Basic and Clinical NEUROSCIENCE

January & February 2025, Vol 16, No. 1

Review Paper

Personality and Aesthetic Preferences in Architecture: A Review of the Study Approaches and Assessment Methods

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Citation Dehghani Tafti, M., Ahmadzad-Asl, M., Fallah Tafti, M., Memarian1, Gh., Soltani, S., & Mozaffar, F. (2025). Personality and Aesthetic Preferences in Architecture: A Review of the Study Approaches and Assessment Methods. *Basic and Clinical Neuroscience, 16*(1), 1-18. http://dx.doi.org/10.32598/bcn.2021.3257.2

http://dx.doi.org/10.32598/bcn.2021.3257.2

Article info:
Received: 21 Feb 2023
First Revision: 08 Sep 2023
Accepted: 12 Sep 2024
Available Online: 01 Jan 2025

Keywords:
Aesthetic preferences, Architectural preferences, Personality, Visual aesthetics, Aesthetic response, Quadruple model

ABSTRACT

Introduction: A clear relationship exists between human personality and architectural preferences. However, reviewing the findings of previous studies reveals that this expectation is not necessarily accurate, as contradictory results have been reported. This study aims to review various research and assessment methods used in previous studies for assessing the relationship between personality and architectural preferences and identify the theoretical and practical shortcomings of each method.

Methods: This is a critical review study. A search was conducted in Google Scholar and Web of Science database for published articles in English using the following keywords: "Visual aesthetics," "personality traits," "architectural preferences," "art preferences," and "aesthetic judgments." These articles were first categorized into four groups based on their methodological approaches (physiological, neurobiological, practical, and psychological) and then their degree of success and generalizability were assessed briefly. Finally, due to having lower implementation limitations and a higher theoretical background, the group using the psychological approaches was structurally analyzed from the methodological and practical aspects to develop a conceptual quadruple model. After presenting the model, neural network modeling was used to discover of hidden patterns.

Results: Based on the analysis of the reviewed studies, the psychological approach was a more feasible option for assessing the relationship between personality and architectural preferences. The quadruple model that proposed for this purpose included **aesthetic variables/** environmental stimuli, context, personality traits, and responses. The machine learning method facilitated the discovery of hidden patterns in relationship between personality and human preferences.

Conclusion: This study proposes a new systematic quadruple model for evaluating aesthetic preferences.

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Highlights

- Personality affects architectural preferences, but previous studies have reported contradictory results.
- Psychological methods can better explain the role of personality in architectural preferences.
- A systematic quadruple model was proposed in this study that links environment, personality traits, context, and responses.
- Machine learning revealed hidden patterns between personality and architectural preferences.
- The results of this study can help architects use the designs that tailored to people' traits.

Plain Language Summary

This article explores how people's personality traits influence their architectural preferences. It reviews previous studies to assess the connection between people's personality traits (such as openness, extroversion, or sensitivity) and how they choose architectural designs. While many assume that there's a clear link between personality and architectural preferences, the findings of previous studies are contradictory. We critically analyzed research methods, including psychological experiments, practical tasks (e.g. spaces), and advanced brain imaging techniques. It was found that psychological approaches (studying how people emotionally and cognitively respond to architectural stimuli) offer the most practical insights. We proposed a quadruple model which divides the factors influencing architectural preferences into four categories: the environment, personality traits, context, and responses. This model can help future researchers explore how different elements interact to each other to shape our aesthetic experiences. Additionally, the study suggests using modern tools such as machine learning to uncover hidden patterns in the connection between personality traits and architectural preferences.

1. Introduction

To take care of their needs, humans have always tried to change their surroundings or build new things using the materials and tools they have had at their disposal. To this end, the ideas and the forms of these man-made devices have not only been governed by the forces in their environment but also by their personalities as one of the determiners of their minds' functions. Personality shows why individuals are the way they are, how and why they are different from each other, and how they experience different behaviors regarding various biological processes of the brain (DeYoung & Gray, 2009). Nostro et al. (2017) claimed no notable relationship between personality traits and grey matter volume in the general population. On the other hand, when the population is split by gender, significant correlations are found in males but not in females. For example, positive correlations are reported between extraversion and grey matter volume of the bilateral precuneus and parieto-occipital sulcus, bilateral thalamus, and left mid-bilateral fusiform gyrus extending into the cerebellum and right cerebellum.

Therefore, personality and its related theories should not only be limited to a particular domain of information processing but must also be considered in affection, cognition, and behavior. Moreover, how these various areas interact and influence one's mind's functions must also be considered (Gray, 2004; Gray et al., 2002). Consequently, it can be stated that humans manifest their minds' function in their surroundings as objects. In addition, the forming of their surroundings or selection of patterns and preferences are influenced by what is in their minds. The function of people's minds determines how they feel about their environment (affection), how they have got to know it and assess it (cognition), what kind of relationship they have established with it (relationship), and how they react to it or interact with it (behavior). In architecture, each individual, with different personality traits, could have a different attitude on how to uses materials, such as wood, in building or selecting a place as residence. These diversities exist because the type of affection (fear, excitement, and dependence on wood and its components such as the color and the texture), cognition (possible functions and usages for the wood), and relationship that a person has established with this material (subjective or non-subjective entity) are different from person to person.

As a result, it could be assumed that these differences have affected the way an individual uses and utilizes these materials and creates products and spaces with specific attributes (for example, the creation of an innovative and abstract model from wood or preserving the organic structure and the texture of the wood in the final product). Therefore, it is generally expected that people with different personalities adopt different patterns or make different decisions regarding avoiding or approaching an environment. Clarifying this relationship in the past often took place using either deductive paradigms or deterministic approaches in philosophy, geography, and medicine (Little, 1987). However, in the past few decades, the main issue has been finding a relationship between the predictors, the components of human personality, and the components of the preferred surroundings. For instance, what forms and environmental attributes does a novelty-seeking individual with high affection and low cognition who is non-subjective in his relationship with his environment and has a high level of impulsivity (Cloninger & Svrakic, 2016) prefer or like? It seems that proving this relationship and determining its dimensions is not straightforward (Swami & Furnham, 2014; Lang, 1987; Mikellides, 1980) and faces scientific and methodological complexities.

The most essential issue of the research is predicting the architectural preferences and the related factors based on the personality structures of humanity that can have comprehensive effects on their behavior, mental health, and well-being. Therefore, in the first phase, a review of the methods to achieve a conceptual model in studying the relationship between personality and architectural preferences is considered. This study includes the results of the review of the methods and describes the selected model for research.

