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Enhancing Citizens' Perceived Restoration Potential of Green Facades through Specific Architectural Attributes

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Abstract: Research on restorative environments has suggested green facades as a promising model for natural spaces in urban and densely populated areas. However, the impact of architectural design attributes of green building facades on perceived restoration potential is insufficiently researched. Therefore, this study aimed to investigate the relationship between architectural design attributes of green building facades and perceived restoration potential. A discrete choice experiment was used. First, seven architectural design attributes (Value, Symmetry, Material, Balcony, Variety, Configuration, and Shape) were identified based on the Content Identifying Method. In the next step, a sample of 204 participants randomly selected a block and evaluated the perceived restoration potential of six pairs of designed images of different green facade scenarios based on the seven architectural design attributes. The results showed that low diversity in greenery was associated with greater influence, and people chose asymmetric greenery more often. Horizontal and scattered greenery was preferred over vertical and concentrated greenery, which had no significant effect on perceived restoration potential. Stone and cement used in green facades were the most influential factors in perceived restoration potential. These findings can aid designers in designing the green facade of residential buildings to increase perceived restoration potential.

Keywords: biophilic design; mental health; restorative environment; mental fatigue; stress reduction; attention fatigue; attention restoration theory; calm and connection theory

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1. Introduction

Urbanization has led to a significant increase in the number of people living in cities. While urban living offers many benefits, including access to employment opportunities, education, healthcare, and social services, it also comes with several challenges [1,2]. One of the most significant challenges is the lack of access to natural green spaces, which can have negative impacts on mental health and well-being. Urban residents who lack access to green spaces are more likely to experience stress, anxiety, and depression, which can lead to a range of physical and mental health problems [3].

Green facades, also known as living walls or vertical gardens, are an innovative solution to the problem of urban green space. These structures are made up of plants that grow vertically on the exterior walls of buildings, creating a green surface that can have positive effects on mental health and well-being by promoting restoration and reducing stress and mental fatigue [4,5]. The potential benefits of green facades in promoting mental health and well-being have led architects and urban planners to incorporate them into building designs [6]. By incorporating green facades into building designs, architects and urban planners can create buildings that not only provide shelter but also contribute to the physical and mental well-being of residents [7]. Our interest is based on architecture and environmental psychology and concerns how facades with vegetation are experienced when viewed. In doing so, we want to include a broad palette of buildings found in urban environments today, which includes living walls and green facades, but also balconies with vegetation, planter boxes, etc. In the search for specific architectural attributes, we have thus broadened the range. In this article, green facades must therefore be understood in the broadest sense.

Of greatest interest in this context are those attributes in the architectural design of green facades can contribute to increasing residential buildings' perceived restoration potential. Despite the possible impact of green facades on the restorative potential of citizens, according to our assessment, there is a knowledge gap about the details of how green facades should be designed. The aim of this study is to investigate how different architectural designs of green facades can affect people's restoration potential. The objectives are partly to identify important attributes for green facades on residential buildings and partly to explore a model of the relationship between these attributes and their restorative potential.

The methodological considerations we made included several steps. To identify important attributes, a literature study was first carried out. The result of this could give us important clues about what to expect from the first experimental study: the Content Identification Method (CIM). The purpose of CIM was to identify groups of important architectural attributes. It is a reliable and frequently used method in architecture and environmental psychology, in which subjects judge a large selection of images. The result is interpreted based on the content of images and literature. The outcomes of this study will be used as stimuli in the second experimental study.

The second objective was to explore a model of the relationship between found architectural attributes and people's restoration potential. We needed to use a simple, valid and reliable self-assessment method regarding restorative potential. One such method that has long been used in environmental psychology research is Perceived Restorative Potential (PRP), which we chose to use in this study.

In order to accomplish the aim of the study, i.e., which architectural attributes in green facades have the greatest positive impact on perceived restoration potential, subjects need to be able to reliably make choices between different environments. The method we apply is the Discrete Choice Method (DCM), in which a sample of the study participants is presented with a set of images and asked to choose an option. It is a method that is reliable and is increasingly used in many different scientific fields.

