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Objective Exploration of the Effects of Architectural Components on Users' Spatial Evaluation: A Neuroimaging Approach

Navid Khaleghimoghaddam*

Abstract

A review of the studies that have been conducted in the field of architectural evaluation reveals that there is insufficient evidence on objective understanding of how architectural components psychologically affect users. This study draws on advances in neuroscience and aims to objectively examine the neurological process of spatial evaluation to create a pleasant environment for users. Research has used quantitative and experimental methods such as surveys and functional magnetic resonance imaging (fMRI). To observe the brain's neural responses and to understand how it works when users evaluate architectural spaces, 36 participants' brains were scanned with an MRI scanner. In addition, 250 volunteers were asked to participate in a survey experiment to determine the contribution of each sensational and perceptional component to the users' spatial evaluation. The results showed that the spatial experience of architecture is involved in the brain's regional, emotional, perceptual, beauty judgment, and evaluation system. Also, the results revealed that pleasant spaces contribute much better to architectural design than unpleasant spaces due to higher attention and memory effects. Furthermore, the results showed that the texture and geometry have a greater ability to produce a pleasant and unpleasant sensation and perception. The high number of patients referred to the radiology polyclinic during the week posed serious problems for the researcher in renting an fMRI scanner and performing the imaging. It is expected that incorporating neuroscience findings into an architectural experience in the form of data can create new perspectives and solutions for qualified architectural design that addresses users' psychological responses and considers their environmental behavior and satisfaction.

Keywords:
Objective spatial evaluation, architectural components, functional magnetic resonance imaging, users' brain

*Department of Interior Architecture, Faculty of Engineering and Architecture, Konya Food and Agriculture University, Konya, Turkey
Email: navid.khaleghi1363@gmail.com

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INTRODUCTION

Nowadays, with the increasing development of technology, the image of the city and architecture are constantly changing. In such a situation, it is more necessary than ever to pay attention to the importance of quality in architectural design and its impact on human perception and emotion. Therefore, to create a pleasant environment, the relationship between people's emotional-perceptual states and the constituent components of the built environment must be fundamentally determined. Many researchers over the past decades have studied the evaluation of architecture and its emotional-perceptual experience to understand and explain how an architectural experience affects people's psyche, preferences, behavior, and quality of life. A variety of methods and approaches have been used in this regard. For example, Pallasmaa (2012) introduced some attributes such as multisensory experience, material poetics, and fragility to create an experience based on human emotions and perceptions. Steven Holl *et al*. (2007) described stimulating perceptions and argued that architecture could be considered a series of partial experiences that correspond to the perceptual and emotional phenomena of the senses, such that dimensions such as color, light, proportion, geometry, material, etc., influence perception and emotion. Concerning the emotional-perceptual evaluation of the environment, Mehrabian and Russell have proposed the ''arousal-pleasure'' model, and Russell (2003) has mentioned the concept of affect and emotional evaluation as a ''core affect'' that provides a theoretical framework for studying the role of physical environmental qualities in people's emotions. Accordingly, in studies conducted by Bowera *et al.* (2019) and Bakker *et al.* (2014), they aimed to determine dialing the sensory inputs evoked by physical attributes with emotional and perceptual processes. In other studies, Abdollahi (2021), Iraji and Zolfagharzadeh (2020), Barati and Soleymannejad (2011), and Ryu and Jang (2008) provided an overview of various effective elements such as light, color, and largeness in architectural space that arouse users' emotions. In their studies, Maroofi *et al.* (2019) and Teh *et al.* (2018) considered proportion and volume components and Shemesh *et al.* (2017) considered geometry as physical stimuli; Elbaiuomy *et al.* (2019), Gogoi (2017), Eun Cho and Kim (2017), and Radberg and Steffner (2003), regarded material and texture; and Ma *et al.* (2018) considered sound as sensory stimuli that appeal to people's emotional-perceptual responses. From the evaluation of these studies, it can be deduced that the process of the emotional-perceptual experience of architecture includes integral steps such as sensation and perception. The step of sensation is physiologically processed by the five senses (vision, touch, auditory, olfaction, gustation), transmitting the collected environmental information to the brain. In the perception phase, the brain selects and organizes specific information to add meaning to them (Pakzad & Bozorg, 2012). Zaredar (2015) showed that the perception of the senses in architecture explains how they function and influence each

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other and the differences between them. She considers all the senses in the context of architecture because they consciously or spontaneously influence the perception of space and make it a place that remembers with five senses. The study of Reghukumar (2019) has shown that the five senses give meaning to architectural spaces and increase human spatial behavior and efficiency.