2. Materials and Methods

Over 100 papers and several PhD dissertations on the preferences and environmental aesthetics were compiled to carry out this study. An extensive literature search was carried out employing the Google Scholar database. The following key terms associated with aesthetic preferences were searched: “Visual aesthetics,” “personality traits,” “architectural preferences,” “art preferences,” and “aesthetic judgments.” Web of Science was used to check the quality of the published literature. The only journals included in the review process were those published in English. These studies were first categorized into four groups based on their methodological approaches and then assessed briefly concerning their degree of success and generalizability. Finally, due to having lower implementation limitations and a higher theoretical background, the group containing the psychological responses was structurally analyzed from the methodological and practical aspects to develop a conceptual model for future research.

3. An Overview of the Research Methodologies on the Relationship Between the Personality and the Environmental Aesthetics

In an overall approach proportionate to the responses received in facing the environmental stimuli from the participants in the reviewed research, all of the studies could be categorized and even predicted in four groups of physiological, neurobiological, practical, and psychological responses.

Physiological research

Part of the research on the relationship between personality and environmental preferences leads to receiving physiological responses and or activities when facing stimuli and various situations. Therefore, a series of experiments have been conducted in which the researcher controls the conditions, and an individual is exposed to environmental stimuli (light, noise, photo, etc.). Then, the person’s level of arousal to each stimulus is measured based on the physiological changes that the body undergoes. Utilizing different methods in personality psychology in a comprehensive domain study, the biological basis of personality has been studied, and the results have been categorized based on genetic, psychophysical, biochemical, neuropsychological, and neurobiological aspects (Strelau, 2006; Zuckerman, 2005). Psychophysiological studies are part of the research to identify the causal relationship between personality traits and the body’s physiological parameters. Blood pressure, pulse, heart rate, cardiovascular activity, eye-blink activity, electromyography, respiratory sinus arrhythmia, electrodermal activity or galvanic skin response, and eye-tracking are just a few of these physiological parameters. Up to a certain limit, measurements of these parameters are influenced by the individual personality characteristics of each person. This factor leads to different unconscious physiological responses displayed by different individuals when exposed to the same environmental stimuli. For instance, in the psychophysiology of extraversion (De Pascalis, 2004), the studies show that where electrodermal activity is used as an indicator for orienting reflex, the orienting reaction expressed in the amplitude of electrodermal activity is lower for the extraverted individuals. Moreover, along with the habituation of an individual to novel stimuli, this

parameter is lowered. This decline in the parameters takes place for the extroverted individuals faster than the introverted ones (Stelmack & Geen, 1992; Eysenck, 1990; Stelmack, 1990, 1981; O'Gorman, 1977).

Even though physiological research is mainly designed to answer questions in the field of psychology, it could be used in research that focuses on the aesthetic experiences of art and architecture (Krupinski & Locher, 1988; Locher & Nodine, 1987; Berlyne et al., 1963). Overall, this group of research suffers from numerous executory limitations. For instance, medical illnesses, environmental situations, and psychological and physical conditions of the participants during the administration of these tests affect the results. Moreover, simple variables and stimuli are required to carry out the tests.

Neurobiological research

Another group of the analyzed research, called neuroaesthetics, deals with the neurobiological mechanisms of the participants when facing environmental stimuli and aesthetic experiences. Neuroscientific investigations have approached this area using imaging and neurophysiological techniques, such as functional magnetic resonance (fMRI), magnetoencephalography, electroencephalography, and positron emission tomography (Cinzia & Vittorio, 2009). In this newly established field, observing the brain and neurobiological functions in aesthetic experiences has revealed numerous interesting findings (e.g. Coburn et al., 2017; Vartanian et al., 2015; Chatterjee & Vartanian, 2014; Vartanian et al., 2013; Cinzia & Vittorio, 2009; Jacobsen et al., 2006). These findings also led to a better understanding of how aesthetic perception is done and which areas of the brain are involved in processing different aspects of visual experiences. A meta-analysis study done by Skov (2009) suggests that diffuse regions of the brain, such as the posterior cingulate cortex, anterior insula, and occipital lobes, are involved when it comes to analyzing a picture or painting (Vartanian & Skov, 2014; Kirk et al., 2009). Another meta-analysis commissioned by Boccia et al. (2016) reveals that 27 brain regions are linked to aesthetic perception. In this study, it is also recommended that different visual stimulants can stimulate distinct brain areas. For instance, the fusiform area is mostly activated when eyes focus on a portrait picture, whereas the parahippocampal gyrus is mostly responsible for the visual processing of natural landscapes. Vartanian et al. (2015) studied the effect of ceiling height and perceived enclosure on aesthetic judgment and approach-avoidance decisions in architecture. In this study, fMRI was used to look for the nerve-related mechanisms in the brain. This research shows that "the rooms with higher ceilings are perceived as more beautiful, and the activated structures involved in visuospatial exploration and attention are located in the dorsal stream." In addition, it was found that "open rooms are perceived as more beautiful and activated structures that underlie perceived visual motion. Furthermore, the enclosed rooms were found to elicit exit decisions more likely and activated the anterior midcingulate cortex (aMCC) — the region within the cingulate gyrus with direct projections from the amygdala." Another related study, which investigated the impact of contour in architecture, reports that the participants are more likely to judge spaces as beautiful if they are curvilinear rather than rectilinear. Neuroanatomically, when contemplating beauty, curvilinear contour activates the anterior cingulate cortex, a region strongly responsive to the reward properties and emotional salience of objects, exclusively" (Vartanian et al., 2013).

Due to the complexity of the subject and the dynamic influences of the personality on various parts of the brain, no outstanding research has been carried out to understand the relationship between the personality and the preferred environment. However, the research in this field could clarify some related facts. Overall, before starting a study in neuroaesthetics and using the customary test, the researcher should establish strong theories by utilizing the required psychological tests. These theories related to personality and environmental preferences do not benefit from a clear-cut form.

Practical research

In the third category of research studies, the practical or action research, the participants are asked to take part in a practical test. This test could be designing a house, deciding the arrangement of the furniture, coloring an object, or any other activity proportionate to the subject of the research (Matthews et al., 2010; Rosenbloom, 2006; Osborn, 1988; Duffy et al., 1986). Ultimately, some results could be obtained by assessing each person's actions in relation to his/her personality traits. For example, to examine the relationship between color preferences and sensation seeking, some students were asked to color the human figure's clothing using paints (Rosenbloom, 2006). The results suggest that sensation seekers prefer to make more complex images and choose red (as a hot and arousing color). In another study, Matthews et al. (2010) reported the relationships between the Myers-Briggs type indicator and three-dimensional form in design choices (design form decisions, ordering principles, and pattern languages). In this study, 91 interior design students were asked to design a personal home environment. Significant differences were found to have occurred between design choices among all personality types.

