing is based on circuitry that is inherent in our

brain, essentially innate, intuitive knowledge that initiates the emotion" (Ruggles, 2017, p.83). This process follows basic rules humans are born with. The way people notice an important part of what is seen, like shapes and edges, involves intuition and thinking (Figure 21).

When connected to the airport experience, the top-down process, which involves cognitive functions such as expectations, attention, and learned visual associations, allows travelers to use knowledge previously acquired and visual cues to interpret the environment. For example, a traveler might subconsciously associate higher ceilings and open spaces with beauty and ease of navigation because of past positive experiences. At the same time, the bottom-up process is more intuitive as it relates to shapes, edges, and spatial arrangements. For instance, the brain might quickly sense if the space feels open or confined, creating an emotional response before humans fully interpret it.

Figure 21

Top-down and Bottom-up processing



Note. Source: Ruggles (2017)

Creating design standards for airports becomes imperative, as it establishes consistency and predictability, which involves the top-down process that includes expectations and learned associations. When airports follow standards in layout, travelers can recall previous experiences or learned information (when first-time travelers) and feel more confident in navigating the space. This aligns with the concept of schemas explored by Goldhagen (2017). As mentioned in Chapter II, schemas are built through experience and learning, and they help the brain quickly categorize and respond to information. When expectations about the flow of the airport experience are met, schemas can simplify decision-making and reduce cognitive load.

Besides Airport A, wayfinding was also an important topic in **Airport B**. The dimly lit corridors leading to the gate caused confusion, disorientation, and fatigue. Boudreau et al. (2016) affirm that travelers prefer to stay by the gates to reduce worry. A long corridor without a significant landmark aligns with the studies conducted by Liang et al. (2023) on the parahippocampal cortex and its role in landmark-based distance estimation. His studies suggest that having clear landmarks increases orientation, improves wayfinding, and reduces cognitive strain. Due to the lack of visual landmarks in an unusual airport setup, the uncertainty of the gate's location and distance, added to the limited time between flights, and tiredness, among personal stressors, can add up to travelers' journeys in a negative way. Wayfinding can also mitigate other pain points extracted from the reviews. Staff rudeness was mentioned by reviewers of different airports. Even though this is not an element that belongs to design, intuitive wayfinding can create a seamless experience and reduce the need for travelers to ask questions.

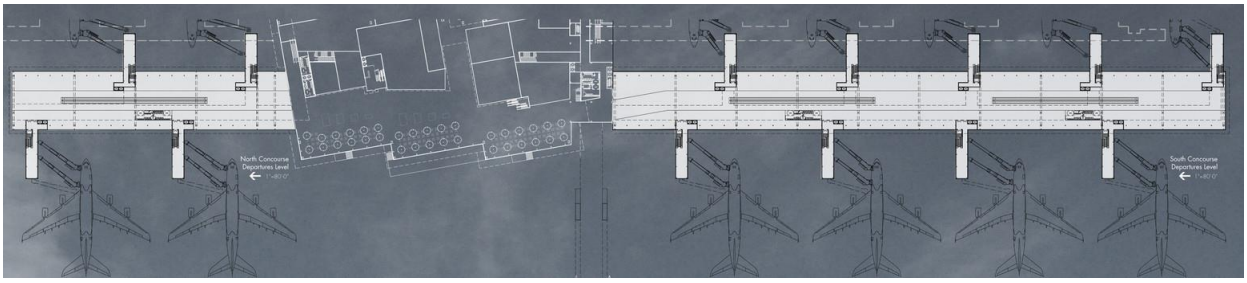
Harding et al. (2011) highlight the fact that in architectural configuration, the plan complexity is directly connected to a decrease in wayfinding performance. The ideal configuration would include linear wayfinding, meaning that there should be easy visual access connecting point

A to point B, decreasing travelers' stress and enhancing their travel experience, as seen in Figure 22. It is also highlighted that linear and easy wayfinding should include architectural differentiation, including different color zones or different design elements, and plan configuration, with a clear and simple layout that is easy to follow. (Harding et al., 2011)

However, it is not always possible to create this linear visual connection, and the support of non-linear wayfinding layouts is more complicated. The solution would be to rely on signage and visual cues whenever that happens. To guide travelers, a well-designed wayfinding system must include **continuity, connectivity, and consistency**. (Harding et al., 2011) Continuity acts as a common thread, ensuring the traveler's journey is seamless (Figure 23). Connectivity focuses on delivering the right information at the right location and time (e.g., close to escalators and elevators, by security or baggage claim area). Consistency is important because it maintains the same terminology, legibility, typography, symbols, format, color, and placement of signage, allowing travelers to easily understand them. (Harding et al., 2011)

Figure 22

Linear Floor Plan



Note. Source: ArchDaily, 2021. Credit: Fentress Architects.

Figure 23

Continuity in Design

Note. Munich Airport's sculpture weaving across the terminal serves as a constant landmark. Source: Harding et al., 2011. Credit: Jon Yee.

