

A Systematic Review of Architecture Stimulating Attention Through The Six Senses of Humans

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Abstract: The climate change crisis is negatively impacting the mental health of people worldwide. Attention is a pivotal pathway to healing ourselves and the world, as it is a sensory that improves mental health and sustainable behavior. Despite the architecture's potential to encourage attention immediately via all six human senses, there is still a wide research gap. Thus, this study aimed to investigate the architecture that stimulates attention through the six senses of humans, including Visual, Touch, Auditory, Olfaction, Taste, and Emotion. This review article was conducted by searching data from Scopus in February 2024, identifying a total of 4,844 related publications. After data screening following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, 32 relevant and accessible research works were identified. Finally, data were extracted from the selected articles and analyzed using thematic analysis to explore their relevance to all six sensory nerves. The results reveal that the architectural features predominantly eliciting attention are mainly related to visual sensory stimuli. Following closely are the architectural features perceived through the emotional sense. The architecture that promotes attention is minimally associated with touch, auditory, and olfaction senses. Finally, no architectural features were found to influence attention perceived through the sense of taste. Nevertheless, this study is merely a synthesis of data from previous research studies. Future research endeavors should aim to empirically validate the findings of this study for broader implications.

Keywords: Architecture; Attention; Human senses; Mental health; Sustainable behavior

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1. Introduction

The worsening climate change situation is negatively impacting the mental health of people worldwide [1-3]. In 2023, the United Nations (UN) reported numerous mental health issues arising from climate change anxiety [4]. The World Health Organization (WHO) has estimated that over 280 million people are currently experiencing depression [5]. Research indicates that not only direct exposure to natural disasters but also experiencing indirect environmental impacts or being informed about ecological news can trigger symptoms of eco-grief [6,7]. The pursuit of finding ways to care for humanity and the planet is of interest to us now.

1.1. The Significance and Approaches to Stimulate Attention

Attention is a pivotal pathway to healing ourselves and our world. Individuals with good attentional abilities can control their emotions to maintain an appropriate state, leading to a more peaceful and contented life [8-13]. On the contrary, if an individual loses control over their attention, they are at risk of encountering mental health problems, including anxiety and depression [14-16]. Moreover, attentional processes are crucial for stimulating enduring human sustainable behaviors, which rely on thoughtful decision-making and mindfulness [17-19]. Therefore, we are studying methods to promote human attention for the next steps.

The definition of attention is a human cognitive process that involves the ability to select what to be interested in, including choosing what to disregard [20-22]. Attention is associated with numerous human biological and psychosocial factors [23-25]. Numerous studies recommend various methods for attention enhancement. It ranged from direct training, such as attention state training (AST), to indirect training through video games [26-29]. However, in recent times, the direction of research has begun to shift.

A study in 2009 demonstrated that the environment could impact attention, as they found that walking in nature promoted attention better than walking in urban areas [30]. In 2018, there was research that utilized 2D images and videos of virtual natural environments to measure attention [31]. Thus, research has demonstrated a trend toward efforts to promote immediate attention rather than training, which requires a long time [32]. These lead us to seek out environments that can immediately improve attention.

1.2. Promoting Attention Through Architecture

Some research indicates that architecture can genuinely stimulate attention [33-35]. This potential stems from the fact that attention is a part of the human cognitive process [36,37], while architecture has the potential to promote human cognition [38-41]. This approach aligns with the principles of neuroarchitecture, which is gaining significant interest [42-45]. However, the aforementioned possibility still leaves significant gaps. A recently published systematic literature review emphasizes that information on architectural design that promotes attention remains scarce [46]. Thus, the research gap between architecture and attention is a crucial focus of this study.

Architecture determines the physical environment by designing structures and their immediate surroundings, with the intention of eliciting psychological responses to the physical setting [47-53]. Previous research has demonstrated that architecture possesses a distinctive capacity to promptly engage human responsiveness and attention through the human senses, even in the absence of direct physical interaction [54-57]. Therefore, this study aims to explore architectural design approaches that can stimulate attention through human sensory perception.

From the literature review aimed at identifying human senses relevant to architecture, it is found that the conventional understanding of human sensory perception encompasses the five senses, which include Visual, Touch, Auditory, Olfaction, and Taste [58-62]. However, recent research increasingly suggests that humans possess an additional sensory perception: Emotion [63-65]. All six of these human senses are related to architecture and attention, which will be elaborated upon in the following section.

1.3. The Six Senses in Relation to Architecture and Attention

The first part concerns visual sensory perception, which is often considered the most crucial sensory input in architecture [59,60]. This sensory has been associated with architecture since ancient Greek times to the virtual visual world of the future [66,67]. Texture, temperature, and density of materials, along with form, place, orientation, and length of space characteristics, are important factors in visual perception [68]. Undoubtedly, several studies demonstrate that architecture can most effectively promote attention through visual [69,70].

The following sequence involves the touch sensory, another essential sensory input for close-range sensation [60]. Tactile perception strongly influences visual perception because tactile surfaces are perceived not only through touch but also through visual inspection, allowing the perception of texture [61]. The surface texture of materials, whether smooth, soft, or rough, all have distinct effects on tactile perception [61,71]. Tactile sensations have the potential to divert people's attention away from the environment they are currently observing [72].

The sensory systems related to auditory perception are omnidirectional and crucial for creating atmosphere [62]. Whether it be disruptive noise, melodious sounds, or even silence, each has an impact on humans [62,73]. Architecture designed with consideration for the sensory experience of hearing has been present since Greek theater and continues to be evident in contemporary theaters [74]. An example of using sound to appeal to attention in architecture that is commonly encountered is the use of music in malls to stimulate customers' interest [75,76].