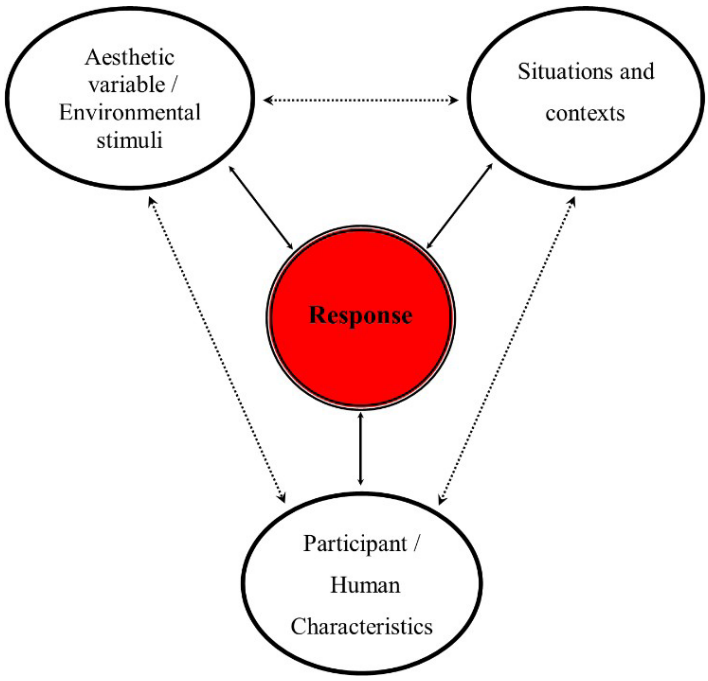

Figure 1. The quadruple model of aesthetic responses

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Moreover, practical research can be done differently by making a checklist and observing an individual's living environment, designed and arranged based on his/her interests and attitudes. This is one way to go about predicting the personality (Meagher, 2016; Graham et al., 2011; Gosling et al., 2005; Gosling et al., 2002; McElroy et al., 1983). The selection of an action research approach always faces limitations in the execution and assessment of the relationships. In this research group, the participants must have certain skills to perform the practical activity (i.e. designing a house). The skill requirement criterion automatically prevents many members of society from participating in such studies. In addition, the participants' worlds of life and professional experiences influence the study, and the action research approach cannot be controlled.

Psychological research

Psychological research is the most common and diverse type used to understand and clarify the relationship between personality and environmental preferences. This research benefits from a long history in environmental, aesthetic studies (Swami & Furnham, 2014). In such research, the environmental stimuli are introduced via various tactics, followed by gathering the participants' psychological responses and analyzing them. The findings of this group of research studies are not focused (Nadal, 2007); some researchers have obtained significant results (e.g. Jankowski et al., 2018; Swami & Furnham, 2012; Chamorro-Premuzic et al., 2010; Chamorro-Premuzic et al., 2009; Feist & Brady, 2004; Rawlings, 2003; Furnham & Walker, 2001a, Furnham & Walker 2001b; Furnham & Avison, 1997; Furnham & Bunyan, 1988); whereas some others have not been able to get any significant results (e.g. Pietras & Czernecka, 2018; Palmer & Griscom, 2013; McManus et al., 2010; Griscom & Palmer, 2010; Furnham & Chamorro-Premuzic, 2004; Zuckerman et al., 1993). This lack of focus could be seen in visual preferences in most architectural studies (e.g. Cleridou & Furnham, 2014; Dębek & Janda-Dębek, 2012; Cook & Furnham, 2012; Ibrahim et al., 2002; Stamps & Nasar, 1997) as an art with a multisensory nature. Generally, the findings of the studies on the relationship between personality and aesthetic preferences are too scattered and have not been verified, especially in architectural preferences. To be more precise, when the research variables are personality and architecture, the results of the decisions and selections of the individuals become more unpredictable than ever. However, the question arises as to which one of these four research categories, with its executory shortcomings and the existing theories, is more suitable for use in architecture. As a result of having stronger theoretical foundations, more focused research, and ease of execution, psychological research seems more feasible when dealing with architecture, and one could use a fresh perspective to create some structural and technical changes. To this end, the studies with psychological responses are chosen for further analysis.

4. The Systematic Quadruple Model of Aesthetic Responses

Any systematic research designed and carried out in environmental aesthetics should utilize certain variables in a coordinated format to get the responses. These variables manifest themselves in three aspects: Environment and environmental stimuli, the person exposed to them, and the situation. Thus, a quadruple conceptual model is obtained that consists of the following components: The aesthetic variable and the environmental stimulus, the variables or the human characteristics associated with the participants in the study, the contexts and the situations in which the test is administered, and 'the responses (Figure 1). Even though this model has been recommended in studying musical preferences (Hargreaves et al., 2012), the research structures and processes point to this model's generalizability to all four environmental aesthetics studies. This model assumes that the factors associated with all three broad variables interact with the other two variables. Therefore, all of the three variables and their factors interact to give rise to a response. In addition, the systematic quadruple model can be used as a framework for organizing numerous research studies on aesthetic preferences. A prime example is using a similar model by some researchers in organizing studies in neuroaesthetics (Chatterjee & Vartanian, 2014) and neuroaesthetics in architecture (Coburn et al., 2017). Respectively, they have reviewed the studies based on a triad model in which the three variables of environmental stimuli, personal characteristics, and situation, and responses are considered in relation to the brain and the nervous system. According to this model, three large-scale systems generate aesthetic experiences: Sensory-motor, knowledge-meaning, and emotion-valuation systems. The sensory-motor scale focuses on the visual and non-visual stimuli or navigation through the built spaces; it also examines how the sensory and motor systems get involved in different brain parts. Personal experiences, education, culture, and the context in which objects are encountered and appraised are considered in the knowledge-meaning scale. The emotion-valuation scale concentrates on the aesthetic responses from the affective and cognitive aspects engaged by the environmental stimuli and the brain mechanisms associated with them (Coburn et al., 2017; Chatterjee & Vartanian, 2014; Leder et al., 2004).

