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The Effect of Neuroscience on the Designing of Residential Buildings; Case Study: Residential Buildings in Sari*

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ABSTRACT

Neurology, as one of the novel sciences, paves the way toward understanding the performance of the human mind and also the surrounding environment. As one of the most complicated body organs, the human brain processes all the information received from external stimuli through five senses and intuitive, emotional, and rational perceptions. Neuroscience can connect the brain and architectural space to achieve the desired outcome and targets for designers and architects. On the other hand, the city views play a key role in users' feelings. Therefore, this research aimed to investigate the effect of neuroscience on architecture and the effect of facade elements on brain stimuli to design the desired view. In this research, seven buildings (three traditional and four contemporary) were investigated by a survey research method. To do this, three hundred eighty-five questionnaires were randomly distributed between passengers in seven districts. The results obtained from these questionnaires showed a significant relationship between neuroscience and architecture and how the facade elements affect the sensory stimuli. In addition, the traditional buildings in Sari and a contemporary building named “residential building era 94” had the physical and contextual elements (such as color, form, texture and materials, rhythm, fitness, etc.) in their facades, which seemed attractive for the passengers. The physical stimuli in these buildings, such as diversity, materials, forms, color, and texture, play a role in better connecting passengers with the facade of these buildings.

Keywords: Architecture, Building Façade, Neuroscience, Residential Building, Sensory Stimuli.

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1. INTRODUCTION

Neuroscience is one of the novel sciences suggested in architecture during recent years since it can facilitate the connection between the brain, architectural space, and place to achieve the desired design goals. There is a reciprocal relationship between people and their perception (Parichehr & Ebrahimzadeh, 2017, p. 1). Understanding the human reaction to architectural space and the effect of space on their emotions is functional in obtaining a common language among architectures, scientists, and the users of social media as well as in improving the quality level in order to increase the productivity of the architectural space which lead to positive emotions in the visitors. The arrangements and rules of architecture and neuroscience seem the same, but architecture traditionally relies on their observations and evidence, while neuroscience is based on practical methods and verifications. Currently, neuroscience can explain how we understand the world around us and the processes by which the physical media around us affect our understanding and our ability to dissolve behavioral issues (Sternberg, 2006).

On the one hand, the researchers found that artificial elements play a significant role in the performance of the brain and neural systems. In some cases, this effect is desirable, while under the other conditions, the shape and the structure of buildings might lead to a certain level of negative responses (Ahadian, 2013, p. 1). Applying this novel area of science in studying and designing architectural spaces can help determine the effect of different building components as visual-architectural stimuli to evaluate their effects on the user's perceptual neural network. In addition, this helps move toward designing the human-derived building architecture according to their needs, which results in their satisfaction. Customers' satisfaction as a novel method in building architecture is in accordance with human neural characteristics. Thus this research focuses on using neuroscience to obtain a suitable pattern for facade designing in the north of Iran.

2. THEORETICAL FRAMEWORK OF RESEARCH

In this section, the theoretical foundations related to the effect of neuroscience knowledge in the design of residential facades are discussed, so that first the knowledge of neuroscience and brain work and then the impact of environment and architecture on brain work will be reviewed.

2.1. Neurology, Neuroscience, and Brain Work

In order to make use of the reactions in the neural network in designing, first, it is necessary to know about the physiological features of the brain. Typically, grey matter accounts for 40% of the cerebrum by mass, while white matter composes the remaining 60%, each holding special duties. Neurons are responsible for processing thoughts, emotions, and memories; thus, they are related to data processing in the human brain. Our thoughts, emotions, and memories are constantly transferred to the brain as certain neural messages through different special ways and subsequently processed by neurons in our brains (Karipour & Shahroudi, 193, p. 2). In research by Linaraki and Woradaki, the relation between neuroscience and human behavior has been investigated, and it was declared that human senses (such as visual, audio, taste, olfactory, and touch senses) cause changes in feelings upon hormonal changes. Each of these hormones makes some special feelings that in this research, aggressive ones, such as anger, stress, depression, and fear, were investigated (Linaraki & Varadaki, 2012). One of the most complicated body organs, the human brain is responsible for processing all the information received from external stimuli through five senses and intuitive, emotional, and rational perceptions (Shahroudi, 2015). In addition, according to their observations in architectural spaces, the neuroscience academy found that space control for the main beneficiaries of space is of major importance. Since the public environment reflects popular culture, this cultural relationship must be somehow flexible not to impose the structure of that space (Salingrous, 2009, p. 156). Therefore, it can be concluded that our environment is full of information and stimuli, and human beings as part of the environment are the receivers of these stimuli. The elements of this architectural space are effective in different levels of emotional and conceptual behaviors of people over a long time. The quality of the physical environment has an outstanding effect on their mental health. So, architectures and designers need to know how the space elements affect humans in order to be able to build a good connection between users and their surroundings.