2. Literature Review

2.1. Theories about the Restorative Impact of Green Environments

Numerous studies confirm that natural environments positively affect people's psychological and physiological well-being [8,9]. Green spaces have been shown to have better restoration effects than urban built settings, supporting the role of natural elements in increasing the restoration of the urban landscape [9,10]. Due to people's lack of access to natural landscapes, parks and green spaces in cities have been introduced as restorative environments that enhance natural beauty and increase perceived restoration potential [11].

Attention Restoration Theory (ART) proposes that focusing on interesting and soft fascinating stimuli can alleviate cognitive inhibitory mechanisms, and sustained fascination can be achieved when the environment is perceived as coherent and extended [12,13]. Restorative settings, which include natural environments, offer opportunities for recovery of directed attention [13,14]. Attention recovery is characterized by four key components, including mystery, which refers to an environment's ability to inspire curiosity in individuals. Restoration is facilitated when individuals can engage in effortless, interest-driven involuntary attention while interacting with their environment [13]. Calm and Connection Theory [15] suggests that enriched natural environments in cities can lead to reduced stress, increased calmness, and vitality, making residents feel a greater sense of belonging and being at home in the city. In dense urban environments, enriched natural elements consisting of diversified, cultural elements can be experienced by all the senses, which increase the possibility of calmness and connection. In addition to sight, it is about hearing, touch and the perception of movement, which softens the static impression of house bodies and creates vitality, curiosity and joy [16].

In summary, ART and CCT provide insights into the restorative benefits of natural environments and highlight the importance of soft, fascinating impressions from an enriched, diversified natural environment, which can enhance opportunities for recovery from directed attention fatigue and high levels of stress. Incorporating green spaces into urban landscapes using green facades can increase the restoration potential of cities and improve people's well-being.

2.2. Building-Integrated Vegetation

In recent decades, the increase in population and urbanization rates have led to a change in the pattern of human habitation. The shift from horizontal to vertical living has resulted in the construction of towers and skyscrapers, which have caused numerous problems. One of the major issues is the rise in environmental stressors and information overload [11,17–19]. Furthermore, the surrounding urban space has become a mechanical, and artificial environment, with artificial areas expanding at a faster rate than natural areas. As a result, traditional life has transformed into apartment living without any access to natural spaces. Additionally, the construction of buildings and the limitation of land for planting plants have deprived citizens of the opportunity to use natural spaces [20].

Integrating nature into high-rise buildings in densely populated areas with limited green space represents an innovative and sustainable solution for green infrastructure in cities [21]. Integrating buildings with vegetation has become a necessity in many metropolises worldwide, expanding the potential of vertical, horizontal, external and internal spaces to accommodate plants. This is particularly discussed in biophilic design [22]. As a result, several studies have suggested implementing vertical gardens and green facades to replace natural spaces in cities with limited greenery [23,24]. These restorative features can effectively reduce mental fatigue and stress levels, ultimately improving people's quality of urban life.

Aletta et al. [25] conducted a study on the benefits of vertical greening in urban areas, which promotes the coexistence of architecture and nature. The findings suggest that vertical gardens can enhance restoration and improve overall well-being in the urban environment, thereby increasing the quality of urban life. The researchers recommend the implementation of vertical gardens as a tool to increase green areas, alter the physical landscape, enhance architectural features, and promote restoration, particularly in dense urban spaces with limited green areas [26]. Similarly, Kozamernik et al. [27] conducted a study on the perception of green facades in urban environments and found that a greener urban environment is generally considered more pleasant, with most people believing that the vertical greenery system improves the quality of urban areas.

Previous studies have also demonstrated that green facades have a positive impact on human well-being and the environment. For instance, research has shown that green facades can improve air quality, reduce noise pollution, and regulate temperature [24]. Additionally, studies have found that incorporating vegetation into residential facades can enhance the aesthetic appeal of buildings and promote restoration, with green facades being perceived as more beautiful and restorative than those without [4]. However, despite these benefits, many residential areas still rely on potted plants on balconies or windowsills to create green facades due to economic, social, and geographical constraints.

The design of residential building facades plays a crucial role in shaping the urban environment and people's daily experiences [28]. Aesthetically pleasing facades contribute to the overall attractiveness of a city, while unappealing ones can have the opposite effect [29]. Given the diversity of ownership and personal taste in facade design, it is important to explore innovative solutions to improve the livability of urban spaces [30]. One promising approach is the use of green facades, which can provide numerous benefits for residents. To better understand the impact of green facades on restorative potential, it is necessary to identify the key design attributes that are most effective in promoting positive residential perceptions.