5. Quadruple Model and the Structure of the Psychological Research

According to the introduced model in environmental aesthetics, 4 separate stages should be completed to carry out research with psychological responses. This could be done by placing participants in a certain context and situation and exposing them to pre-measured environmental stimuli. The final stage is gathering and analyzing their cognitive, affective, and perceptual responses.

Environmental stimulus

In the first stage, selecting a few aesthetic variables and preparing the photos or other visual stimuli for displaying in the questionnaire is necessary. Thus, in reality, the first stage can be summarized in three steps: Selection of the environmental attributes/aesthetic variables, selection and measurement of environmental stimuli, and the mode of presentation in the questionnaire (Nasar, 2008).

Selection of the environmental attributes/aesthetic variables

The selection of aesthetic variables is based on the theoretical foundation of the research and the research questions and is carried out using various approaches (e.g. Gifford et al., 2000; Nasar, 1994). One examines the formal aesthetic variables. The second approach considers more abstract variables than the formal ones mentioned. In the third approach, the type and the style of the building or an art piece are considered the symbolic aesthetic variables (Table 1).

Selection and measurement of the stimuli for the test

After the aesthetic variable is determined, in the second step, the selection of the stimuli to be used in the test, the rating and coding of the stimuli, and the determination of the sample size are considered. The test stimuli can be selected using the following formats: Graphic representation (Madani Nejad, 2007; Heath et al., 2000; Imamoglu, 2000), oral description, black and white, and color photos (Nasar & Devlin, 2006; Nasar & Kang, 1999; Stamps & Nasar, 1997; Devlin & Nasar, 1989; Shafer & Richards, 1973), video (Zhang et al., 2006; Nasar 1984), virtual reality, or being exposed to the actual context or the real-life situation (Meyers-Levy & Zhu, 2007). The selection of each format benefits from certain strengths and weaknesses in the way they measure, rate, and control the experiment setting, as well as the degree of realism (Nasar, 2008; Taylor et al., 1987). Moreover, the selection creates different capabilities concerning the

Table 1. Aesthetic variables

Type	Variables	Examples of Studies
Formal variable	Angular vs rounded shapes, size, aspect ratio, ceiling height, symmetry, color, etc.	Jankowski et al., 2018; Swami & Furnham, 2012; Hidayetoglu et al., 2012; Dębek & Janda-Dębek, 2012; He et al., 2011; McManus et al., 2010; Nasar & Stamps, 2009; Madani Nejad, 2007; Meyers-Levy & Zhu, 2007; Bar & Neta, 2006; Zhang et al., 2006; etc.
Abstract variable	Complexity/simplicity, representation/abstractness, clarity/ambiguity, harmony, etc.	Palmer & Griscom, 2013; Chamorro-Premuzic et al., 2010; Griscom & Palmer, 2010; Nadal, 2007; Imamoglu, 2000; Heath et al., 2000; Herzog, 1992; Zuckerman et al., 1993; Furnham & Bunyan, 1988; etc.
Symbolic variable	Art and architectural styles/types	Carl et al., 2018; Cleridou & Furnham, 2014; Cook & Furnham, 2012; Chamorro-Premuzic et al., 2009; Rawlings, 2003; Cela-Conde et al., 2002; Furnham & Walker, 2001a, Furnham & Walker, 2001b; Nasar & Kang, 1999; Stamps & Nasar, 1997; Furnham & Avison, 1997; Stamps, 1993; Purcell & Nasar, 1992; Devlin & Nasar, 1989; etc.

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number of participants. In the rating phase, a few judges use the Likert scale to measure the test stimuli based on the aesthetic variables and the factors related to them. The rating could occur based on various policies concerning the level of the judges' expertise or whether they are rating stimuli individually or in a panel format. However, a study may not have a rating phase, and the researcher may use software to create a different spectrum of environmental stimuli to eliminate possible errors (Dębek & Janda-Dębek, 2012; Madani Nejad, 2007). Regardless of the researcher's choice, the second step's product is a final sample of pre-determined coded environmental stimuli prepared for the questionnaire. All the actions in selecting and measuring the environmental stimuli must be done in a way that leads to the least possible degree of bias. Therefore, the research's validity and reliability depend significantly on this step's selection process, choices, and judgments.

The presentation mode in the questionnaire

The last step in the first stage is how the researcher introduces the stimuli in the questionnaire. This decision is always made through interaction among the steps. The subject and the theoretical foundation of the research, the number of participants, the format of the coded stimuli, the received responses, the instrumentation, the context, and the situations are the factors affecting the presentation mode in the questionnaire. Using a software or hardware format for the questionnaire, administration of the test in a controlled environment or an online format, the number of stimuli and the trials that are to be displayed for each participant, the duration of the display, the reaction time, and some other technical details are some of the issues determined in this step.

Study participants

The second stage in the execution of the study depends on the participants in the test and their human characteristics. Various studies have analyzed environmental preferences such as identity, biological and sociocultural factors, environmental familiarity, and expertise (Table 2).

Contexts and situations

In the third stage of the conceptual model, attention is focused on the contexts and situations. Even though in this stage, the results of the responses are anticipated not to have any direct impact, some studies show that these factors can affect the results. In general, four groups of factors associated with this stage are identified in the visual preferences: The location of the test, the time of the test, the type of the assessment (private/public), and the alternate preferences. For instance, while the research is ongoing, dissatisfaction and lack of interest in a specific form and color are created, or a participant is informed that his preferences and assessments are to be judged by a panel (Zhang et al., 2006). Another situation could be that the participants are asked about their color preferences in architecture based on the building's function and interior/exterior (Dębek & Janda-Dębek, 2012).

The response

The final stage in the conceptual model is the response stage, where different responses are elicited from the participants using various instruments, and the received responses are statistically analyzed. In the response section of the study, an individual can provide the researcher with three types of perceptual, affective, and cognitive responses when exposed to the stimuli. Sensing the stimulus takes place in less than a second (Victor et al., 2001),

Table 2. Participant variables

Participant	Variables	Examples of Studies
Identity factors	Sex, age, etc.	Most studies have examined the identity variables such as age and sex.
Psychobiological factors	Temperament, personality traits, schizotypy, etc.	Jankowski et al., 2018; Pietras & Czernecka, 2018; Cleridou & Furnham, 2014; Palmer & Griscom, 2013; Cook & Furnham, 2012; Dębek & Janda-Dębek, 2012; Swami & Furnham, 2012; McManus et al., 2010; Chamorro-Premuzic et al., 2010; Chamorro-Premuzic et al., 2009; etc.
Sociocultural factors	Religion, ethnicity, education, race, major, political orientation, etc.	Nasar & Devlin, 2006; Feist & Brady, 2004; Imamoglu, 2000; Nasar & Kang, 1999; Nasar, 1984; etc.
Expert/Non-expert	Background and training in art/ architecture, artistic experience, aesthetic activities, etc.	Pietras & Czernecka, 2018; Miu et al., 2016; Cela-Conde et al., 2002; Ibrahim et al., 2002; Locher e al., 2001; Devlin & Nasar, 1989; etc.
Familiarity with the environment	Familiar/Unfamiliar	Furnham & Walker, 2001; Ibrahim et al., 2002; Imamoglu, 2000; etc.

