# AWE IN BUILT ENVIRONMENTS:

# HOW ARCHITECTURAL STYLE AND VIEWING PERSPECTIVE INFLUENCE VISUAL RECOGNITION MEMORY

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We certify that we have read this thesis and that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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# ABSTRACT

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In recent years, there has been a growing interest in neuroarchitecture. This emerging field integrates neuroscience, psychology, and architecture to investigate the built environment's impact on cognition, emotion, and behavior. Aesthetic and emotional responses to architecture, especially the experience of awe, are becoming more recognized as significant factors influencing cognitive processes, including attention, memory, and decision-making. However, the association between awe, components of architecture, and perceptual perspective is still insufficiently examined. The present study investigated the interactions among awe, architectural style, and viewing angle on visual recognition memory in built environments, employing a 2 (awe: awe-evoking vs. non-awe-evoking) × 2 (style: traditional vs. modern) × 2 (angle: eye-angle vs. low-angle) within-subjects design. Thirty-six participants participated in a visual recognition memory task involving real-life architectural imagery. Analyses of recognition sensitivity $d'$ indicated that traditional architecture revealed higher recognition sensitivity than modern architecture, and eye-angle perspectives yielded better sensitivity than low-angle perspectives. Awe alone did not yield a significant main effect; however, it interacted with architectural style, diminishing discriminability for modern architecture while having no effect or a slight improvement on traditional architecture. Analyses of the response criterion $c$ revealed that awe, style, and angle independently modulated decision thresholds, with awe-evoking images eliciting a more liberal bias. This study contributes to the existing literature by establishing the contextual restrictions of awe's mnemonic effects, indicating that architectural stimuli's perceptual and stylistic characteristics moderate its influence on memory. The combination of affective science, neuroarchitecture, and signal detection theory provides a new framework for analyzing the interplay between aesthetic and perceptual factors in shaping memory within the built environment.



*Keywords:* Awe, visual recognition memory, architectural style, viewing angle, signal detection theory, neuroarchitecture.

# ÖZET

# YAPILI ÇEVRELERDE HUŞU: MİMARİ STİL VE BAKIŞ AÇISININ GÖRSEL TANIMA BELLEĞİNE ETKİLERİ

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Eylül 2025

Son yıllarda, sinirbilim, psikoloji ve mimarlık alanlarını birleştirerek yapılı çevrenin biliş, duygu ve davranış üzerindeki etkilerini araştıran nöromimari alanına yönelik ilgi giderek artmaktadır. Mimariye verilen estetik ve duygusal tepkiler, özellikle huşu deneyimi, dikkat, bellek ve karar verme gibi bilişsel süreçleri etkileyen önemli unsurlar olarak giderek daha fazla kabul görmektedir. Ancak, huşu ile mimarinin bileşenleri ve algısal bakış açısı arasındaki ilişki hâlen yeterince incelenmiş değildir. Bu çalışma, yapılı çevrelerde huşu, mimari stil ve bakış açısının görsel tanıma belleği üzerindeki etkileşimlerini incelemektedir. Araştırmada, 2 (huşu: huşu uyandıran vs. huşu uyandırmayan) $\times$ 2 (stil: geleneksel vs. modern) $\times$ 2 (açı: göz hizası açı vs. alçak açı) tekrarlı ölçümler tasarımı kullanılmıştır. Otuz altı katılımcı, gerçek hayattan alınmış mimari görselleri içeren bir görsel tanıma belleği deneyine katılım sağlamıştır. Tanıma duyarlılığı $d'$ analizleri, geleneksel mimarinin modern mimariye kıyasla; göz hizası bakış açısının ise alçak açıya kıyasla anlamlı derecede daha yüksek duyarlılık sağladığını ortaya koymuştur. Huşu tek başına anlamlı bir ana etki göstermemiş; ancak mimari stil ile etkileşime girerek, modern mimaride ayırt edilebilirliği azaltmış, geleneksel mimaride ise herhangi bir olumsuz etki yaratmamış veya hafif bir artış sağlamıştır. Karar kriteri $c$ analizleri, huşu, mimari stil ve bakış açısının karar eşiklerini bağımsız olarak etkilediğini, huşu uyandıran görsellerin daha liberal yanıt eğilimi oluşturduğunu göstermiştir. Bu çalışma, huşunun bellek üzerindeki etkilerinin bağlama bağlı sınırlarını ortaya koyarak, bu etkinin mimari uyaranların algısal ve stilistik özellikleri tarafından modere edildiğini göstermektedir. Duygulanım

bilimi, nöromimi ve sinyal belirleme kuramının entegrasyonu, yapılı çevrede estetik ve algısal faktörlerin belleği nasıl ortaklaşa biçimlendirdiğine ilişkin yeni bir analiz çerçevesi sunmaktadır.

*Anahtar sözcükler*: Huşu, görsel tanıma belleği, mimari stil, bakış açısı, sinyal belirleme kuramı, nöromimari.

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# Chapter 1

# Introduction

## 1.1 Neuroarchitecture

A developing multidisciplinary field called “neuroarchitecture” studies how human behavior, emotion, and thought are influenced by architectural design. According to Eberhard [2], neuroarchitecture examines how the physical surroundings affect psychological experiences and brain functions. Recent advancements in neuroscience illuminate the mechanisms by which we perceive and explore our environment, as well as the influence of our physical surroundings on cognition, problem-solving, and emotional states [3]. Abbas et al. [4] also define neuroarchitecture as examining architectural design’s profound influences on human behavior, emotional reactions, and cognitive functions.

The term “neuroarchitecture” gained popularity in the early 2000s with the establishment of the Academy of Neuroscience for Architecture (ANFA), which sought to align insights from neuroscience with architectural practice to improve human well-being [2]. The field prioritizes the creation of environments that are not only functional but also psychologically supportive; as Wang et al. [5] emphasize, the built environment can influence affective regulation and cognitive functioning.

There has been an increasing emphasis on human-centric and experiential approaches to space since the 1960s, when Modernist architectural paradigms began to decline [6]. This shift has motivated architects to examine how spatial forms interact with users' perceptions and behaviors, advocating a design philosophy that emphasizes emotional resonance and psychological engagement [6, 7]. Recent studies affirm that both natural and artificial settings consistently engage the human sensorimotor system [8]. Djebbara et al. [8] showed that architectural elements can provoke distinct brain responses, subtly influencing perception and movement. These findings highlight the environment's significant influence on behavioral and attentional tendencies. This continuous interaction with our environment prompts us to intuitively adjust our behavior in response to characteristics that capture attention [8].

From these observations, one can infer that those environments are not passive backdrops but active participants in shaping our responses and experiences. Environmental cues affect both cognitive and affective systems from a neuroscientific standpoint. Cognition entails the processing and interpreting of sensory data, whereas emotion comprises adaptive responses to that data - both functions are mediated by integrated neural networks [9]. Consequently, architectural design can either promote or obstruct mental states, contingent upon its efficacy in aligning with human perceptual and emotional requirements.

Integrating neuroscience into architectural design offers significant prospects for improving well-being through strategic planning. Karakas and Yildiz [6] contend that this synthesis enables designers to create surroundings that correspond with human experience, fulfilling both functional needs and psychological wellness. Eberhard [2] asserted that comprehending the brain foundations of perception, emotion, and behavior allows architects to design environments that promote cognitive and emotional well-being. Vartanian et al. [10] illustrate that particular architectural elements—such as ceiling height and enclosure—can profoundly affect emotional and cognitive responses, underscoring the importance of a neuroscience-informed perspective. Ulrich et al. [11] emphasized that evidence-based design in healthcare settings, guided by psychological and physiological principles, enhances patient outcomes and staff satisfaction. The evolution of neuroarchitecture is a crucial development in designing places that improve quality of life by aligning built spaces with the cognitive and emotional experiences of their inhabitants.

### 1.1.1 Behavioral Studies of Neuroarchitecture

Neuroarchitecture integrates aspects of environmental psychology, architecture, and neuroscience to examine how physical environments influence mental processes and behaviors [6]. This interdisciplinary domain acknowledges that architectural elements—such as lighting, color, and spatial arrangement—significantly influence emotional and cognitive processes [4, 10, 12]. Empirical research regularly demonstrates how environmental factors can influence psychological and physiological reactions. Ulrich et al. [11] reported that hospital patients with natural landscape views experienced faster recovery and required fewer analgesics than those facing brick walls, indicating the restorative benefits of biophilic components in healthcare environments. Moreover, Aries et al. [13] underscore the importance of visual aesthetics, revealing that access to appealing window views is associated with fewer physical and psychological complaints among building inhabitants. This highlights architects' need to incorporate strategic window placement and exterior visual access into their design processes to improve well-being and quality of life.

Additionally, designing stimulating educational spaces with cool colors and compact configurations has enhanced student performance, further underscoring the critical role of environmental design in cognitive effectiveness [14]. This suggests that educators and architects should collaborate to create learning environments that maximize educational outcomes through deliberate design choices. Equally important, Bower et al. [12] find that exposure to a blue condition reduces heart rate variability while significantly increasing respiratory range and skin conductance response. This physiological response may suggest heightened arousal, possibly reflecting a state of stress or alertness. These changes imply that the blue condition may influence emotional and physiological states, potentially enhancing vigilance or engagement. Consequently, these insights suggest that color schemes in environments can be strategically employed to elicit specific psychological and physiological responses, highlighting a nuanced approach to environmental design.

As Perry [15] highlighted, inadequate stimulation from one's surroundings can be detrimental to cognitive functioning, reinforcing the necessity for well-considered environmental design. By integrating these diverse insights, neuroarchitecture not only underscores the profound impact that thoughtful design can have on our cognitive and emotional well-being but also offers a roadmap for architects and designers aiming to create environments that truly support and enhance human health, performance, and overall quality of life. Thus, integrating natural elements, strategic use of color, and a focus on visual appeal emerge as key considerations in designing for human betterment.

### 1.1.2 Neuroimaging Studies of Neuroarchitecture

The scientific investigation of how individuals perceive their environment has illuminated the complex cerebral mechanisms underlying visual perception and comprehension [4]. Accordingly, recent investigations into experimental participants' brain activity, particularly in response to actual and virtual environmental conditions, establish a substantial foundation for future design and research [16]. This research indicates that architecture is not merely a backdrop for human activity; it significantly stimulates neural activity and may even alter genetic expression [17]. Various neuroimaging tools have been employed to enhance our understanding of the neurological underpinnings of environmental perception; techniques such as functional Magnetic Resonance Imaging (fMRI), magnetoencephalography (MEG), and electroencephalography (EEG) can provide critical contributions to how individuals perceive the built environment [5]. However, it is essential to note that while stationary research typically maintains reasonable experimental control, it often lacks ecological validity, frequently presenting uncluttered, two-dimensional views of complex three-dimensional settings without allowing participants to interact physically with these environments [5].

In contrast, portable procedures allow participants to engage with actual and simulated three-dimensional spaces, significantly enhancing ecological validity. Yet, this engagement introduces noise into the recordings due to the inherent unpredictability of real-world settings, creating a fundamental trade-off in neuroarchitectural research [18]. Consequently, while user interaction enriches the contextual understanding of spatial experiences, it complicates data collection.

For these reasons, many studies in the literature investigating the neural basis of architecture have been conducted in lab environments with high experimental control. Vartanian et al. [19] found that participants rated curvilinear interiors as more aesthetically pleasing than their rectilinear counterparts. Utilizing fMRI, Vartanian et al. [19] demonstrated that these curved architectural forms elicited heightened activation in the lingual and calcarine regions of the visual cortex during approach–avoidance judgments. The brain regions implicated in visual processing suggest that curved forms stimulate the visual system more profoundly or favorably than angular patterns. Moreover, the beauty assessment distinctly activated the anterior cingulate cortex, suggesting that aesthetic appeal profoundly influences neural response [19]. This research highlights that architectural aesthetics are not merely subjective preferences but are rooted in quantifiable brain responses that may affect behavior and emotional experiences in constructed spaces.

Reinforcing these observations, Vartanian et al. [10] examined the influence of ceiling height and perceived enclosure on visually appealing evaluations. Their findings indicated that rooms with high ceilings were frequently considered more appealing, stimulating brain areas associated with visuospatial exploration and attention in the dorsal stream [10]. In addition, open rooms were generally perceived as more aesthetically pleasing than confined environments, stimulating areas in the temporal lobes linked to perceived visual motion [10]. This suggests that spaciousness in design not only looks appealing, but it can also stimulate cognitive flexibility and exploration, emphasizing the psychological importance of open, breezy spaces. In another insightful study, Naghibi Rad et al. [20] conducted a psychophysics experiment utilizing EEG to explore how various window forms on building facades affect individuals' emotions and cerebral activity. Their behavioral findings illustrated that participants favored window designs, such as rectangular, square, circular, and semi-circular arches, while triangular and arch-shaped triangular windows were found unappealing. It can be concluded that more symmetrical and conventional shapes (e.g., rectangular, circular) were chosen. This means that architectural features, even at the level of window design, have a demonstrable impact on user comfort and aesthetic satisfaction, lending credence to the notion that design influences perception as well as neurological reaction.

Furthermore, the EEG data indicated that positive visual stimuli elicited a more pronounced response in the brain's left hemisphere than negative stimuli, reinforcing the neural foundations of aesthetic preference [20]. Thus, one can infer that aesthetic choice is neurologically based, with pleasant visual stimuli stimulating the left hemisphere more significantly, a pattern typically linked to approach-related feelings and affect. This underscores that the brain does not merely perceive architecture passively; instead, it actively processes and assesses design elements both emotionally and cognitively, connecting architectural aesthetics with hemisphere asymmetries in emotional processing.

Examining landscapes also reveals critical insights into how spatial environments affect brain activity. In a study by Tang et al. [21], fMRI was employed to investigate the effects of diverse landscapes—urban, mountain, forest, and aquatic—on brain activity in specific regions. Their findings indicated divergent responses to urban versus natural environments, especially regarding the brain's activation of visual and attentional regions [21]. The contrast between urban and aquatic settings revealed distinct activation patterns, particularly in the right cingulate gyrus and left precuneus [21]. The findings suggest that exposure to nature activates the brain differently than urban settings, potentially providing cognitive and emotional advantages absent in constructed environments, particularly by stimulating the right cingulate gyrus and left precuneus, regions associated with self-referential thinking and relaxation. Ultimately, architecture activates several sensory networks, encompassing visual, auditory, somatosensory, olfactory, and vestibular systems, fostering rich emotional and cognitive responses [10]. The complex interplay between architectural design and neural activity emphasizes the importance of integrating principles from cognitive neuroscience into architectural practices.

## 1.2 Memory and Recognition within Neuroarchitectural Contexts

The interdisciplinary domain of neuroarchitecture integrates insights from neuroscience, psychology, and architecture to examine how built environments affect brain function and behavior. Central to this emerging field is the recognition that environmental features can modulate cognitive and emotional processes, including memory [22]. Recent neuroscience research has emphasized the brain's remarkable plasticity, showing that exposure to enriched or impoverished environments alters synaptic connectivity and neurogenesis, particularly in regions associated with memory such as the hippocampus [23, 24]. These findings align with evidence from visual recognition memory studies, which demonstrate that memory encoding and retrieval are sensitive to both perceptual salience and emotional valence—factors that are often shaped by architectural design [25]. For instance, variations in light, geometry, spatial layout, and acoustic conditions can significantly influence attentional load and memory performance [22].

Furthermore, environments that evoke heightened emotional states, such as awe, have enhanced autobiographical and conceptual memory, particularly in educational and cultural spaces [26]. Accordingly, Paiva [27] stated that schools can be precisely designed to optimize cognitive function, promote learning, and enhance memory performance. These findings underscore the crucial role of memory in linking environmental perception to behavioral response and suggest that architectural interventions can be strategically designed to support memory-dependent cognitive functioning.