Next is the olfactory sensory, which possesses the potential to preserve, capture memories, and identify locations [59]. Some architects choose to use materials that emit distinctive scents or design features that allow scents from the surrounding environment, such as gardens, to permeate into the building, enhancing the sensory experience for the users [77-79]. Indeed, the scent of a space is another factor that can capture people's attention [80].

The sensory related to taste perception, which seemingly does not receive direct influence from the building [81,82]. Although architecture may not directly influence taste sensation, it can still stimulate and evoke taste perceptions [59,83]. A typical example is the use of color in restaurants [84]. In the realm of restaurant design, utilizing warm tones such as yellow and red can indeed stimulate attention in terms of appetite [85].

Lastly, the sensory aspects pertaining to emotion are crucial as people perceive the atmosphere more through emotional rather than intellectual means [65]. The components and space of architecture can influence humans' moods and feelings [59]. The use of music and color in architecture can impact the emotions and well-being of humans [81]. Furthermore, architecture and its surroundings have the potential to evoke various emotions that lead to capturing people's attention [86-88].

Therefore, it can be summarized that the six senses of humans, which are visual, touch, auditory, olfaction, taste, and emotion, are likely to be associated with architecture for promoting attention.

As previously mentioned, to heal ourselves and our world, it is essential to promote attention, a human cognitive function with the potential to improve mental health and foster sustainable behavior [8-19]. Numerous studies have demonstrated the potential of architecture to immediately stimulate human attention [33-35]. However, there remains a significant gap in the research on architectural design aimed at stimulating attention [46]. A review of the literature indicates that architecture can promote attention through the six human senses [54-57], which include visual, touch, auditory, olfaction, taste, and emotion [58-65]. It can be concluded that the objective of this research is to explore architectural design that stimulates attention through the six human senses. The conceptual framework can be represented as depicted in Figure 1.

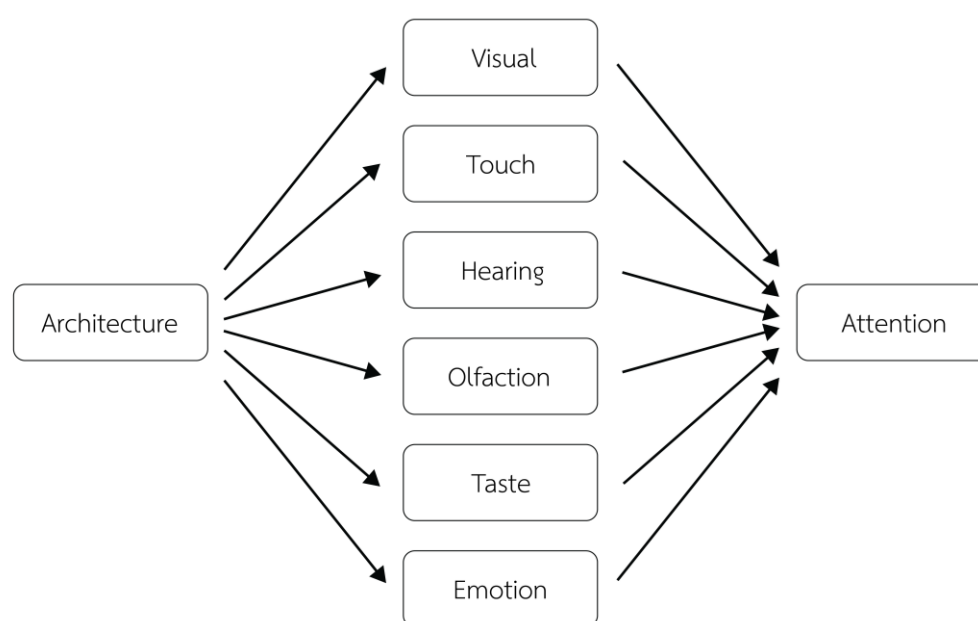


Figure 1. The conceptual framework of Architectural design stimulates attention through the six senses of humans.

RQ: Architectural design that stimulates attention through all six senses of human exhibits what characteristics?

2. Methodology

The systematic review employed to address the question of what characteristics of architectural design stimulate attention through all six senses of human exhibits. Because there is scarce information available on architectural design to promote attention [46]. Due to the rationale that this approach is particularly apt for exploring enhancement strategies in design efficiency [89]. In the subsequent section, we proceed to delineate the selected database, data collection methods, and data analysis techniques.

2.1. Database

The data source chosen for conducting the systematic review in this instance is Scopus. Due to the rationale that Scopus is a widely used academic database and the largest repository of scholarly knowledge, it is consistently selected for use [89,90]. The database access for this instance was carried out in February 2024.

To ensure the most relevant data retrieval aligned with the research objectives, the search strategy in the database is guided by the following measures: The search was managed by applying specific keywords in titles, abstracts, and keywords [91], as these areas concisely encapsulate the essential terms from previous studies. To ensure that the articles found are most relevant to architecture, the search criteria were limited to documents only and were categorized under architecture and engineering, focusing on content related to architecture published in English [92]. These publications, crucially, must be classified as articles, reviews, conference papers, and conference reviews to ensure the reliability of our research [93]. These types of academic articles are typically comprehensive and peer-reviewed.