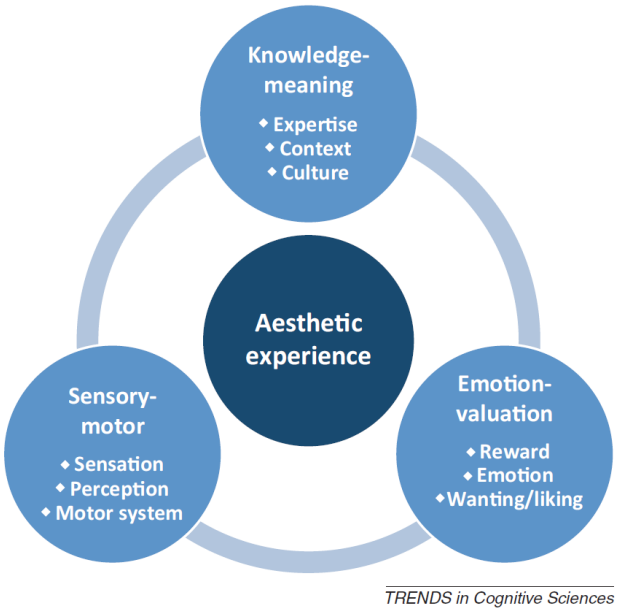
Observing people's behavior in **Airport C**, with some travelers pacing and walking from side to side, possibly due to a lack of comfortable waiting spaces or to pass the time, brings the conclusion that their experiences triggered the sympathetic nervous system: when the brain can't rest. This indicated that the space lacked areas conducive to relaxation since it was overcrowded, with limited seating options. Having no lighting variations, with an overall dark atmosphere, can affect mood, as Shadidi et al. (2021) asserted. As mentioned in Chapter II, lighting has a critical role in mood regulation, which is influenced by photosensitive retinal ganglion cells (ipRGCs) that affect circadian rhythms. (Trujillo et al., 2021) Research by Milosavljevic (2019) shows that disruptions to these rhythms, such as those caused by shift work or international travel, can have a negative impact on mood. Shahidi et al. (2021) further emphasize that lighting temperature affects mood, with warm light creating a calming atmosphere, while cool light increases alertness but can disrupt circadian rhythms. For airport environments, indirect lighting with dynamic systems that adjust to mimic natural daylight could help balance alertness and relaxation,

improving travelers' well-being, as mentioned in Chapter II. Furthermore, the behaviors could have also been triggered by boredom when a space is understimulating, and a lack of positive distractions can lead to an absence of visual engagement. (Goldhagen, 2017)

A common word used by reviewers was "outdated." The older amenities seemed to bother travelers significantly. Boudreau et al. (2016, p.106) affirm that "worn surfaces, poor lighting, older fixtures and furnishings, darker color schemes, and unchecked growth in permanent and temporary signage make it harder to maintain an image of cleanliness and order in older terminals." Cleanliness was highly mentioned in **Airport C's** reviews. However, the perceived cleanliness could have been influenced by design elements, according to Boudreau et al. (2016). Reviewers' complaints also align with the principles of neuroaesthetics, as a stressful experience can be exacerbated by the aesthetic of a space. It was evident that travelers were even more upset with their travel experience when the space was not aesthetically pleasing to them.

Figure 24

Aesthetic Triad



Note. Source: Chatterjee & Vartanian (2014).

The aesthetic triad developed by Chatterjee and Vartanian, illustrated in Figure 24, could explain the negative reactions of travelers to outdated terminals. The triad integrates sensory-motor, emotion-valuation, and knowledge-meaning systems. The visual qualities of the terminal, which other authors have discussed the impact on people's experiences, such as worn surfaces (Boudreau et al., 2016), ceiling height (Vartanian et al., 2015), and cluttered signage (Goldhagen, 2017), engage the sensory-motor system in a negative manner, triggering the regions in the visual cortex, responsible for interpreting spatial and visual details. As mentioned by Chatterjee and Vartanian (2014), it can fail to activate the brain's reward circuitry, causing stress instead. Travelers can feel more unsettled in a space that, besides functionality, doesn't provide a positive aesthetic experience. This could be evidenced in the reviews when the dissatisfaction with other travel issues was intensified by what they described as an "outdated" design. Figure 24 illustrates the aesthetic triad explored by Chatterjee and Vartanian (2014).

Chatterjee and Vartanian (2014) aimed to understand the neural activity of human cognitive experiences related to beauty. Although the authors who explore this concept accept that beauty is a subjective matter, they also emphasize that neuroscience provides a framework for understanding shared elements of aesthetic appreciation. (Chatterjee & Vartanian, 2014; Pearce et al., 2024; Tawil et al., 2022) For example, Tawil et al. (2022) discuss how curved versus angular contours can contribute to different emotional responses. By conducting research using virtual reality, the authors identified that positive responses were more often correlated with curved contours. Even though the study in Neuroaesthetics still needs to be further expanded, it is important to take aesthetics into consideration. Oftentimes, airports will be crowded, but having a positive aesthetic experience can ease the travelers' negative feelings within the space.

Overall, it was possible to connect the observations' insights to the online reviews, and design elements such as spatial layout, lighting, and wayfinding were connected to travelers' cognitive and emotional states through neuroarchitecture concepts, reinforcing the need to prioritize human-centered design as a way to promote well-being and ensure satisfaction. While learning the theory is fascinating, being able to evidence the elements through observations and real travelers' comments makes it even more compelling to continue investigating the impact of design elements on people's experiences.

CHAPTER V – DISCUSSION & CONCLUSION

Introduction

In this chapter, the four themes that were most relevant, taking into consideration the literature review, observations, and online reviews, were selected to be analyzed in order to answer the following research questions:

1. What key environmental design factors in airport gate waiting areas most effectively enhance travelers' experiences from the perspective of the travelers themselves?
2. How do these design factors align with neuroscience principles to reduce stress and improve well-being in airport waiting areas?
3. How can the design of wayfinding systems in airport gate areas improve traveler navigation and overall satisfaction, particularly in reducing stress and enhancing cognitive ease?