In general, whatever could be taken from reviewing the studies mentioned above and other endeavors (Bowera *et al.,* 2019; Bakker *et al.,* 2014; Barati & Soleymannejad, 2011; Ryu & Jang, 2008; Vogles, 2008; Bigne *et al.,* 2005; Ellsworth & Scherer, 2003; Galindo & Rodriguez, 2000), it can be inferred that studies conducted in the field of architectural perception or affective assessment have been subjectively evaluated. Indeed, the results of the cases reviewed show that affective qualities, through perceptions and sensations evoked by features of a space, constitute a subjective experience that leads to reactions or behavior. It is time to investigate how the perceptual process is objectively influenced by architectural components. For this purpose, it is necessary to examine the cortical behavior of the brain as an organ responsible for organizing the perceptual process. Based on recent achievements in neuroscience, some studies have shown that a perceptual appraisal of architecture activates brain regions associated with visual perception (Djebbara *et al.,* 2019; Zhang *et al.,* 2019: Choo *et al.,* 2017; Lowe *et al.,* 2017), rewarding system (Barker *et al.,* 2019; Vartanian *et al.,* 2015: Kirk *et al.,* 2009), and esthetic judgments (Coburn *et al.,* 2017; Vartanian et al., 2015). This means that neuroscientific approaches offer designers and architects the opportunity to objectively observe the physiological and cognitive processes of the brain and see how spatial features of an architectural environment influence the brain's perceptual mechanism (Paiva, 2018; Papale *et al.,* 2016; Wiesmann & Ishai, 2011; Eberhard, 2009). For instance, Djebbara *et al.* (2022) used a neuroscientific method to monitor environmental characteristics and sensorimotor responses in the brain and body. They demonstrated how the built environment fundamentally contributes to the neurodynamic and behavior of individuals. Gregorians *et al.* (2022) developed a novel dataset of videos of trajectories through built environments and used it to explore the connections between emotions and the psychological dimensions of architectural experience. They proposed that parameters central to spatial mapping and navigation (spatial complexity) are embedded in the affective and aesthetic processing of built environments. Bowera *et al.* (2019) have shown that brain and body activity can occur in response to design features without conscious perception. Thus, knowledge and measurability of these effects could lead to a new standard for evaluating built environments. Gepshtein and Snider (2019) believe that neuroscientific methods have evolved to a degree of sophistication that allows researchers to test hypotheses about perception and action in realistically complex environments. Therefore, we can methodologically apply neurological techniques such as fMRI, EEG, PET, or MEG to objectively investigate the neurophysiological impacts of architecture on the individual's emotion and perception.

The present study, based on the experimental approaches of neuroscience and cognitive psychology, aims to objectively investigate the effects of architectural components on the emotional-perceptual experience of users. To this end, two questions will be answered: 1) Is there a relationship between the emotional-perceptual experience of architecture and the regional response of the brain? 2) To what extent do the sensory and perceptual components of architecture contribute to such an experience? Then, to answer these questions, two experiments were conducted. Firstly, to objectify the effects of architecture on brain emotional-perceptual and sensorimotor functions, the most effective method of cognitive methods such as functional magnetic resonance imaging (fMRI) technique was applied when users experience architectural spaces. In this context, users were shown the images of four different architectural spaces (office, polyclinic, educational institution, and traditional space) as stimuli. Secondly, to measure the contribution of each sensory and perceptual component, a survey including questions about sensory and physical factors was distributed to the users. The questioning test was indeed an approach to support and strengthen the neuroimaging results regarding the recognition of brain areas involved in emotions since functional brain imaging does not provide data on the contribution of architectural components. Ultimately, the results of the neuroimaging and survey experiments were compared.

METHODOLOGY

EXPERIMENT 1

This experiment aims to identify the regional activations of the brain during an architectural experience. In this context, architectural features are expected to engage brain areas involved in emotion and perception.

Participants

36 volunteers (18 males, mean age = 25.3 ± 4.7 & 18 females, mean age = 31.7 ± 3.2) participated in the brain imaging process. All the participants had normal color vision and were informed about the experimental procedure in detail.