### 1.2.1 Environmental Influences on Memory and Spatial Encoding

The Method of Loci (MoL), referred to as the "memory palace" or "mind palace," is a historical mnemonic technique that associates spatial environments with memory enhancement [28, 29]. This method entails seeing a familiar spatial arrangement—such as one's residence—and mentally positioning vivid representations of items to be recalled at designated positions along a known path [30, 31]. During retrieval, individuals mentally traverse the path, visiting each location to recall the corresponding item. The dependence on spatial encoding and imageability renders the Method of Loci especially efficacious for serial recall [28, 32]. As emphasized in the Art of Memory, the foundational components of memory consist of imagination, association, and location [33]. Imagination and association are instrumental in forming new memories, while location plays a crucial role in establishing sequence and anchoring information [33]. This demonstrates that immersive and well-designed spatial environments can significantly enhance the efficacy of memory methodologies. Experimental research indicates that both physical and virtual settings can function as loci, yielding comparable memory results, particularly when the spatial pathway is distinctly structured [31]. This presents fascinating opportunities for employing virtual reality as a means to improve memory training and indicates a favorable path for educational and cognitive advancement. Accordingly, Gerard et al. [33] explored the impact of spatial design on memory performance by employing the Memory Card Game and the Recall Board, utilizing the Method of Loci within a virtual reality framework involving 18 participants. The Virtual Memory Palaces created for the participants included two distinct conditions: the Palladian Palace and the Crooked Palace. The findings revealed that the Method of Loci, delivered through virtual reality, resulted in a significantly enhanced recall accuracy rate among the experimental group compared to the control group, which relied solely on traditional desktop methods [33].

Similarly, in an experiment involving 56 participants, Werner and Schindler [34] evaluated way-finding capabilities and spatial memory across four virtual environments that varied solely in their floor plan layouts. They presented empirical evidence indicating that an individual's ability to navigate and orient themselves in their environment is partially influenced by the geometric relationships among different components of a place [34]. The authors assert that architectural elements causing discrepancies in local cognitive reference frames impair way-finding and disrupt the integration of spatial knowledge [34]. The results indicate a significant relationship between architectural design and memory, especially for processing spatial information. It suggests that architectural designs must account for geometric relationships to improve wayfinding efficacy. Furthermore, neurocognitive models indicate that MoL activates the hippocampus and retrosplenial cortex, regions implicated in spatial navigation and episodic memory [28].

Speaking of spatial navigation, O'Keefe and Nadel [35] pioneered research clarifying the function of the hippocampus in memory and spatial navigation. They identified that individual neurons in this brain region—later termed "place cells"—become activated when rats navigate particular regions within a designated area, such as a box. This activation pattern indicates that these neurons contribute to the brain's formation of a cognitive map, enabling organisms to navigate their surroundings through spatial recognition rather than mere sensory signals [35]. This brain activity suggests that particular architectural elements, including landmarks, pathways, and spatial layouts, can improve memory retrieval by generating cues that stimulate these place cells. Thus, architecture that corresponds with our cognitive functions might facilitate effective navigation and enhance memory retrieval.

Neuroimaging research has demonstrated that environmental cues, including architectural designs, spatial configurations, and natural features, can activate memory-associated areas of the brain, including the hippocampus and parahippocampal cortex [36, 37]. Supporting this, immersive spatial experiences have been shown to activate brain networks linked to spatial memory and emotional regulation, indicating that architectural environments serve as active contributors to memory encoding and retrieval [38]. Comprehending the impact of architecture on memory processes—especially recognition memory—is crucial for creating environments that enhance well-being, navigation, and learning. Therefore, this section will examine recognition memory as a fundamental cognitive mechanism within the neuroarchitectural framework.

### 1.2.2 Recognition Memory and the Visual Domain

Recognition memory denotes identifying previously experienced stimuli as familiar, usually evaluated by experimental procedures that differentiate between studied and newly experienced stimuli [39]. These paradigms typically comprise an initial encoding phase where participants encounter a sequence of stimuli, succeeded by a test phase after a delay, during which they must differentiate between previously studied objects (targets) and unfamiliar items (foils). This process involves two distinct yet complementary cognitive mechanisms: familiarity, which provides a swift, automatic recognition of prior encounters, and recollection, which entails the retrieval of specific contextual details linked to the initial experience [25, 39]. Responses based on familiarity are generally quicker and less demanding, occurring within approximately 400 milliseconds, whereas recollection is slower and requires greater cognitive resources [25]. Neuroanatomically, these functions are supported by distinct yet interconnected regions in the medial temporal lobe, with the perirhinal cortex predominantly governing familiarity and the hippocampus essential for recollection [39, 40].

Further evidence verifying the hippocampus's essential function in recognition memory is derived from lesion research. Broadbent et al. [40] established that rats with significant hippocampal impairment displayed considerable deficits in recognition memory, especially when over 75% of the hippocampus volume was compromised. Although minor damage may preserve identification capabilities, the hippocampus becomes progressively essential as lesions worsen. Eichenbaum et al. [39] highlight the crucial function of the hippocampus in recollection-based recognition, particularly when associative or contextual retrieval is necessary.

Moreover, electrophysiological and neuroimaging investigations substantiate this differentiation by demonstrating hippocampal activation patterns associated with episodic retrieval, while familiarity-based responses have a stronger correlation with perirhinal cortex activity [25, 39]. The accumulating evidence emphasizes the hippocampus as a fundamental substrate for recollection-dependent recognition memory, while also illustrating the extensive role of medial temporal lobe components in recognition processes overall.

This discussion will exclusively focus on visual recognition memory (VRM), a form of recognition memory evaluated within the visual domain, highlighting the exceptional ability of humans to encode and retrieve intricate visual information [25]. Visual recognition memory (VRM) denotes the ability to identify whether a visual input, such as a photograph or item, has been previously experienced [25, 39]. VRM is a fundamental topic in cognitive neuroscience as it involves both familiarity-based and recollection-based processes, both underpinned by separate brain mechanisms [39]. Humans exhibit an exceptional ability for precise visual recall, accurately storing hundreds of images even after brief exposure [41, 42], as summarized by Besson et al. [25]. Moreover, experimental paradigms have demonstrated that aspects including the stimulus detail can influence VRM performance [41] and the temporal dynamics of brain processing, with familiarity judgments arising between 370–420 ms after stimulus presentation [25]. This precision underscores VRM as an evolutionarily beneficial system that enables swift decision-making in visually complex contexts.

Preliminary research in this domain has primarily examined the precision of visual recognition memory. In a pivotal experiment, Standing [43] exposed subjects to 10,000 distinct pictures, each shown for under five seconds, achieving a remarkable 83% recognition accuracy. Likewise, Shepard [44] presented participants with 612 unique images and recorded an identification accuracy of 98%. These seminal experiments established the foundation for future study by emphasizing the human brain's remarkable ability to encode and retrieve substantial amounts of visual information.

In another significant study, Brady et al. [42] investigated the capacity of individuals to recognize and recall intricate visual details. By presenting participants with 2,500 images, they observed an impressive 87% accuracy rate in differentiating subtle variations in object states or postures (e.g., an open bag versus a closed bag). These results indicate that visual recognition memory can retain considerable detailed perceptual information.

Building on this foundation, a subsequent study examined the factors affecting the precision of visual recognition recall. Richler et al. [45] investigated the role of verbal processing—particularly the vocalization of object names—during the encoding phase. During the test phase, participants were presented with 240 color photographs of items. The findings indicated that labeling objects improves recognition memory, especially when the items are drawn from diverse categories [45]. Nonetheless, the study also revealed a divergent effect: verbal labeling can hinder recognition performance by diminishing perceived distinctiveness when objects are consolidated into fewer or less varied categories [45]. Richler et al. [45] conclude that the uniqueness of visual stimuli is crucial in determining the efficacy of verbal encoding methods, such as naming, in recognition memory.

Vogt and Magnussen [46] substantiated this idea by showing that recognition accuracy markedly decreased when perceptual details were eliminated, despite the basic concept of the image remaining intact. Memory performance for images within the same category—such as colored depictions of doors—declined from 85% to 65% accuracy when intricate features were excluded, despite retaining the overarching conceptual label (e.g., "big red door") [46].

Researchers have further investigated the elements influencing visual recognition recall, examining whether certain variables exert no significant effect. Evans et al. [41] investigated whether domain-specific visual expertise enhances general visual memory. Their research contrasted the performance of two medically untrained control groups with that of cytologists and radiologists specializing in mammography. Participants observed a variety of stimuli, encompassing medical imagery (e.g., mammograms and cervical micrographs) and non-medical situations (e.g., indoor and outdoor locations). The findings indicated no substantial differences between experts' and non-experts' recognition memory for sceneries or items. The findings indicate that although expertise improves task-specific perceptual abilities, it does not inherently lead to enhancements in general visual recognition memory [41]. The research by Evans et al. [41] indicates that visual expertise is predominantly domain-specific and does not contribute to improved general visual recognition memory.

### 1.2.3 Signal Detection Theory as a Framework for Recognition Performance

Although visual recognition memory allows humans to ascertain if a visual input, such as an image or scene, has been previously experienced, performance on recognition tests cannot be sufficiently represented by mere accuracy scores. Conventional accuracy measurements neglect to consider variations in response tendencies, such as a participant's inclination to answer "old" or "new" depending on subjective thresholds rather than the strength of memory. Signal Detection Theory (SDT) provides a comprehensive framework to overcome this issue by partitioning recognition performance into two separate elements: memory sensitivity (often represented by $d'$) and reaction bias (criterion placement) [47, 48]. This methodology enables researchers to separate the genuine discriminative capacity of the memory system from strategic or motivational biases in decision-making [49, 50]. Consequently, SDT has emerged as a fundamental instrument in cognitive psychology and neuroscience for elucidating recognition memory with enhanced precision and theoretical clarity.

Signal Detection Theory (SDT) provides a structured framework for modeling decision-making under ambiguity and has been extensively applied across various psychological fields, including perception, attention, and memory [47, 51, 52]. In the field of recognition memory, SDT posits that memory decisions stem from an internal continuum of memory strength, where both familiar ("old") and unfamiliar ("new") items are assumed to produce overlapping distributions [48, 53]. Each test item generates a familiarity signal derived from these distributions, and recognition judgments depend on whether this internal signal exceeds a response requirement. Items that surpass the requirement are designated as "old," whereas those that do not meet the threshold are categorized as "new" [50, 54]. This model enables researchers to independently estimate essential parameters—such as discriminability ($d'$) and decision bias—thus offering a sophisticated analysis of recognition performance that surpasses mere binary accuracy metrics [52, 53].

Signal Detection Theory produces four primary response outcomes in recognition memory tasks: hits (correctly identifying old items), misses (failing to recognize old items), false alarms (incorrectly identifying new items as old), and correct rejections (accurately recognizing new items as novel). These results establish the foundation for two principal indices: $d'$ (d-prime), which indicates an individual's capacity to differentiate between familiar and novel items, and $c$ (criterion), which measures response bias or decision threshold [47, 49]. The $d'$ measure rises with increased divergence between the memory-strength distributions of old and new items, whereas $c$ reflects the participant's tendency toward liberal or conservative responses, irrespective of their actual memory sensitivity [48, 53]. This decomposition enables researchers to analyze recognition performance with enhanced diagnostic precision compared to relying solely on raw accuracy ratings [50, 51].

Signal Detection Theory (SDT) has evolved over time to enhance the understanding of how humans identify previously encountered stimuli. A significant variant, unequal-variance signal detection theory (UVSD), posits that previously encountered items generate memory signals that are both stronger and more variable than those of new items, elucidating why individuals may exhibit heightened confidence or diminished consistency in recognizing familiar items [52]. Another variant, mixture-SDT, acknowledges that individuals may not consistently maintain complete attention during the task; responses to previously encountered items may arise from a mixture of focused and distracted trials, resulting in a blend of strong and weak memory signals [54]. These models illustrate how SDT can adapt to intricate scenarios, particularly in visual memory, where attention and stimulus specifics are significant factors.

Several researchers have attempted to integrate SDT with dual-process theories. These theories propose that recognition comprises two distinct processes: recollection, which involves recalling particular details about prior encounters with the item, and familiarity, which pertains to the item simply feeling known. In dual-process signal detection models (DPSD), recollection is regarded as a binary event—occurring or not—whereas familiarity is represented as a continuous signal [52]. Numerous studies now indicate that employing a more straightforward, single-process model such as UVSD can account for the data equally well [52, 53].

Finally, certain researchers have investigated whether the decision rule in Signal Detection Theory—the threshold at which an individual determines an item to be "old" or "new"—remains consistent over all trials. This concept is referred to as criterion noise, indicating that the decision point may fluctuate unpredictably from one trial to another. Although initial investigations suggested significance [55], subsequent studies indicated that these small fluctuations have minimal effect. This reinforces the notion that the original SDT model remains a robust and dependable framework for comprehending recognition memory [50].

In summary, Signal Detection Theory (SDT) provides a thorough and scientifically substantiated framework for comprehending recognition memory, especially in visually oriented paradigms. By separating sensitivity from bias and integrating both cognitive and perceptual factors, SDT continues to be fundamental for examining recognition processes in contemporary memory research. For these reasons, this study will analyze the performance of visual recognition memory using SDT.

## 1.3 Understanding Awe

One of the most significant factors mediating the relationship between the built environment and memory within the domain of neuroarchitecture is the multifaceted emotion of awe. Awe is a multifaceted, self-transcendent emotion elicited by things regarded as vast, unique, or beyond one's existing cognitive framework, frequently leading to a fundamental reorganization of cognitive schemas, a process termed "accommodation" [56, 57]. While awe is frequently experienced daily, especially in natural or constructed settings, individuals often lack the terminology to explicitly identify the sensation [57, 58]. Vastness, which is one of the requirements for revealing awe, refers to the encounter with an entity that surpasses an individual's own dimensions or frame of reference. This concept encompasses both physical magnitude and social dimensions, such as reputation, prestige, authority, superiority, or power [56]. In other words, vastness can manifest itself in two forms: it may be perceptual, as in the visual experience of observing the immense scale of the Grand Canyon, or conceptual, as in the intellectual contemplation of infinite ideas such as eternity [57]. For instance, standing before a panoramic natural landscape or observing the intricate design of a cathedral dome can elicit a profound sense of perceptual vastness, not solely due to physical scale, but because these stimuli challenge our mental frameworks and necessitate cognitive accommodation [56, 59]. Individuals may be seen as awe-inspiring when their presence or actions, such as moral courage, intellectual brilliance, or profound creativity, significantly influence others and alter their worldview [57]. This interpersonal awe reaction illustrates the social aspect of awe, wherein respect for human excellence engenders a sense of diminished self and heightened connectedness to others [58, 60]. Research consistently demonstrates that awe-inspiring experiences, regardless of their natural, constructed, or social origins, promote self-transcendent states that restructure cognition and improve meaning-making processes [26, 61]. Supporting these findings, Shiota et al. [62] argued that individuals who frequently experience awe are particularly susceptible to altering and revising how they view the world.

Awe is not solely a positive experience; it includes both positive and negative forms, each characterized by unique psychological and neural signatures. Guan et al. [63] highlighted this distinction, identifying varying neural correlates linked to each type. Positive awe, typically triggered by beauty, moral virtue, or nature, is related to feelings of elevation, heightened introspection, and increased prosocial behavior. Neuroimaging research has associated it with increased gray matter volume in the precuneus, a region involved in self-referential thought and perspective-taking, and decreased volume in the fusiform gyrus, potentially facilitating inward-focused contemplative states [63]. Negative awe, in contrast, emerges from stimuli that are both vast and threatening, including natural disasters, authoritarian displays, or existential uncertainty, activating neural areas associated with emotional discomfort and regulation—such as the insula and superior temporal gyrus—and indicating increased vigilance and anxiety [59, 63]. Both variants exhibit core elements of vastness and a need for accommodation; however, their affective tones and subsequent consequences diverge significantly. Positive awe fosters connection and openness, while negative awe can elicit fear and submission [56, 64]. Given its significance for cognitive enrichment, the current discussion will concentrate solely on positive awe. Unless explicitly stated otherwise, the term “awe” in this context refers specifically to its positive manifestation. Accordingly, awe embodies a dichotomy of the human experience, emphasizing our destructive potential alongside our collective resilience and creativity when confronted with hardship [58]. This paradox illustrates the adaptive function of awe in human existence; it promotes social cohesion by reducing self-centeredness and enhancing feelings of connectedness to something greater [65, 66]. Neurophenomenological research indicates that awe activates certain attentional and self-referential neural networks, promoting reflective cognition and receptivity to novel viewpoints [67]. Awe has been demonstrated to enhance epistemic humility, prosocial behaviors, and psychological well-being, underscoring its significance as a transformational and integrative emotional experience [64, 68]. This expansive and dynamic paradigm positions awe as both global and profoundly personal—an emotion that connects the subjective with the communal, the internal with the external, and the ordinary with the transcendent.