Selecting a limited number of themes allows a deeper and more focused exploration to delve into design recommendations. The major findings were determined by listing and describing the design elements that impact travelers' experiences in airports, specifically at the departure gates' waiting areas, also called holdrooms. The analyzed themes are:

1. **Wayfinding**
2. **Ceiling Height**
3. **Illumination**
4. **Layout Complexity**

Through the lens of neuroarchitecture, it was possible to understand how some elements affect the brain. Using these major findings and case studies of real aviation projects, potential solutions, and design recommendations were developed to improve the airports studied and other projects that could face similar challenges.

Wayfinding

Major Findings in Literature

- Landmarks and Signage: Visual and stable landmarks improve orientation and reduce cognitive strain (Liang et al., 2023), while moving entities increase wayfinding time and become a distraction in spaces such as airports (Yang et al., 2018). Landmarks activate the parahippocampal cortex (PHC), helping travelers with distance estimation and navigation (Liang et al., 2023). Signage in airports should be consistent and clear, maintaining the same terminology, legibility, typography, symbols, format, color, and placement (Harding et al., 2011).
- Design Elements: Design variations using different colors and elements, such as skylights or ceiling structures, guide travelers toward their destination: the holdrooms (Boudreau et al., 2016; Hubregtse, 2013). Wayfinding systems should take advantage of architectural elements and design cues (Boudreau et al., 2016).

Major Findings in Observations & Online Reviews

Crowding, confusing layouts with long corridors, and uncertain distance estimation weaken the wayfinding experience and become stressors for travelers, aligning with research that highlights the importance of visual cues.

Ceiling Height

Major Findings in Literature

- Spatial Perception: Higher ceilings can positively affect wayfinding and create feelings of openness and perceived beauty. (Erkan, 2018; Higuera-Trujillo et al., 2021; Vartanian et al., 2015)
- Cognitive Impact: On the contrary, lower ceilings can create feelings of enclosure, impact spatial perception, and become a stressor when associated with cluttered and busy environments. (Goldhagen, 2017; Vartanian et al., 2015)

Major Findings in Observations & Online Reviews

Through observations, it was possible to notice that in spaces with lower ceilings, travelers had more complaints about crowding and feelings of enclosure. Travelers expressed satisfaction at the recently renovated holdrooms, which had higher ceilings.

Illumination

Major Findings in Literature

- Mood and Circadian Rhythms: Lighting can significantly affect travelers' mood and circadian rhythms. (Higuera-Trujillo et al., 2021; Milosavljevic, 2019) Cooler lights increase alertness but disrupt the circadian rhythms; warm lights are more calming and help reduce stress. (Kopec, 2017; Shahidi et al., 2021)
- Impact on Perception: Appropriate lighting enhances spatial clarity and affects the environment's ambiance. Darker spaces can contribute to discomfort, anxiety, and mood disruptions. (Milosavljevic, 2019)

Major Findings in Observations & Online Reviews

Poor lighting conditions and a lack of light variation were noted in spaces where travelers also complained about crowding. At Airport B, the inadequate lighting in the corridor negatively impacted reviews. However, travelers responded positively to well-lit environments in Airport A.

Layout Complexity

Major Findings in Literature

- Navigational Challenges: Complex layouts, especially those lacking visual access or non-linear designs, affect wayfinding negatively, increasing stress and anxiety. Linear layouts are recommended to minimize confusion. (Harding et al., 2011)
- Cognitive Load: A cohesive design with open spaces, natural materials, color coding, and landmarks reduces the cognitive load, promoting calmness and satisfaction (Kopec, 2018; Proshansky, 1978).
- Repetition and Hierarchy: Using repetition with architectural elements and hierarchy by drawing attention to specific design cues can facilitate wayfinding and ease of navigation. (Ching, 2014; Hubregtse, 2020)

Major Findings in Observations & Online Reviews

Observations and online reviews have shown that complex, non-linear layouts and limited visual access to final destinations can negatively impact the overall experience. This situation often leads to a reliance on staff assistance, which can be stressful depending on the nature of the interactions.

Case Studies & Design Recommendations

In order to bridge theoretical concepts and practical design solutions, examining case studies can be a very helpful tool. Analyzing relevant aviation projects made it possible to identify the themes extracted from this research, including **wayfinding, ceiling height, illumination, and layout complexity.** One notable project worth sharing that includes excellent solutions is the High C Gates Interior Fit-Out by Corgan Design Associates. As Corgan mentioned, the redesigned High C gates at DFW Airport set precedents for future airport projects. The High C gates won the 2023 IES Illumination Award, and according to Corgan, the project's innovative lighting adds refined elegance, intuitive wayfinding, and Illuminated Biophilia. Natural lighting is very prominent in the area; with tall and long windows, there is a big connection between the interior and the exterior. Proper lighting design can enhance mood, concentration, productivity, and cognitive function, contributing to a positive indoor environment and occupants' well-being. (Friedman, 2012) Understanding how light interacts with our biological clock is crucial for therapeutic application. Light serves to reset our circadian rhythm, regulating our cyclical biological activities tied to the day-night cycle, as mentioned in Chapter IV.

Figure 25 shows that the tall ceilings in the corridors and holdrooms are different, with the flooring following the same pattern. This design enhances the organization of the space. The blue illuminated signs at every boarding gate provide clear signage, positively influencing wayfinding. Ching (2014) emphasizes that repetition fosters unity and coherence, offering visual cues that decrease the cognitive load. As Kopec (2018) notes, the human brain prefers order, and the rhythmic elements create a more comfortable environment.