2.2. Data collection

For this study's synthesis, we meticulously followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, a key pillar of our

research methodology that ensures transparency and accuracy [94–96]. After following the 4 standard PRISMA steps, detailed reporting can be provided as follows:

The first step of this section follows from the PRISMA model called the Identification phase. In order to search for architecture that stimulates attention, the keywords 'architecture' and 'attention' are defined. The search strategy employed in this instance is specific search,' which involves searching for information using at least one keyword, excluding synonyms or closely related terms, to ensure the most precise alignment with the research objectives [97–103]. When combined with the search criteria outlined in section 2.1, the formula used to search on Scopus is:

TITLE-ABS-KEY ((architecture) AND (attention)) AND (LIMIT-TO (SRCTYPE,"j") OR LIMIT-TO (SRCTYPE,"p")) AND (LIMIT-TO (OA,"all")) AND (LIMIT-TO (PUBSTAGE,"final")) AND (LIMIT-TO (SUBJAREA,"ENGI")) AND (LIMIT-TO (DOCTYPE,"cp") OR LIMIT-TO (DOCTYPE,"ar") OR LIMIT-TO (DOCTYPE,"re") OR LIMIT-TO (DOCTYPE,"cr")) AND (LIMIT-TO (LANGUAGE,"English"))

During this step, three undergraduate architecture students, who are familiar with architecture, carried out and cross-checked the process for validity [104]. A total of 4,844 relevant publications were found. Before recording the discovered documents, we examined a thorough review to determine their relevance to architecture. To ensure accuracy, an architecture graduate student, experienced in architecture and research article reading, evaluated the titles and abstracts of all articles. As a result, 4,627 articles were excluded due to their focus on engineering, computers, and mechanics.

For the screening phase, the 217 selected publications from the previous architecture-related step will be reviewed for content accessibility. The 4 articles were removed due to missing or inaccessible documents. This was attributed to the limited access provided by Scopus through KMITL permissions. The architecture graduate student mentioned is responsible for this step, as she regularly accesses academic databases.

In the eligibility phase, the first author, with the same graduate student, evaluated the suitability of the remaining 213 documents concerning the review's objectives, explicitly focusing on architecture that promotes attention. The involvement of two individuals in this phase was due to one being the most experienced researcher in the team, while the other was most familiar with the gathered articles. Of these, 181 articles were excluded as they did not contain relevant content on architectural characteristics promoting attention.

From the initial pool of 4,844 articles, only 32 studies met the criteria outlined previously, indicating architectural characteristics that stimulate attention and were accessible. Finally, the inclusion phase has concluded, with this review including all 32 publications containing architectural content that stimulates attention, as shown in Table 1.

Table 1. The data collection outcomes according to the PRISMA guideline.

Phases	Recorded Items	Excluded Records
Identification	4844	4627
Screening	217	4
Eligibility	213	181
Including	32	-

2.3. Data analysis

The data analysis process is divided into two main steps to address the research question, 'What characteristics does architectural design that stimulates attention through all six senses of humans exhibit?'

The first step involves conducting content analysis to decode the selected articles from the previous step, aiming to identify which characteristics of architecture can stimulate attention. The architectural features that tend to promote attention were extracted from the 32 articles selected from the previous steps. The content analysis method was chosen because it ensures structured analysis, increased reliability, replicability, and reduced bias in the research process [105-107]. Additionally, content analysis is utilized to decode the data as it can be integrated with systematic review to provide a clear procedural framework [108,109]. A research assistant with a master's degree in architecture who had not previously been engaged in the data collection process conducted the task to minimize potential biases.

The second step of conducting thematic analysis is based on the rationale that architecture that promotes attention can influence all six human senses, as discussed in section 1. Thus, the extracted data from the content analysis process was then subjected to thematic analysis using the six senses: visual, touch, auditory, olfaction, taste, and emotion. Thematic analysis will allow for the conclusion regarding the characteristics of architecture that stimulate attention through each of the six human senses. In this step, three researchers, who were experts in architecture, conducted the process independently of each other. Using triangulation with multiple researchers in this instance serves to reduce bias from the researchers [110]. "The final data set represents the consensus of opinions from all three individuals."

The data analysis of this review is summarized as content analysis and thematic analysis, as previously discussed. Both methods are qualitative. Due to content analysis involving decoding the architecture that attracts attention from previous research into words. Given the manageable quantity of decoded results, the findings are summarized qualitatively through description.

3. Results

3.1 The result of systematic review

The results of this research have been compiled from 32 articles related to architecture that stimulates attention, obtained from a Scopus search and selected according to the PRISMA method as outlined in sections 2.1 and 2.2. Before analyzing, as described in section 2.3, the publication year, journal, type of architecture studied, and type of attention discussed in the selected articles were detailed to help readers understand their characteristics. The list of selected publications is provided in Table 2.

Table 2. The article focuses on architecture that stimulates attention.

Authors	Title	Source
Gargiulo, M.; Carleo, D.; Ciampi, G.; Masullo, M.; Chías Navarro, P.; Maliqari, A.; Scorpio, M.(2024)	Assessment of the historical gardens and buildings lighting interaction through virtual reality: the case of Casita de Arriba de El Escorial.[111]	Buildings
Zhang, D.; Shan, X.; Zhang, X.; Chen, H.; Zheng, Y.(2023)	Spatial feature analysis of the Beijing forbidden city and the Shenyang imperial palace based on space syntax[112]	Buildings