### 1.3.1 Elicitors and Consequences of Awe

Awe is not a uniform emotional state; it emerges from many experiences that elicit feelings of vastness and necessitate cognitive adjustment [56, 62]. Keltner [58] highlighted that a combination of developmental phases, cultural narratives, and personal experiences influences awe. It may be elicited by experiences of natural magnificence—such as vast mountain ranges or star-studded skies—or through more personal instances like parental nurturing, artistic excellence, or contemplations on mortality and acts of moral beauty [58, 60, 69].

Keltner [58] established eight specific domains in which awe is frequently encountered: moral beauty, collective effervescence, nature, music, visual design, spiritual and religious narratives, life and death stories, and epiphanies or "aha moments." Nature and visual design have gained significant empirical focus, primarily because of their replicability in controlled experimental settings [58, 59]. Recent studies have shown that virtual reality (VR) serves as an effective and manageable method for inducing feelings of awe, particularly through immersive simulations of natural or cosmic settings [59, 70]. Chirico et al. [59] demonstrated that virtual reality environments constructed to evoke awe, such as those featuring towering trees, can successfully induce feelings of vastness and a diminished sense of self, especially when a heightened sense of presence. Limpt et al. [70] examined the phenomenon of awe in virtual reality through a space-themed experience intended to elicit the "overview effect," a cognitive shift in awareness similar to that experienced by astronauts. The findings indicated that awe facilitated learning gains in elementary school students, significantly influenced by factors such as immersion, presence, and compassion. This underscores the potential of VR to elicit emotional responses and promote profound conceptual understanding.

Additionally, individuals exhibiting high levels of dispositional awe demonstrate enhanced benefits from such experiences, showing increased openness to revising mental schemas when confronted with awe-inspiring stimuli [62, 70]. Rudd et al. [61] demonstrated that awe-inducing VR content can expand individuals' perception of time, leading to a sense of increased time availability, which in turn enhances life satisfaction and prosocial tendencies. The findings are consistent with existing research indicating that awe, whether experienced in virtual reality or real-world contexts, can enhance humility, generosity, and social connectedness [66]. VR's immersive and emotionally impactful characteristics make it a suitable medium for exploring and applying awe in educational, psychological, and prosocial contexts.

Keltner and Haidt [56] posited that expansive stimuli provoke awe and disrupt established cognitive frameworks, including religious and spiritual encounters, charismatic figures, natural marvels, magnificent artworks, and transcendent experiences. Subsequent research has broadened the range of awe-inducing triggers based on this core paradigm. Awe can be elicited by architectural sophistication, including monumental scale, sophisticated design, or the spatial magnificence of religious places [16, 71]. Interpersonal moral beauty—manifested through acts of courage, generosity, or compassion—has been demonstrated to be a significant provoker of awe [58, 64]. Moreover, music that elicits a sense of the sublime, especially when it expresses emotional intensity or cultural significance, consistently inspires awe [72]. Pilgrim et al. [72] demonstrated that complex, reflective musical compositions consistently elicited feelings of awe, especially in individuals with a high need for cognition and a low need for cognitive closure. The identified personality traits seem to enhance receptivity to transcendent experiences, enabling listeners to accept and even welcome ambiguity and novelty in music. The emotional tone of the music, whether joyful or melancholic, significantly enhanced the awe response. This indicates that both positive and negative emotional content can trigger this emotion when the music is experienced as expansive and psychologically profound. This is consistent with Keltner [58]'s comprehensive framework, which categorizes music as one of the eight fundamental wonders that typically elicit awe, in conjunction with nature, moral beauty, and spiritual narratives. The immersive quality of musical experiences parallels other awe-inspiring stimuli, including architecture and virtual reality, as it can provoke a "small self" perspective and an enhanced sense of interconnectedness [59, 62]. The findings highlight the value of music as both an aesthetic experience and a psychologically significant instrument that can elicit awe, encourage introspection, and potentially enhance prosocial behavior and well-being.

In addition to external stimuli like nature or music, internal personality traits significantly influence individuals' susceptibility to awe. Ejova et al. [73] demonstrated that individuals with high openness to experience were significantly more inclined to report feelings of awe when exposed to evocative stimuli, including nature documentaries and expansive visual scenes. This trait, defined by intellectual curiosity, aesthetic sensitivity, and imaginative thinking, seems to enhance the ability to recognize vastness and integrate new cognitive frameworks—two essential elements of the awe experience. The findings align with previous research by Shiota et al. [62, 74], which indicated a positive correlation between dispositional awe and openness, cognitive engagement, and a diminished need for closure. The link between awe and curiosity is particularly noteworthy. Anderson et al. [68] demonstrated that individuals prone to awe exhibit increased curiosity, thereby strengthening the connection between awe and epistemic exploration. Anderson et al. [68] further revealed that individuals who frequently experience awe are also more curious, a relationship supported by both self- and peer-reports.

Furthermore, awe indirectly predicted academic engagement, work ethic, and self-efficacy via its effect on curiosity [68]. Supporting these findings, Anderson et al. [68] and Cruz [75] indicate that awe frequently arises when individuals face phenomena that contest their established frameworks, inciting both curiosity and a pursuit of comprehension. Awe enhances openness to experience and epistemic humility, significantly contributing to learning and meaning-making processes [60, 69]. Therefore, it can be said that awe is not merely an emotional response but a motivational force that drives learning and growth, suggesting practical applications in educational and developmental settings. These studies indicate that awe functions as both a situationally induced emotion and a personality-driven phenomenon, influenced by persistent individual differences in cognitive and affective processing.

### 1.3.2 Awe from the Perspective of Neuroarchitecture

In the fields of environmental psychology and neuroarchitecture, both natural and built environments serve as significant sources of awe, influencing perception, cognition, and social behavior [59]. Nature is a universally awe-inspiring domain, characterized by vast landscapes, powerful storms, starry skies, and wildlife encounters that frequently evoke a sense of humility and wonder [57, 69, 76]. Historically, natural environments, including vast mountain ranges, forests, oceans, and celestial phenomena, have been the primary subjects of awe-related research. Such environments are typically marked by their vastness, dynamism, and organic complexity, eliciting feelings of insignificance, wonder, and connectedness [62, 77]. The natural environment offers diverse sensory experiences and unpredictable formations that elude human control, resulting in a profound and frequently affirmative feeling of awe [58]. Experiences in forests, deserts, oceans, and canyons have been demonstrated to elicit the “small self” effect. Bai et al. [77] assert that immersion in expansive natural environments, such as forests and oceans, consistently induces the small-self effect, characterized by a reduced sense of individual self and an enhanced perception of belonging to a larger whole. This phenomenon subsequently mediates increases in prosocial behavior and life meaning. Piff et al. [66] conducted field studies on awe-inducing nature exposure, such as tall trees, and found that participants reported increased feelings of connectedness and humility, consistent with the “small self” construct. The findings align with those of Stellar et al. [78], who contend that awe facilitates social integration by diminishing self-importance and enhancing prosocial behaviors. Studies highlight that individuals exposed to awe-inspiring videos of natural environments, such as waterfalls or views of space, report heightened perceptions of a reduced self in relation to a larger context. Supporting this, Chirico et al. [59] demonstrated that immersive natural environments, such as digital simulations of nature, consistently elicit awe-related physiological and behavioral changes. On the other hand, Sturm et al. [65] demonstrated that regular exposure to natural awe, exemplified by “awe walks,” can improve emotional well-being in older adults by decreasing stress and fostering social connectedness.

However, recent multidisciplinary research in architecture, neuroscience, and environmental design has increasingly acknowledged that built spaces can evoke significant awe [59, 71]. Architectural settings, especially those characterized by symbolic, monumental, or complex elements, can reflect the psychological effects of nature by eliciting comparable sensations of expansiveness and perceptual overwhelm. Coburn et al. [71] claim that constructed settings can evoke awe through spatial expansiveness, complexity, and sensory novelty, mirroring the perceptual attributes of natural stimuli. Historic cathedrals, modern museums, and civic monuments frequently integrate spatial and visual components designed to evoke reverence, humility, and awe [79].

Awe in architectural contexts is frequently elicited by particular design elements, including verticality, broad openness, curved shapes, and sudden shifts from enclosed to enormous areas (Coburn et al., 2017; Chirico et al., 2018; Higuera-Trujillo et al., 2021). These attributes activate perceptual and emotional processing systems, potentially enabling cognitive transformations and promoting a feeling of transcendent immersion (Chirico et al., 2018; Pilgrim et al., 2017). Empirical studies have identified several specific architectural design features associated with eliciting awe. Ceiling height is a crucial element that affects perceptual spaciousness, cognitive style, and affective state. Research indicates that elevated ceilings correlate with increased perceptions of freedom, improved emotional responses, and a transition to more abstract and holistic cognitive processing, all fostering psychological conditions favorable to experiencing awe. Meyers-Levy and Zhu (2007) conducted a foundational study revealing that individuals in environments with higher ceilings (10 feet versus 8 feet) showed increased activation of freedom-related concepts, improved performance on abstract thinking tasks, and reported more positive affect compared to those in lower-ceiling environments. This indicates that spatial elevation may unconsciously affect cognitive style, fostering mental states linked to openness and transcendent thinking, which are essential elements of the awe response. Vartanian et al. (2013) expanded upon these findings by employing functional MRI (fMRI) to examine the neurological correlations linked to architectural characteristics. The study demonstrated that variations in ceiling height significantly impacted brain activity in areas related to aesthetic evaluation, including the orbitofrontal cortex and parahippocampal gyrus. Higher ceilings and open spaces were associated with increased activation in these areas, suggesting enhanced emotional and aesthetic responses. The observed neural activations correspond with established patterns linked to awe, specifically the integration of emotional salience and spatial cognition. Moreover, Vartanian et al. (2015) observed that participants experienced heightened feelings of "being moved" and "transported" in architectural settings with high ceilings and vertical openness, commonly regarded as "cathedral-like." The subjective reports correspond with theoretical frameworks that define awe as a synthesis of perceptual vastness and the necessity for cognitive accommodation. Coburn et al. (2017) also highlighted that ceiling height, in conjunction with other volumetric characteristics of space, plays a significant role in fostering a sense of spatial vastness, a key precursor to awe. The authors contend that the visual system swiftly processes characteristics such as vertical scale, eliciting a physiological "wow" response before completing cognitive evaluation. In addition, immersive architectural volumes, including domes and vaulted ceilings, augment the perception of spatial vastness and facilitate the dissolution of self-boundaries, which is characteristic of the awe experience (Chirico et al., 2018). In summary, empirical and neurocognitive evidence indicates that high ceilings serve as a significant architectural feature that enhances the experience of awe by promoting perceptual openness, abstract cognition, and positive emotional responses. The findings support the notion that awe can be deliberately induced through spatial design in constructed environments.

In addition to ceiling height, other architectural factors that evoke awe encompass verticality, ornamentation, complexity, and the dynamics of light. Verticality, represented by towering structures, steeples, and domes, encourages an upward gaze and perceptual submission, activating neural and behavioral indicators of awe akin to those produced by natural landscapes. Verticality, manifested in tall towers, spires, domes, or upward-expanding spaces, elicits perceptual and psychological responses associated with elevation, sublimity, and transcendence. Joye and Verpooten [79] assert that vertical structures activate evolved perceptual mechanisms that were originally adapted to respond to tall natural features, such as trees or cliffs, which historically provided cues for refuge or danger. In architectural contexts, these features elicit an emotional response akin to that generated by natural expanses, rendering verticality a significant cue for inducing awe. Coburn et al. [71] describe how the perception of vertical scale engages particular attentional and emotional pathways, notably those associated with vigilance and arousal. Tall structures elicit an upward gaze, which correlates with submissive or reverential postures, physically manifesting awe. This upward gaze posture promotes a reduced sense of self and enhances awareness of the surrounding spatial magnificence. Their findings indicate that verticality is frequently processed automatically and rapidly within the visual system before comprehensive aesthetic or symbolic evaluation. Neuroaesthetic research confirms this concept. Vartanian et al. [19] demonstrated that participants exhibited significant activation in the orbitofrontal cortex, a region linked to reward and aesthetic appreciation, when viewing architectural images marked by high verticality and openness. Neural signatures align with those identified in awe experiences, indicating that verticality influences spatial perception and emotional and cognitive transcendence. Moreover, verticality serves a symbolic function. In various cultural and religious architectures, including steeples in cathedrals, minarets in mosques, and monumental columns in civic structures, the upward orientation of design signifies a connection to the divine, the infinite, or the transcendent. The symbolic verticality enhances the perceptual experience by adding existential significance, fostering awe by evoking spiritual humility and reflection [59]. Overall, verticality functions as both a sensorimotor and symbolic trigger of awe. The perceptual qualities evoke feelings of grandeur, elevation, and transcendence, while the symbolic associations enhance the emotional impact, particularly in spaces designed for contemplation, worship, or public remembrance.

Ornamentation, complexity, and light dynamics are significant architectural elements that can evoke awe by stimulating perceptual, emotional, and symbolic systems. Architectural ornamentation, characterized by intricate decorative elements within structures, enhances emotional responses by enhancing perceptual richness and visual interest. Joye and Verpooten [79] assert that ornamentation attracts attention by appealing to inherent perceptual preferences for pattern, symmetry, and texture. Presenting features in a novel or elevated manner, such as gilded ceilings and intricate facades, generates aesthetic pleasure and can evoke awe when the decoration reflects craftsmanship that surpasses ordinary human effort. Ornamentation contributes to semantic depth, especially in religious or historic buildings, where motifs possess symbolic significance that enhances the sense of sacredness or grandeur. Architectural complexity, characterized by the richness, diversity, and layering of design elements, is directly associated with increased aesthetic appreciation and awe-like responses. Coburn et al. [71] explain that moderate complexity, defined by variation without disarray optimizes cognitive engagement and aesthetic reward. Their findings indicate that complex environments pose challenges to perceptual and cognitive systems, fostering attention, curiosity, and emotional resonance, especially when the observer is unable to categorize or fully understand the structure immediately.

On the other hand, light serves as a significant element in architectural environments. Vartanian et al. [19] and Coburn et al. [71] highlight that light movement, natural daylight penetration, and luminance contrast direct attention and enhance architectural features, including height, texture, and volume. Light passing through stained glass, skylights, or perforated façades produces transient patterns that imply impermanence and beauty, eliciting wonder and spiritual reflection. The effects are particularly pronounced in sacred spaces, where light is frequently employed symbolically to imply divinity or transcendence. These features work together to enhance architectural environments' aesthetic and psychological effects.

Biophilic design, which incorporates natural elements into architectural spaces, has considerable potential to generate awe by eliciting profound psychological, physiological, and cognitive responses. Although not consistently designated as "awe" in biophilic design literature, numerous effects linked to awe, such as sensations of wonder, immensity, the "small self," and cognitive transformations, are reflected in the established advantages of biophilic environments. Ryan et al. [80] establish three categories of biophilic design - Nature in the Space, Natural Analogues, and Nature of the Space - each encompassing design patterns such as visual connection to nature, dynamic light, prospect and refuge, mystery, and complexity, all of which are recognized to evoke perceptual and emotional richness that can promote awe-like states. Visual associations with biodiverse landscapes or dynamic natural elements, such as flowing water and shifting light, are notably linked to mood enhancement, activation of the parasympathetic nervous system, and restoration of attention - physiological indicators closely related to experiences of awe [80]. Kellert and Calabrese [81] further asserts that experiences of sensory richness and a connection to natural processes inherent in architectural design can foster spiritual fulfillment and heightened consciousness, which are fundamental aspects of awe. Despite the scarcity of empirical studies directly connecting biophilic design and awe, the overlap in their psychological effects—such as enhanced well-being, humility, and expanded attention—indicates that biophilic environments are favorable to eliciting awe, particularly when design elements are arranged to evoke complexity, scale, and dynamic interaction with natural systems.