Materials

In this experiment, participants were shown pictures of four different architectural buildings to image and observe the brain's emotional-perceptual response to architectural environments. In a previous test, 280 colored images representing the outdoor and indoor spaces of four office, polyclinic, educational institution, and traditional buildings were rated as pleasant and unpleasant spaces by 280 participants based on the emotional rating model of pleasure-arousal proposed by Mehrabian

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and Russell (1974). Accordingly, 40 most rated pictures were divided into two groups of 20 pleasant/positive spaces (10 pcs of traditional buildings & 10 pcs of office buildings) and 20 unpleasant/negative spaces (10 pcs of polyclinic & 10 pcs of educational buildings) and were shown to the participants in the MRI scanner separately. As an experimental paradigm, pictures of each file were adapted into three blocks: rest time slides, pleasant or unpleasant slides, and neutral slides. Firstly, the anatomical imaging (TR: 2400ms, TE: 3.54ms, FOV: 240mm) was acquired for 4 min & 42 sec. Then, for 4 min and 14 sec, the functional imaging of the brain (TR: 4000ms, TE: 50ms, FOV: 220 mm) started (Fig. 1).

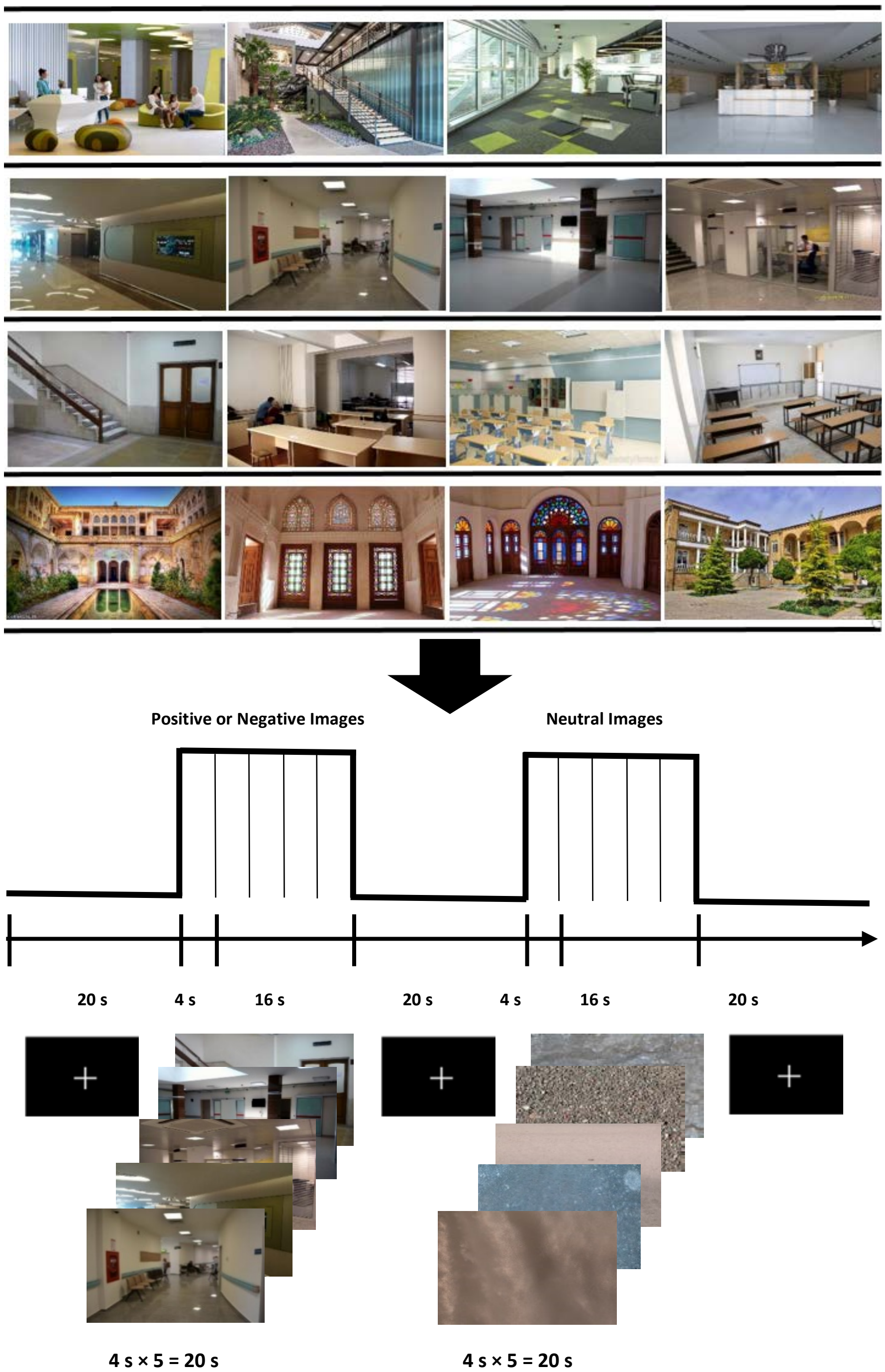

Figure 1. An example of experimental procedure involving different architectural stimuli used at the study (Provided by the Author, 2022).