2.3. People's Preferences for Architectural Features of Building Facades

In the literature review, it can be argued that although previous studies on restoration may not have directly addressed the identification of architectural features for green facades, information on environmental preferences can still provide valuable insights to inform this process. By analyzing individuals' preferences for green facades and their associated characteristics, the architectural components that contribute to these preferences can be identified. This can be used to extract relevant architectural features, although the specific focus of these studies was not on restoration.

The approach of using preference studies to identify architectural features can be considered valid and valuable. First, the use of this approach can result in the identification of important features that may have been overlooked in previous studies of restoration. Ultimately, incorporating these features into the restoration process can lead to more successful and sustainable restoration outcomes. Second, research studies show significant relationships between environmental preference and restorative qualities, indicating that environments with higher restorative qualities tend to be preferred by individuals [31].

Natural areas are often preferred over urban built environments due to their ability to regenerate and restore individuals [32]. Preference and choice are emotional responses to the surrounding environment, reflecting cognitive processes and perception. Understanding human perception of the environment requires an understanding of preference as an indicator of behavior and perception. Therefore, people's interaction with their surroundings is influenced by their preference for a particular place or landscape, which can create a sense of place for specific settings [33].

The literature review showed that specific attributes of greenery lead to more preferred and perceived beauty. *Greenery* has been identified as the most important factor in people's preferences, as *higher amounts of greenery* in streets have been associated with increased willingness to ride bicycles [34] and pay for residences on those streets [35]. The element "many trees" has the greatest effect on preferences, while the element "some trees" has a lesser effect [36]. Studies have also shown that the more available green spaces a residential area contains, the higher the preferences. Proximity, accessibility and quality can lead to the preference for green spaces varying within a residential block [37]. Moreover, higher vegetation cover has been found to increase the probability of restoration [11], and greater variation in perceived qualities of greenery has been shown to lead to more outdoor activities, higher neighborhood satisfaction, and better self-rated health among residents [38].

Research has shown that while *symmetry* is generally preferred in shapes and faces, natural landscapes without complete symmetry are preferred over those with two-way symmetry [39]. Additionally, the role of symmetry in the aesthetic judgment of residential buildings is influenced by people's expertise in architecture, with symmetrical facades corresponding to the taste of nonexperts [40]. However, a preference for symmetrical and complex stimuli may vary among nonartistic individuals [41]. Nevertheless, most studies suggest that visual qualities such as symmetry are influential in determining visual preferences for architectural views.

The relationship between *architectural elements* and visual preferences has been studied extensively. Researchers have found that the *diversity of architectural elements* in facades correlates positively with increased preference for windows. Additionally, the *variety of plants* in a residential area can also impact participants' preferences [36,42]. van Dongen et al. (2019) discovered that horizontal greenery had a greater impact on residential streets than vertical greenery, and concentric configurations were generally less preferred [43]. Chen (2011) listed various spatial arrangements and noted that each creates a distinct sense of place. For instance, a *concentrated organization* with a tree in the center can serve as a dominant space, while a linear organization encourages movement in a straight line and offers a powerful perspective [44].

Furthermore, the choice of *materials* for green facades can also affect people's preferences. Research has indicated that architects tend to prefer brick and cement facades, while nonarchitects prefer stone facades [45]. Materials not only contribute to the identity of the facade but also play a crucial role in creating visual elements that evoke historical or modern perspectives. Therefore, designers should carefully consider the materials used in creating green facades to ensure that they enhance the aesthetic appeal of the urban environment and meet people's preferences [46].

Recent research highlights the potential of terraces and *balconies* as highly desirable features of apartment buildings in subtropical cities like Australia. Private outdoor spaces, such as balconies, contribute significantly to residents' perception of livability, offering additional living space for a range of daily indoor activities [47]. With the reduction of vegetation in inner-city areas and increasing densification, these spaces are becoming increasingly important for restoration with appropriate greenery [23]. The absence of a balcony or garden can directly impact life satisfaction, leading to a desire to move [2].