Chirico et al. [59] and Monroy and Keltner [60] highlighted that spiritual ceremonies, contemplative environments, and interpersonal ethical excellence, including observing altruistic behavior or communal rituals, can consistently evoke feelings of awe. Symbolic and cultural components in architecture also evoke awe by invoking shared meanings, historical continuity, and transcendental implications. Sacred architecture has become known for eliciting deep emotional and cognitive reactions related to spatial and symbolic significance. Coburn et al. [71] illustrate via neuroaesthetic research that sacred structures—imbued with religious or cultural significance—stimulate brain regions linked to reward, self-transcendence, and emotional meaning-making, indicating that awe responses are influenced not solely by form but also by culturally embedded symbolism. Higuera-Trujillo et al. [16] contend that emotional reactions to religious environments are heightened when architectural elements are viewed through a culturally recognized symbolic framework, such as domes, spires, or iconography, which indicate a connection to the divine and encourage self-diminishment. Moreover, symbolic architecture's narrative and ritual roles - such as altars, pilgrimage routes, or sacred alignments - augment the perception of significant immensity, an essential element of awe [64]. Cultural framing is particularly significant: settings that align with an individual's cultural perspective are more prone to evoke awe through identity, continuity, and moral elevating mechanisms [58, 66]. Collectively, these results confirm that awe in constructed environments is not merely a result of perceptual magnificence but is profoundly connected to symbolic meaning and culturally influenced interpretation.

The transformative nature of awe stems not only from its emotional intensity but also from the neurophysiological responses it evokes in the brain's attentional and reflective systems. Awe induces various physiological and neurophysiological responses that extend beyond mere subjective emotional experiences. Individuals frequently describe physical sensations including chills, goosebumps, and tearfulness, alongside cognitive effects such as altered time perception, diminished self-focus (often referred to as the "small self"), and an enhanced sense of connection to a broader context [57, 61, 62, 69]. The subjective effects correspond with quantifiable biological responses. Neurophysiological research indicates that awe stimulates the parasympathetic nervous system, reducing heart rate and enhancing vagal tone, which signifies a transition to a calm and receptive state [59, 69]. Awe concurrently activates brain regions associated with attention, self-referential thought, and salience processing, specifically the medial prefrontal cortex, posterior cingulate cortex, and the default mode network [67]. Awe's restorative physiological effects can be attributed to its capacity to shift attention from self-focused rumination to a broader, interconnected world perspective. Awe frequently activates the parasympathetic nervous system, linked to calmness, decreased heart rate, and lower physiological arousal, facilitating psychological and somatic recovery [59, 67]. Awe promotes emotional regulation and cognitive flexibility by shifting attention from internal stressors to external vastness, facilitating a perceptual decentering [57, 68].

The relationship among awe, attentional redirection, and mood enhancement is especially pronounced in nature-based settings. Sturm et al. [65] demonstrated that brief, guided "awe walks" in natural settings significantly alleviated daily distress and enhanced feelings of wonder and connectedness among older adults. In the study conducted by Sturm et al. [65], participants in the awe group were encouraged to explore new places weekly and reminded that awe is most likely found in environments with novelty and physical vastness. These participants reported higher awe levels and stronger feelings of connection to something greater than themselves. Notably, their photographs during these walks contained more images of the environment and fewer of themselves—a visual representation of reduced self-focus. These outcomes suggest that awe enhances connectedness and perspective, encouraging individuals to feel integrated within a broader life and natural context. Cultivating awe, then, improves emotional resilience and social connection, supporting healthy aging. Monroy and Keltner [60] assert that exposure to awe-inducing stimuli, including trees, skies, or bodies of water, decreases inflammation and enhances vagal tone, thereby benefiting cardiovascular and emotional health. The findings by Lopes et al. [82], although not part of your collection, align with this evidence: natural environments improve mood and decrease rumination, whereas urban settings typically do not provide the same physiological calm or psychological uplift. Collectively, these findings indicate that awe significantly influences attentional reframing, redirecting focus outward and alleviating chronic concerns. This redirection enhances emotional well-being and biological resilience, positioning awe as a significant asset in mental health, aging, and therapeutic design.

Electrophysiological evidence suggests that awe enhances theta and beta oscillations in EEG recordings [59]. Theta oscillations play a significant role in long-term memory encoding and emotional processing, whereas beta waves are linked to attentional engagement and cognitive integration [59]. The oscillatory changes may indicate cognitive restructuring processes induced by awe, known as the "need for accommodation," which is a defining characteristic of awe as described by Keltner and Haidt [56]. This mechanism elucidates how awe promotes deeper information encoding, improves memory consolidation, and encourages reflective thought [69]. Awe serves as both an emotional state and a biologically rooted, cognitively broad experience that affects information processing, storage, and retrieval [58, 64].

### 1.3.3 Exploring Awe as a Mediator Between Architecture and Memory

Awe is a multifaceted and transformational emotion defined by the experience of vastness and the necessity for cognitive adaptation — a reconfiguration of existing mental frameworks to assimilate new knowledge [56]. These elements differentiate awe from other positive feelings, making it particularly important in educational settings. Psychological and neuroscientific research has increasingly investigated awe's ability to improve learning and memory by affecting attention, engagement, and the profundity of cognitive processing [59, 62]. Awe fosters introspective thought, curiosity, and receptiveness to new knowledge, potentially acting as a powerful mechanism to enhance encoding and support long-term retention. Kolb's Experiential Learning Theory (ELT) offers a fundamental framework for comprehending the impact of awe on learning. Kolb [83] contends that learning occurs via a cyclical process incorporating concrete experience, reflective observation, abstract conceptualization, and active experimentation. Awe, especially in experiential or immersive settings, amplifies the emotional significance of the concrete encounter, fostering introspection and facilitating conceptual transformation [84, 85]. Cuzzolino [86] analyzed scientists' autobiographical accounts of formative learning moments and discovered that experiences of awe frequently served as cognitive catalysts, transitioning learners from superficial comprehension to profound conceptual reorganization — a definitive instance of epistemic emotion facilitating structural learning transformation.

Numerous studies indicate that awe improves memory consolidation and enhances attentional focus. Shiota et al. [62] examined the psychophysiological characteristics of awe, revealing that awe-inducing stimuli elicited reduced skin conductance responses and extended pre-ejection periods, indicating a distinct parasympathetic profile relative to other positive emotions. Chirico et al. [59] employed immersive 360° VR environments to manipulate awe experimentally. Participants exposed to awe-inducing videos, such as panoramic scenes of Earth from space, reported significantly higher levels of awe, perceived vastness, and need for accommodation than those viewing the same stimuli on 2D screens. These experiences increased parasympathetic activation, associated with reflective attention and deeper encoding, both essential for memory consolidation. Limpt et al. [70] also demonstrated that virtual reality simulations of the "overview effect," which refers to the cognitive shift experienced by astronauts when observing Earth from space, effectively induced feelings of awe and enhanced subsequent learning motivation and emotional arousal. This suggests a potential correlation between awe and improved memory encoding through affective engagement.

The impact of awe is particularly pronounced in museum and informal learning environments. Price et al. [26] examined visitors' recollections of experiences in art and science museums, revealing that awe-related experiences were notably more likely to be remembered and articulated with vividness, emotional depth, and temporal extension. The study employed narrative analysis of museum-goers' recollections, demonstrating that awe memories frequently correlated with enhanced understanding and connection to scientific or artistic concepts. Research by Cuzzolino [86] indicated that awe often appeared in scientists' retrospective narratives of significant learning experiences, commonly linked to "aha" moments that transformed their comprehension of essential concepts.

Experiential learning frameworks highlight the importance of hands-on, emotionally engaging experiences for facilitating profound learning. Bauerle and Park [87] examined environmental science students engaged in field-based research, revealing that experiences of awe during these activities significantly enhanced long-term memory and knowledge retention. Students frequently described these moments as "eye-opening" or "perspective-shifting," consistent with Kolb's concept of concrete experience facilitating reflective learning. In the article "Experiential Learning: Hands On, Minds On" [88], educators indicated emotionally intense learning contexts, such as encounters with nature, enhanced student engagement and retention by rendering abstract content more personally meaningful. Bergsteiner et al. [85] contend that the emotional aspect of experiential learning is frequently overlooked, yet it is crucial for its effectiveness. Awe, characterized as a high-intensity emotional state, serves as a motivational amplifier in the experiential learning cycle.

Neuroscientific research has started to clarify the mechanisms through which awe influences learning. Reinerman-Jones et al. [67] demonstrated that awe activates the default mode network and prefrontal cortex, which are linked to self-referential thought, the integration of new information, and memory processes.

Research utilizing EEG [62] has demonstrated increased theta activity during states of awe, a frequency linked to encoding and memory consolidation. Chirico et al. [59] showed that awe-inducing VR experiences resulted in both subjective and physiological presence indicators, including increased heart rate variability and decreased skin conductance. These findings suggest a parasympathetic response that supports contemplative learning and mental accommodation. These findings indicate that awe may enhance both the quantity of information retained and the nature of encoding, shifting from shallow, detail-oriented memory to gist-based, conceptual memory.

Physical environments can evoke awe and subsequently affect cognitive processes associated with learning. Llorens-Gámez et al. (2022) performed a systematic review on neuroarchitecture, concluding that awe-inspiring spatial features, including expansive areas, elevated ceilings, and biophilic elements, improve attentional control and working memory by fostering calmness, curiosity, and decreased stress levels. The review indicates that architecture is cognitive in influencing information processing and retention, suggesting that learning environments should deliberately include awe-inspiring elements to enhance memory and learning outcomes. The experience of wildlife and expansive natural environments has been demonstrated to evoke awe and facilitate reflective thinking. Hicks and Stewart (2020) conducted a study on wildlife-inspired awe, revealing that these experiences improved participants' recall of ecological facts and heightened their sense of connection to the natural world, indicating a cognitive and emotional synergy between awe and retention. Overall, awe serves as a significant enhancer of learning and memory across diverse contexts, including virtual reality, museum exhibitions, wildlife encounters, and architectural spaces. This is accomplished through affective and cognitive pathways: enhancing emotional significance, fostering reflective attention, and improving memory consolidation through parasympathetic and prefrontal activation. The strategic elicitation of awe, whether achieved through immersive VR, biophilic architecture, or engaging fieldwork, constitutes a significant advancement in educational design. Future research should investigate the systematic integration of awe into curricula and learning environments to enhance understanding, facilitate conceptual change, and improve long-term memory retention.

### 1.3.4 Current Study

While awe has been extensively examined as a multifaceted emotional experience that impacts attention, perception, and social cognition, its particular effects on memory have not been thoroughly investigated in an architectural domain. Studies indicate that awe can broaden attention, diminish self-focus, and increase receptiveness to new information - cognitive conditions that may influence memory formation [60, 62, 68]. Monumental built environments, characterized by complex design and symbolic significance, consistently evoke feelings of awe by inducing perceptions of vastness and the sublime [71, 79]. Although numerous studies have explored the connection between awe and architectural or environmental design, there is a significant lack of research specifically addressing the relationship between awe and memory performance in built environments. This gap is particularly evident in Turkish academic literature, where empirical research on awe, particularly in the fields of architecture and cognitive science, is scarce. Addressing this dual gap, this study aims to examine whether awe-inspiring architectural imagery improves visual recognition memory performance. A norming study was initially performed to discover architectural scenes that consistently evoked awe and neutral reactions. The stimuli were subsequently employed in a visual recognition memory experiment, examined within the context of Signal Detection Theory. Accordingly, this study poses the following research question: Does awe, which is elicited by built environments, enhance visual recognition memory sensitivity compared to neutral architectural scenes? Moreover, whether awe's interaction with building style (modern vs traditional) and viewing angle (eye-angle vs. low-angle) increases recognition sensitivity was also investigated.

# Chapter 2

# Methods

## 2.1 Norming Study

The purpose of the norming study was to systematically identify and validate the photographic stimuli to be used in the main experimental investigation examining the effect of awe on visual recognition memory within built environments. This validation step was methodologically essential, as the internal validity of the main study depended on the use of stimuli that were affectively distinct in terms of their awe-inducing capacity. Participants rated each photograph using a six-item awe scale, which provided a standardized and reliable measure of their subjective awe experiences. These ratings enabled the empirical verification of the hypothesized distinction between awe-evoking and non-awe-evoking images, ensuring that subsequent categorization was grounded in participants' affective responses rather than solely on theoretical or aesthetic assumptions. This process ensured that the stimuli used in the main experiment were both perceptually and affectively validated in terms of their awe-inducing potential.

### 2.1.1 Participants

A total of 519 individuals initially participated in the norming study. Of these, 296 were excluded due to incomplete data, and only those demonstrating 100% progress and completing the entire survey were included in the study. One person was eliminated for indicating "I do not agree to participate" on the informed consent form. The survey of two demographic screening questions aimed at assessing participants' comprehension of the notion of awe, each supplemented with a concise description of that feeling. A conditional screening process was implemented for individuals who answered "I partially understand" or "I do not understand at all" to the initial questioning. Seventeen participants were removed for not responding "I fully understand" to the second question after all. After all screening standards, the final sample comprised 205 individuals in the norming study.

The prerequisites for participating in the study were being over 18 years of age and having normal or corrected-to-normal vision. As expected, all participants were confirmed to have no visual impairment through informed consent at the beginning of the study. The ages of the participants ranged from 18 to 56 years ($M = 22.10$, $SD = 6.25$). Out of 205 participants in the sample, 118 participants categorized themselves as female, 83 as male, three as non-binary/third gender, and one as "prefer not to say." Concerning educational background, 122 individuals possessed a high school diploma, 64 held an undergraduate degree, and 19 attained a master's or doctoral degree.

Participants were recruited through mostly the Bilkent University participant pool, social media platforms, email lists, and word of mouth. The research was executed online using the Qualtrics platform. The participants were predominantly undergraduate and graduate students from Bilkent University, encompassing both Turkish and international backgrounds; thus, the survey was administered in English. Undergraduate participants at Bilkent University were awarded course credit as compensation for their participation.

Before collecting data, the Bilkent University Ethics Committee approved the study protocol. In addition, all subjects were provided with informed consent before completing the survey.

### 2.1.2 Measures

In the norming study, participants viewed 96 architectural photographs and evaluated each image using a six-item questionnaire designed to assess the intensity of awe elicited by the photograph. The primary objective of this procedure was to identify and select the most suitable stimuli for inclusion in the main experiment.

The initial pool of architectural stimuli was compiled by systematically searching openly accessible online databases of photographs. Specifically, building images were collected from Unsplash (www.unsplash.com), Pexels (www.pexels.com), Pixabay (www.pixabay.com), Burst by Shopify (www.burst.shopify.com), and Freepik (www.freepik.com). These platforms were chosen because they provide high quality, copyright-free visual material suitable for academic research purposes. Initially, a comprehensive collection of building pictures from these databases was evaluated for their relevance to the study objectives. Only photographs that distinctly represented architectural structures without significant obstacles (e.g., vegetation, people, or overlapping objects) were included. In the subsequent phase, the chosen photos were further classified by name and architectural style (e.g., modern, traditional) to guarantee comprehensive representation of the necessary stimulus categories. This edited pool served as the foundation for the ensuing norming study, wherein participants evaluated the photographs based on the degree to which they experienced awe.

The 96-item stimuli pool is categorized into two main conditions: Awe-Evoking Built Scenes (manipulation group) and Non-Awe-Evoking Built Scenes (control group). It is expected that the photographs in the manipulation group will evoke awe, while those in the control group will not. Each category was further divided by two independent variables: building type (traditional versus modern) and photographic perspective (eye-angle versus low-angle). To simulate a direct frontal perspective of a built structure, eye-angle photographs refer to images of built structures captured from a frontal view, at angles approaching 90 degrees.

Conversely, low-angle photographs refer to images of built structures captured from a ground-level viewpoint, simulating the perceptual experience of gazing upward at the structure. This led to a factorial design of 2 (awe-evoking vs. non-awe-evoking) $\times$ 2 (modern vs. traditional) $\times$ 2 (eye-angle vs. low-angle), resulting in a total of eight subcategories. The categorization of the stimuli is presented in Figure 2.1, and an example stimulus is provided in Figure 2.2.