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fMRI analysis

Imaging data were preprocessed using SPM12 implemented in MATLAB 2018 with the Data Processing and Analysis of Brain Imaging extension software. A combination of voxel-level and cluster-size correction was used to control false positives. A t-statistical test was applied to evaluate the mean difference in signal intensity. A significance level of P values < 0.05 was considered for statistical correlation. The extent of activation in each area was calculated as the number of active voxels (determined by the t test).

EXPERIMENT 2

Since determining the regional activation of the brain does not provide a way to measure the contribution of each architectural components to the spatial evaluation, Experiment 2 aims to measure the contribution of each sensory and perceptual components to the users' architectural experience by means of a survey.

Participants

250 participants (125 men and 125 women) voluntarily completed the surveys. Ages ranged from 22 to 42 years old. Participants were informed about how to complete the survey. The questionnaires were answered in groups of 4 or 5. The time spent completing each survey ranged from 25 to 30 minutes.

Materials

Regarding assessing the impact of spatial components on architectural experience, the previous studies (Stokolos & Altman, 1987; Cohen & Areni, 1991; Cacioppo *et al.,* 2001; Radberg & Steffner, 2003; Eun Cho & Kim, 2017) have introduced color, light, texture (touch), sound, and odor as sensory measurements. In addition, they have introduced largeness, height, width, depth, geometry, order, proportion, and rhythm as perceptual measures (physical factors). Accordingly, the survey questions in this experiment were divided into a sensation part and a perception part. The questions in the sensation part included pleasant and unpleasant images of spaces, which were rated based on sensory components such as color, light, texture (touch), sound, and odor. The questions in the perceptual part included pleasant and unpleasant images of spaces evaluated by physical components such as size, height, width, depth, geometry, order, proportion, and rhythm. All images used in this experiment were the same as those used for brain imaging in Experiment 1 (Fig. 1; 15 images representing pleasant spaces and 15 images representing unpleasant spaces. While viewing the images, participants answered questions (Pleasant space: Rate the following criteria that lead to the following spaces being perceived as pleasant by giving the highest score; Unpleasant spaces: Rate the following criteria that lead to the following spaces being perceived as unpleasant by giving the highest score) on a five-point scale from '1, meagerly' to '5, extremely'.

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Data analysis

Data analysis was performed with SPSS 20 using the t test for independent samples. The variables used for the t-test were p-value and sig. (2-tailed). The 'confidence level' of the test is reported as 95% and the magnitude of the p-value.

RESULTS

Figures 2 and 3 show the more activated brain areas when participants saw pleasant and unpleasant spaces. The corresponding brain imaging figures represent the midsagittal slice, coronal slice, and horizontal slice. As a result of the fMRI analysis regarding pleasant spaces (office buildings and traditional buildings), a total of 31312 active voxels were detected in 38 clusters. Accordingly, the most significant regional activations were identified in cluster 14 (T=6.37, p= 0.000 < 0.05, x=28, y=62, z=-11, K=27908). In this context, areas such as the occipital lobe, temporal lobe, parietal lobe, cuneus, precuneus, frontal lobe, fusiform, middle occipital lobe, parahippocampal, middle temporal lobe, superior temporal lobe, middle frontal lobe, and superior frontal lobe were activated (see Figure 2 and Table 1).

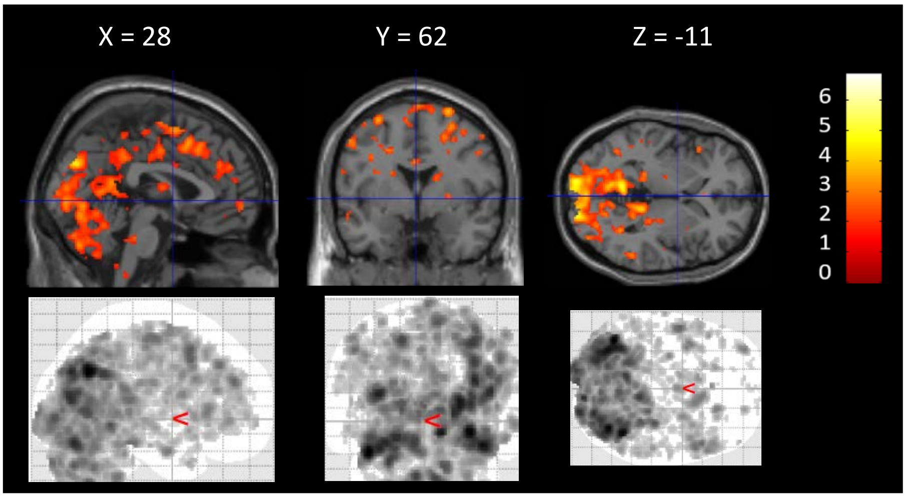

Figure 2. The main areas activated in experiencing pleasant architectural spaces (Provided by the Author, 2022).