Authors	Title	Source
Asim, F.; Chani, P. S.; Shree, V.; Rai, S.(2023)	Restoring the mind: a neuropsychological investigation of university campus built environment aspects for student well-being [113]	Building and environment
Zhong, W.; Schroeder, T.; Bekkering, J.(2023)	Designing with nature: advancing three dimensional green spaces in architecture through frameworks for biophilic design and sustainability [114]	Frontiers of architectural research
Fadda, R.; Congiu, S.; Roeyers, H.; Skoler, T.(2023)	Elements of biophilic design increase visual attention in preschoolers [115]	Buildings
Wang, P.; Song, W.; Zhou, J.; Tan, Y.; Wang, H. (2023)	AI-based environmental color system in achieving sustainable urban development [116]	Systems
Luo, Y.; He, J.; Long, Y.; Xu, L.; Zhang, L.; Tang, Z.; Li, C.; Xiong, X.(2023)	The relationship between the color landscape characteristics of autumn plant communities and public aesthetics in urban parks in Changsha, China [117]	Sustainability
Ghouchani, M.; Taji, M.; Roshan, A. H. Y.(2023)	Spirituality of light in the mosque by exploring Iranian-islamic architectural style [118]	Gazi university journal of science
Chanbenjapipu, P.; Chuangchai, W.; Thepmalee, C.; Wonghempoom, A.(2023)	A review article: fall incidents and interior architecture— influence of executive function in normal ageing [119]	Article
Krastiņš, J.(2023)	Nancy art nouveau architecture [120]	Article
Kosara Kujundzic ; Slavica Stamatovic Vuckovic ; Ana Radivojević(2023)	Toward Regenerative Sustainability: A Passive Design Comfort Assessment Method of Indoor Environment [121]	Sustainability
Pei, W.; Guo, X.; Lo, T.(2022)	Pre-evaluation method of the experiential architecture based on multidimensional physiological perception [122]	Journal of asian architecture and building engineering
Truspekova, K. K.; Sharipova, D. S.(2022)	Architecture of post-soviet Kazakhstan: key stylistic references in public facilities [123]	Civil engineering and architecture
Almssad, A.; Almusaed, A.; Homod, R.Z.(2022)	Masonry in the context of sustainable buildings: a review of the brick role in architecture [124]	Sustainability
Zhong, W.; Schröder, T.; Bekkering, J.(2022)	Biophilic design in architecture and its contributions to health, well-being, and sustainability: A critical review [125]	Frontiers of architectural research
Alajmi, M.; Al-Haroun, Y.(2022)	An architectural analytical study of contemporary minaret design in Kuwait [126]	Frontiers of architectural research
Lianto, F.; Trisno, R.(2022)	Discovering the factor of the bird's nest stadium as the icon of Beijing city [127]	International journal on advanced science engineering information technology
Fang, Y.; Que, Q.; Tu, R.; Liu, Y.; Gao, W.(2021)	How do landscape elements affect public health in subtropical high-density city: the pathway through the neighborhood physical environmental factors [128]	Building and environment

Authors	Title	Source
Lee, J. H.; Ostwald, M. J.(2021)	Fractal dimension calculation and visual attention simulation: assessing the visual character of an architectural façade [129]	Buildings
Suárez, L. A. F.(2020)	Subjective experience and visual attention to a historic building: A real-world eye-tracking study [130]	Frontiers of architectural re-search
Xu, R.; Xia, H.; Tian, M.(2020)	Wayfinding design in transportation architecture – are saliency models or designer visual attention a good predictor of passenger visual attention? [131]	Frontiers of architectural re-search
Sami, Z.; Dincer, M. E. E.(2020)	Study of physical, social and functional structures in bagdat Street (Istanbul) as public space [132]	Civil engineering and architecture
Szuta, A. F.; Szczepański, J.(2020)	Striking elements – A lifebelt or a fad? searching for an effective way of adapting abandoned churches [133]	Frontiers of architectural re-search
Dutsev, M. V.(2020)	Contemporary urban environment: the image of the history and the history of the image [134]	IOP conference series: materials science and engineering
Aatty, H. M. S.; Al Slik, G. M. R.(2019)	Iconic architecture and sustainability as a tool to attract the global attention [135]	IOP conference series: materials science and engineering
Bystrova, T. Y.(2019)	Concept of organic architecture in the second half of the xx th century in the context of sustainable development [136]	IOP conference series: materials science and engineering
Sadafi, N.; Sharifi, M. A.(2019)	A study of the concept of Iranian traditional architecture in bazaars and shopping centres [137]	Journal of construction in developing countries
Kłopotowska, A.(2017)	Tactile architectural models as universal 'urban furniture' [138]	IOP conference series: materials science and engineering
Halarewicz, A.(2017)	Study of selected components of architectural environment of primary schools - preferences of adults and analysis of the specialist literature [139]	IOP conference series: materials science and engineering
Cho, H.(2016)	A study on the comparison of the visual attention characteristics on the facade image of a detached house due to the features on windows [140]	Journal of asian architecture and building engineering
Moghaddam, E. V.; Ibrahim, R.(2016)	People's evaluation towards media façade as new urban landmarks at night [141]	Archnet-IJAR
Butko, D. J.(2011)	The sound of daylight: the visual and auditory nature of designing with natural light [142]	WIT transactions on the built environment

These studies were published between 2011 and 2024, with 2023 having the highest number of research publications on this topic [112-121]. In 2022, articles were published

the second most frequently [122-127]. In 2020 and 2019, there were 5 and 3 articles published [131-137]. In 2016, 2017, and 2021, there were 2 articles published each year [129-130,138-141]. In 2011 and 2024, there was 1 article published each year that met the specified criteria [111,142]. Before 2011 and between 2012-2015, as well as in 2018, no articles containing the keywords 'architecture' and 'attention' related to architecture stimulating attention were found. (Figure 2)