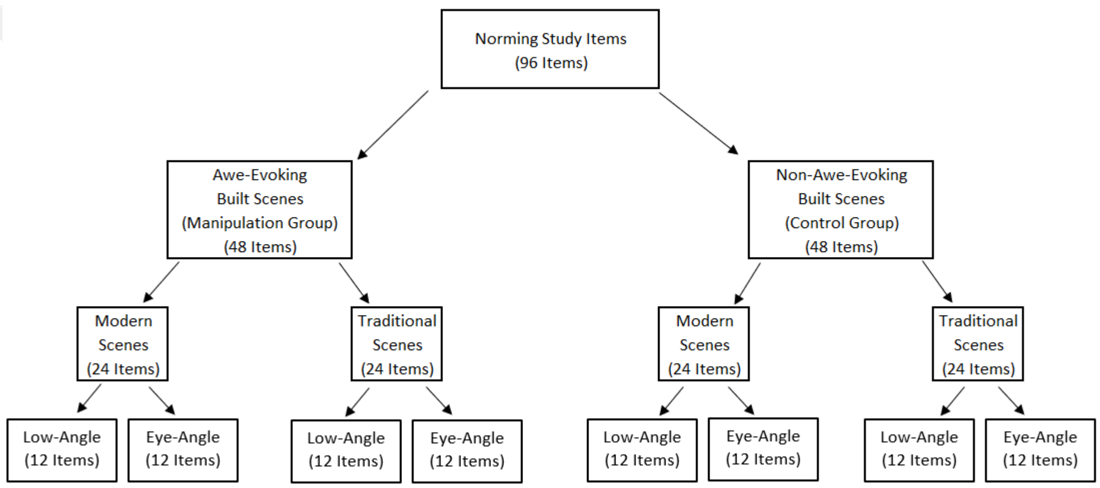


Figure 2.1: Hierarchical categorization of the stimuli used in the norming study

A total of 96 photographs, comprising 12 for each of the eight subcategories, were presented to participants in the norming study. The number exceeded the required threshold for the main experiment (9 per category), facilitating the removal of inappropriate stimuli according to participant ratings. Based on the results of the norming study, the nine photographs with the highest awe ratings were planned to be selected for the awe-evoking condition. In comparison, the nine photographs with the lowest awe ratings were planned to be selected for the non-awe-evoking condition within each subcategory for inclusion in the main study.

To assess the degree of awe elicited by each image, participants completed a 6-item version of the Awe Experience Scale (AWE-S) (see Table 2.1). This version was adapted from Yaden et al. [57], who originally proposed a multifactorial 30-item scale, later simplified by Yang et al. [1] through the selection of the

Figure 2.2: Example of an awe-evoking modern building photographed from a low-angle perspective

highest-loading item from each of the six subscales: altered time perception, self-diminishment, connectedness, perceived vastness, physical sensations, and need for accommodation. The adapted 6-item version of the AWE-S [1] was used to rate 96 photos of built environments in the norming study.

| | Variables and Items | M | SD | Loadings |
|---|---|---|---|---|
| 1 | I sensed things momentarily slow down. | 4.22 | 1.96 | 0.62 |
| 2 | I felt that my sense of self was diminished. | 3.37 | 1.90 | 0.67 |
| 3 | I had the sense of being connected to everything. | 4.17 | 1.91 | 0.69 |
| 4 | I felt that I was in the presence of something grand. | 4.21 | 1.90 | 0.77 |
| 5 | I felt my jaw drop. | 4.01 | 1.95 | 0.78 |
| 6 | I felt challenged to mentally process what I was experiencing. | 4.39 | 1.95 | 0.69 |

*Note*. M = Mean; SD = Standard deviation.

Table 2.1: Descriptive statistics and factor loadings for AWE-S items (1 = totally disagree, 7 = totally agree) adapted from Yang et al. [1].

Participants rated each item using a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). All 96 photographs were rated with no time limit imposed for completing the task. All items were presented to all participants in a standardized, fixed order. The survey was administered to participants in

English, which was consistent with its original version.

### 2.1.3 Procedure

The norming study was conducted online using the Qualtrics platform and distributed through various channels, including Bilkent University's announcement system, email distribution lists, social media, and word of mouth. Participants accessed the survey by clicking on the provided link. Upon accessing the survey, participants were initially provided with a concise introduction to the study, including details of the study, estimated duration (10-15 minutes), and the voluntary nature of their participation. Following this, participants provided their informed consent to participate. Demographic questions, including age, gender, and educational level, were then collected. Participants were subsequently provided a definition of the emotion of awe. This was a conditional question to ensure participants comprehended the studied emotion. Participants who expressed complete comprehension of awe by choosing "I fully understand" proceeded directly to the survey. Conversely, individuals who said "I partially understand" or "I don't understand at all" received an additional, more straightforward clarification of awe. Those who still indicated no understanding ("I don't understand at all") were automatically redirected to the end of the survey and excluded from further participation. Eligible participants proceeded to the main portion of the survey, which consisted of 96 photographs. They were asked to rate the extent to which each photograph elicited feelings of awe, using the 6-item AWE-S scale [1]. Participants responded on a 5-point Likert scale for each photograph, ranging from "Strongly Disagree" to "Strongly Agree". After the survey, participants were asked to provide their full name and university ID to receive course credit, if applicable. Data was collected through the Qualtrics platform, with responses stored securely for analysis. The study was then concluded.

### 2.1.4 Data Analysis

The norming study aimed to validate and categorize the stimulus set for the main experiment based on participant awe ratings. A total of 205 participants rated 96 photographs on a six-item awe questionnaire (1–5 Likert). For each photograph, item responses were averaged within raters and then aggregated across raters to yield a composite awe score per image.

To dichotomize the 96 photos for the main experiment, we empirically set a photo-level mean cut-off after visual inspection of the distribution of photo means (scatter and histograms): the threshold was set to 2.75. Photographs with a mean $\geq 2.75$ were labeled awe-evoking (experimental), and those $< 2.75$ were labeled non-awe (control). Visualizations were created in Excel (scatter plot) and JASP (distribution and descriptives), and the classification rule was established during the norming phase and applied consistently thereafter.

As a quality check, we assessed internal consistency of the six-item scale at the rating-instance level (participant $\times$ photograph). Reliability was estimated with Cronbach's $\alpha$ and a 95% CI; item diagnostics (corrected item–total correlations; $\alpha$ if item deleted) were examined. To align with the main experiment's design (nine images per each of eight categories), we planned to select the nine highest-rated awe-evoking and nine lowest-rated non-awe photographs within each category.

## 2.2 Main Study

### 2.2.1 Participants

A total of 36 individuals (26 females [72.2%], 10 males [27.8%]) took part in the visual recognition memory experiment. Participants ranged in age from 19–60 years ($M$ = 27.72, $SD$ = 8.09). Eligibility criteria required normal or corrected-to-normal vision, verified via self-report. Participants were recruited between

July and August 2025 using a convenience sampling method through Bilkent University's announcement system, email groups, social media platforms, and word of mouth. Sample size determination was conducted using GPower 3.1.9.7 for a two-tailed paired $t$-test ($d = 0.50$, $\alpha = .05$, power = .80). The analysis revealed that at least 34 participants were necessary to identify a medium effect size with sufficient statistical power—the final sample of 36 persons satisfied this requirement.

The Bilkent University Ethics Committee approved the research protocol, and all participants were provided with written informed consent before participation. Before the experiment, they received a verbal briefing outlining the study's content, the number of stages, and the expectations for their involvement. Participation was voluntary, and no compensation was provided. All participants completed the study in full, resulting in no exclusions from the dataset. The study employed a within-subjects design in which all participants were exposed to the same experimental conditions.

### 2.2.2 Measures

The experiment was programmed and executed through PsychoPy version [2024.2.4] [89] running on a desktop computer in full-screen mode. All task instructions and on-screen labels were presented in Turkish, the participants' native language, to ensure complete comprehension of the task requirements. Before collecting data, pilot tests were done to ensure any further revisions; pilot data were not included in the final analyses.

The visual stimuli consisted of high-resolution color photographs in JPEG (.jpg) format depicting architectural structures from various perspectives. All files were stored in the experiment's working directory and labeled using a coded naming convention (e.g., E-ML12 for Experimental-Modern-Low-Angle; E-TL3 for Experimental-Traditional-Low-Angle; C-TE5 for Control–Traditional–Eye-Angle) to indicate experimental condition (see Figure 2.3). To ensure uniform presentation, images were displayed in PsychoPy's normalized unit system, with a height of 1.5 norm units (approximately 75% of the total screen height) and proportional width adjustments to preserve the original aspect ratio. This procedure prevented geometric distortion and maintained the original composition. Image resolution was preserved without pixel resampling.

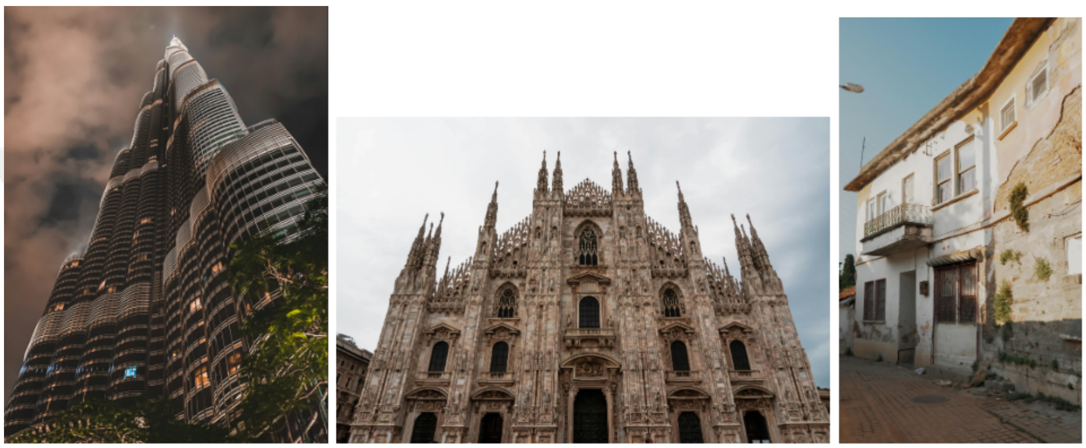

Figure 2.3: Example of an E-ML, E-TL, and C-TE building photos respectively

Forty-eight photographs were presented in the study phase. These stimuli were selected based on a preliminary norming study to validate their categorization. The design followed a 2 (awe-evoking vs. non-awe-evoking) × 2 (modern vs. traditional) × 2 (eye-angle vs. low-angle) factorial structure, with six photographs in each of the eight subcategories. Half of the images were awe-evoking, and half were non-awe-evoking. Subcategories are illustrated in Figure 2.4.

Following the study phase, participants viewed a 10-minute animation sequence compiled from three separate animated films. The design of this distractor task was inspired by Besson et al. [25] and aimed to reduce short-term rehearsal effects before the recognition test.

The test phase comprised 48 photographs, half of which were the same images from the study phase (24 "old" images) and half novel (24 "new" images) (see Figure 2.5). For each subcategory, the three images with the highest awe scores and the three with the lowest non-awe scores from the study phase were selected as "old" stimuli. "New" stimuli were chosen by ranking the unused images from the norming study: the next highest-scoring images for the awe-evoking categories

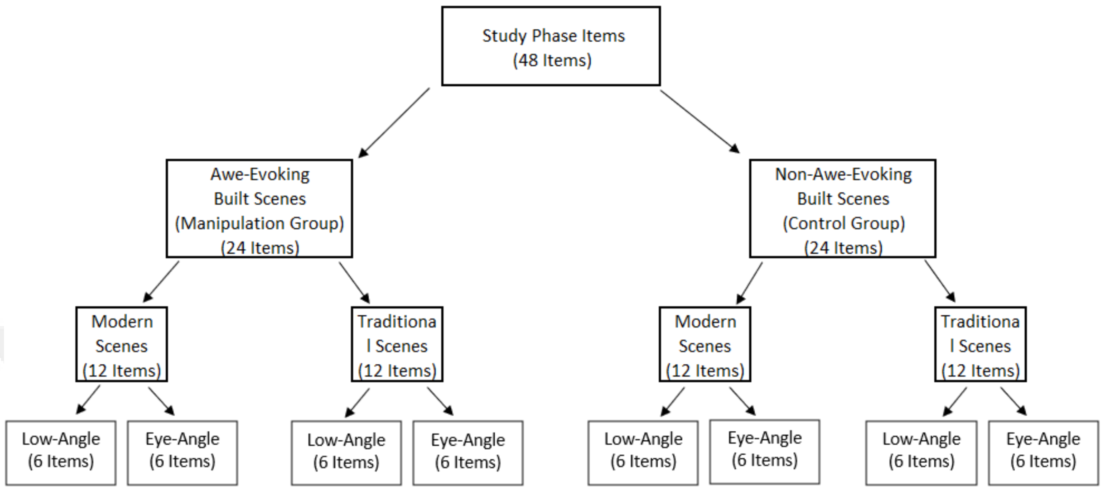


Figure 2.4: Hierarchical categorization of the stimuli used in the Study Phase of the main experiment

and the next lowest-scoring images for the non-awe-evoking categories. Stimulus order was randomized within each phase, and in the test phase, old and new stimuli were fully intermixed. Counterbalancing ensured an equal distribution of awe-evoking and non-awe-evoking stimuli across participants.

Recognition performance was scored on a trial-by-trial basis. Responses were categorized as *hits* (correctly identifying an old image as old), *misses* (incorrectly judging an old image as new), *false alarms* (incorrectly judging a new image as old), and *correct rejections* (correctly identifying a new image as new). Accuracy was computed as the proportion of correct responses (sum of hits and correct rejections) across all trials.

In addition to response accuracy, reaction times (RTs) were recorded for each recognition judgment during the test phase. RTs were measured from the onset of the response screen until the participant pressed the designated key. These data were stored alongside accuracy outcomes for subsequent statistical analysis.

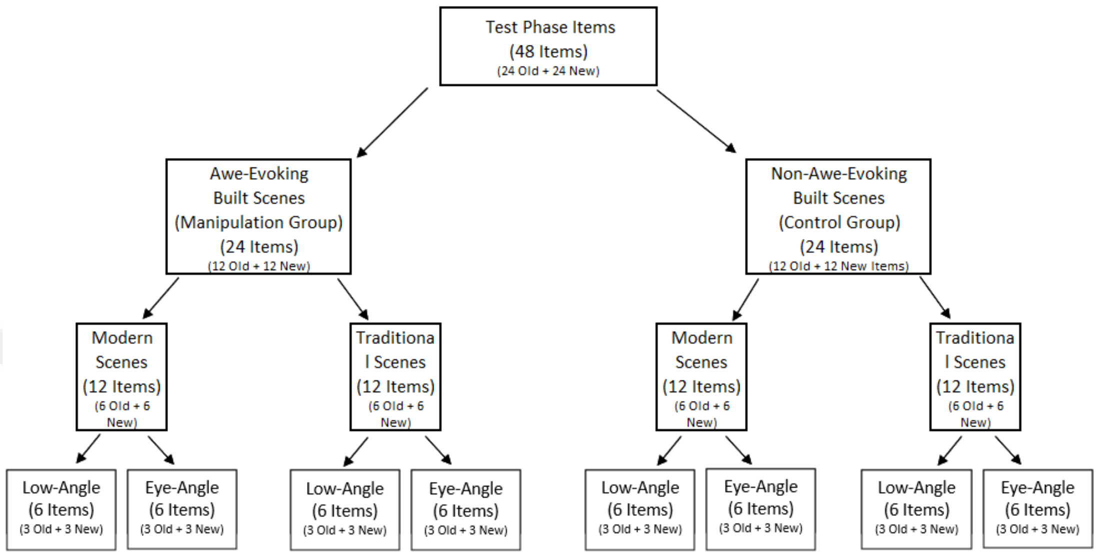


Figure 2.5: Hierarchical categorization of the stimuli used in the Test Phase of the main experiment

### 2.2.3 Procedure

The experiment was conducted individually in a quiet laboratory testing room, with all tasks administered via PsychoPy software [89] on a desktop computer, which controlled stimulus presentation and recorded responses. Participants provided written informed consent prior to participation and received on-screen instructions at the beginning of each phase.

The procedure consisted of three consecutive phases, following general methodological approaches commonly used in visual recognition memory research [e.g., 25, 41, 45]. In the study phase, participants were presented with 48 photographs of architectural structures, including both awe-evoking and non-awe-evoking stimuli. They were instructed to view each image attentively and memorize it for a later memory test. Each photograph appeared centrally on the screen for 3,000 ms, followed by a fixation cross ("+") for 2,000 ms before the next image was displayed. No blank inter-stimulus interval (ISI) was included; the subsequent trial's fixation cross appeared immediately after image presentation. The timing of stimulus presentation was consistent with procedures used in previous recognition memory experiments [25, 41]. The sequence progressed automatically, and participants were not required to respond during this phase, aligning with typical intentional encoding protocols in visual memory paradigms [41].

Immediately after the study phase, a distraction phase was introduced to reduce the influence of short-term memory and prevent rehearsal of the images. Participants viewed a 10-minute compilation of animated video clips presented continuously without interruption. This task was intended to occupy attention and create a temporal gap between encoding and retrieval. Using an unrelated video to generate an interference interval is consistent with prior work [25], which employed a 3-minute cartoon presentation in the interference phase to disrupt short-term retention and strengthen reliance on long-term memory processes.