2.2. The Effect of Space and Architecture on Brain Performance

The senses help us to understand our surroundings. We see by our eyes, hear by our ears, and smell by our nose. Our tongue tastes, and through these senses, we receive most information from our environment (Atkinson, 1996). When people go into a new environment start to pay attention to their surroundings, get to know and give ideas. The designers aware of this fact use mental power to design to engage the senses of sight, hear, smell, and touch. Each of the five senses is a way toward healing and therapy; for example, eyes and ears are the ways for color therapy and music therapy. The sense of touch gave rise to massage therapy, and the ability to smell made aromatherapy possible. Tasting different flavors help us enjoy our daily diet (Gimbel, 1993). Therefore, our surroundings play a significant role both physically and mentally. This phenomenon in an architectural space has consequences for the person, and his

senses are typically referred to as people's reactions to their surroundings. As a result, the architectures are always focused on creating a desirable physical space that could help improve their spiritual and somatic conditions. According to Hansard, "We shape our buildings, and afterward, our buildings shape us" (Hansard, 1943). Roger Ulrich, who studied the effect of buildings and their surroundings on users' health, believes that "there is various scientific evidence on how unhealthy can be a poor design" (Roger Ulrich 1990). In this way, the purpose of architects and designers must be centered on the promotion of users' health through their physical environment, which is usually mentioned as "mental support" (Ruga, 1989).

2.2.1. Visual Sense

Visual, hearing, and smell are the only senses that can capture information in a far distance; thus, they are vital, especially in all humans (Atkinson, 1996). Out of all the five senses, vision seems the most important that influences human behavior in architectural space. Each sense responds to a certain physical energy that acts as the main stimulus. For example, light is the physical stimulus for vision. Light not only does not have any psychological effect but is also capable of promoting productivity by reducing the heart rate and systolic blood pressure (Gappell, 1999). Therefore, designers must take these effects into account in architectural designs. It is worth noting that good lighting helps better perceive colors, shapes, and materials texture (Elyacoubi, 1999). Colors play a crucial role in our lives that without them, we cannot perceive our surroundings and their components. The color itself is not important, but its reaction is highly important (Riley, 1995). It must be taken into account that no one would distinguish the different shapes, levels, and elements in each space without perceiving colors. Therefore, color is one of the important elements in designing that holds the functional, physiological, and psychological effects on humans.

2.2.2. Hearing Sense

Both vision and hearing are the two key senses to perceive the environment. Atkinson declares that "besides vision, the hearing is also one of the main ways to get the information from the environment" (Atkinson, 1996) and also there is a strong connection between these two senses, so that hearing is affected by light intensity, as by reducing the noises around, the visual acuity increases (Mazer, 1992). In addition, noise has been suggested as one of the most common stressors in environmental psychology surveys and is also one of the reasons that people might not prefer an environment. Studies have shown that annoying noises are closely connected with severe chronic diseases. Psychological surveys have indicated that a high noise level can lead to sensory apprehension and anger (Cohen et al., 1986; Glass & Singer, 1972). Thus it is possible to reduce noise through a good space architecture.

2.2.3. Touch

An architect must take into account the local climate in his design. Research has shown that the behavior in each space is affected by unusual levels of heat, cold, and wind. Skin is sensitive to all these stimuli, and the human body needs a special temperature to feel comfortable (Anderson, 2005). Studies suggested a close connection between temperature and the behavior of the users attended in a space. There is evidence of the presence of a close knit between heat and aggression (Bell, 1996).

2.3. Investigating the Brain Performance in Creating the Sense of Place and Place Attachment

Attachment to a place is greatly considered in psychology and environmental studies. Place attachment describes the emotion or feeling we have for a place that attracts people emotionally and culturally. The attachment to a place is centered on the emotional, affectional, and internal sense of a place on people as humans can be absorbed by a thing, house, buildings, neighborhood, or a natural environment. The attachment to a place is a symbolic connection to a place shaped by giving common affectional and sensual meanings to land and provides the basics of people's perception and connection to a place (Low & Altman, 1992, p. 5). The attachment to a place holds a three-dimensional framework, including Person-Process-Place (PPP). The person-place bond indicates the individual or collective meanings and concepts in the personal dimension.

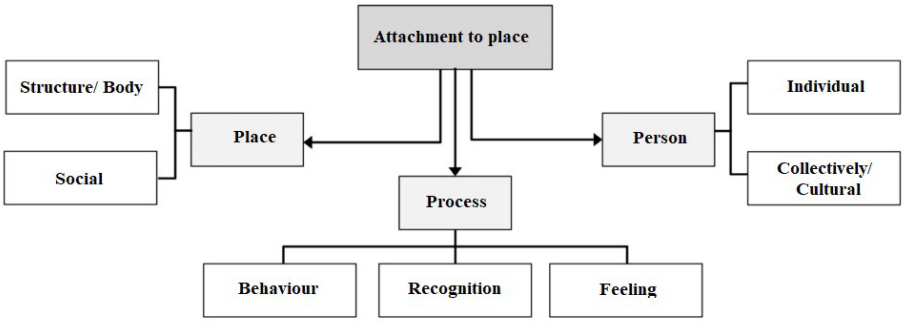

Fig. 1. The Elements of Attachment to a Place

The attachment to a place in the people's sector includes individual and group sections; the process is divided into three main parts: emotions, recognition, and behavior, and the place is the third element within this framework. It must be considered that understanding the environment occurs via these three elements. In more detail, while the human faces the environment, the information is primarily sent to the brain; following that, it is processed and stored, then restored if necessary. This process is very common when a person connects to the environment. Following attention, information is passed from the sensory memory into short-term memory.