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and the person can respond perceptually to whether the stimulus is light or dark, simple or complex, open or closed. Affective responses point to the inner state of the participant, originate, and depend on how he/she feels toward the environment. The emotional responses are applied in pleasure, excitement, arousal, and calmness (Nasar, 2008). In cognitive responses, environmental stimuli can be assessed from different aspects, such as whether they are stable or unstable, safe or unsafe, modern or traditional. Overall, the type of responses (emotional responses versus aesthetic judgments) largely depends on the theoretical framework of the research, the fundamental theories in psychology, and the affective and cognitive mechanisms of perception and aesthetics. In this regard, different psychological and neuroscientific models of perceptual mechanisms have been introduced in aesthetic judgments and experiences (Bakker et al., 2014a; Skov, 2009; Chatterjee, 2004; Leder et al., 2004; Nasar, 1994; Cloninger, 1994). Understanding these models can significantly impact designing various stages of the research and the received responses more accurately.

After determining the types of the received responses, the instruments are selected. Selection of the instruments takes place in interaction with the type of the received responses and the mode of presentation of the stimuli in the questionnaire (step three of the first stage). Sorting, selecting among the group members, using the Likert scale rating, comparing the choices, opening and closing questionnaires, and combining these are some of the instruments used to elicit preference stimuli. This part of the process, as far as the reaction time is concerned (e.g. McManus et al., 2010; Smith et al., 2006; McWhinnie, 1993), and the forced-choice blocks and the Likert-type items can be modified.

At the end of this section, the responses are gathered as the data and are from the study. In addition, various statistical methods and models are utilized to analyze the data. In most recent studies, correlation and regression analysis are carried out to investigate the relationship between the study variables and the aesthetic responses.

To achieve the study's goal of determining the relationship between personality and architectural preferences, the methodology of preferences studies of 20 recent research studies on visual art and architecture were reviewed, and the results are tabulated in Table 3. The framework used in the review process of these research studies was based on the quadruple model's components and factors. Moreover, the significance of the relationship between the personality and aesthetic variables is displayed in the result column (Table 3).

6. Limitations and Future Directions

The goal of establishing a much better relationship between human beings and architecture, studying architecture while taking individual and personal characteristics of the clients, is of great importance. Therefore, discovering the preferred patterns for each person and considering them by the designers and builders could, ultimately, create conditions that result in the satisfaction of that person. This review study analyzed the methodological structure of the environmental preferences research with a psychological approach. The review showed two reasons why research on the relationship between personality and aesthetics in architecture has

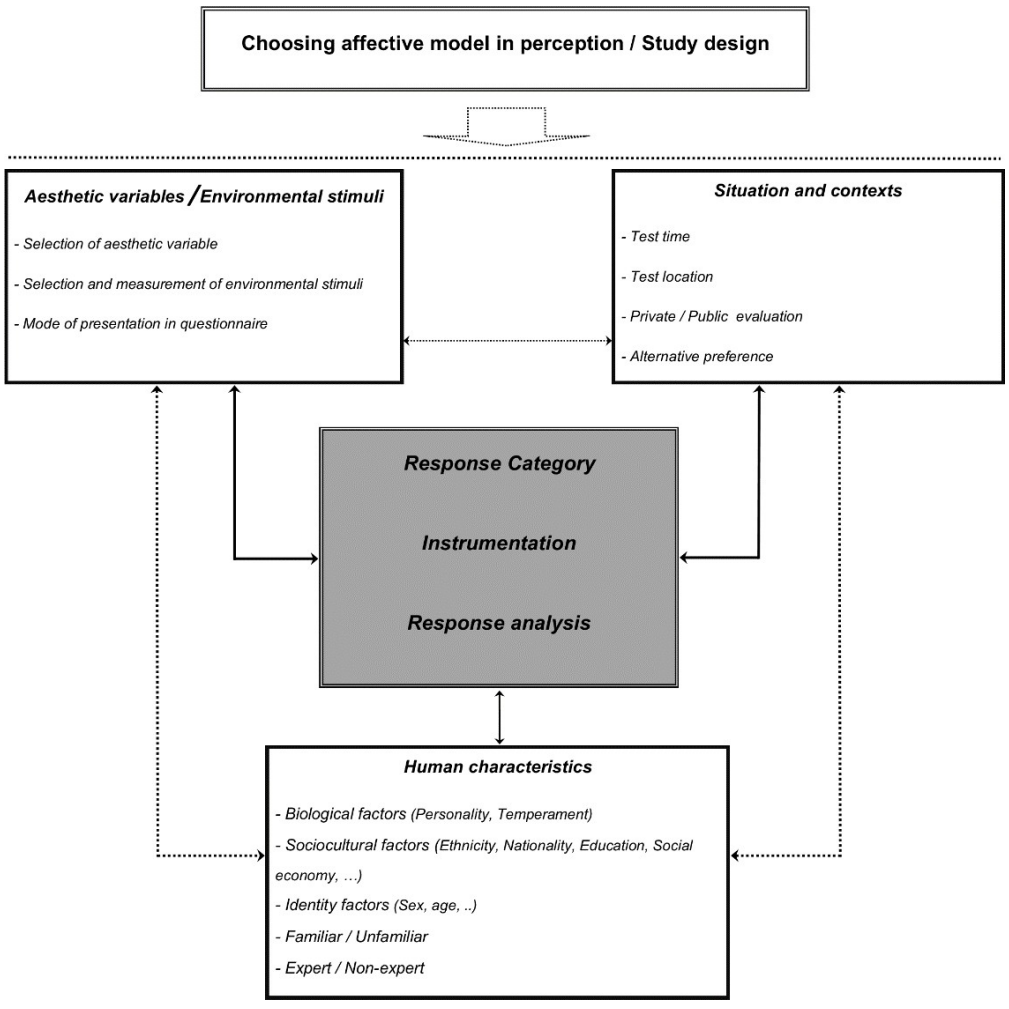

Figure 2. The quadruple model of psychological responses in preference architecture

not gained clear and significant results. The first group of reasons is fundamental and relates to the nature of the aesthetics and the variables in this study, personality, and architecture. Architecture is defined as a multisensory art that a thorough understanding of becomes possible only by directly experiencing it, and personality is considered a dynamic organization of psychobiological systems (Cloninger & Svrakic, 2016; Allport, 1961). These factors have yielded no results using the traditional methods and quantitative paradigms.