Following the distraction phase, participants entered the test phase, which was designed to investigate visual recognition memory performance. In this phase, 48 photographs were presented in a randomized sequence: 24 "old" images displayed during the study phase and 24 "new" images not previously encountered. This equal distribution of old and new stimuli mirrors prior recognition test designs [25, 41]. Each image was displayed for 3,000 ms, followed by a gray response screen. On this screen, the response options were displayed as text prompts: "OLD" positioned above the letter `D` on the left side of the screen and "NEW" positioned above the letter `L` on the right side. Participants were instructed to press the `D` key to indicate that the image had been presented during the study phase, or the `L` key to indicate that the image was novel. As in previous work [41, 45], the response period was self-paced with no time limit, and the next trial commenced automatically once a response was made.

In both the study and test phases, all participants were exposed to the same set of stimuli; however, the presentation order was randomized for each participant using PsychoPy's randomization functions to minimize order effects and potential serial position biases. This randomization approach is consistent with procedures used in prior work [25, 45], which similarly randomized stimulus presentation to control for sequence-related confounds. The structured sequence in the present study allowed for controlled encoding, interference, and retrieval phases, enabling precise measurement of recognition accuracy and decision-making parameters following the principles of Signal Detection Theory.

### 2.2.4 Data Analysis

Recognition performance through Signal Detection Theory (SDT) with two dependent measures, sensitivity ($d'$) and response criterion ($c$), was analyzed. For each participant ($N = 36$) and for each cell of the 2 (Awe: awe-evoking vs. non-awe) $\times$ 2 (Style: modern vs. traditional) $\times$ 2 (Angle: eye vs. low) within-subjects design, trials were tallied into hits, misses, false alarms, and correct rejections according to SDT.

Sensitivity ($d'$) and response criterion ($c$) were analyzed using Signal Detection Theory (SDT) formulas [90]. Hit rates (HR) and false alarm rates (FAR) were first computed with the loglinear correction proposed by Hautus [91] to avoid infinite $z$-scores in cases of extreme proportions:

$$\text{HR} = \frac{H + 0.5}{H + M + 1}, \qquad \text{FAR} = \frac{FA + 0.5}{FA + CR + 1}$$

Where $H$ = number of hits, $M$ = number of misses, $FA$ = number of false alarms, and $CR$ = number of correct rejections.

Subsequently, $d'$ and $c$ were computed as:

$$d' = z(\text{HR}) - z(\text{FAR}), \qquad c = -\tfrac{1}{2}\left[\, z(\text{HR}) + z(\text{FAR}) \,\right]$$

Where $z(\cdot)$ denotes the inverse of the standard normal cumulative distribution function, higher $d'$ values indicate greater sensitivity, whereas positive or negative $c$ values indicate conservative or liberal response biases, respectively.

Two separate repeated-measures ANOVAs (one on $d'$ and one on $c$) were conducted with Awe, Style, and Angle as within-subject factors. Analyses were performed in R using $afex$ for ANOVA, *emmeans* for estimated marginal means (EMMs), and *ggplot*2 for visualization. We report Type III sums of squares, two-tailed $\alpha = .05$, and partial eta-squared ($\eta_p^2$) as the effect size. Because all factors had two levels, sphericity is not a concern. Because interactions were significant, we decomposed them with EMM-based simple-effects comparisons. Plots show EMMs with 95% confidence intervals. Our primary confirmatory focus was the main effect of Awe on $d'$ (hypothesis: awe-evoking images improve recognition sensitivity). Secondary analyses examined interactions with Style and Angle and assessed response bias via $c$ (negative = liberal "old" responding; positive = conservative).

# Chapter 3

# Results

## 3.1 Norming Study Findings

**Stimulus separation and cut-off.** The scatter plot of photo-level means indicated a clear separation between candidate awe-evoking and non-awe stimuli (see Figure 3.1).

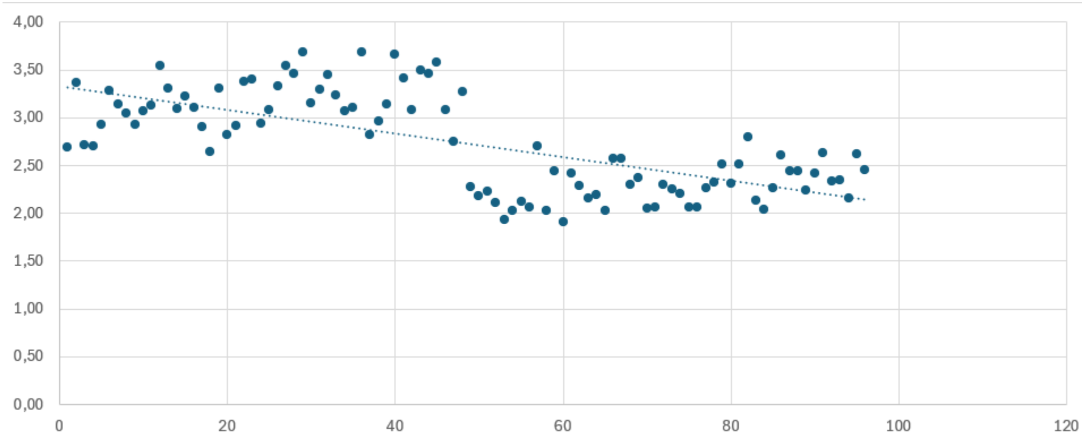


Figure 3.1: Scatter plot illustrating the distribution of mean awe ratings for the experimental and control stimuli using Excel

Guided by this distribution, the cut-off was set at 2.75: images above this value were classified as awe-evoking and those below as non-awe. Distribution plots corroborated this threshold, with experimental stimuli clustering above 2.75 and control stimuli below (see Figure 3.2). Applying this rule yielded 48 awe-evoking and 48 non-awe photographs.

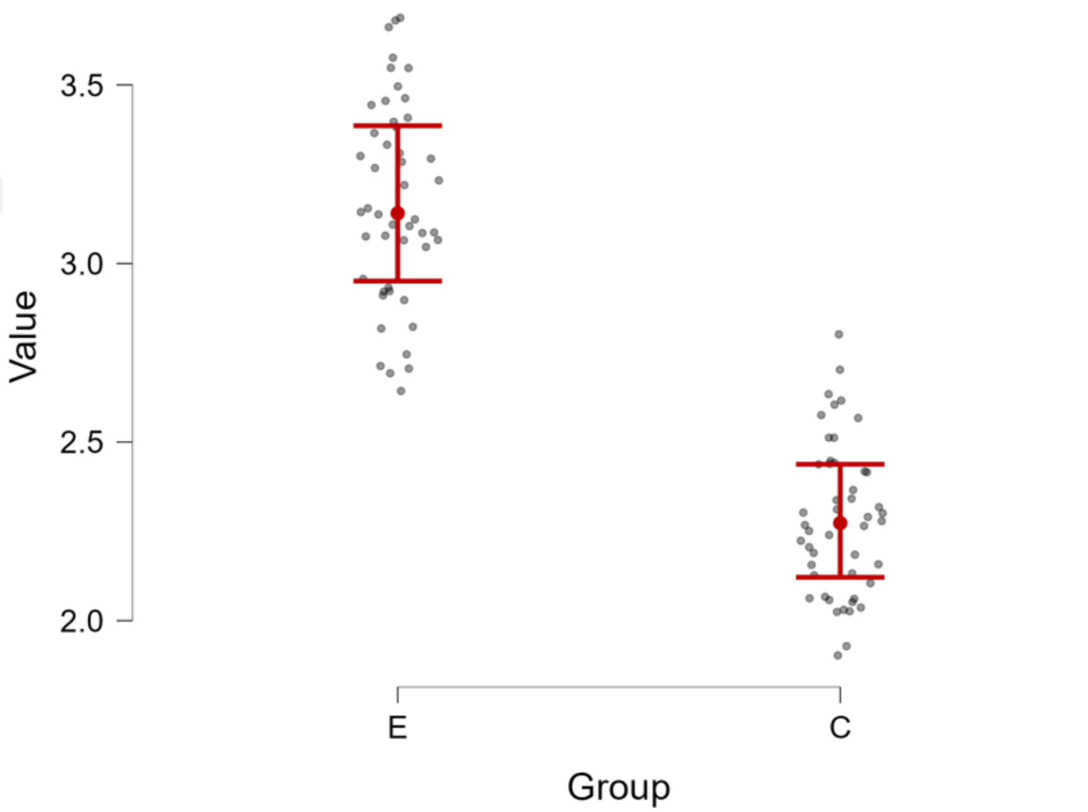


Figure 3.2: Comparison of Value Distributions between Experimental (E) and Control (C) Groups using JASP

Using the photo-level mean ratings (one value per item; n = 48 awe-evoking, 48 non-awe), a Welch two-sample t-test showed that awe-evoking photos were rated substantially higher than non-awe photos, $t(87.77) = 17.51$, $p < .001$, 95% CI for the mean difference [0.786, 0.988], Hedges' $g = 3.55$ (very large). Descriptively, the awe-evoking set averaged $M = 3.173$, $SD = 0.279$, whereas the non-awe set averaged $M = 2.286$, $SD = 0.213$. These results confirm a strong separation between the two stimulus pools and are consistent with the 2.75 cut-off adopted in the norming phase: the group means fall on opposite sides of this threshold, and the confidence interval for the mean difference excludes zero, indicating that the cut-off effectively distinguishes awe-evoking from non-awe images. Moreover, photo-level means confirmed a substantial separation between sets: awe-evoking, M = 3.173, SD = 0.279; non-awe, M = 2.286, SD = 0.213 by using JASP (see Figure 3.3).

*Descriptive Statistics*

| | E | C |
|---|---|---|
| Valid | 48 | 48 |
| Missing | 0 | 0 |
| Mean | 3.173 | 2.286 |
| Std. Deviation | 0.279 | 0.213 |
| Minimum | 2.643 | 1.902 |
| Maximum | 3.688 | 2.802 |

Figure 3.3: Descriptive statistics illustrating the comparison between the stimuli of experimental (E) and control (C) groups using JASP

**Reliability.** Across 19,680 rating instances (205 participants × 96 photographs; no missing items), the six-item awe scale showed good internal consistency: Cronbach's $\alpha = .883$ (standardized $\alpha = .883$), 95% CI [.880, .886], with average inter-item correlation $\bar{r} = .557$. Corrected item–total correlations were uniformly positive and sizable (.653–.751), and $\alpha$ if item deleted ranged .853–.869, indicating that all six items contributed meaningfully and none warranted removal. Reliability was comparable across sets (Experimental $\alpha = .863$; Control $\alpha = .867$), supporting measurement stability across image categories.

**Stimulus selection for the main experiment.** Consistent with the study plan, we selected the nine highest-rated photographs from the awe-evoking pool and the nine lowest-rated from the non-awe pool within each of the eight categories, producing a rigorously validated and well-separated stimulus set for the main task.

## 3.2 Main Study Findings

### 3.2.1 Analyses of Recognition Sensitivity ($d'$)

A $2 \times 2 \times 2$ repeated-measures ANOVA showed significant main effects of Style, $F(1, 35) = 18.38$, $p < .001$, $\eta_p^2 = .344$, and Angle, $F(1, 35) = 18.27$, $p < .001$, $\eta_p^2 = .343$ (see Figures 3.4 and 3.5). The main effect of Awe was not significant, $F(1, 35) = 2.15$, $p = .151$, $\eta_p^2 = .058$. Two two-way interactions reached significance—Awe × Style, $F(1, 35) = 5.36$, $p = .027$, $\eta_p^2 = .133$, and Style × Angle, $F(1, 35) = 4.88$, $p = .034$, $\eta_p^2 = .122$—whereas Awe × Angle was not significant, $F(1, 35) = 0.36$, $p = .551$, $\eta_p^2 = .010$. The three-way interaction (Awe × Style × Angle) was also not significant, $F(1, 35) = 0.01$, $p = .932$, $\eta_p^2 < .001$. These results indicate that recognition sensitivity varies reliably across architectural styles and viewing angles, and that the effect of awe depends on style; by contrast, angle does not moderate the awe manipulation, and there is no evidence for a conjoint three-factor pattern.

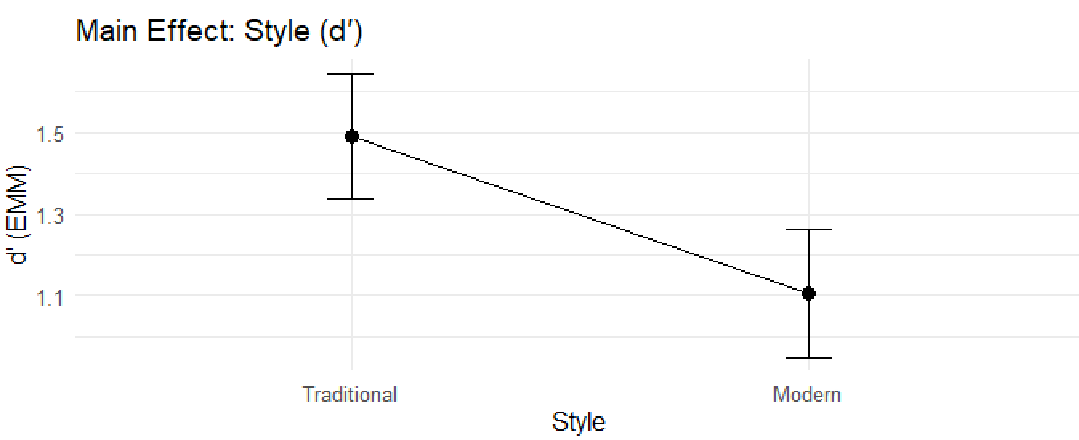


Figure 3.4: Main effect of Style on recognition sensitivity ($d'$). Points are EMMs with 95% CIs, averaged over Awe and Angle.

**Main-effect directions.** Collapsing across the other factors, $d'$ was higher for traditional scenes ($M_{\text{EMM}} = 1.49$, 95% CI [1.34, 1.64]) than modern scenes ($M_{\text{EMM}} = 1.11$, 95% CI [0.95, 1.26]; $\Delta M = 0.38$), and higher for eye-angle views ($M_{\text{EMM}} = 1.47$, 95% CI [1.32, 1.61]) than low-angle views ($M_{\text{EMM}} = 1.13$,

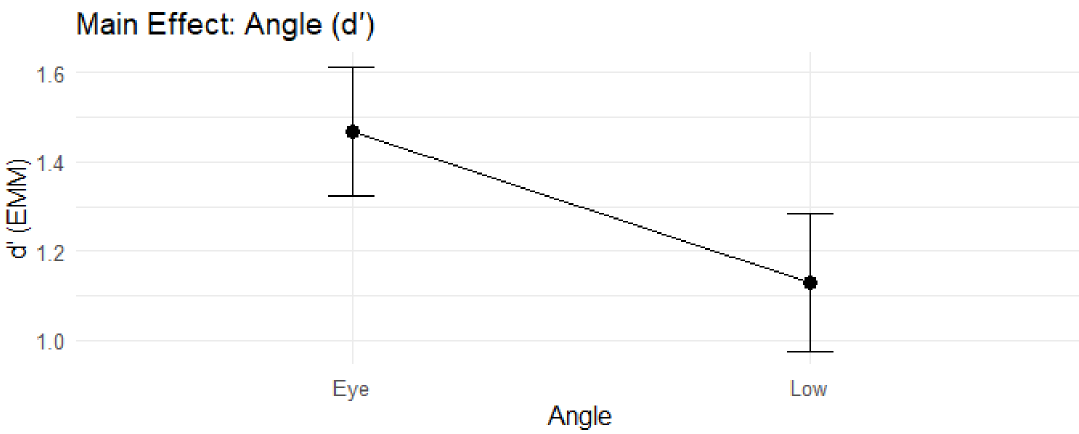


Figure 3.5: Main effect of Angle on recognition sensitivity ($d'$). Points are EMMs with 95% CIs, averaged over Awe and Style.

95% CI [0.98, 1.28]; $\Delta M$ = 0.34). In contrast, the awe manipulation did not yield an overall sensitivity advantage: non-awe images showed slightly higher $d'$ ($M_{\text{EMM}}$ = 1.35, 95% CI [1.21, 1.49]) than awe-evoking images ($M_{\text{EMM}}$ = 1.25, 95% CI [1.10, 1.40]; $\Delta M$ = 0.10), consistent with the nonsignificant Awe main effect reported above.