Conceptualization, mental imagery, and cognitive mapping are the mental competencies toward information coding and storing. In this way, by using templates and rules, the mind can simplify and summarize the information to be classified and stored in different parts of the mind (Solso, 2003). The mental process of simplifying and organizing the information is called conceptualization, and the code used either as a word or a category for one or a group of phenomena is known as the concept (Pakzad & Bozorg, 2013, p. 185). The mental image is an image that is created from an event in a person's mind. This image is made in person's mind from one phenomenon and is then affected by his ideas, values, and experiences from a place and might include mental representation in the shape of sensual aspects such as hearing, smell, and taste (Esterenberg, 2014) since the required information about things are acquired through these senses from the brain. The mental data and analysis in different people can affect these senses. Therefore, the brain as a part that is responsible for the analysis and processing of the data is of high importance in providing the sense of place attachment. The data acquired after encoding is stored in long-term memory. Restoring is how information is recalled, associated, and decoded from memory upon needing (Pakzad & Bozorg, 2013, p. 175). In the association process, when two phenomena recur either coincidently or at time intervals, some linkages are formed in our neural pathways so that upon activating one of these phenomena, the other one is also activated (Solso, 2003, p. 527). Moreover, the cognitive map is part of a mental image specifically oriented upon relations between different spaces. They are internal representations that simulate the physical space of our surroundings (Rumelhart & Norman, 1988).

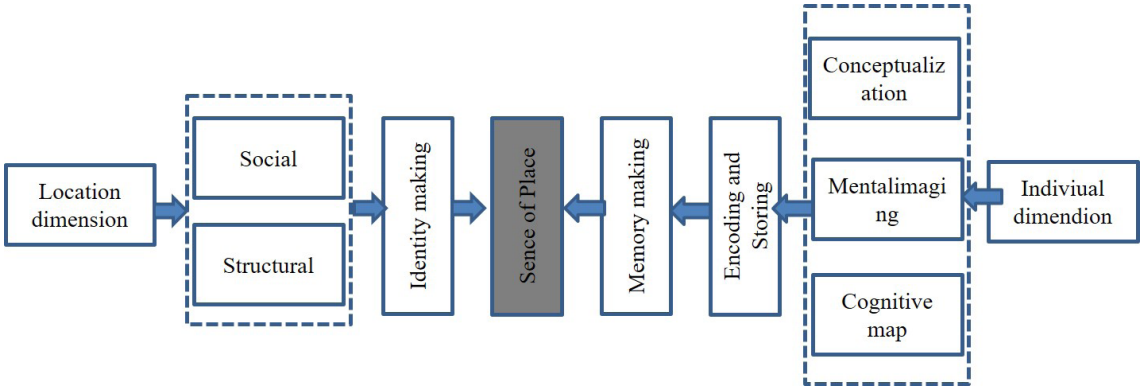

Fig. 2. The Individual and Place Dimensions Affecting the Environment and the Sense of Place

According to figure 2, it can be mentioned that the two personal and place dimensions are effective in providing the sense of place, which the latter connects the environments through mental elements such as conceptualization, mental imaging, and cognitive mapping. Subsequently, memory-making occurs via encoding and storing the information. As discussed, some other components in the individual dimension create the sense of place, but in this research, the three components, i.e., memory making, mental imaging, and cognitive mapping, are characterized as the three effective personal components.

2.4. The Shape of Building and Neuroscience

The study of brain and neural processes often helps find information regarding the act to external stimuli (Nanda, 2013). The components of buildings facades as part of cities organization are the elements of external stimuli that can positively and negatively affect users' performance and health conditions (Harting, 2004). Neuroscience helps clarify the effects of these transactions and architectural components on humans' neural systems. Taking the complex brain and neural processes into consideration assists in obtaining the desired structure in the users of an environment (Nanda, 2013). Recent studies have shown that the special buildings stimulate the visitors' feelings and limit the focus to the architectural space. The studies on cognitive sciences indicate that the main part of the brain in human beings when facing the facades is involved in characterizing and recognizing the place, while the other information is specially related to the visual system (Ostwald et al., 2012). Façade, as the first contact point, must be considered in observing the components which create a positive feeling in the visitor. The effect of external stimuli indicates that the com-

ponents such as color, light, odor, texture, temperature, sound, and music all affect the perception of our surroundings. The stimulus is perceived via human senses form the environment, and following analysis and processing in the brain, it is stored and leads to memory-making.