Figure 26 demonstrates a strong focus on wayfinding. The illuminated signs at the departure gates enhance navigation, while lighting and ceiling variations delineate zones for

circulation and holdrooms. The layout is linear, allowing for easy visual access throughout the space.

Figure 25

High C Gates - DFW

Note. Illuminated Biophilia, Seating Variation, Big Windows, Intuitive Wayfinding. Source: Corgan

Figure 26

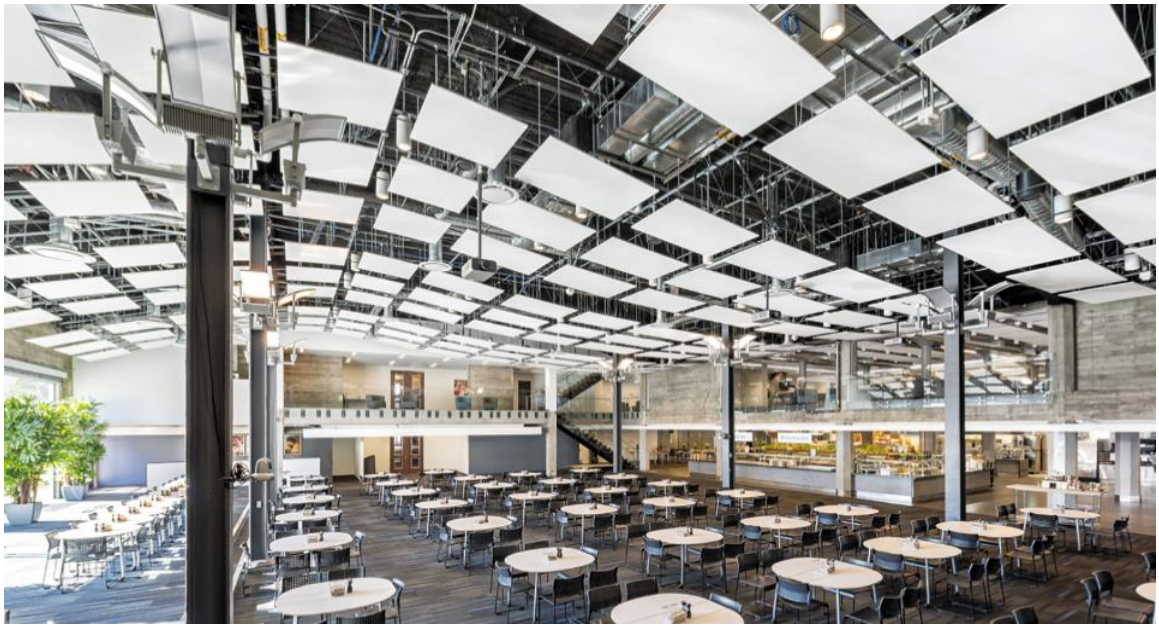
High C Gates - DFW

Note. Illuminated Biophilia, Seating Variation, Big Windows, Intuitive Wayfinding. Source: Corgan

In **Airport A**, the lower ceilings can create a closed-in feeling due to visual compression and challenges with lighting and sound reverberation. To mitigate these issues, exposed ceilings can be implemented with acoustic panels. Even with low clearance, exposing the ceiling can create the illusion of a taller space. This is because the eye is drawn upwards, making the room feel more spacious. Painting the ceiling a lighter color or using reflective materials can also enhance this effect. Acoustic panels on the exposed ceiling help absorb sound since not having regular ceiling tiles can negatively impact acoustics. Figure 27 shows a possible solution that mitigates this issue and creates a very interesting design element on the ceiling.

Figure 27

Exposed Ceiling with Acoustical Elements



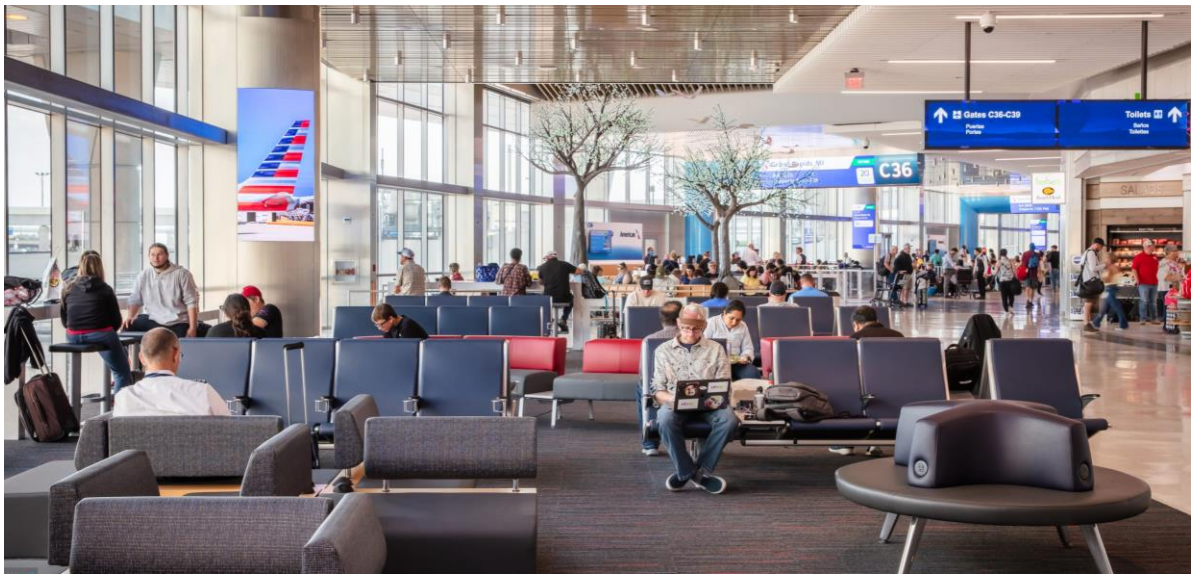
Note. Armstrong Ceilings & Wall Solutions. Source: Retrofit Magazine

It is possible to notice that the High C Gates' holdrooms provide different seating options, which is a very inclusive solution. (see Figure 28) There are different types of travelers; the solo traveler and the pilot might prefer to sit by themselves. The family with two small children will

probably want to have a spacious area for all the bags and for the kids to move. The businessman would be looking for a desk space with outlets. The diversity of travelers needs to be considered in order to create a space that provides the best experience for each person. Having different zones can help prevent crowding and ease stress by creating spaces that accommodate them.