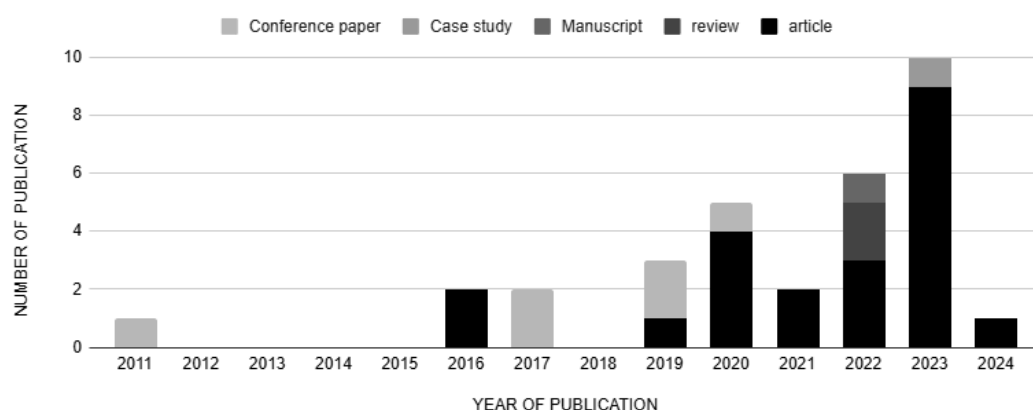


Figure 2. The distribution of publication years for the selected articles.

From the total of 32 articles, the journal *Frontiers of Architectural Research* has published the most, with 7 [114,125-126,130-131,133]. Following it is the 'IOP Conference Series: Materials Science and Engineering', with 5 [134-139]. Other journals have published only a few, as seen in Figure 3.

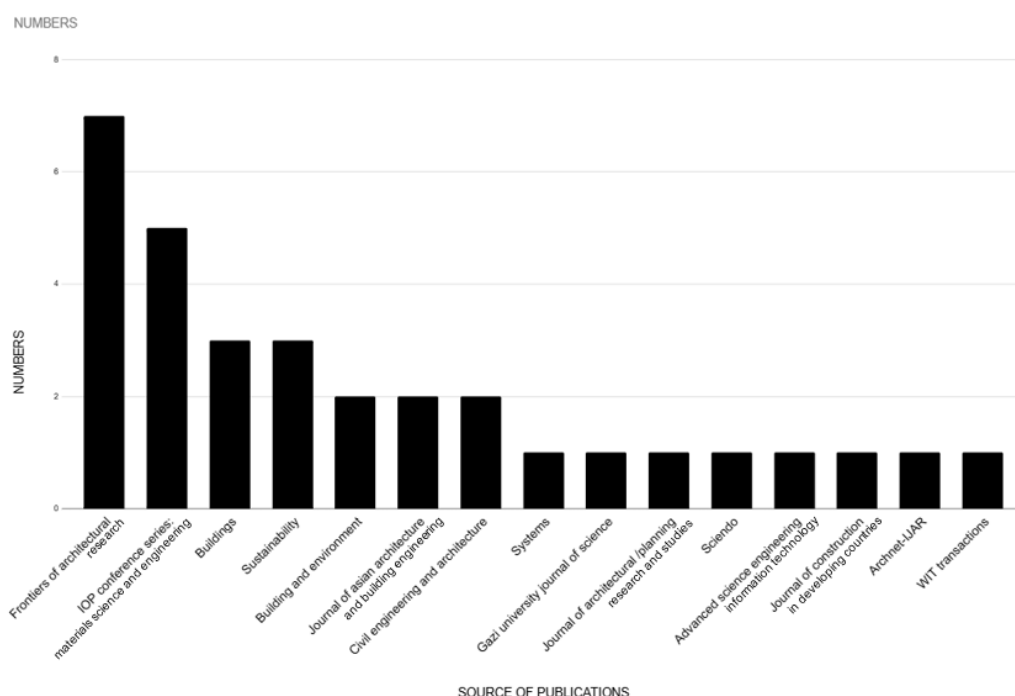


Figure 3. The distribution of the sources of the selected journal publications.

Upon examining the types of architecture studied in the selected articles, it was found that education buildings[113,115,125,139,142], landscapes[116-117,122,128,132], and residential buildings[125,129,132,134,140] were the most frequently studied.

Office[123,135-136,141] and religious buildings[118,125-126,133] were the second most studied types of architecture. Historical buildings[111,120,130], museums[125,134-135], retail spaces[123,137,141] and studies that did not specify a building type[121,124,138] ranked third in frequency. Palaces[112,123], hospitals[114,125], and transportation hubs[125,131] were each studied in two articles. Theaters[123], hotels[114], monuments[123], and stadiums[127] were the least studied, each examined in only one article. (Figure 4)