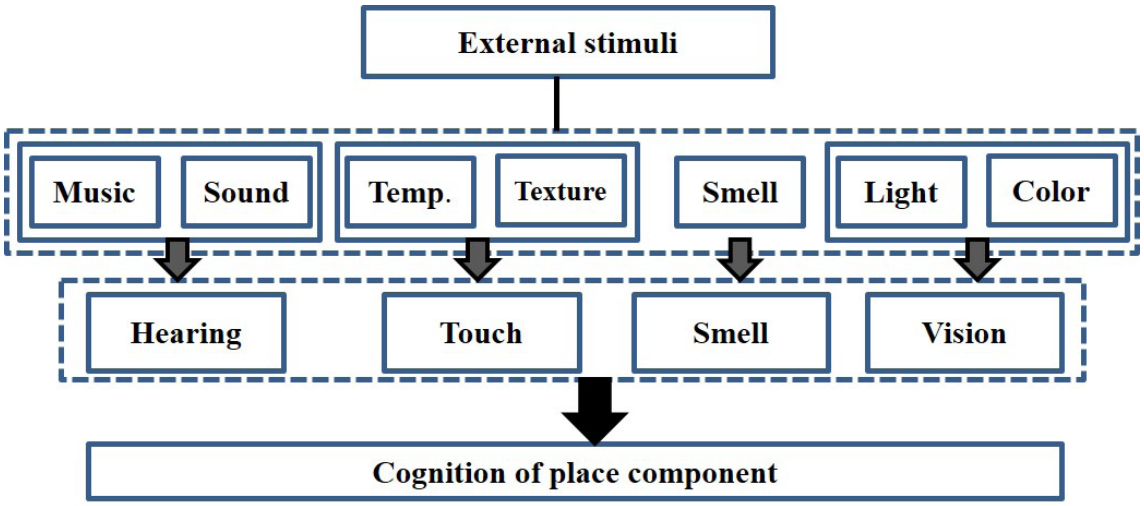

Fig. 3. The External Stimuli Effective on the Brain

3. THE CONCEPTUAL RESEARCH MODEL

In this research, a survey research method is used for data analysis as an effective element for designing the façade, focusing on creating a desirable feeling in visitors. In this analysis, the components applicable to the façade of the building are extracted and separately investigated. In order to better analyze and compare the facades in traditional and contemporary buildings in Sari, their characteristics were assessed in two separate parts. In the first part, the physical elements related to the structural components of façade, i.e., materials, texture, color, decoration, etc., which affect the brain through perception by neural cells of the brain, were studied. In the second part, the content elements include the unity of elements, the balance and cognitive map (the formation of time and place memory), place cells, routing, hierarchy, rhythm, etc. Due to affecting human perception, the latter effectively affect the contextual brain perception from its surroundings, and the final information processing arrives. In addition, the physical and contextual components of traditional houses will be investigated in the second part.

3.1. Physical Elements

Six physical elements are considered in this research to gather data on the analysis of elements that affect the sensory stimuli of the brain through the façade of residential buildings. Relating to materials, it can be mentioned that a good variety of natural materials is helpful in better legibility and comprehension of brain and thus a better connection with architectural space and surroundings. Due to natural materials, the color component in these buildings is closed to nature and hence is easily perceived by the neural structure and brain cells. It is worth noting that good decoration can provide comfort for users about decoration and details. The shape is one of the major components in the façade of buildings and plays a key role in the visitors' perception of their surroundings. In terms of texture, since the natural building materials with various textures are more identical to nature than artificial ones, by stimulating the senses of vision and touch, more designing details are transferred to the human mind through using these materials. Light is one of the key elements that suppress melatonin in the brain and promote alertness. Moreover, the type of light, color, and intensity are the key elements that significantly influence the readability of the environment and spatial perception by the human brain.

3.2. The Conceptual Elements

There are five different conceptual components assessed in this research including, the unity of elements, balance, rhythm, and cognitive plans. The unity of elements: recombining the elements as a unified whole helps create a purposeful combination that will eventually be conceptualized in visitors' minds. Mental conceptualization is the simplification and organization process of information in the mind. The balance is one of the key elements on top of visual and conceptual qualities, which indicates the inherent attention of humans to quality balance. Rhythm: in designing, the ordered rhythm is the coordination pattern from special parts, which is often a single independent component of the category, including shape, form, color, light, shadow, and sound that promotes balance and unity and creates positive mental stimuli. Balance: symmetry is an applicable concept in a wide range of science and technologies that allows the organization and arrangement of a complex in a simple way. Proportionality: golden proportionalities

or the proportionalities such as module or wayfinding in traditional Iranian architecture are easily perceivable by the human mind due to considering the human dimensions and proportionalities that facilitate the connection between visitors and the environment also helps in better comprehension of the total façade proportionalities. Cognitive mapping: A cognitivmap describes each person's understanding of a special area. The cognitive map is a phenomenon which, through it in each person, a special understanding is formed about a certain fact. In such a map, just one aspect of science or personal perceptions, not all the dimensions and aspects, is represented.

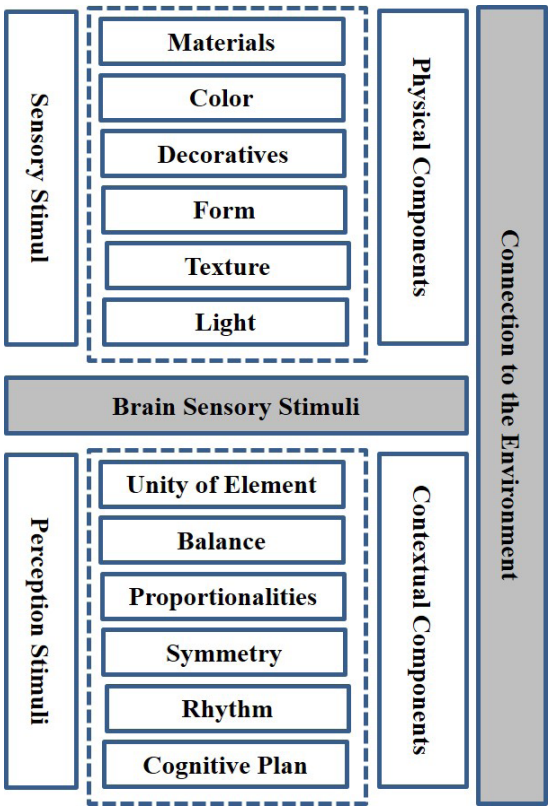

Fig. 4. Conceptual Model of the Research

4. THE SURVEY METHOD

In this research, a survey method was used to investigate the connection between the façade elements and the perceived mental stimuli that lead to a sense of interest in natural and artificial environments. The data gathering tool is in library and field research methods. The questioners have also been used for data collection in survey methods. In this research, seven houses, three historical from the Qajar dynasty and four contemporary houses, were randomly selected from different districts in Sari in order to investigate the effect of neuroscience on the façade of the buildings. In this part, the Cochran formula was used for calculating the size of the statistical society at the confidence level of 5%, which is typical of statistical analysis in social science.