The other set of reasons could lead to positive results by changing and reviewing the theoretical orientation, the structure, and the execution tactics. To this end, the literature was reviewed from a methodological aspect.

By studying the research on visual aesthetics, a systematic quadruple model along with a series of the model's components and factors were obtained. Dealing with this model and its components in action greatly depends on the subject, aims, and the study's theoretical framework (Figure 2).

Based on the quadruple model, a projective model or concept map was created to study and analyze the relationship between personality and aesthetic variables in architecture. This map benefits from a core concept (the relationship between personality profile and architectural preferences profile). In the projective model, all of the relationships between the variables are present and placed under the researcher's control, like a neural network. By utilizing this neural network, assessing and determining the weight of all of the relationships and predicting the architectural preference patterns for each personality becomes possible (Figure 3). In this case, for sophisticated statistical analysis, extracting the hidden information or obvious patterns and relationships in a large volume of data and their interrelations, there is a need for data mining (Fayyad et al., 1996). Data mining, which takes place using statistical models, mathemati-

Table 3. The review of the methods and the results of preferences studies for visual art and architecture stimuli

Study	Environmental Stimulus			Participants			CO & SI	The Responses			Domain and Results
	Variables	Stimuli	Presentation	Subjects	PT	Variables	Variables	Response Category	Instrumentation	Statistical Analysis	
Cleridou & Furnham, 2014	5 artistic styles	30 images of paintings/buildings	Online task software	148 F, 44 M Age: 18-30 y	IPIP	Sex, ethnicity, artistic experience	No variable	Affective: Like/Dislike	Rating, 9-point Likert-scale	Correlation, factor analysis, regression	For ARCH: N for art: C, N, O
Palmer & Griscom, 2013	Harmony	Color stimuli: 56 colored pairs dot patterns: 22 five-dot images circle-in-a-frame images: 35 images	Software, response time (2000 ms) interval (500 ms)	90 students mean age: 21.4 y	BFI SSS	Background training in visual art and color	No variable	Affective: Like/Dislike Cognitive: Harmonious/disharmonious for color pairs, simple/complex for dot patterns, good fit/bad fit for circle-in-a-frame	Rating: Continuous rating scale (−100 to + 100)	Correlation, chi-square, SEM, factor analysis	For harmony: Non-significant
Cook & Furnham, 2012	6 British styles	24 photographs of British buildings	In a large lecture theater	74 F, 10 M Age: 18-25	NEO-FFI	Familiarity	No variable	Affective: Attractiveness Cognitive: familiarity	Rating in 10 seconds	Bonferroni correction, regression, PCA	For ARCH: E, N, A
Dębek & Janda-Dębek, 2012	Color, form, & shape	12 architectural models	Software questionnaire	290 F, 144 M	FCZ-KT	Sex, age, residence	Alternative preferences	Emotional,	Rating, 5-point Likert-scale	GLM, LSD	For ARCH: non-significant
Swami & Furnham, 2012	Symmetry/asymmetry	57 colored images of paintings by Piet Mondrian	In a large lecture theater	83 F, 75 M Age: 18-39 y	SSS-V TIPI	Sex, age, WPT, ToA, AA, NRT, religion, ethnicity, education	No variable	Affective: Like/Dislike	Rating, 7-point Likert-scale	ANOVA, correlation, regression	For Mondrian's original painting: O
McManus et al., 2010	Aspect ratio square/rectangle golden section	210 pairs of 21 different rectangles	Computer presentation, response time	54 F, 25 M Age: 18-25 y	BFI-2-the 30-item	Sex, age, AA, ToA, need for cognition, schizotypy, vocational types	No variable	Affective: Attractiveness & nice	Paired comparison	Q-Mode factor analysis, correlation	For rectangle preferences: Non-significant
Chamorro-Premuzic et al., 2010	Complexity/Simplicity	20 paintings of 4 distinct visual art genres	Online task Software	2253 F, 1001 M Age: Under 20-70 y	B5S	Sex, age, education, unconventionality, visits to museums	No variable	Preferential: hate/love Emotional: Sad/happy cognitive: Simple/Complex	Rating, 5-point Likert-scale	SEM, correlation	For visual art preferences complexity: O, E, N, C
Chamorro-Premuzic et al., 2009	4 painting styles	24 images of paintings	Online task software	91692 (M & F) Age: 13-90 y	IPIP	Sex, age, education, artist vs scientist	No variable	Affective: Like/Dislike	Rating, 7-point Likert-scale	Descriptive statistics correlation, SEM	For art: A, C, O, E
Feist & Brady, 2004	Ambiguity, abstractness/representation	45 works of art	With a projector in a classroom	Low O: 32 F, 16 M High O: 36 F, 19 M	SSS-V NEO-FFI	Sex, age, tolerance of substance use, race, major, political orientation	No variable	Affective: Like/Dislike	Rating, 9-point Likert-scale	ANOVA	For abstract art: O
Furnham & Chamorro-Premuzic, 2004	Basic principles of aesthetic	The maitland graves design judgment, 90 slides	In a large lecture theater	46 F, 28 M Age: 18-24 y	NEO-FFI	Income, sex, age, political idea, art interests, activities & knowledge	No variable	Art judgment: Preference (selecting a better design in a slide)	The correct response from paired or triple images	Multiple regression	For art judgment: E, C