3. Methods

3.1. The Content Identifying Method

The Content Identifying Method (CIM) was developed by Stephen Kaplan and colleagues [48,49]. It involves having a selection of study participants' rating images to obtain information about people's preferences for features and qualities in the landscape. In the procedure, study participants are asked to rate a series of landscape scenes based on their *preferences* for each scene. After the subjects have rated the images, the data are processed with exploratory factor analysis. The aim of a factor analysis is to reveal underlying phenomena that explain relationships between several outcomes, in our case, architectural attributes. We used SPSS exploratory factor analysis, principal component analysis with varimax orthogonal rotation, where each factor has an eigenvalue greater than or equal to one [50].

The result of the analysis will be a number of groups of images. Each group of images has been judged similarly by the subjects, where some essential attribute or quality of the images has brought them together into the group. The higher the factor loading of an image, the more clearly the essential attribute appears in that image. Images with a factor loading of 0.40 and higher are included in each group. These groups of images are analyzed and interpreted based on their content and spatial qualities by researchers. In our case, the interpretation was based partly from our literature review and partly from acquired knowledge as architects, to reveal people's responses to input stimuli.

CIM is based on people's preferences and is considered reliable, because preference decisions are easy for people to make because people make many preference decisions for their daily routines. That is, people's reactions to environments are not solely based on immediate feelings but also on perceptual–emotional categories that are somewhat general. However, studies have shown that familiarity with a place can impact environmental priorities [51,52]. Additionally, research has found that the preferences of residents and visitors to a place may differ. Therefore, when conducting environmental preference studies including pictures, it is important to consider the familiarity of participants with the stimuli presented [53].

The steps involved in the CIM include questionnaire design, involving the scene collection procedure, the scene selection procedure, and the scene presentation procedure. Data collection was performed using a photo-questionnaire. A photo questionnaire is an excellent approach to show the natural environment [54–57]. In order to gauge people's preferences for green facades on residential buildings, a collection of images depicting various types of green facades was obtained through a stratified selection process. As all the images were sourced from virtual space, there was a wide range of designs and styles represented in the green views. This allowed for a comprehensive assessment of people's preferences for different types of green facades, and provided valuable insights into the most popular styles and designs. Overall, this study highlights the importance of incorporating greenery into urban environments, and the potential benefits that can be derived from doing so.

More than 200 images of residential buildings of green facade were collected, and 100 images taken from the front view were ultimately selected. These photos were grouped based on their similarity, and a researcher supervision committee was responsible for this process to reduce bias and increase the questionnaire's validity. After this process, 32 images were selected for use in the survey questionnaire. After reaching this set of 32 images, four additional images at the beginning and another four at the end of the image sequence were added. The purpose of the first four images was to familiarize participants with the image rating method, while the final four images helped prevent participants from predicting subsequent images [55]. Participants were asked to rate their preferences using a scale ranging from one to five (1 = I do not like this scene, to 5 = I like this scene very much).

SPSS software (Version 26) was utilized in this study to analyze questionnaire data. Descriptive analysis was employed to gather demographic information about the participants. Based on the preferences of the students, a mean analysis was conducted, and the landscape patterns were ranked accordingly. The scenes were categorized into groups to reduce the amount of information based on these patterns. To classify scenes that were similar to one another based on loading factor, exploratory factor analysis was carried out using principal component analysis, with an internal consistency threshold of above 0.7 recommended. This method has been used in many research studies [57–60].

Study Participants

The participants in the CIM study had different backgrounds in terms of gender, age and education level. There were 39 males (39%) and 61 females (61%). Participants were in the age group of 15–20 years (n = 18, 18%), followed by 21–25 years (n = 38, 38%), 26–30 years (n = 18, 18%) and above 30 (n = 26, 26%). The majority of participants were between 21 and 25 years old. Participants' education level was as follows: high school (n = 7, 7%), diploma (n = 25, 25%), associate degree (n = 18, 18%), Bachelor of Science (n = 38, 38%), Master of Science (n = 9, 9%) and Doctorate (n = 3, 3%) (Table 1).

Table 1. Sample Classification for CIM study.