$$n = \frac{\frac{z^2 pq^2}{d}}{1 + \frac{1}{N}\left[\frac{z^2 pq^2}{d} - 1\right]}$$

N= statistical society;
T= 95% confidence coefficient is 1.96;
d= possible accuracy;
The confidence level in this research is 10%. Thus the desirable possible calculated accuracy is 5%. Finally, 385 questioners were randomly distributed among passengers passing the seven districts during one month (55 questioners per district). Data collection in this research necessitates the physical attendance in those buildings, watching the structures and behaviors of people, and interviewing with the passengers and inhabitants. With the aid of the factor loading method, the constructing methods on dependent variables and their role in defining the hidden variable are determined. The analysis of questions, reliability calculations, and validity of tests is performed in SPSS software. The validity of the structure and main hypothesis will be assessed, focusing on the relation between façade and the positive feeling in users.

4.1. The Range of Studies

As discussed, to study the effect of façade design on sensory reception of brain cells and achieve the right pattern for the façade design in the north of Iran, three historical and four contemporary buildings in different districts of Sari were selected chosen for this study. The traditional buildings were included Kolbadi historical house from the times of Qajar dynasty located in Enghelab street, Ab Anbar district; Fazeli house from Qajar dynasty located in the vicinity of Saat square, Bargh crossroad district; Ramadani house in the new Ab Anbar district near the Fazali house which belongs to the times of Qajar dynasty but during the Pahlavi dynasty, some major changes were made into this house. In addition, four houses were considered in selecting the contemporary houses in Sari. In selecting the contemporary houses, the diversity in the structure, levels, and materials was considered to achieve the best results. Therefore, residential complexes such as Miarkola located in Ghaemshahr-Jouybar street were manufactured within the Mskan-e-Mehr projects; 600-building unit complex located in Khazar boulevard in Sari; Shaghayegh complex for military housing; and Asre 94 residential complex which was personally manufactured, were investigated in this research.

Table 1. The Characteristics of the Places Investigated.

Title	Photograph	Historical Period	Number of Floors	Title	Photograph	Historical Period	Number of Floors
Kolbadi House		Qajar	2	Maskan-e-Mehr Miarkola		Contemporary	8
Fazeli House		Qajar	2	600-Building Unit Complex		Contemporary	4
Ramadani House		Qajar-Pahlavi	2	Shaghayegh Residential Complex		Contemporary	6
Asre 94 Residential Complex		Contemporary	6				

5. DATA ANALYSIS

In this research, to investigate the effect of façade elements on the mental stimuli of passengers, which eventually creates positive or negative sense to the building façade, 385 questioners were randomly distributed among passengers in 7 districts, an average of 55 questioners per district, in Sari. In the 385 questioners, 17 were put aside due to the lack of response to many questions, and the rest of 368 questioners, including 58% male and 42% female, were assessed. In addition, most respondents have been inhabited for more than seven years in the districts mentioned above. Thus it can be concluded that they are familiar with the facades of buildings.

Table 2. The Statistical Distribution of Demography Variables

Variables	Group	Frequency	Percent
Gender	Male	210	58
	Female	157	42
Age	18-28	59	16
	29-39	120	32
	40-50	86	23
	51-62	103	29
Familiarity with the Place	Below 1 year	10	4.38
	1-3 years	24	10.52
	3-5 years	47	20.61
	5-7 years	44	19.29
	More than 7 years	103	45

5.1. Hypothesis Testing

The questioners included 25 questions. The first nine questions primarily centered on the relation between neuroscience and the building façades, questions number 10-17 are related to the connection between the effects of physical elements of façade and sensory stimuli in the brain, and questions number 18 to 25 focused on the relation between contextual components of building façade and the sensory stimuli in

the brain.

First Hypothesis:

neuroscience affects architectural design.

In the case of the first hypothesis, seven houses were assessed considering the first nine questions related to the first hypothesis on the connection between the received sensory stimuli and the building façade; the results are shown in Table 3.

Table 3. The Results of the First Hypothesis Testing

	Test Value = 0					
	t	df	Sig.	Mean Difference	95% Confidence Interval of the Difference	
					Lower	**Upper**
Fazeli House	140.076	54	0.000	4.2666667	4.205599	4.327735
Ramadani House	159.187	54	0.000	3.8141414	3.766104	3.862179
Kolbadi House	160.244	54	0.000	3.8161616	3.768416	3.863907
Maskan-e-Mehr Miarkola	110.995	54	0.000	3.4121212	3.350489	3.473754
600-Building Unit Complex	151.765	54	0.000	3.8565657	3.805619	3.907512
Shaghayegh Residential Complex	110.522	54	0.000	3.4383838	3.376011	3.500756
Asre 94 Residential Complex	119.398	54	0.000	3.4666667	3.408456	3.524877

Column t in this table indicates the effect of neuroscience on architectural design. This column determines the amount of effect in the hypothesis. The higher this effect, the more is the effect of neuroscience on architectural design and vice versa. Column sig. shows the significance level of the test, the most important value in every statistical analysis. A significance level higher than 0.05 means that the hypothesis is not acceptable. The significance level for the first hypothesis is 0.000 for all seven assessed houses, which is lower than 0.05. This confirms that the first hypothesis is accepted for all the houses in this survey. Therefore, neuroscience affects architectural design, and there is no difference between historical and contemporary hoses.