Table 1: Activated brain areas when experiencing pleasant spaces. The activations are *p-FWE*-uncorrected at the voxel and cluster level (p<0.05).

Cluster	Total Voxels Number	Brain Area	KE	Peak MNI Coordinate X Y Z	t	p
14	*27908*	Occipital Lobe	7122	28 62 -11	6.37	0.000
		Temporal Lobe	3411			
		Parietal Lobe	3029			
		Cuneus	2147			
		Precuneus	2002			
		Frontal Lobe	1639			
		Fusiform	1010			
		Middle Occipital	856			
		Parahippocampal	811			
		Middle Temporal	699			
		Superior Temporal	648			
		Middle Frontal	182			
		Superior Frontal	130			

As for the results of the survey, a descriptive statistical analysis, the arithmetic mean, and the standard deviation of the distribution of the users' measurement data about pleasant spaces were studied. Accordingly, the individual measurement data were determined as follows: Light 22.63/3.21±4.11, Texture 25.33/4.24±4.26, Color 23.13/3.41±4.16, Sound 14.13/3.01±5.89 and Odor 11.81/2.16±3.66. It was found that the measurement of texture (touch) has the highest score and is considered the most effective sensory factor to perceive the spaces in question as pleasant. The measurement of odor has the lowest score in this regard. Likewise, the scores for color and light are also close to each other.

Table 2: Users sensation measurement data related to pleasant spaces

Sub-Component	Mean ($\bar{X}$)		SD
Light	22.63	3.21	4.11
Texture (Touch)	25.33	4.24	4.26
Color	23.13	3.41	4.16
Sound	14.13	3.01	5.89
Odor	11.81	2.16	3.66

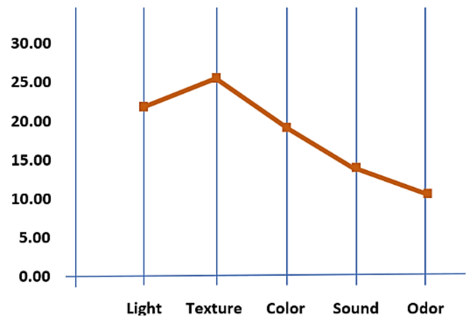

Diagram 1: Sensation measurement data of participants in relation to pleasant spaces (Provided by the Author, 2022).

Analysis of user perception data related to pleasant spaces revealed that geometry (25.41/3.23±4.64) was the most effective physical factor for the pleasantness of the spaces in question.

Table 3. Users perception measurement data related to pleasant spaces

Sub-Component	Mean ($\bar{X}$)		SD
Proportion	22.17	3.71	4.22
Order	23.36	3.26	5.16
Rhythm	20.26	3.15	5.61
Geometry	25.11	3.23	4.64
Width	21.41	3.33	4.29
Height	20.83	3.14	4.33
Depth	19.28	3.01	4.10
Largeness	21.81	3.66	4.28

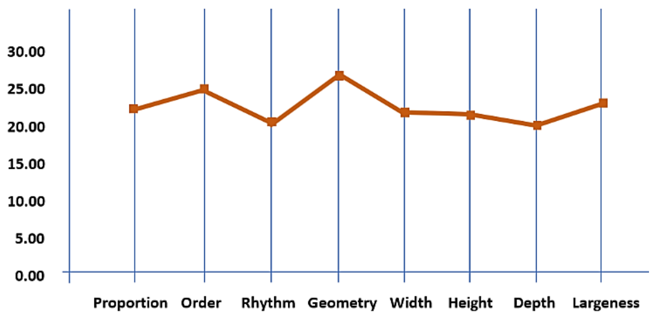

Diagram 2: Measurement data on users' perception of pleasant spaces (Provided by the Author, 2022).

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For the experience of unpleasant architectural spaces, a total of 22643 active voxels were detected in 50 different clusters. In this context, in cluster 8 (T=5.15, p= 0.000 < 0.05, x=44, y=-52, z=-31, K=14178) the activation of brain areas such as the occipital lobe, temporal lobe, parietal lobe, cuneus, fusiform, left fusiform, parahippocampal, middle occipital lobe, precuneus, middle temporal lobe, frontal lobe, cingulate, and left precuneus was detected (Figure 3 and Table 4).