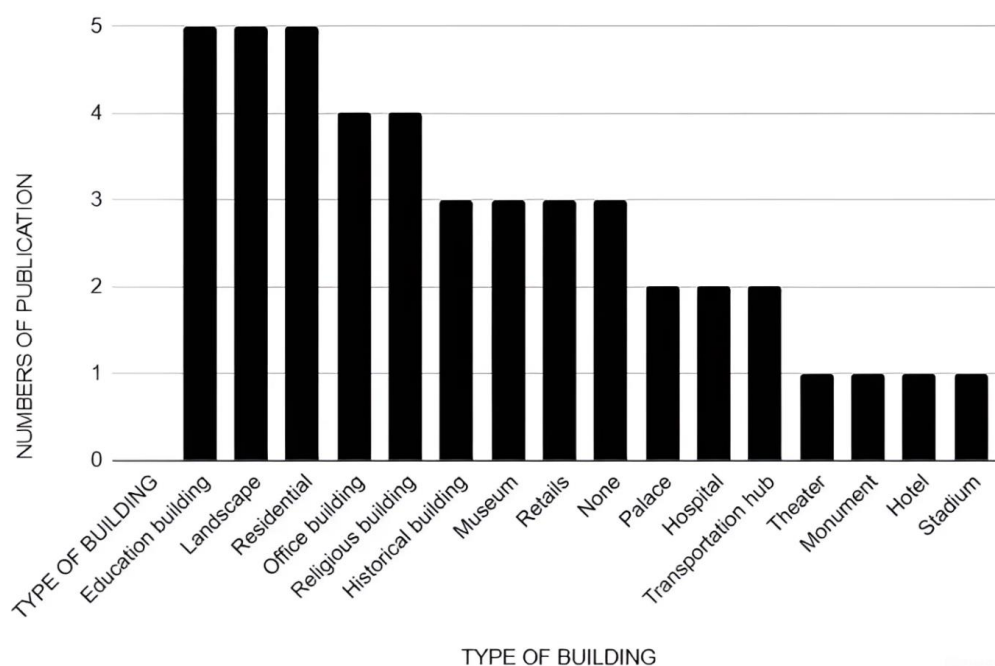


Figure 4. The types of buildings studied in the selected articles.

Visual attention is the most studied type of attention in articles containing the keywords 'architecture' and 'attention' and related to architecture stimulating attention. Visual attention appears in 27 out of 32 articles [111,115-124,126-127,129-142]. The attention related to architectural space was found in 5 articles. The Attention Restoration Theory was published in 4 articles, ranking third in frequency. Other types of attention are paid to the selected articles in only 1-3 articles each. (Figure 5)

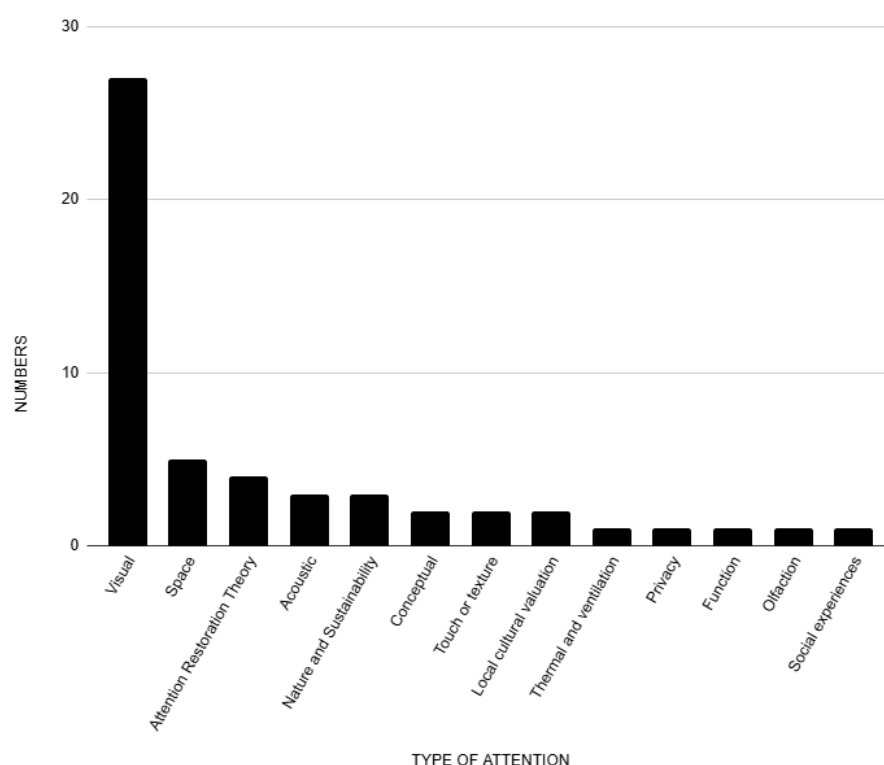


Figure 5. The types of attention studied in the selected articles.

3.2 The result of data analysis

The next step involves presenting the results from conducting content and thematic analysis of the selected 32 articles, following the method outlined in section 2.3. The results obtained comprise architectural characteristics with the potential to stimulate attention through all six human senses, including visual, tactile, auditory, olfactory, taste, and emotional. Under each sensory category, the explanation will be divided into direct architectural features, characteristics of the building's landscape, and objects related to the building to facilitate understanding.

3.2.1. Architectural design that stimulates attention through the visual sense

Visual sense has the most items analyzed to be architecture stimulating attention.

In the section on architecture stimulating attention through the visual sense, the exterior of the building, such as exciting and eye-catching form [135], size in large and high [116,123], façade [111,122,140–141], roof [125,138], relationship with the structures [127], location [129], and design on entrance including the opening: door and window [140]. In the interior, the architecture stimulating attention is the space [137], layout of walls [121], axis space [122], and pathway priority [111]. In addition, luminosity stimulates attention through visuals on arranged interior and exterior areas, especially on façade or media facades, to create dynamic.

The section on landscape stimulating attention through the visual sense has characteristics of natural features: trees [111,129], plants [115,125], indoor environment biophilic design elements [115], and green views: green spaces [114,125,128], landscape belts [122], and natural environments [113,115,125], both outdoor and indoor. It also includes a keyhole-shaped aperture that is created from natural features and surroundings.