**Interactions (averaged over the third factor).** For Awe × Style, in modern scenes, sensitivity was lower for awe-evoking than non-awe images ($M_{\text{EMM}}$ = 0.93, 95% CI [0.71, 1.14] vs. 1.29 [1.07, 1.51]; Awe − NonAwe = −0.362, SE = 0.150, $t(35) = -2.41$, $p = .021$; see Figure 3.6). Thus, the awe manipulation selectively reduced recognition sensitivity for modern architecture, clarifying why the overall awe main effect was not significant when collapsed across style. In traditional scenes, the numerical reversal was not reliable ($M_{\text{EMM}}$ = 1.57 [1.39, 1.75] vs. 1.41 [1.21, 1.61]; Awe − NonAwe = +0.153, SE = 0.111, $t(35) = 1.38$, $p = .177$). For Style × Angle, it can be concluded that the style effect depended on the viewpoint. At eye level, traditional scenes ($M_{\text{EMM}}$ = 1.57, 95% CI [1.390, 1.76]) tended to elicit higher sensitivity than modern scenes ($M_{\text{EMM}}$ = 1.36, 95% CI [1.166, 1.56]) (see Figure 3.7), although this contrast did not reach significance (Modern − Traditional = −0.212, SE = 0.122, $t(35) = -1.73$, $p = .092$). At the low-angle, the style difference was large and reliable—traditional ($M_{\text{EMM}}$ = 1.41, 95% CI [1.235, 1.58]) > modern ($M_{\text{EMM}}$ = 0.85, 95% CI [0.639, 1.06]; Modern

− Traditional = −0.557, SE = 0.115, $t(35) = -4.83$, $p < .001$). This pattern indicates that the traditional advantage in sensitivity is especially pronounced from a low-angle view.

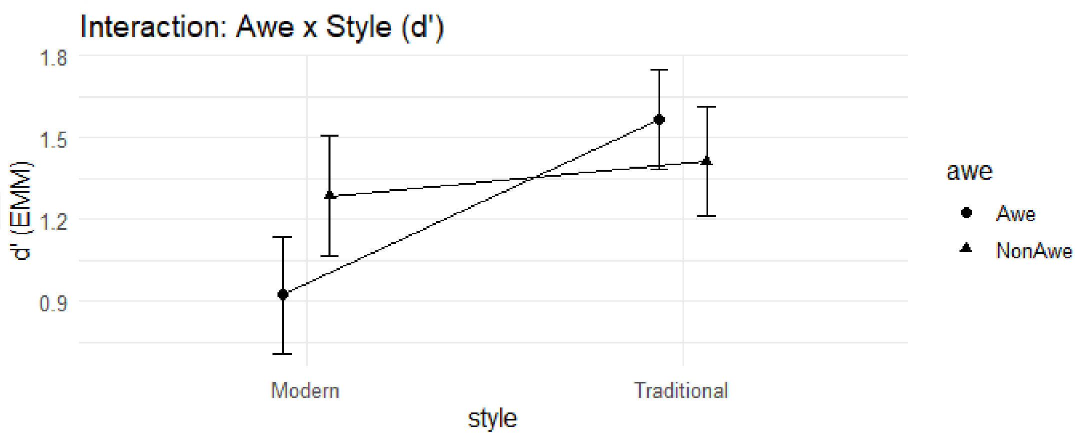


Figure 3.6: Awe × Style interaction in $d'$ (EMMs ± 95% CIs; averaged over Angle).

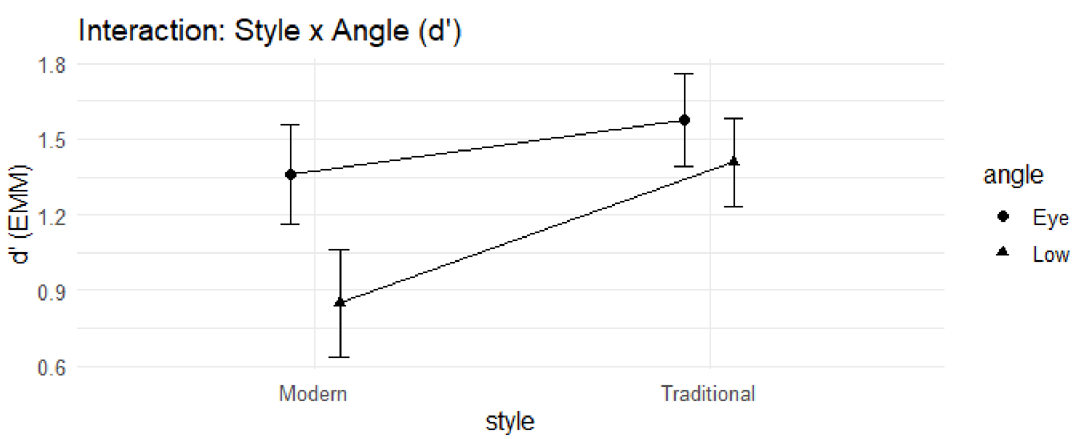


Figure 3.7: Style × Angle interaction in $d'$ (EMMs ± 95% CIs; averaged over Awe).

### 3.2.2 Analyses of Response Criterion ($c$)

A 2 × 2 × 2 repeated-measures ANOVA revealed significant main effects of Awe, $F(1, 35) = 7.53$, $p = .009$, $\eta_p^2 = .177$; Style, $F(1, 35) = 12.15$, $p = .001$, $\eta_p^2 = .258$; and Angle, $F(1, 35) = 13.61$, $p < .001$, $\eta_p^2 = .280$. As shown in Figure 3.8, responses were more conservative (higher $c$) for non-awe than for awe-evoking images, consistent with the Awe main effect. As shown in Figure 3.9, the criterion was more conservative for traditional than modern scenes. As shown in Figure 3.10, eye-angle views elicited more conservative responses than low-angle views, which is consistent with the Angle main effect. No interactions were reliable—Awe × Style, $F(1, 35) = 0.04$, $p = .846$, $\eta_p^2 = .001$; Awe × Angle, $F(1, 35) = 1.09$, $p = .303$, $\eta_p^2 = .030$; Style × Angle, $F(1, 35) = 2.02$, $p = .165$, $\eta_p^2 = .054$; and Awe × Style × Angle, $F(1, 35) = 0.26$, $p = .614$, $\eta_p^2 = .007$. Taken together, these results indicate that response bias (liberal vs. conservative) differed across awe, style, and viewing angle independently, with no evidence that the effect of any factor depended on the others.

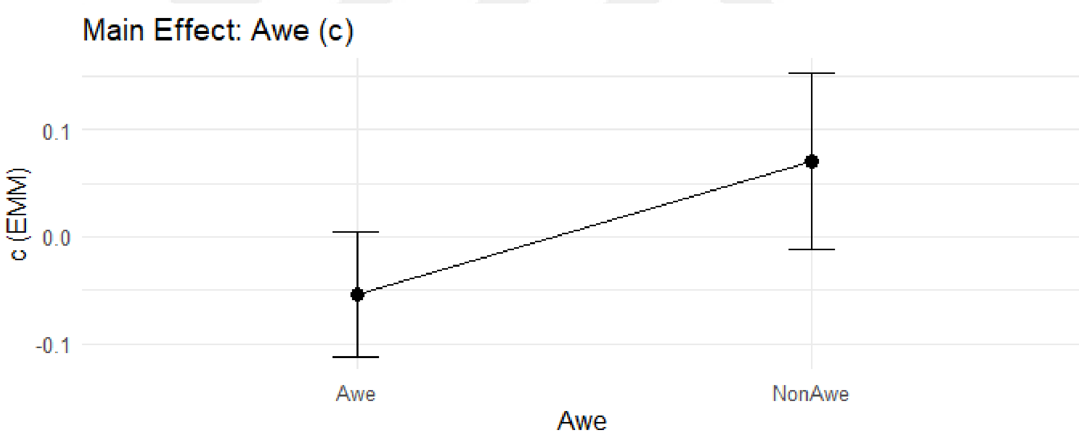


Figure 3.8: Main effect of Awe on response criterion ($c$)

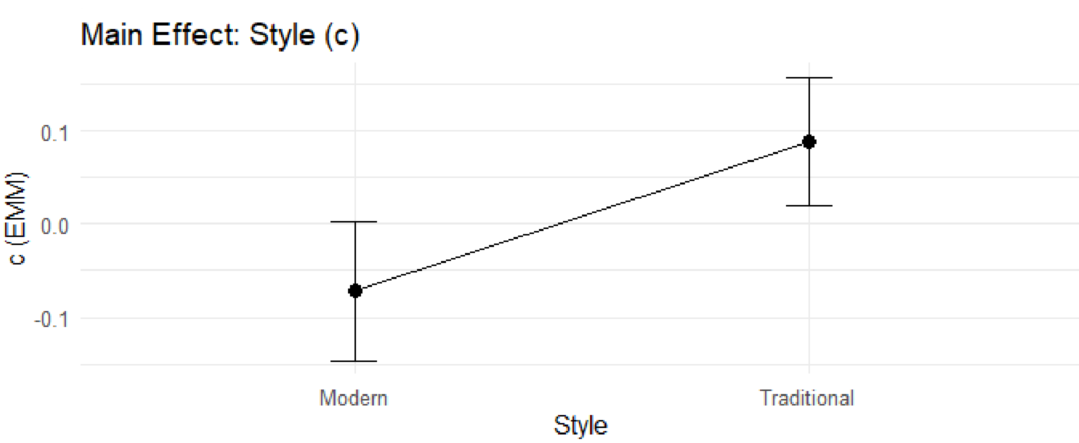


Figure 3.9: Main effect of Style on response criterion ($c$)

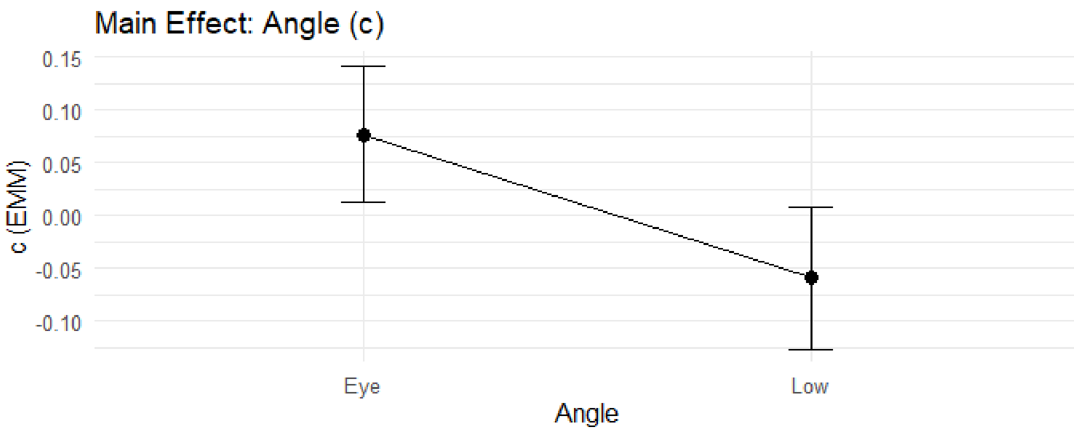


Figure 3.10: Main effect of Angle on response criterion ($c$)

**Main-effect directions.** Collapsing across the other factors, responses were more conservative for non-awe images ($M_{\text{EMM}} = 0.07$, 95% CI [$-0.01$, 0.15]) than for awe-evoking images ($M_{\text{EMM}} = -0.05$, 95% CI [$-0.11$, 0.00]; $\Delta M \approx 0.12$; see Figure 3.8). Criterion was also more conservative for traditional scenes ($M_{\text{EMM}} = 0.09$, 95% CI [0.02, 0.16]) than for modern scenes ($M_{\text{EMM}} = -0.07$, 95% CI [$-0.15$, 0.00]; $\Delta M \approx 0.16$; see Figure 3.9). Finally, eye-angle views elicited more conservative responding ($M_{\text{EMM}} = 0.08$, 95% CI [0.01, 0.14]) than low-angle views ($M_{\text{EMM}} = -0.06$, 95% CI [$-0.13$, 0.01]; $\Delta M \approx 0.14$; see Figure 3.10).

# Chapter 4

# Discussion

This study investigated whether awe, induced by architectural imagery, improves visual recognition memory performance as assessed by Signal Detection Theory (SDT). The research specifically examined whether awe-evoking architectural environments would produce greater memory sensitivity ($d'$) than neutral architectural environments, and whether this effect would be influenced by building style (modern vs. traditional) and viewing angle (eye-angle vs. low-angle). The study filled a significant gap in the literature by integrating principles from neuroarchitecture, visual recognition memory research, and empirical data on awe to examine the cognitive effects of awe in built environments. Based on existing research showing that awe can expand attention, encoding and retention mechanisms [62, 68], the study initially predicted that awe-evoking stimuli would correlate with increased discriminability between familiar and novel images. The results are consequently examined regarding these guiding questions, considering both the primary and interaction effects within the framework of existing theoretical and empirical paradigms.

Contrary to the primary hypothesis, which is awe, elicited by built environments, enhance visual recognition memory sensitivity compared to neutral architectural scenes, the main effect of awe was not found statistically significant, indicating that, when aggregated across styles and angles, awe-evoking stimuli did not yield an effect on recognition sensitivity. Descriptively, non-awe images exhibited marginally higher sensitivity compared to awe-evoking images; however, this difference was minimal and statistically insignificant, suggesting that the impact of awe may vary depending on context rather than being consistent. A plausible argument for the absence of a significant main effect of awe resides in the characteristics of visual recognition memory and the cognitive transformations prompted by awe. While previous research has shown that awe can expand attentional focus, enhance semantic encoding, and support long-term retention in conceptual or autobiographical contexts [26, 62, 68], these advantages may not directly apply to tasks necessitating precise perceptual discrimination. Awe has been linked to a transition towards global, gist-based processing and abstract cognition from a cognitive-processing standpoint [56, 92]. Although these processing modes may enhance comprehension, integration, and meaning-making, they may also diminish focus on local, item-specific characteristics essential for distinguishing between closely related visual stimuli in recognition evaluations. Within the realm of minimalist modern architecture - typically defined by little ornamentation and repeated geometric shapes - this transition may further decrease the presence of unique perceptual indicators, resulting in diminished discriminability. Moreover, awe is recognized for fostering a self-transcendent focus and increased emotional engagement [57], which may direct cognitive resources towards introspective or emotional appraisal, thus diminishing detailed perceptual recording. The experimental conditions of this study - brief stimulus presentation, an interference task, and a recognition test necessitating rapid old/new judgments - may have intensified these trade-offs, exposing a boundary condition wherein the cognitive benefits of awe do not extend to immediate, fine-detail visual recognition.

The present study demonstrated distinct and systematic variations in recognition sensitivity ($d'$) based on architectural style and viewing angle. Participants exhibited greater sensitivity in response to traditional architectural scenes relative to modern scenes, as well as when observing eye-angle perspectives compared to low-angle perspectives. These main effects were statistically significant and of moderate-to-large magnitude, demonstrating that both the architectural stylistic features and the subject's vantage point reliably influence visual recognition performance. The enhanced recognition sensitivity for traditional architecture and eye-angle perspectives can be attributed to the varying availability of diagnostic visual features, the perceptual processing benefits of canonical viewpoints, and possible novelty effects. Traditional architectural styles typically feature increased ornamentation, symmetry, textural variation, and unique structural elements [71, 79]. The abundance of cues enhances the uniqueness of individual exemplars, facilitating more precise discrimination during retrieval. In addition to feature-level explanations, the infrequency of traditional architectural forms in the daily environments of many participants may have enhanced their memorability due to a novelty effect. As in literature, novel stimuli elicit increased attentional engagement and deeper encoding, leading to improved subsequent recognition [93].

On the other hand, the positive impact of eye-angle perspectives corresponds with scene-perception research, which suggests that canonical viewpoints maintain familiar spatial relationships and enhance recognition [94]. In contrast, low-angle perspectives can obscure important details and heighten perceptual complexity by introducing geometric distortions and foreshortening. Overall, visual richness, perceptual optimality, and novelty-driven distinctiveness likely explain the observed main effects in recognition sensitivity. A possible explanation may be that recognition sensitivity was more significantly affected by the structural diagnosticity and perceptual accessibility of the stimuli than by awe itself. Architectural style and viewing angle may offer more reliable markers for differentiation, although awe, due to its broad attentional and emotional impacts, may not necessarily improve the detailed encoding required for recognition.