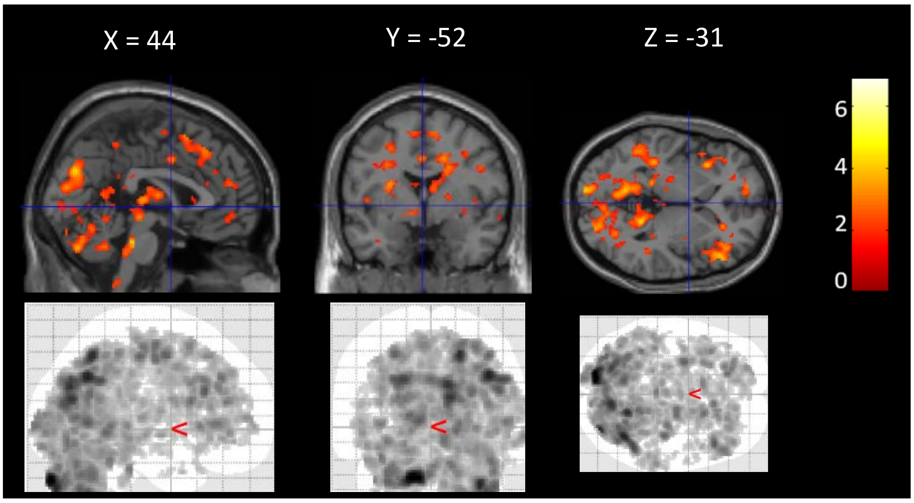

Figure 3. The main areas activated in experiencing unpleasant architectural spaces (Provided by the Author, 2022).

Table 4: Activated brain areas for participants when experiencing unpleasant spaces. The activations are *p-FWE*-uncorrected at the voxel level and cluster level (p<0.05).

Cluster	Total Voxels Number	Brain Area	KE	Peak MNI Coordinate X Y Z	t	p
8	***14178***	Occipital Lobe	3232	44 -52 -31	5.15	0.000
		Temporal Lobe	1614			
		Parietal Lobe	1147			
		Cuneus	1004			
		Fusiform	869			
		Left Fusiform	733			
		Parahippocampal	511			
		Middle Occipital	455			
		Precuneus	412			
		Middle Temporal	369			
		Frontal Lobe	337			
		Cingulate	121			
		Left Precuneus	78			

Descriptive statistical analysis of sensations measured by users in relation to unpleasant spaces showed that texture (touch) measurement (34.58/4.64±4.16) was the most effective sensory factor in eliciting unpleasant feelings.

Table 5: Data measuring participants' perceptions of uncomfortable spaces

Sub-Component	Mean ($\bar{X}$)	SD
Light	24.13 3.11	3.91
Texture (Touch)	34.58 4.64	4.16
Color	30.03 3.81	4.66
Sound	8.13 3.11	5.29
Odor	2.81 3.16	3.06

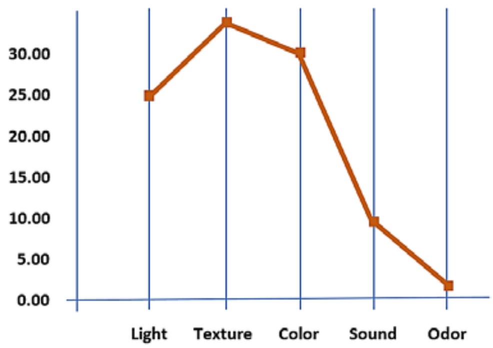

Diagram 3: Users sensation measurement data in related to unpleasant spaces (Provided by the Author, 2022).

Data on users' perceptual measures of unpleasant spaces showed that geometry (34.04/3.13±4.11) and proportion (32.17/3.21±4.61) were the most important physical factors that made the spaces in question unpleasant.