In the section of objects stimulating attention through the visual sense, objects vary in characteristics of forms [129,135,141], shapes [120,126,135], curves [134], colors [116,121,124,130], contrast of elements [111,130], lighting levels [121], reflection elements

[134], visual qualities [130], textures, and materials of elements in the area, including
entourage elements or recycled materials such as furniture [121,136], potted plants [115],
works of art in a museum [130], water [137], and others. (Table 3)

Table 3. Architectural design that stimulates attention through the visual sense

345		Main pathway, The strong contrast between dark and the bright, The order of element, Escorial monumental complex in Spain, Secondary pathway, Façade, The lit façade, The angle space in the distance, Large single building, Expressive silhouette, Layout of walls, The axis space design, The horizontal corridor in axis space, Façade of the main building, Vision, Building entrance, School gate stone, High-rise building, Relationship between architecture and structures, Particular location, Illuminated area, Luminosity, Wayfinding, Exciting and eye-catching form, Visual aspect of space, Physical aspect of space, Unfamiliar perspective presenting roofs, Opening area (windows or doors), Façade component, Exterior façade lighting, The dynamic character of contents for media façades
	Architecture	
	Landscape	Tree, Natural surrounding, Natural environment, Green views, Indoor nature, Biophilic design in indoor, Environments, Keyhole-shape aperture, Plant landscape belt, Plants, Green roofs, Landscape, Urban green spaces, Green spaces, Natural feature, Line of the landscape
	Object	Sphinxes, Potted plant, Flowers, Environment object, Close-range object, Variety of bright color, Lighting levels, Color, Furniture, Stone carving on the ground, Brick of various colors, Daylight, Well balance symmetrical shape, Geometric characteristic of forms, Geometric characteristic of images, Entourage elements, Salient proto-objects, Visual qualities of objects, Contrasting element, Works of art in a museum, Decorative textiles, External element, Curves, Light reflection, Forms, Shapes, Furniture is from natural wood, Stair railings are made of birch, Handles are of metal, Recyclable materials, Water, Reflecting window, Uniform lighting, Exterior lighting, The element locate on the way

3.2.2. Architectural design that stimulates attention through the tactile sense

No relevant characteristics have been found in the section on architecture stimulating attention through the sense of touching.

The section on landscape stimulating attention through touching categorizes indoor natural features [115], including trees [111,129], plants [125], biophilic design in indoor elements [115], natural environment [113,115,125], and landscape [125,134].

In the section on objects stimulating attention through the sense of touching, the use of natural materials in furnishings, such as furniture made from natural wood [136], stair railings made of birch [136], and handles made of metal [136], was categorized as including little elements like potted plants [115] and flowers [115]. (Table 4)

Table 4. Architectural design that stimulates attention through the tactile sense

357	Architecture	-
358	Landscape	Landscape, Tree, Indoor nature, Green walls, Biophilic design in indoor environments, Natural environment, Landscape, Plants
359	Object	Potted plants, Flowers, Furniture, Touch, Furniture is from natural wood, Stair railings are made of birch, Handles are of metal

3.2.3. Architectural design that stimulates attention through the auditory sense

No relevant characteristics have been found in the section on architecture stimulating attention through the sense of hearing.

In the section on landscape stimulating attention through the sense of hearing, only the natural surroundings or natural environments were considered [113,115,125].

The section on objects stimulating attention through the sense of hearing, the human audition [122], and the diversity of sound were considered [121]. (Table 5)

Table 5. Architectural design that stimulates attention through the auditory sense

368	Architecture	-
	Landscape	Natural surrounding, Natural environment
	Object	Diversity of sound, Audition

3.2.4. Architectural design that stimulates attention through the olfactory sense

No relevant characteristics have been found in the section on architecture stimulating attention through olfaction.

The section on landscape stimulating attention through olfaction involves various natural surroundings[113], environments[113], and features such as trees [111,129], flowers [115], and biophilic design in indoor environments[115,125].

In the section on objects stimulating attention through olfaction, only the term ‘olfactory’[122] is identified as related to stimulating attention, without any further details provided. (Table 6)

Table 6. Architectural design that stimulates attention through the olfactory sense

379	Architecture	-
380	Landscape	Landscape, Tree, Natural surroundings, Flowers, Biophilic design in indoor environments, Natural environment
381	Object	Olfaction

3.2.5. Architectural design that stimulates attention through the taste sense

All three sections did not find information relevant to architecture stimulating attention through taste.

3.2.6. Architectural design that stimulates attention through the emotional sense

Architecture that stimulates attention is secondarily related to the sense of emotion. In the section on architecture stimulating attention through emotion, there were categorized architecture by space (visual aspect of space, sphere or geometry of architectural space and urban public space), architectural components (entrance, door, and window), architectural lighting (illuminated area, lit and media façade[111], contrast of dark and bright in the area[111])

The section on landscape stimulating attention through emotion considered various green spaces [125,128], natural surroundings [113], environments[113,115,125], and features such as trees[111,129], green walls[115], green roofs[125], green views[114], and indoor environment biophilic design[115,125].