Study	Environmental Stimulus			Participants			CO & SI	The Responses			Domain and Results
	Variables	Stimuli	Presentation	Subjects	PT	Variables	Variables	Response Category	Instrumentation	Statistical Analysis	
Rawlings, 2003	Abstractness/ representation, pleasant/ unpleasant	18 Unpleasant/ 18 Pleasant Photographs, 44 Slides Of 4 Painting Styles (Pr, Ur, Pa, Ua)	Slide-show, Session 1: In A Lecture Theater, Session 2: In A Small Classroom	188 M & F Mean age: 21.97 y	IPIP SSS-V EPQ-R	Sex, age, schizotypy (UE), expert/ non-expert	No variable	Affective: Like/Dislike	Rating, 5-point Likert-scale	Pearson correlation, PCA, regression	For art & photography: SS, UE, P, O, N
Furnham & Rao, 2002	Original vs facsimile	100 slides of 2 modern abstract painters & sketches	Slide-show	77 F, 52 M Age: 16-19	NEO-FFI	Sex, age, ethnicity, level of education	No variables	Affective, cognitive	Rating, paired comparison task	Correlation, multiple regression	For preference ratings: C
Ibrahim et al., 2002	Non-familiar/ familiar ARCH	Familiar ARCH: 6 Exterior, four interior/ Non-familiar ARCH: 7 exterior, three interior	In a laboratory, presented on a white surface table	30 expert, 30 non-expert 24 expert, 28 non-expert	16PF	Sex, familiarity, expert/non-expert, level of study	No variables	Perceptual: 7 items Affective: 10 items cognitive: 15 items	Rating, 7-point Likert-scale	Factor analysis, correlation	For ARCH: non-significant
Furnham & Walker, 2001a	4 painting styles Japanese traditional pop-art, abstract, & representational	40 slides of paintings (10 paintings for each style)	Slide-show in a room	101 M & F Age: 16-18 y	SSS-VI NEO-FFI WPAI	Sex, age, occupation, nationality, ethnicity, home location, experience of art, interest in art, Visits to galleries	No variable	Affective: like/ dislike Cognitive: Familiarity, paying for the painting, artist talent	Rating, 11-point Likert-scale	Correlation, multiple regression, curve analysis,	For art styles preferences: CON, SS, O, C
Furnham & Walker, 2001b	3 painting styles Pop art, realistic and abstract art	24 slides of paintings (8 paintings for each style)	Slide-show In a room	45 M, 76 F Age: 16-58 y	SSS-VI NEO-FFI	Sex, age, occupation, home location, art level studied, visits to galleries	No variable	Affective: Like/Dislike	Rating, 11-point Likert-scale	Factor analysis, correlation	For art styles preferences: SS, A, O, N, C
Rawlings et al., 1998	Complexity	24 polygons	Hardware, presented on A4 paper	- 33 M, 82 F Mean age: 19.7 y	EPQ-R SSS-V STA	Sex, age, background, interest in art	No variable	Affective & cognitive: 8 rating scales (or 8 items)	Rating, 7-point Likert-scale	Correlation, t test, regression, CCA	For complexity: SSS-V, STA
Stamps & Nasar, 1997	High style vs popular style in ARCH	35 photographs of houses' scenes	Hardware, photos mounted on the boards	45 F, 37 M Age: under 20- over 40 y	SSS-ES	Sex, age, education, ethnicity, city, political idea, income, occupation, major activity last week	No variable	Affective: Pleasant/Unpleasant	Rating, 7-point Likert-scale	ANOVA	For high style/ popular style: Non-significant
Furnham & Avison, 1997	Painting styles: Representation / surreal, variety of elements	20 slides of paintings (5 RM, 5 RF, 5 SM, 5 SF)	Slide-show	32 M, 30 F Age: 18-34 y	SSS-V NEO-FFI	Sex, age, ToA	No variable	Affective: Like/Dislike	Rating, 11-point Likert-scale	Correlation, factor analysis, multiple regression	Preferences for art: SS strong effect / E, A, O weak effect
Zuckerman et al., 1993	Complexity, tension, Style	52 slides of nature paintings	Slide-show	- 84 M, 135 F - 62 M, 91 F	SSS-V	Sex	No variable	Affective: Like/Dislike	Rating, 5-point Likert-scale	MANOVA, factor analysis, correlation	For complexity: Non-significant

Study	Environmental Stimulus			Participants			CO & SI	The Responses			Domain and Results
	Variables	Stimuli	Presentation	Subjects	PT	Variables	Variables	Response Category	Instrumentation	Statistical Analysis	
Furnham & Bunyan, 1988	Complexity/ simplicity, abstractness/ representation	20 paintings (5 CA, 5 SA, 5 CR, 5 SR)	Slide-show	25 M, 35 F Age: 18-27	SSS-V	Sex, age	No variable	Affective: Like/Dislike	Rating, 7-point Likert-scale	Correlation	For complexity: SS

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Abbreviations: CO: Contexts; SI: Situations; PT: Personality test; RM: Representational painting with more elements; RF: Representational painting with fewer elements; SM: Surreal painting with more elements; SF: Surreal painting with fewer elements; CA: Complex/abstract; SA: Simple/abstract; CR: Complex/representational; SR: Simple/representational; PR: Pleasant representational; UR: Unpleasant representational; Pa: Pleasant abstract; UA: Unpleasant abstract; M: Male; F: Female; ARCH: Architecture; NEO-PI-R: Revised NEO personality inventory; FCZ-KT: Formal characteristics of behavior-temperament questionnaire; IPIP: International personality item pool; SSS-V: Sensation seeking scale form V; BFI-2-the 30-item: The 30-item forms of the big five inventory–2; TIPI: Ten-item personality inventory; B5S: Big 5-short inventory; 16PF: Cattell's 16 personality factors test; SSS-ES: Experience seeking scale; EPQ-R: Eysenck personality questionnaire-revised; STA: Schizotypal personality scale; SSS-VI: Sensation seeking scale form VI; WPAI: Wilson-Patterson attitude inventory; BFI: Big five index. SSS: Sensation seeking scale; AA: Aesthetic activities; ToA: Tolerance of ambiguity; NRT: Numerical reasoning test; WPT: Wonderlic personnel test; SEM: Structural equation model; PCA: Principal component analysis; GLM: General linear model; LSD: Least significant difference; ANOVA: Analysis of variance; MANOVA: Multivariate analysis of variance; CCA: Canonical correlation analysis; C: Conscientiousness; N: Neuroticism; O: Openness to experience; A: Agreeableness; E: Extraversion; SS: sensation seeking; CON: Conservatism; P: Psychoticism; UE: Unusual experience (schizotypy).

cal algorithms, and machine learning methods, leads to data analysis and prediction of the results (e.g. prediction of patterns of architectural preferences) (Piatetsky-Shapiro & Parker, 2011). In past studies, simple statistical models were usually used to analyze the data. This approach to data analysis has led to missing the correlation between personality and preferences. For instance, it is possible for only a part of a set of data related to personality profiles to be associated with part of a set of data regarding the architectural preferences profile in a dataset originating from an experiment. A simple statistical analysis method often neglects the intricate and complex relationship between two data sets.