5.2. Physical Components

The second hypothesis: physical elements such as color, texture, materials, and the form in the building façade influence the perception of mental stimuli. This hypothesis has been evaluated relating to the effect of physical components of façade on sensory stimuli of passengers in the seven houses in Sari within the number of questions 10 to 17 in the questionnaire. The results are shown in Table 4.

Table 4. The Results of the Test on the Second Hypothesis

	Test Value = 0					
	t	df	Sig.	Mean Difference	95% Confidence Interval of the Difference	
					Lower	**Upper**
Fazeli House	135.345	54	0.000	3.9454545	3.887010	4.003899
Ramadani House	140.021	54	0.000	4.4954545	4.431087	4.559822
Kolbadi House	184.483	54	0.000	4.4977273	4.448848	4.546606
Maskan-e-Mehr Miarkola	31.323	54	0.084	1.5113636	1.414625	1.608102
600-Building Unit Complex	19.860	54	0.201	1.5659091	1.407830	1.723989
Shaghayegh Residential Complex	17.330	54	0.152	1.6727273	1.479207	1.866248
Asre 94 Residential Complex	144.453	54	0.000	4.4863636	4.424097	4.548630

According to table 4 and by considering the amount of t, it has been shown that this hypothesis is most and least verified in the houses of Kolbadi and Shaghayegh, respectively. The significance level in the three historical houses (Fazeli, Ramadani, & Kolbadi) and Asre 94 residential complex was 0.000 and is less than 0.05, which shows that the second hypothesis is verified for these four houses which possess the physical components and is of interest of visitors. In comparison, for the three other houses, i.e., Maskan-e-Mehr Miarkola, 600-building unit complex, and Shaghayegh residential complex, the significance level was higher than 0.05, indicating that the mentioned buildings lack the physical components attractive for passengers.

Furthermore, to assess the criteria mentioned above

in the seven houses in Sari, the physical components in the building's façade were evaluated. Six physical components have been considered, including light, texture, decoration, form, color, and material, compared between historical and contemporary houses in Sari.

Table 5. Evaluating the Physical Stimuli in Houses in Sari

	Physical Components				
Case Sample	**Materials**	**Color**	**Decoration**	**Details**	**Form Variety**
Kolbadi House	Brick, wood, lime-ash, rice straw, color glass, plaster	The color of the material: white, brown, yellow, red, green (colored glass)	Colored glass, wooden decorative	Making use of details in the designing of door and window	In various forms
Fazeli House	Brick, wood, lime-ash, rice straw, color glass	The color of the material: white, orange, brown, colored glass	Colored glass, wooden decorative	Making use of details in the designing of door and window	In various forms
Ramadani House	Brick, wood, lime-ash, rice straw, color glass	The color of the material: white, brown, and colored glass	Colored glass, wooden decoration	Making use of details in the designing of door and window	In various forms
Maskan-e-Mehr Miarkola	White cement	Monochromatic white	No decoration	No details	No various forms
600-Building Unit Complex	White cement	Monochromatic white	No decoration	No details	No various forms
Shaghayegh Residential Complex	Colored cement	A combination of red and white colors	No decoration	No details	No various forms
Asre 94 Residential Complex	Brick, glass, and impregnated wood	Brown, white, black, cream	Brick decoration and window decoration	Some details in openings and applying bricks	In various forms

The results show that in the historical houses, the investigated components are in more accordance with the considered patterns. It can be deduced that the patterns are more observed in historical houses than contemporary houses. It is indicative of the better relationship between the visitor and building façade since the investigated physical stimuli affect the human senses, especially vision. Among the six components relating to light, decorations, texture, color, and material, these components are more highlighted in historical houses than contemporary ones. While the characteristics specific to each space, such as light, are witnessed appropriately in historical houses.

Regarding the color combination and texture, the natural materials with cream to brown color were chosen to be closed to nature and create a sense of security and safety. On the other hand, in contemporary houses, the colors and materials are generally selected cost-effectively, especially in mass construction projects. In this way, in the residential buildings such as Asre 94, the components such as light, form, materials, color, and texture are in high accordance with the defined paradigms and visual stimuli since the color proportionalities, forms, and materials are close to nature. Thus the mental stimuli of visitors provide better responses facing the façade of these buildings.

5.3. Contextual Components

Third Hypothesis:

the contextual components such as proportionalities, symmetry and rhythm, the unity of elements in the building façade can affect the mental stimuli of the brain. This hypothesis has been investigated regarding the effect of contextual components on sensory stimuli in passengers in seven houses in Sari through questions number 18-25 in the questionnaire; the results are shown in Table 6.