Table 6: Users perception measurement data related to unpleasant spaces

Sub-Component	Mean ($\bar{X}$)		SD
Proportion	32.17	3.21	4.61
Order	21.36	3.22	4.36
Rhythm	24.21	3.65	5.01
Geometry	34.04	3.13	4.11
Width	27.01	3.73	4.19
Height	28.85	4.14	5.03
Depth	29.12	3.21	4.00
Rhythm	22.26	4.15	3.41
Largeness	28.81	3.56	4.18

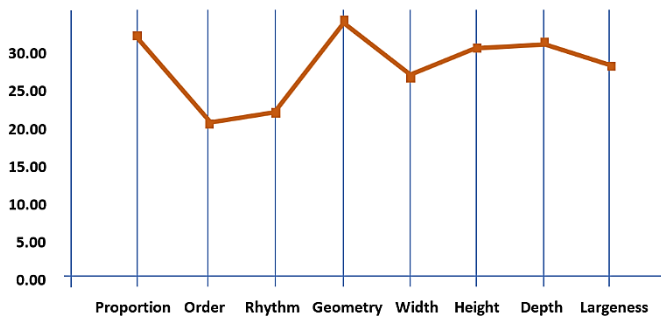

Diagram 4: Users perception measurement data in related to unpleasant spaces (Provided by the Author, 2022).

DISCUSSION

This study was conducted to observe the effects of architectural components on the perceptual processing of users' brains when encountering architectural spaces. Regarding the first research question of the study, the results showed the relationship between the emotional-perceptual experience of architecture and the regional response of the brain. In this regard, for both pleasant and unpleasant spaces, the results showed significant activation in the occipital lobe, temporal lobe, middle temporal lobe, and parietal lobe, which are involved in visual perception (form, color, and recognition of objects) and spatial perception (height, depth, geometry). In this case, Zhang *et al.* (2019) have demonstrated that experiencing architectural parameters is associated with activation of the occipital lobe (responding to perceptual information about architecture).

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Furthermore, it has been shown that brain activations associated with the perception of height, depth, geometry, and shape have been shown to be associated with the occipital, parietal, and temporal lobes (Arellano, 2015; Mallgrave, 2011; Costa *et al.,* 2010). Results also showed greater activation of the precuneus, middle occipital, and frontal lobes, which are involved in esthetic evaluation, reward, and beauty judgments (Zhang *et al.,* 2019; Vartanian *et al.,* 2013). Parahippocampal activity may support the findings of the Vartanian *et al.* (2015) study that the parahippocampus responds selectively to spaces and is involved in scene perception, perceived seclusion, and beauty judgments of spaces. In addition, greater activation was detected in the cuneus and fusiform area. According to previous studies, activation of the fusiform area is consistent with its role in neural representation of architectural styles and object recognition (Choo *et al.,* 2017), and activation of the cuneus is related to appreciation of representational materials (Mizokami *et al.,* 2014). Based on the fMRI results of this study, pleasant spaces were also found to increase activation in the middle and superior frontal areas. Consistent with recent studies (Zhang *et al.,* 2019; Vartanian *et al.,* 2013), activation of these areas is related to the brain mechanism for pleasantness, esthetic judgment, and approach behavior. Therefore, this may support the role of pleasant spaces in arousing approach decisions. Moreover, regarding unpleasant spaces, activation was detected in the cingulate area. In this regard, previous studies have claimed that the activation of the cingulate cortex is associated with avoidance behavior (Zhang *et l.,* 2019; Vartanian *et al.,* 2015; Vartanian *et al.,* 2013; Barrett & Wager, 2006). It means that unpleasant spaces may elicit the avoidance decision.

It means that unpleasant spaces may evoke the avoidance decision. As shown, significant brain activations were detected in relation to the emotional-perceptual evaluation of architectural spaces. Pleasant spaces were exclusively associated with strong activations, and the highest value of voxels was found (31312) compared to unpleasant spaces (22643). Such a difference provides evidence that pleasant spaces elicit emotions to a greater extent than unpleasant spaces when spatial and architectural qualities are used, so that brain areas concerned with emotions and perception respond more effectively and strongly to pleasant spaces than to unpleasant ones. These results show that areas associated with pleasantness and reward processing are involved in preferences involving good (pleasant) or bad (unpleasant) designs. In other words, due to greatly increased activity in visual areas of the occipital lobe (v=7122), in areas of visuospatial perception (form, color, and recognition of objects) of the temporal lobe (v=3411), in areas of spatial orientation, touch, and perception (motion, depth, height, width, geometry) of the parietal lobe (v=3029), appreciation of materials areas of the cuneus (v=2147), esthetic evaluation areas of the precuneus (v=2002), beauty judgment areas of the frontal lobe (v=1639), representation of architectural styles areas of the fusiform (1010), esthetic and beauty judgments areas of the middle occipital (v=856), architectural experience of large spaces and landscapes areas of the parahippocampal (v=811), and perception of movement in architectural space areas of the middle temporal lobe (v=699) related to pleasant spaces rather than the same areas for unpleasant spaces [occipital lobe (v=3232), temporal lobe (v=1614), parietal lobe (v=1147), cuneus (v=1004), precuneus (412), frontal lobe (v=337), fusiform (v=869), middle occipital lobe (v=455), parahippocampal (v=511), middle temporal lobe (v=369)], it is hypothesized that positive spaces in terms of providing architectural qualities may attract more attention to design. Regarding the second question of the study, it was concluded that the sub-component of “texture” had the highest score; and the “odor” had the lowest score from the users’ point of view. The results have been quite similar in two rerspects, both for pleasant spaces (texture; M=4.24; odor; M=2.16) and for unpleasant spaces (texture; M=4.64; odor; M=3.16). Therefore, the texture sub-component was the most effective item in creating a pleasant or unpleasant feeling for a space, and the odor sub-component was the least effective item. A more refined examination of the numerical results of the sensation component in the users’ emotional-perceptual experience in both pleasant and unpleasant conditions shows that the ‘odor’ and ‘sound’ subcomponents differ significantly from the other items. It can be suggested that the four subcomponents of ‘texture’, ‘material’, ‘light’ and ‘color’ are recognized as the most important subcomponents of the emotional perceptual experience of spaces and are different from the subcomponents of ‘odor’ and ‘sound’.