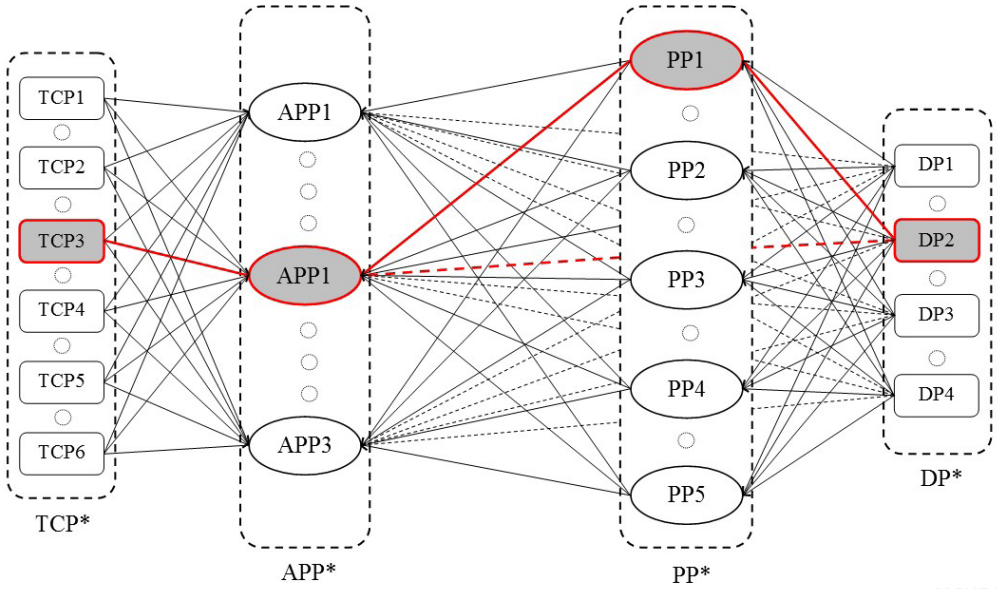

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Figure 3. A neural network model in the study and analysis of the relationship between personality and architecture

Abbreviations: APP: Architectural preference profile); PP: Personality profile; DP: TCP: Demography profile.

Another part of the changes in the methodology relates to the execution tactics. As previously mentioned, the researcher must understand the study's theoretical framework concerning the process and the mechanism of perception and aesthetic preferences (Hardiman & Zernich, 1977). For instance, a researcher could adjust the theoretical orientation of his study based on the neuroaesthetics Chatterjee's model, which believes that "the viewer experiences pleasure without obvious utilitarian consequences of this pleasure" (Chatterjee, 2004). Chatterjee divided visual processing into three dimensions: Early, intermediate, and late visions. In his model, frontoparietal circuits and occipital cortex are primarily responsible for early and intermediate visions (processing features such as color, shape, location, and motion of the objects), while late vision, including visual cognition and visual attention, is significantly derived from the interaction between insula, temporal pole and orbital-frontal regions (Leder & Nadal, 2014; Chatterjee, 2004; Chatterjee & Vartanian, 2016).

Chatterjee's model is in contrast with Leder et al. model, who believed that the aesthetic experience takes place when "exposure to art provides the perceiver with a challenging situation to be classified, understand, and cognitively master the artwork successfully" (Leder et al., 2004, 493). Many decision theorists believe that human beings, when deciding on their preferences, often act in less than a second according to their intuition process (Dijksterhuis, 2004; Dijksterhuis et al., 2006; Zajonc, 1980). In other words, the role of logic and the cognitive process is not very dominant. In studying the relationship between personality and architecture, most research has involved the cognitive process in aesthetic preferences by unlimited visual stimuli's observation and selection time. The lack of time limitation here provides the participants with different experiences and memories, with an opportunity to come up with different assessments of the stimuli. In contrast, the assessed characteristic may not have been part of the intended aesthetic variables (Bakker et al., 2014b). In such a situation, controlling the research and the relationships involved will be affected by the intervening variables that have not been predicted in the research framework. Lack of attention to this issue could be one of the reasons that the studies on the relationship between personality and architecture have not yielded any significant results. Therefore, selection and dealing with the affective and cognitive processes that are involved in aesthetic preferences have a direct impact on the theoretical orientation and the executory tactics and could create changes, such as the selection of the aesthetic variables, the presentation mode of the stimuli, the received responses, the instrumentation, the reaction time, and the methods and models of statistical analysis in the components of the quadruple model.

7. Conclusion

This review offers a suitable methodological approach for studying the relationship between personality and architectural preferences. It could be used to aid researchers in designing a sophisticated study in this domain and enabling them to perform complex analyses. To this end, two general recommendations were made for future studies. First, the use of the quadruple model adopts a systematic approach to the issues and makes it possible to collect all the data impacting the results of a study and to knowledge discovery by the use of machine learning. The second is the selection of a perceptual model in aesthetic preferences that has a direct impact on the quadruple model and the process of execution of the research. To this end, Chatterjee's model is the best model among others, as the role of cognition in aesthetic preference is notably limited. This model's visualization process is divided into three dimensions: Early, intermediate, and late visions. According to Chatterjee, early vision seems responsible for understanding morphological features at first glance, while intermediate vision mainly processes spatial status. Memory-related contents are apprehended by late vision.

Based on these two recommendations, focused and step-by-step research could be designed to solve the problem and identify the preferred patterns in art and architecture. The quadruple model is like a framework in which all variables from various parts (environmental variables, subject variables, contexts and situations, and responses) and the existing relationships between them are presented. In addition, this model offers specific tools for analyzing the data and can adapt to the theoretical foundations (i.e. foundations of visual perception) and being affected by them.

Ethical Considerations

Compliance with ethical guidelines

This article is a review study with no human or animal sample.

Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

Authors' contributions

Study design: Mohsen Dehghani Tafti, Masoud Ahmadzad-Asl, and Gholamhossein Memarian; Writing the original draft: Mohsen Dehghani Tafti, Mehrnaz

Fallah Tafti, and Sarvenaz Soltani ; Review and revise: Farhang Mozaffar revised the draft.

Conflict of interest

The authors declared no conflict of interest.

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