Table 6. The Results of the Tests on the Third Hypothesis

	Test Value = 0					
	t	df	Sig.	Mean Difference	95% Confidence Interval of the Difference	
					Lower	**Upper**
Fazeli House	170.251	54	0.000	4.3022727	4.251609	4.352936
Ramadani House	132.987	54	0.000	4.4886364	4.420967	4.556306
Kolbadi House	187.489	54	0.000	4.2318182	4.186566	4.277070
Maskan-e-Mehr Miarkola	36.926	54	0.102	1.3340909	1.261657	1.406525
600-Building Unit Complex	19.874	54	0.198	1.5795455	1.420199	1.738892
Shaghayegh Residential Complex	19.740	54	0.200	1.8295455	1.643732	2.015359
Asre 94 Residential Complex	123.998	54	0.000	3.8590909	3.796695	3.921487

According to table 6 and by considering the amount of t, it is shown that the hypothesis is verified the most in Kolbadi house and the least in Shaghyegh residential complex. The significance level in the three houses (i.e., Fazeli, Ramadani, & Kolbadi) and the Asre 94 residential complex is 0.000, less than 0.05. Thus, the third hypothesis for these four buildings indicates that three historical houses in Sari and the Asre 94 residential complex contain the target physical components that absorb the passengers' attention in those districts. However, for the three other buildings, including Maskan-e-Mehr Miarkola, 600-building unit complex, and Shaghayegh residential complex, the confidence level was 0.05, indicating that these three residential buildings lack the contextual components of interest in passengers. This result shows that three out of four contemporary houses lack the required contextual components, while those components influence the passengers in historical houses. These options will be separately assessed in the following. The contextual components of façade are elements that play a role as perception stimuli and provide a general concept through meaning and by inducing familiar patterns (rhythm, golden proportionalities, and symmetry) that are desirable and perceivable in visitors' minds. In order to test the third hypothesis, six elements have been proposed, including unity, balance and equilibrium, proportionalities, symmetry, rhythm, and cognitive plan.

Table 7. The Assessment of Contextual Components in the Houses in Sari

Contextual Components \ Building		Kolbadi House	Fazeli House	Ramazani House	Maskan-e-Mehr Miarkola	600-Building Unit Complex	Shaghayegh Residential Complex	Asre 94 Residential Complex
Unifying Components	Harmony and Proportionality	■	■	■	-	-	■	■
	Emphasis on Symmetry	■	■	■	■	■	-	■
	Equilibrium and Balance	■	■	■	■	-	■	■
	Rhythm	Horizontal	Horizontal	Horizontal	Vertical	Vertical	Vertical	Horizental and Vertical
Cognitive Plan		■	■	■	-	-	-	■

According to the results, it can be mentioned that these elements due to making the form of the façade by the use of model and in Iran's historical architecture affect the visitors' perception of the façade. The façade components in historical buildings benefit from providing a balanced and proportionate fraction of the buildings since the Iranian greatly considers the human body proportions. In the case of symmetry, it is worth noting that symmetry is greatly observed in the historical architecture in Iran. As symmetry is an important symmetry agent in perceiving the environment, it facilitates the readability of the different parts of the building. It is worth noting that symmetry, besides over-simplicity, makes the environment boring, therefore in addition to symmetry, details, and other components in

architectural design, a façade can also be considered. In addition, using elements such as rhythm, balance, proportionality and equilibrium yields a meaningful whole in the building façade which eventually leads to the creation of unity of the façade. Unity is one of the components that create positive mental stimuli. In contemporary buildings, especially mass construction projects in Sari, the lack of contextual elements is highly perceived. This lack of contextual elements gives in façade that does not match the observers' mental patterns and gives rise to an undesirable boring façade. In Asre 94 project, the target patterns are greatly noticed in the concepts of balance, rhythm, proportionality, and symmetry. It is worth noting that the mentioned elements together can work as a solution for designing the façade of residential buildings in Sari. In the following parts, some designing suggestions are provided.

6. CONCLUSION AND REMARKS

Based on the results, there is a significant relation between neuroscience, the stimuli perceived from the environment, and the façade of the building. This relation indicates the importance of the effect of artificial environment on the feeling of attendance in a space. The building façade as an outstanding effective component in streets and neighborhoods can lead to a positive or negative feeling in facing those elements. As discussed in the previous sections, two fundamental components, known as physical and contextual components, are involved in the façade of a residential building. In this research, two components in the façade of residential historical and contemporary buildings have been investigated. The results showed that these components completely affect the mental stimuli in our brain. Components such as curved form or the brownish cream color in the façade of a building and using nature-derived texture and materials can positively affect the mental stimuli in visitors. The components other than the elements mentioned above have also been investigated. In this way, components such as rhythm, equilibrium and balance, unity, proportionality, and cognitive plan have also been assessed. Based on results, these components affect the mental stimuli in humans and also due to the mental background on elements such as rhythm, repetition, proportionality, symmetry, and golden proportions, the designed form might have a positive effect if the balance is observed in observers' mind. Based on the results, the two physical and contextual components in historical houses are more observed than residential complexes. In the past, by utilizing balanced and proportionate details, diverse colors, forms, and materials, and the aid of components such as symmetry, rhythm, and proportion, the façade of the building was providing a positive effect in memory making and yielding a positive mentality in observers. While contemporary buildings are usually performed within mass construction projects, they often hold simple forms without proportionate material and color. As previously mentioned, the high simplicity of passing information to the brain makes the façade boring and miserable. The components mentioned above were suggested as a portion of the elements influencing the designing of façade in the residential buildings in Sari. Considering and observing the designing process proportionate to the physical and mental conditions of observers is of high interest to authorities and officials who work in construction to make the façade of today's buildings more attractive to observers. In the end, the following items are recommended for designing the façade of buildings:

1. Considering the natural materials and making use of their capacity in designing the façade of buildings;
2. Making use of local materials;
3. Observing the color harmony in facades and refusing various colors;
4. Utilizing cream and the other colors close to natural colors;
5. Using the patterns close to nature helps in creating positive stimuli in the visitors' minds;
6. Applying the patterns close to nature which helps in providing positive mental stimuli in the observers' mind;
7. The curved forms activate the lateral occipital of the brain and lead to a better connection between building and observer;
8. Employing a sloping roof in the façade of the building is more taken into consideration from the side of observers and provides positive feedback;
9. Taking the advantages of natural textures such as wood helps in better perception of the façade materials by brain cells;
10. Exploiting the proportionalities, especially the proportionalities at human scale in façades, results in positive mental stimuli in the brain that positively affect the observers' perception.
11. Utilizing the rhythm and repetition in building's façade and creating an ordered pattern (by considering the equilibrium and balance).