Two significant interaction patterns have been determined. The influence of awe was contingent upon architectural style. In modern architecture, images that evoke awe consistently showed lower recognition sensitivity than non-awe images. As mentioned above, the style-dependent effect of awe may be attributable to differences in feature diagnosticity and processing style. This shift may hinder item-specific encoding in minimalist modern architecture, where distinctive cues are limited, resulting in decreased sensitivity. Conversely, this trend was reversed numerically in traditional architecture, though it lacked statistical reliability. This indicates that awe manipulations may hinder recognition of modern scenes, while recognition of traditional scenes remains relatively unaffected or may even improve slightly. Secondly, the influence of style was contingent upon the viewing angle. The traditional advantage was evident from both perspectives, but it was especially pronounced from a low-angle viewpoint, where traditional architecture demonstrated significantly greater sensitivity than modern architecture. The traditional advantage at eye-angle was minimal and did not achieve statistical significance. The pronounced traditional advantage at low-angle viewpoints likely indicates the interplay between viewpoint geometry and stylistic characteristics. Low angles alter proportions and obscure elements, resulting in recognition that relies heavily on detailed, distinctive cues, which are more prevalent in traditional façades. Conversely, contemporary low-angle perspectives provide diminished salient cues, thereby exacerbating the sensitivity gap. The results suggest that recognition memory for architectural scenes is more significantly influenced by building style and the observer's vantage point than by awe alone. It can be concluded that awe may not directly affect the recognition sensitivity by itself; it may affect the interaction of other contexts.

Examining response criterion ($c$) revealed that awe, architectural style, and viewing angle independently affected participants' decision-making strategies during recognition. Participants exhibited a more conservative response bias when presented with non-awe-evoking images, which means they require stronger mnemonic evidence to endorse an item as "old". In contrast, awe-evoking images were correlated with a slight shift towards a more liberal bias, indicating an increased propensity to categorize items as “old” in situations of ambiguity. The liberal bias towards awe-evoking images may indicate greater subjective familiarity or a sense of having “seen before,” which is linked to enhanced emotional engagement and global processing [57]. The architectural style also influenced response tendencies, with traditional scenes prompting more conservative responses than modern scenes, suggesting increased decision thresholds for this category. A comparable trend was noted regarding viewing angle, where eye-angle perspectives yielded more conservative judgments than low-angle perspectives, which encouraged a more liberal response pattern. The conservative preference for traditional architecture and eye-angle perspectives may arise from the increased availability and clarity of diagnostic cues, which elevate decision thresholds by facilitating more confident rejections of novel items. On the contrary, the liberal bias towards modern and low-angle perspectives may indicate diminished cue distinctiveness and increased perceptual uncertainty, leading to more lenient old/new judgments. The lack of notable interactions suggests that these effects were additive, with each factor affecting response bias independently of the others. These response bias patterns may indicate the influence of awe in regulating subjective familiarity and decision-making thresholds rather than objective memory accuracy. The style and angle presumably offered diagnostic cues that prompted more conservative judgments, whereas awe may have influenced participants' interpretations of ambiguous signals, resulting in more liberal endorsements without necessarily improving discriminability.

This study is unique as it systematically investigates both recognition sensitivity and response criterion in relation to awe and architectural perception, a combination that has received no empirical attention. Previous research on awe has focused on its influence on broad attentional shifts, meaning-making, and emotional engagement. However, the current findings indicate that these effects do not directly lead to increased perceptual discriminability. Simultaneously, the majority of architectural and memory studies have focused on the diagnostic characteristics of style and perspective in influencing sensitivity, yet they have rarely examined the decision-making biases associated with recognition. This research demonstrates that awe has a greater impact on response criterion compared to sensitivity, thereby contributing to the literature by differentiating between the mechanisms of memory accuracy and decision-making thresholds. This dual perspective highlights the importance of combining Signal Detection Theory with neuroarchitectural and affective frameworks, providing a deeper comprehension of the influence of architectural experiences on cognition.

## 4.1 Limitations

Recognizing various methodological and design-related factors is essential when interpreting the current findings. The sample size of the primary experiment, while exceeding the a priori power requirement for identifying medium effects, was relatively modest (N = 36). A larger and more demographically diverse sample would enhance the generalizability of the results. The participant pool primarily consisted of individuals from a single university, which may restrict the generalizability of the findings to broader cultural, educational, and architectural contexts. Besides, the study did not directly measure differences in participants' prior familiarity with traditional and modern architecture, nor their dispositional tendency to experience awe. Both factors may have moderated recognition performance and response bias.

The visual stimuli comprised static, two-dimensional photographs of real-life buildings. First, while the visual stimuli underwent careful selection and validation through the norming study, they were derived from actual architectural scenes and thus lacked complete standardization. The presence of extraneous visual elements, including surrounding vegetation, bodies of water, lighting conditions, and color composition, may have introduced noise and potential confounds, complicating the isolation of the effects of the intended manipulations. Generating multiple illustrations of the same building (for example, eye-level and low-angle views of a created modern building) while removing extraneous visual confounds such as vegetation, water, or coloring would enhance experimental control and diminish visual noise. Second, the exclusive use of static and two-dimensional images restricts ecological validity, as these stimuli fail to capture the spatial depth, multisensory cues, and embodied experiences characteristic of architectural interactions. This approach enabled experimental control but fails to incorporate the multisensory and embodied aspects of in-situ architectural experiences, which are essential for eliciting and maintaining awe [10, 16]. Future research may overcome these limitations by utilizing rigorously standardized image sets or implementing more immersive methodologies, such as real-world field experiments or virtual reality (VR) presentations, to evoke awe with enhanced ecological and experiential fidelity. Third, a further limitation of the current study regards participants' previous experience with particular buildings they were exposed to. If participants had prior exposure to specific architectural structures via personal experience, education, or media, this pre-existing knowledge may have independently affected recognition performance, regardless of the intended manipulations of awe, style, or viewing angle. This familiarity may improve perceptual fluency and distort memory evaluations, thereby complicating the analysis of recognition sensitivity and response bias. To overcome this restriction, forthcoming research may implement strategies such as pre-screening participants for prior exposure, obtaining trial-level familiarity ratings to be used as covariates, or employing less recognized or procedurally created architectural stimuli. These methodologies would provide a more accurate evaluation of the influence of architectural attributes and awe experiences on recognition memory, hence reducing the confounding effects of prior information. Finally, the current study utilized only behavioral and self-report measures. Incorporating neurophysiological techniques, such as mobile EEG or functional near-infrared spectroscopy (fNIRS), may yield convergent evidence regarding the neural correlates of awe in both controlled and real-world contexts. Multimodal approaches would enable future research to investigate the relationship between architecture and awe at both experiential and neuroarchitectural levels.

## 4.2 Implications and Future Research

The current findings suggest that the effects of awe on recognition depend on both style and viewpoint: feature-rich, traditional forms and eye-level perspectives enhance sensitivity, while awe applied to minimalist modern façades and low-angle views reduces discriminability. Architects and urban planners, who are qualified with designing environments where accurate recall and navigation are essential, such as museums, hospitals, campuses, and transit hubs, must prioritize perceptual legibility at the pedestrian scale. This can be achieved by incorporating diagnostic cues—such as ornamentation, material texture, articulated joints, distinctive silhouettes, and calibrated color and lighting contrast—into primary pathways and decision points. Essential vistas, maps, signage, and digital wayfinding must present canonical, eye-level perspectives to ensure alignment between user perception and memory retention. The evidence indicates a design equilibrium where aesthetic intensity is coupled with cognitive accessibility, facilitating meaning-making through awe while ensuring clear, diagnostic information for recognition and navigation.

From a social perspective, the findings indicate that mnemonic performance within the built environment is closely linked to issues of cultural continuity, inclusivity, and collective experience. The enhanced recognition sensitivity noted for feature-rich, traditional forms, especially when positioned at eye level, suggests that these architectures serve as mnemonic anchors for collective narratives and place attachment. Awe, when combined with minimalist, modern façades - particularly from low-angle perspectives - was linked to diminished discriminability. This trend may lead to feelings of placelessness or social disorientation in urban areas characterized by abstract iconography. Secondly, many users, including children, older adults, and certain neurodivergent populations, depend significantly on recognition memory for daily navigation. Environments that provide clear and diagnostically rich cues at the pedestrian scale seem to promote social inclusivity, while awe-inspiring minimalism may disproportionately disadvantage these groups, thereby perpetuating accessibility disparities. The observation that awe liberalizes response criterion, leading to a greater tendency to endorse "old" suggests significant social implications. In civic, religious, or cultural contexts, awe may foster collective emotions, enhance cohesion, and promote openness to new ideas, while also altering judgment thresholds to favor gist over detail in later recollections. The findings suggest that the social dimension of architecture relies on a balance between emotional resonance and memory clarity, impacting identity, equity, and the quality of communal experiences.

From a neural standpoint, the results may suggest a potential neural distinction between systems that facilitate item-specific encoding and those which govern decisional policy, characterized by increased recognition sensitivity for feature-rich, traditional forms and eye-level views, as well as a liberalization of response criterion related to awe. Traditional façades and canonical, eye-level views likely provide more diagnostic cues for regions of the ventral visual stream (e.g., lateral occipital complex, fusiform gyrus) and scene networks (parahippocampal and retrosplenial cortex), thereby facilitating hippocampal pattern separation and enhancing the precision of mnemonic traces. In contrast, low-angle perspectives result in geometric distortion and foreshortening, which heighten the requirements for viewpoint transformation and diminish cue diagnosticity, potentially weakening the contributions of the medial temporal lobe to discriminability. Concurrently, the observation that awe influences response bias towards more liberal "old" endorsements, without an overall increase in sensitivity, aligns with affective-control interactions that adjust decision thresholds rather than enhancing mnemonic signals. The prefrontal circuitry involved in criterion setting, such as the dorsolateral and anterior cingulate regions, along with dopaminergic and striatal pathways that regulate exploratory responses, may be activated during experiences of awe. Additionally, arousal profiles that favor parasympathetic activity are likely to facilitate reflective and gist-oriented processing. In minimalist modern contexts characterized by sparse perceptual cues, this global, meaning-focused mode may compete with fine-grained encoding in the ventral temporal cortex, resulting in reduced discriminability. Overall, the findings reinforces a contextual neuroarchitecture model in which affect (awe), perceptual familiarity (style), and viewpoint collaboratively influence the balance between hippocampal–visual encoding mechanisms and prefrontal–striatal decision policies in recognition processes.

Future research should also distinguish recognition sensitivity from response criterion, as the current study indicates that these dimensions may diverge in the context of awe. Most existing research has concentrated primarily on accuracy, neglecting the exploration of how emotional states influence decisional thresholds in recognition memory. This underscores the necessity of differentiating between memory accuracy and response strategies in the examination of emotional impacts on cognition, a distinction frequently neglected in prior awe research. Moreover, these effects should be investigated through ecologically valid and immersive methods, including virtual reality or in-situ architectural exposure, to effectively capture awe's multisensory and embodied aspects. In addition, examining individual variations in susceptibility to awe, alongside assessing simultaneous neural activity using methods such as mobile EEG or fNIRS, may elucidate the underlying cognitive and neurophysiological mechanisms. Moreover, longitudinal and cross-cultural studies can help ascertain whether the observed effects generalize across various populations, exposure histories, and architectural traditions.

# Chapter 5

# Conclusion

This study investigated the effects of awe, architectural style, and viewing angle on visual recognition memory through a controlled Signal Detection Theory framework. Recognition sensitivity ($d'$) was influenced more by architectural style and viewpoint than by the experience of awe itself, $d'$ was consistently higher for traditional scenes compared to modern ones and for eye-level perspectives compared to low-angle perspectives. Awe did not yield an overall sensitivity advantage; rather, its impact varied by style - specifically, awe diminished discriminability for modern architecture, while recognition of traditional architecture remained unaffected or showed slight enhancement under awe. A subsequent interaction demonstrated that the traditional advantage in sensitivity was most pronounced at low angles, underscoring the significance of viewpoint geometry in feature diagnosticity. Response-criterion analyses supported these findings. Awe influenced decisions towards a more liberal decision (lower $c$), whereas traditional style and eye-level perspectives resulted in more conservative thresholds; these criterion effects were additive, with no significant interactions observed. The findings suggest that design features and vantage point primarily influence recognition accuracy, while awe modifies decision thresholds - an asymmetry that elucidates when emotionally powerful environments facilitate or obstruct precise visual memory.

This research integrates Signal Detection Theory with neuroarchitecture and affective science, thereby extending the literature on awe and memory by identifying a boundary condition for the mnemonic benefits of awe in built environments. The findings indicate that awe does not universally improve memory; instead, it interacts with perceptual and stylistic factors to yield context-specific results. This contribution highlights the necessity for architectural and cognitive research to collaboratively address affective states, perceptual affordances, and stylistic complexity in analyzing design's impact on human cognition.

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# Appendix A

# Ethics Approval

**Bilkent Üniversitesi**
Akademik İşler Rektör Yardımcılığı

**Tarih** : 3 Haziran 2024

**Gönderilen** : Beyza Gülzehra Ekinci

**Danışman** : Yasemin Afacan, Burcu Ayşen Ürgen

**Gönderen** : H. Altay Güvenir
İnsan Araştırmaları Etik Kurulu Başkanı

**Konu** : *"The Investigation of ..."* çalışması etik kurul onayı

Üniversitemiz İnsan Araştırmaları Etik Kurulu, 3 Haziran 2024 tarihli görüşme sonucu, *"The Investigation of Awe and Recognition Memory Performance in Built Environments: The Memorability of Awe in Built Environments"* isimli çalışmanız kapsamında yapmayı önerdiğiniz etkinlik için etik onay vermiş bulunmaktadır. Onay, ekte verilmiş olan çalışma önerisi, çalışma yürütücüleri ve bilgilendirme formu için geçerlidir.

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

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

Etik Kurul Üyeleri:

| **Ünvan / İsim** | **Bölüm / Uzmanlık** | |
|---|---|---|
| Prof.Dr. H. Altay Güvenir | Bilgisayar Mühendisliği | Başkan |
| Prof.Dr. Haldun Özaktaş | Elektrik ve Elektronik Müh. | Üye |
| Doç.Dr. Işık Yuluğ | Moleküler Biyoloji ve Genetik | Üye |
| Dr. Öğr. Üyesi Burcu Ayşen Ürgen | Psikoloji | Üye |
| Dr. Öğr. Üyesi A.Barış Özbilen | Hukuk | Üye |
| Prof. Dr. Özgür Ulusoy | Bilgisayar Mühendisliği | Yedek Üye |
| Dr. Öğr. Üyesi A.Barış Özçelik | Hukuk | Yedek Üye |

Kurul karar/toplantı No: 2024_06_03_01

Başvuru No: 553

**Bilkent Üniversitesi İnsan Araştırmaları Etik Kurulu Hakkında:**

- Kurul aşağıda ünvan, isim, uzmanlık alanı/bölümü belirtilen 5 asli ve 2 yedek üyeden oluşur:

  Prof.Dr. H. Altay Güvenir (Başkan), Bilgisayar Mühendisliği
  Prof.Dr. Haldun Özaktaş, Elektrik ve Elektronik Mühendisliği
  Doç.Dr. Işık Yuluğ, Moleküler Biyoloji ve Genetik
  Dr.Öğr. Üyesi Burcu Ayşen Ürgen, Psikoloji
  Dr.Öğr. Üyesi Arif Barış Özbilen, Hukuk
  Prof. Dr. Özgür Ulusoy (Yedek Üye), Bilgisayar Mühendisliği
  Dr.Öğr. Üyesi Barış Özçelik (Yedek Üye), Hukuk

- Kurul toplantılarına katılamayan asli üyelerin yerine yedek üyeler görevlendirilir.
- Kurul en az 3 üye ile toplanabilir.
- Bir başvurunun onay alması konusunda olumsuz oy kullanan üyeler bunu onay belgesindeki isimlerinin yanına muhalefet notu düşerek belirtirler.
- Bir başvurunun onay alabilmesi için en az 3 üyenin olumlu oy kullanması gerekir. Onay belgesinde isimlerinin yanında muhalefet notu bulunmaması, o üyelerin olumlu oy kullandıkları anlamına gelir.