Figure 28

High C Gates - DFW



Note. Seating Variations. Source: Corgan

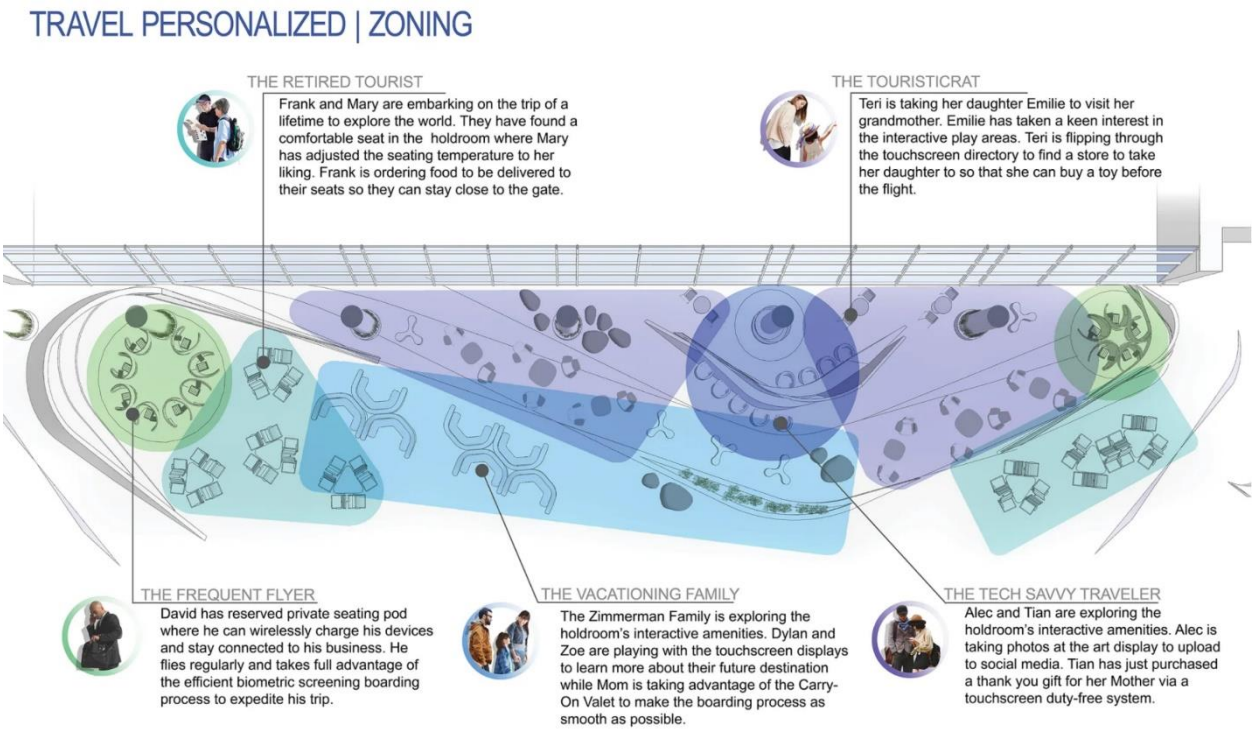
In **Airport C**, some travelers highlighted that the space is not well utilized in the specific terminal. *"[…] there is such a lack of chairs that most of the space is wasted […]" "[…] the space it's not utilized as good as it could have been […]"* This shows that in this terminal, solutions could be applied to better accommodate different travelers and enhance comfort and satisfaction. One interesting approach would be to create zones within the space.

As a firm that prioritizes human-centered design, Corgan focuses on conducting research on important topics to create spaces that adapt to different users' needs. When developing a project to reimagine Airports' traditional departure waiting areas, Corgan created the "holdroom of the

future." It prioritizes efficiency, flexibility, and travelers' comfort. This project includes technology, adaptable furniture, and enhanced amenities. The idea is to create zones for different traveler types and personalize each experience. This new concept focuses on catering to different needs and activities. The design also aims to create a sense of calmness through natural lighting, curated aesthetics, and intuitive wayfinding. Figure 29 shows what the zoning concept would look like. Different seating options that would provide inclusive design for individuals, families, or groups.

Figure 29

Holdroom of the Future - Zoning.



Note. Travel Personalized – Zoning. Source: Corgan

By incorporating lighting variation with different fixtures and lighting levels, the design can also create different zones. This would enhance ambiance and aesthetics, as well as energy

efficiency. The Lounge at Strigino International Airport, designed by Nefa Architects, brings this type of solution. Aiming for comfort, well-being, and productivity, the space has various areas with adjustable lighting to create a personalized experience for different travelers, according to Castro (2018). Figure 29 shows one of the spaces in the lounge. It is possible to see that they utilized task lighting for each booth.