REFERENCES

- Ahadian, M., & Ahadian, P. (2013). Architecture Neuro architecture: Linking Architecture and Neuroscience, 2nd Basic and Clinical Neuroscience Congress.
- Anderson, B. (2005). RTO Design for the Senses. An Article Published in the Internet.
- Anderson, R. A.P., Rex, A., Atkinson, P., & Coffey, A. (2018). Making Sense of Qualitative Data. Thousand Oaks, CA:Sage
- Bell, P. A., Greene, T. C., Fisher, J. D., & Baum, A. (1996). Environmental Psychology. Fourth Edition, *Holt, Rinehart, and Winston*, Inc., USA.
- Cohen, R., Kessler, C., & Gordon, L. (1986). Measuring Stress. New York: *Oxford University Press*. 175-192.
- Elyacoubi, E. (1999). Psychology and Architecture, What Relationship? A Psychological Approach to the Traditional Moroccan House. A Paper Published in the Internet, ElyasSoft Virtual Site.
- Gappell, M. (1991). Psychoneuro-Immunology. A Paper Presented in the Fourth Symposium on Healthcare Design, Boston, MA.
- Gimbel, T. (1993). The Colour Therapy Workbook. A Guide to the Use of colour for Health and Healing. *Element Books Ltd*, Great Britain.
- Glass, D. C., & Singer, J. E. (1972). Urban Stress. New York: *Academic Press*.
- Harting, T., Evans, G.W., Jamner, LD., Davis, D.S., & Garling, T. (2004). Tracking Resoration in Natural and Urban Field Settings. *Journal of Environmental Psychology*, 23(2), 109-123. https://doi.org/10.1016/S0272-4944(02)00109-3
- Karipour, F., & Shahroudi, A. (2015). The Principles and Criteria of Designing the Architectural Space Based on Neuroscience. National Conference of Architecture and Novel Urbanization, Tabriz (In Persian).
- Linaraki, D., & Voradaki, G. (2012). The Interaction of Space with the Human Nervous
- System and Its Impact on Human Psychology. Department of Neurology, Torrance: UCLA.
- Low, S.M., & Altman, I. (1992). Place Attachment: A Conceptual Inquiry. In I. Altman and S.M. Low (Eds.), Place Attachment, *Plenum Press*, New York.
- Mazer, S., & Smith, D. (1992). Beyond Silence: Music as Environmental Design. A Paper Presented in the Fifth Symposium on Healthcare Design, San Diego, CA.
- Nanda, U., Pati, D., Ghamari, H., & Bajema, R. (2013). Lessons from Neuroscience: Forms Follows Function, Emotion Follows Forms. *Intelligent Building International*, 5(1), 61-78. https://doi.org/10.1080/17508975.2013.807767
- Ostwald, M. J., Kenny, H., & Chalup, S. (2012). Pareidolia Analysis of Architecture: Reading the Emotional Expression of a Building Façade. *OstwaldPoster*.pdf.
- Pakzad, J., & Bozorg, H. (2013). The Alphabet of Psychological Environment for Designers. *Armanshahr Publications*, Tehran (In Persian).
- Parichehreh, E., & EbrahimZadeh, F. (2017). Investigating the Movement Perception on Students' Brain in Communication with the Environment. The Second International Conference on Novel Findings in Civil Engineering, Architecture and Urban Management, Tehran (In Persian).
- Riley, C. A. (1995). Color Codes Modern Theories of Color in Philosophy, Painting and Architecture, Literature, Music, and Psychology. *University Press of New England*, USA.
- Ruga, W. (1989). Designing for the Six Senses. *Journal of Health Care Interior Design, Proceedings from the Annual National Symposium on Health Care Interior Design*.
- Rumelhart, D.E., & Norman, D. (1988). Representation in Memory. In R.C. Atkinson; R.J. Herrnstein; G. Lindzey; R.D. Luce (Eds.), Stevens' handbook of experimental psychology, *learning and cognition*, New York, Wiley, (2), 511-587.
- Salingrous, N. A. (2009). A Theory of Architecture. Translated by Saeed Zarinmehr, Zahir Mottaki publications, and the center of urbanization and architectural surveys.
- Shahroudi, A. (2015). Applying Neuroscience in Promoting the Quality of Architectural Space. The Second National Convention on Architecture and Urbanization Over Time in Pursuit of the Lost Space (In Persian).
- Solso, R. (2003). Cognitive Psychology. Translated by Farhad Maher, *Roshd publications*, Tehran (in Persian).
- Sternberg, R. J. (2006). Cognitive Psychology. Translated by Kamal Kharazi and Elahe Hejazi, fourth edition, *published by Institute of Cognitive Sciences* (In Persian).
- Ulrich, R. S. (1990). Effects of Healthcare Interior Design on Wellness: Theory and Recent Scientific Research. A Paper Presented in the Third Symposium on Healthcare Design, San Francisco, CA.

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