	Classification	**Frequency Percentage (%)**
Gender	Male	39
	Female	61
Age	15–20 years old	18
	21–25 years old	38
	26–30 years old	18
	Over 30 years old	26
Education	High school	7
	Diploma	25
	Associate degree	18
	Bachelor of Science	38
	Master of Science	9
	Doctorate	3

3.2. The Perceived Restorative Potential

One overarching object of the study was to measure overall perceived restorativeness; that is, how much a study participant would agree that a certain place would be great to take a break in, restoring from high stress levels and mental fatigue. A valid and reliable single measure of overall perceived restorative potential was developed by Herzog et al. [14], who asked students to recall a time when sustained effort led to fatigue, and then rate how good different locations would be for taking a break and restoring the ability to work effectively on a project. Since then, the Perceived Restorative Potential (PRP) measure, has come to be used increasingly frequently, and refers to restoration from both directed attention fatigue and high stress levels [61].

In this study, participants were first instructed to imagine walking home alone in the afternoon after a mentally taxing day at work. Next, they chose the image they thought would be most restorative. Perceived restorative potential was measured by instructing subjects to do the following: "Remember a time when you felt overwhelmed, stressed, tired, and anxious. Reflect on how you felt at that moment and put yourself in that mindset. Continue to reflect on this mindset when you look at the pictures and imagine yourself in each setting. For each of the pictures presented, rate the degree to which you think it would be a good place for you to take a break and make you feel less stressed and anxious to be in that environment."

3.3. The Discrete Choice Method

To investigate the relationship between the green facade of a residential building and PRP, a discrete choice experiment was conducted. The Discrete Choice Method (DCM) is a popular approach for studying people's preferences in a variety of fields [62], including environmental economics, tourism, marketing, transportation, and health [63–67]. In our case, we did not ask for the subjects' preferences, but, instead, asked for their estimate of the Perceived Restorative Potential (PRP) as described above.

In this method, respondents are presented with a set of choices and asked to select one option [68]. Each option in the set represents a different combination of attributes that describes a desired product or service. These attributes are assigned different levels, allowing researchers to examine how changes in the attributes affect people's choices. An attribute can be, for example, a tree in the image. The level can then be 1 = there are trees, or 0 = there are no trees. The levels can also be missing = 0, few = 1 and many = 2. One of the main steps in this method is to determine the attributes and their levels. In this study, we used the Content identifying method (CIM) for this purpose. A full factorial design takes into account all possible combinations of attributes and levels. A full factory design is appropriate when there are only a few components to consider. However, when there are many components to consider, and when many possible combinations probably have little effect, a calculation of a subset of important combinations, a so-called fractional factorial design available in the ADX Interface SAS/QC, allows an estimation of the main effects, giving a better opportunity to focus on them [69,70].

The images used in this experiment were generated using Photoshop and SketchUp software (SAS Version 9.2), in order to include the attributes and levels that CIM resulted in. The validity of using images instead of real environments is high, and research show no significant differences between preference ratings of images versus actual environments [53,54].

3.3.1. Questionnaire Design

We used online questionnaire for data collection. The questionnaire was divided into two parts: the first part focused on gathering demographic information such as gender, age, marital status, education, and occupation. The second part utilized a visual discrete choice experiment. Respondents were randomly assigned to a block of 6 sets, each with three options: option 1, option 2, and none. Participants were presented with different scenarios and asked to select the option that maximized their utility based on their perceived restorative potential, PRP. The desirability of each option was determined by its attributes, which were presented visually rather than textually. Participants were instructed to imagine walking home alone in the afternoon after a mentally taxing day at work, and to choose the image that they believed would be most restorative. The questionnaire consisted of six series of questions, each containing two suggested options and a "none" option to prevent respondents from feeling forced to choose an option and to reduce the possibility of exaggerated preferences. Each respondent made six choices in total.

3.3.2. Study Participants

The participants in this study had diverse backgrounds in terms of gender, age, education level, marital status, and occupation. There were 60 male participants, accounting for 29% of the total sample, and 144 female participants, accounting for 71% of the total sample. They were divided into different age groups: 8% (16 participants) were between 15 and 20 years old, 33% (68 participants) were between 21 and 25 years old, 23% (47 participants) were between 26 and 30 years old, and 36% (73 participants) were 30 years old or older. Fifty-one percent (110 participants) of the participants were single, and 49% (94 participants) were married. Participants' education level was as follows: undergraduate (n = 56, 26.5%), Bachelor of Science (n = 99, 48.5%), Master of Science (n = 39, 19.5%) and Doctorate (n = 10, 5%) (Table 2).

Table 2. Sample Classification for DCM study.