Figure 30

The Lounge at Strigino International Airport – Nefa Architects

Note. Lighting Solutions. Credit: Ilya Ivanov. Source: ArchDaily

According to Castro (2018), one of the challenges designers faced when planning this space was the lack of natural lighting. The design incorporated unique lighting solutions to create a visually compelling lounge, including custom lamps and reflective materials. This issue with natural lighting was also observed in the airports studied in this research. For instance, reviews and observations of **Airport B** highlighted the small number of windows and, consequently, the

lack of natural lighting near the gates. Maximizing artificial lighting and design elements can create an inviting area that prevents a sense of confinement or gloominess. In Figure 31, it is possible to see that the lounge uses perforated metal in the background, which creates a sense of amplitude and is reflective. Reflective materials and mirrors bounce light around the space, increasing the illumination levels and perception.

Figure 31

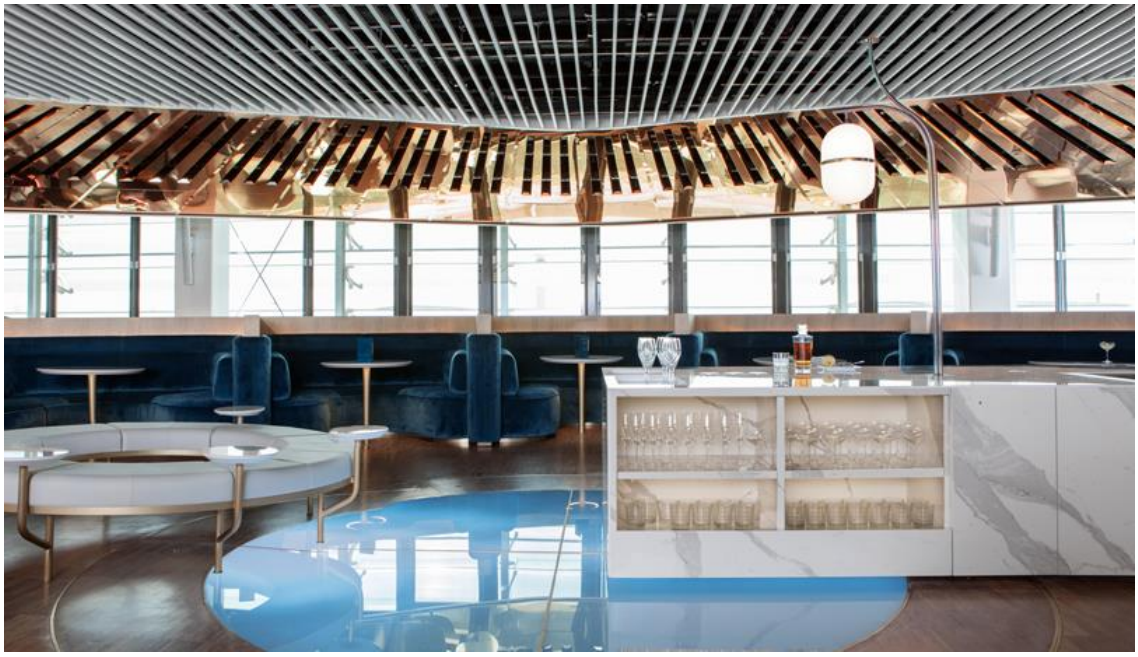
The Lounge at Strigino International Airport – Nefa Architects

Note. Perforated Metal Panel. Credit: Ilya Ivanov. Source: ArchDaily

Mirrors create the illusion of expansiveness by reflecting natural and artificial light sources. In smaller or cramped spaces, they can make the area feel larger and more open. These elements have to be strategically placed to avoid glare. Figure 32 showcases the Air France Lounge at the Paris-Charles de Gaulle Airport, designed by Mathieu Lehanneur, that utilizes mirrors and reflective materials.

Figure 32

Air France Lounge at the Paris-Charles de Gaulle Airport



Note. Reflective materials as a design solution. Credit: Felipe Ribon. Source: DesignBoom