Given the direct relationship of the four main subcomponents of the sensation component of the emotional-perceptual experience of space (texture, materials, light, and color) to the senses of ‘vision’ and ‘touch,’ the primary role of these senses in producing a pleasant or unpleasant feeling of space is emphasized. In this respect, the results obtained are consistent with an important part of postmodern theorists and architects such as Johannes Pallasma, Peter Zumthor and Steven Hall, who emphasize the visually oriented and multisensory architectural experience. These views emphasize that the architectural work is not experienced as a series of isolated visual images, but rather offers a specific experience of the surrounding world within the framework of a body-oriented approach that takes into account the senses of the body - the physical and the tactile. Thus, along with the tactual components such as touch and material, visual components such as light and color also ensure that a space is perceived as pleasant or unpleasant. Based on the data analysis of the perception component in the survey experiment, the results showed a trivial difference between the subcomponents (the highest score of M=3.23 for geometry and the lowest score of M=3.01 for depth) for pleasant spaces and the highest score of M=3.13 (for geometry) and the lowest score of M=3.22 (for order) for unpleasant spaces. The expressions of the other components in the pleasant and

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unpleasant conditions were different. This shows that in contrast to the 'sensation components', which were similarly expressed under both pleasant and unpleasant conditions, the 'perception components' were different. This suggests that the perceptual subcomponents vary greatly depending on the characteristics of the user. Numerical analysis of the perceptual data showed that the 'largeness' and 'depth' subcomponents had the least influence on the pleasant feeling. In other words, the sense of pleasantness of a space may not depend significantly on its depth or size. Other data also suggest that the unpleasant feeling of a space does not depend significantly on its size or height. The importance of the three subcomponents of geometry, order, and proportion to the pleasurable perception of space underscores the impact of ''formal properties,'' ''mathematical relationships of physical elements,'' and ''visual clutter rate'' on the architectural experience of users.

CONCLUSION

The emotional-perceptual experience of space is one of the most important factors in evaluating the relationship between the individual and the environment in creating qualified environments. In this study, as a result of neurological and quantitative experiments on the evaluation of the emotional-perceptual experience of architecture through the involvement of brain regions, the hypothesis was supported that the perceptual and emotional evaluation of an architectural space depends on the specific neural areas that are active when people see or experience pleasant (positive) or unpleasant (negative) scenes. Moreover, the corresponding results support the cognitive basis of the experience of amenity on the neuroscience underlying users' perception and appreciation of architecture. In this context, the neural responses indicated that the emotional-perceptual experience of a space is specifically associated with the activation of brain areas responsible for emotion and perception, architectural experience, approach/avoidance decisions, and beauty judgments. As a contribution to future studies, it is worth mentioning that the results of this study objectively show why users prefer spaces and which components of an architectural environment increase user satisfaction. The methodological approach of the current study could potentially improve the reliability and validity of determining specific brain areas involved in positive and negative emotions when experiencing an architectural space. Also, it is anticipated that future neuroimaging studies will add to the current findings, but the patterns identified in this study are important components of the emotional-perceptual experience of architecture.

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Resume

Navid Khaleghimoghaddam works on key topics in architecture and neuroscience with psychological and physiological approaches, such as the study of the brain's perceptual mechanism and emotional behavior, neuroarchitecture, cognitive and environmental psychology.

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