	Classification	**Frequency Percentage (%)**
Gender	Male	29
	Female	71
Age	15–20 years old	8
	21–25 years old	33
	26–30 years old	23
	Over 30 years old	36
Relevance	Single	51
	Married	49
Education	Undergraduate	26.5
	Bachelor of Science	48.5
	Master of Science	19.5
	Doctorate	10.5

3.3.3. Data Analysis

According to the data analysis, the multinomial logit (MNL) model was used, which is suitable for discrete choice tests. The multinomial logit model is called multinomial choice as one of the discontinuous selection models. The essential feature of the multinomial logit model is that the assumptions related to the probability distribution of error sentences suggest the hypothesis of independence of unrelated options. In other words, the relative choice of two options depends only on their usefulness. First, the necessary data for the parameters in the mathematical relationships of this model should be generated to use the logit model and define the significance of variables after solving the model. The probability and type of influence (positive or negative) of each of the significant variables on the dependent variable (revival) was obtained.

More choices are considered in the multinomial logit model, which is defined with the assumption that the error sentences are independent of each other and have Gamble distribution (Equation (1)).

$$P_{in} = \Pr(y_n = i) = \frac{\exp(v(x_{in}\ \beta)}{\sum_{i=1}^{i} \exp(v(x_{in}\ \beta)} \quad (1)$$

According to the researcher, the probability that a person chooses an option is between zero and one (zero to 100%). The outcome of the decision is represented by y for each choice set. The probability of selecting an option tends to be one as the observed utility increases, and zero if the utility decreases [71].

$$\underset{v \to \infty}{\mathrm{Lim}} \Pr(y = 1) = 1 \quad (2)$$

$$\lim_{v \to \infty} \Pr(y = 1) = 0 \quad (3)$$

One level (level 1) is removed from each variable. Other levels are defined relative to the removed level to analyze the results because the information is entered as 0 and 1 for each feature.

A Dummy coding method was used for this analysis. For example, 1 = no similarity, 2 = similarity; 1 = centralized, 2 = decentralized; 1 = brick material, 2 = cement material, 3 = stone material; 1 = low volume, 2 = medium volume, 3 = high volume; 1 = horizontal shape, 2 = vertical shape; 1 = diversity, 2 = no diversity; 1 = absence of a balcony, 2 = presence of a balcony.

3.4. Main Survey Process

Due to the impact of COVID-19, an online survey questionnaire was used to collect data, which was created and administered through the Porsline.ir website. To encourage participation, nonmonetary incentives were offered, as is common in web-based surveys. The questionnaire was designed using an online platform that allows for easy creation, editing, and promotion of surveys. The survey was widely distributed through social media, including WhatsApp, Telegram, and Instagram, which have been used successfully in previous studies, allowing for maximum reach with minimal time and cost. CIM and DCM questionnaires were uploaded to Porsline Website and a questionnaire link was generated and sent to people.

4. Results

4.1. The Content Identifying Method

4.1.1. Participants' Preferences for Green Facades

Figure 1 shows that scene 2 (M = 28.4, S.D. = 0.80) was the most preferred scene according to the participants followed by scene 26 (M = 4.15, S.D. = 0.71), scene 5 (M = 4.05, S.D. = 1.02), scene 11 (M = 4.03, S.D. = 0.95) and scene 21 (M = 4.02, S.D. = 0.84). The scenes illustrated the medium value and liner greenery. The majority of these scenes have horizontal greenery (scenes 2, 11 and 21), symmetry (scenes 2, 26 and 21) and four scenes (scenes 2, 26, 5 and 21) have stone and cement material. Scene 2 has the highest mean, so facades with medium value, liner, symmetry and horizontal greenery and stone and cement material have the most preferences.

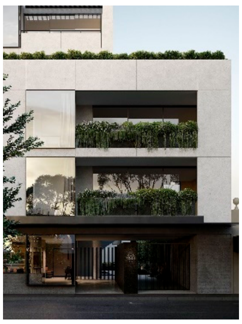
Scene 2	Scene 26	Scene 5	Scene 11	Scene 21
				
M = 4.28, S.D. = 0.8	M = 4.15, S.D. = 0.71	M = 4.05, S.D. = 1.02	M = 4.03, S.D. = 0.95	M = 4.02, S.D. = 0.84

Figure 1. Five most-preferred scenes for the greenery on façades.