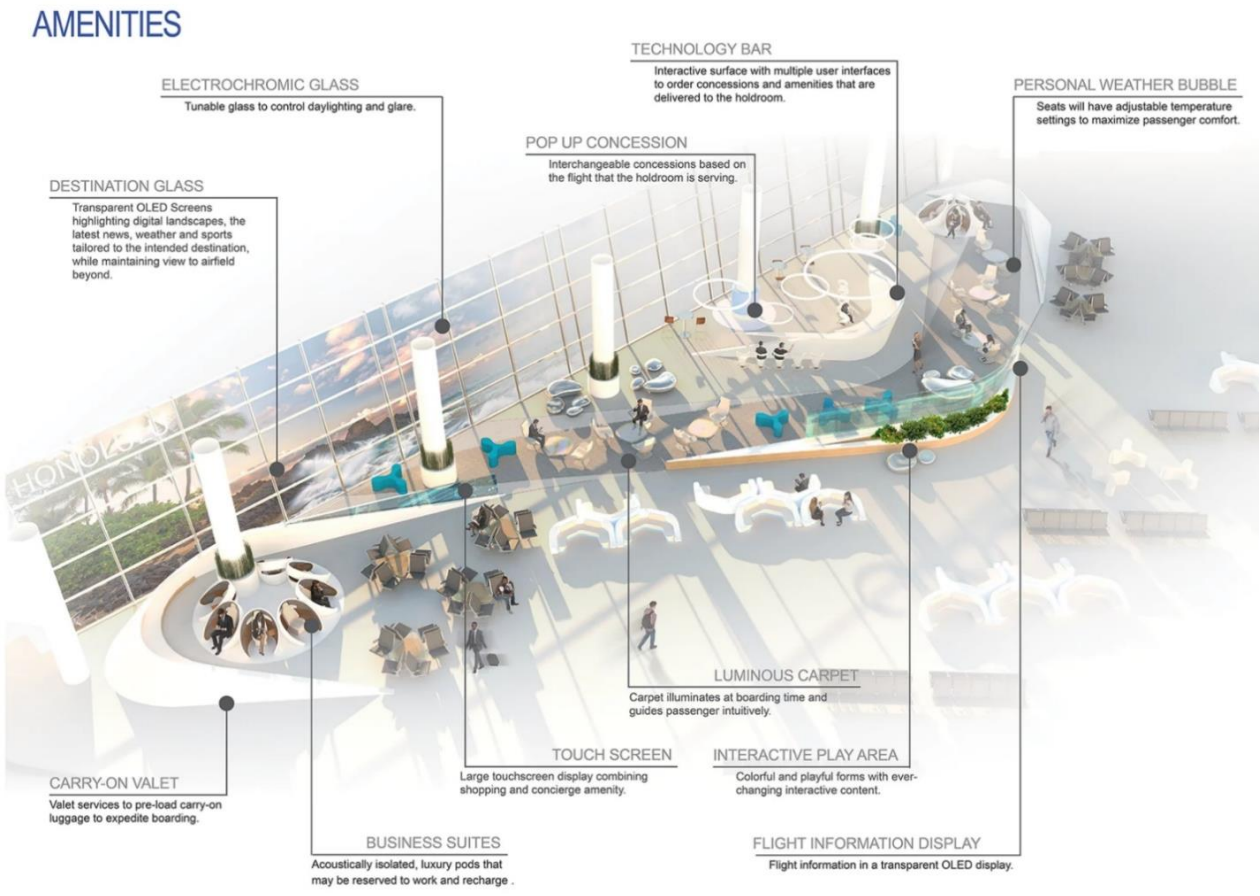
Incorporating creative lighting solutions in airport design is also a great way to improve wayfinding. As mentioned in Chapter II, skylights, besides increasing the level of natural lighting, can also enhance wayfinding, as Hubregtse (2020) mentioned. The author mentions Beijing's Terminal 3, where the ceiling with thin slats aligned with the main directional flow, allowing light to shine through the skylights and creating intuitive wayfinding. Solutions like skylights would not be feasible in spaces like **Airport B's** boarding area. However, other solutions could be applied in order to promote wayfinding. When describing the Holdrooms of the Future, Corgan highlighted design elements that would benefit the departure gate waiting areas.

In Figure 33, there are many design solutions that can be applied to the space. The zones previously described would benefit from different personalized solutions, such as adjustable temperature in the personal weather bubble to enhance thermal comfort, acoustically isolated pods

for business travelers, or interactive play areas for families with small children. A relevant solution that could be used in **Airport B** is the use of a luminous carpet (Figure 34). This would guide travelers throughout the long corridor, reducing the need for overhead signage since the space has a low ceiling height and would increase visibility, improving safety and accessibility. Besides that, this could also add a visually appealing element that can increase the traveler's interest, addressing the area's current lack of visual engagement.

Figure 33

Holdroom of the Future - Amenities.



Note. Travel Personalized – Amenities. Source: Corgan

Figure 34

Holdroom of the Future – Illumination

Note. Travel Personalized – Illuminated Carpet and Other Elements. Source: Corgan

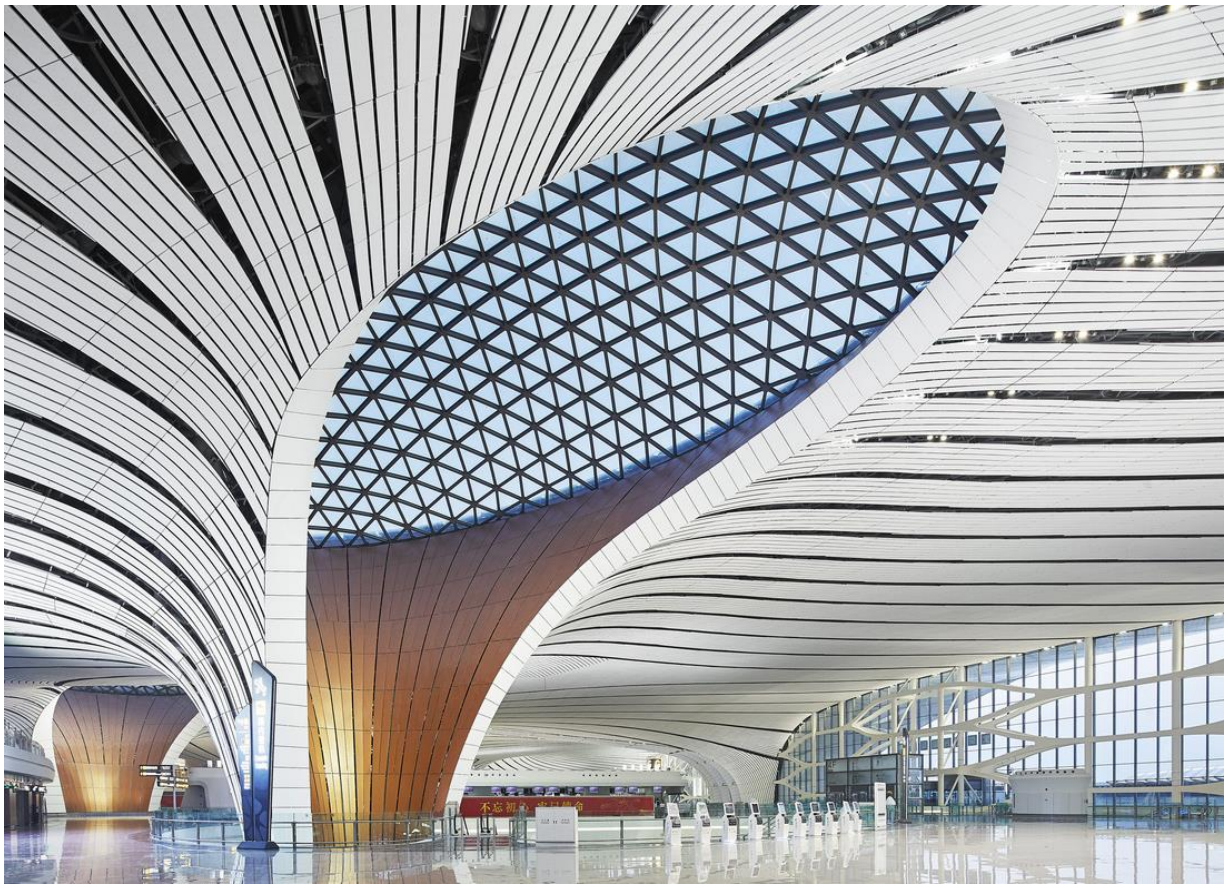
Emphasizing that the gate at **Airport B** is located at the end of the corridor can enhance travelers' sense of orientation. Large, illuminated signage placed at the corridor's entrance would effectively capture their attention and guide them in the right direction. Additionally, placing more seating options before the corridor would allow travelers to feel comfortable sitting farther from the gate, as increased wayfinding clarity would provide them with greater confidence in navigating the space.