In the section on objects stimulating attention through emotion, the diversity of elements is genuinely remarkable. Psychological elements[137], such as the order of elements, colors[116,124], lighting levels[121], natural lighting[137], materials, natural features[132], and diversity of sound [121], were all considered to stimulate attention through emotion. This broad spectrum of objects includes sphinxes [111], works of art in museums [127], decorative textiles [130], furniture [121,136], daylight [125], water [137], and flowers [115]. (Table 7)

Table 7. Architectural design that stimulates attention through the emotional sense

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Architecture	The strong contrast between dark and the bright, The lit façade, Building entrance, High-rise buildings, The sphere of architectural space, Illuminated area, Visual aspect of space, Urban space of public spaces and squares, Opening areas (windows or doors), Exterior façade lighting, The dynamic character of contents for media façades	
Landscape	Tree, Natural surroundings, Natural environment, Green Views, Indoor nature, Green walls, Biophilic design in indoor environments, Green roofs, Landscape, Urban green spaces, Green spaces, Natural features	
Object	Sphinxes, Potted plants, Flowers, Variety of bright colors, Lighting levels, Color, Furniture, Diversity of sounds, Daylight, Plants, Contrasting element, Works of art in a museum, Decorative textiles, Furniture is from natural wood, Natural lighting and properties, Psychological of elements, Water Uniform lighting, Exterior lighting, The order of elements	

4. Conclusions & Discussion

The climate change crisis is negatively impacting the mental health of people world-wide [1-3]. Attention is a pivotal pathway to healing ourselves and the world, as it is a sensory that improves mental health and sustainable behavior [8-19]. In the past, attention enhancement was often attributed to training interventions [26-29]. However, recent research has demonstrated efforts to instantaneously stimulate attention [30-32]. Several research studies have revealed the potential of architecture to enhance human attention [33-35]. Despite recognizing such potential, studies related to architectural designs that stimulate attention remain relatively scarce [46]. At the outset, it is found that architecture may potentially stimulate attention through all six senses of humans [54-57], including visual, touch, auditory, olfaction, taste, and Emotion [58-65].

4.1 The conclusion of systematic review

In order to search for architectural design development guidelines, systematic review is the chosen method [46, 89]. Through a systematic literature review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [94-96], a search on Scopus in February 2024 using the keywords 'architecture' and 'attention' yielded 32 articles providing information on architectural designs that stimulate attention. The majority of these articles were predominantly published in 2023 [112-121], and were primarily disseminated by the journal 'Frontiers of Architectural Research' [114,122,125-126,130-131,133]. The most commonly found building types are educational buildings [113,115,125,139,142], architectural landscapes [116-117,122,128,132], and residential buildings [125,129,132,134,140]. The most prevalent type of attention found is visual attention, accounting for 27 out of the 32 articles [111,115-124,126-127,129-142]. However, the results of this systematic review were constrained by the selected database and the method of article selection, as detailed in sections 2.1 and 2.2. Although it represents the most appropriate selection and evaluation in our opinion, these choices must have limitations as well. Hence, future studies should expand the search results by using additional keywords, selecting alternative data sources, or employing different methods for article screening. .

4.2 The conclusion of data analysis

The results of this study stem from decoding all 32 selected articles, which were then subjected to thematic analysis based on the entirety of human sensory categories, encompassing visual, tactile, auditory, olfaction, taste, and emotion. In the following section, the author will summarize the findings, discuss the results, identify the limitations of the research, and suggest directions for future research.

Overall, the results of the thematic analysis indicate that architectural features perceptible through visual perception were the most commonly discovered. The aforementioned conclusion suggests that if one intends to design architecture to stimulate attention, emphasis should be placed on visual elements. This conclusion aligns with the findings of the review in section 1, which revealed that visual sensory perception is the most crucial sensory input in architecture. However, since this study is merely a compilation of data from previous research, future research endeavors should aim to test the hypotheses presented herein once again. The architectural features perceivable through emotional senses were found to be predominant as the second most prevalent. Despite emotion being less frequently discussed among sensory perceptions, it appears to hold considerable importance. The aforementioned results are relatively consistent with the findings of the literature review, which stated that people perceive the atmosphere more through emotions. However, future research should delve deeper into this topic. Ultimately, the architecture that enhances attention is scarcely associated with the senses of touch, auditory perception, and olfaction. Furthermore, no architectural features were identified as influencing attention perceived through the sense of taste. The author perceives these findings may not be conclusively accurate due to limitations in the research methodology. Therefore, future research should broaden the scope of data collection or conduct experiments in real-world environments.

If the aim of designing architecture is to promote attention through the visual sense, it should feature prominent external characteristics and consider the presence of openings. For interior architectural design, consideration must be given to space and layout. Designing the landscape to attract attention should focus on green spaces. Objects that capture attention through sight depend on various factors, including shape, color, texture, material type, etc. The characteristics of architecture that stimulate attention through tactile sensation often focus on natural elements, including indoor trees. Furthermore, tactile sensation involves interaction with materials and architectural components such as handrails. To stimulate attention through auditory perception, architecture should be designed to incorporate natural ambiance, including human sounds and various blended noises. The details of architecture that stimulate attention through the olfactory sense include natural scents both outdoors and indoors. No architecture was found to stimulate attention through gustatory sensation. The spatial components and lighting must be considered if architectural design aims to stimulate attention through emotional sensation. Furthermore, similar to other sensations, it involves incorporating natural elements both outdoors and indoors. Various types of objects in architecture can also evoke exciting emotions.

Natural components are significant factors for each sensory perception when considering architecture that stimulates attention through all six human senses. Additionally, space layout and objects within the building are found to be substantial factors in architecture for fostering attention. However, this finding is merely a compilation of data from previous research. Therefore, in future studies, the results of this study could be empirically tested through methods such as surveys, experiments conducted in real locations, or any quantitative measurements.

The objective of this paper is to explore architectural design that stimulates attention through the six human senses, as stated in section 1, utilizing a systematic review approach outlined in section 2. Therefore, it can be concluded that the results of this study merely involve the collection, decoding, and analysis of data from previous studies, without validating these various findings. Therefore, this study serves as a compilation of architectural features that promote attention, with the hope that future research endeavors will empirically test these findings to provide evidence for broader implications.

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