As mentioned in Chapter IV, even though creating linear floor plan layouts benefits visual connection and navigation (Harding et al., 2011), it is not always possible to do so. Complex layouts require creative solutions to generate a visual connection throughout the space. Harding et al. (2011) highlight the use of continuity, connectivity, and consistency. This can be directly connected to Wertheimer's (1938) idea of similarity, continuity, and figure-ground, and Ching's

(2014) idea of repetition. Chapter II mentioned that repetition (Ching, 2014) and continuity (Wertheimer, 1938) can be used by consistently incorporating shapes, materials, or forms throughout the space to create unity and coherence. Subtle variations can add interest while keeping a steady rhythm. The law of Figure-ground (Wertheimer, 1938) emphasizes specific elements and is an important solution for complex layouts. Zaha Hadid's Beijing Airport Design, shown in Figure 35, includes tall ceiling elements that create a sense of amplitude. Although the layout is not linear, the space has dramatic skylights highlighting important points, such as departure gates.

Figure 35

Beijing International Airport – Zaha Hadid



Note. Wayfinding by using a dramatic skylight element. Photo: Hufton+Crow. Source: ArchDaily.

Hadid’s skylights exemplify Liang et al.'s (2023) findings that landmark elements significantly enhance wayfinding by reducing travelers' time to reach their destinations. The strategic repetition of these features also creates a sense of coherence within the space, allowing travelers to anticipate and navigate their journey more intuitively. Not every airport’s departure area is able to have such monumental elements, but using contrast in colors, materials, and lighting already provides a differentiation that facilitates wayfinding in the area.

Future Research Opportunities

Future research could benefit by focusing on Neuroaesthetics, as it explores how environmental aesthetics influence emotional and cognitive experience. Chatterjee & Vartanian (2014) laid a foundational framework on the topic by studying how beauty affects neural activity. Studies suggest that while beauty is subjective, as Chapter IV mentioned, there are shared elements in how humans perceive and respond to it. The attempt to quantify and understand beauty and the aesthetic experience can be challenging due to its subjectivity. Taking advantage of advanced tools, such as neuroimaging, augmented and virtual reality with eye tracking, and studying emotional reactions to design elements can expand the knowledge in this field. Airports can serve as a prime candidate for neuroaesthetic explorations, since it is a hub where many human interactions happen. The field of Neuroaesthetics, which is still evolving, offers a promising path to creating intentional design and spaces that aim for emotional and physical well-being.

Conclusion

In conclusion, the main environmental design factors at the departure gates’ waiting areas in airports that improve travelers' experience in an efficient way include **wayfinding elements,**

ceiling heights, lighting variation, and intentional spatial layouts. From travelers' point of view, these elements contribute to a more comfortable and less stressful space, facilitating wayfinding in a seamless way, clearer navigation, and spatial clarity.

Aligning these factors in design with neuroscience principles highlights their role in stress reduction and well-being enhancement. For example, ceiling height influences openness and comfort perceptions, while lighting affects mood and circadian rhythms, playing essential roles in cognitive ease. The neuroarchitecture concepts explored include **brain function, schemas, cognitive maps, sympathetic and parasympathetic nervous systems, the environmental stressor theory, and neuroaesthetics.** By exploring them, it was possible to see that layout simplicity and repetition of visual cues can reduce the cognitive load, improving travelers' capacity to anticipate spatial transitions and navigate intuitively.

Efficient wayfinding techniques contribute even more to navigation enhancements and overall satisfaction. By incorporating stable landmarks and clear signage, designers can promote cognitive ease, reducing travelers' stress, even when terminals have a high layout complexity. In essence, the combination of environmental and neuroscientific elements creates functional spaces that support travelers' mental and emotional well-being, creating holdrooms that are inviting, accommodating, efficient, and enjoyable.

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