Figure 2 shows scene 18 (M 1/4 1.59, S.D. 1/4 0.79) as the least preferred scene of green facades followed by scene 17 (M 1/4 1.63, S.D. 1/4 0.83), scene 25 (M 1/4 0.67, S.D. 1/4 1.74), scene 1 (M 1/4 2.01, S.D. 1/4 1.11) and scene 15 (M 1/4 2.15, S.D. 1/4 1.01). These scenes have a low value and scattered greenery. The majority of these scenes have no symmetry (scene 25, 1 and 15) and no greenery on both sides (scenes 18, 17 and 1). Thus, high value, greenery on both sides, symmetry and horizontal greenery are important for facades.

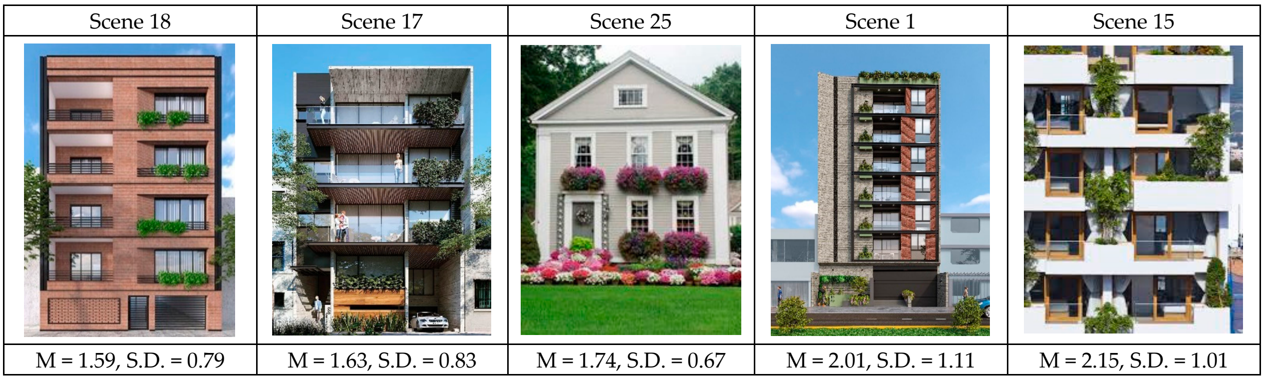


Figure 2. Five least-preferred scenes for the greenery on facades.

4.1.2. Factor Analysis Output into Green Facades Scenes

The first factor (high value of greenery) had the highest mean (3.87), explained variance of 7.46 and reliability coefficient of 0.93 with three scenes of a high amount of greenery on facades. The second factor (stone and cement material) had a mean of 3.74, 7.16 explained variance and 0.63 as a reliability coefficient with four scenes of greenery on facades. The third factor (one-sided) with a mean of 2.45, an explained variance of 5.8, and 0.45 as a reliability coefficient, contained four scenes of green facades (Table 3).

Table 3. Factor scenes based on factor analysis.

	Scene	Mean	S.D.	Factor Loading	Variance Explained
High value	-	**3.87**	**0.93**	-	**7.46**
	Scene 5	4.05	1.02	0.73	
	Scene 9	3.7	1.2	0.68	
	Scene 16	3.8	1.16	0.43	
Stone and cement material	-	**3.75**	**0.63**	-	**7.16**
	Scene 24	2.88	1.33	0.59	
	Scene 2	4.28	0.8	0.55	
	Scene 21	4.02	0.84	0.43	
	Scene 13	3.81	1.16	0.41	
One side	-	**2.45**	**0.45**	-	**5.8**
	Scene 23	2.3	0.83	0.65	
	Scene 27	2.36	0.65	0.57	
	Scene 10	2.22	1.31	0.47	
	Scene 18	1.59	0.79	0.42	
Concentrated	-	**2.74**	**0.4**	-	**5.73**
	Scene 12	3.08	0.72	0.59	
	Scene 19	4.01	1.05	0.53	
	Scene 25	1.74	0.67	0.53	
	Scene 15	2.15	1.01	0.41	
	Scene 31	3.6	1.08	0.42	
Symmetrical	-	**3.75**	**0.68**	-	**5.48**
	Scene 14	3.8	1.1	0.63	
	Scene 6	3.75	1.38	0.6	
	Scene 7	3.71	1.2	0.55	
Greenery in the balcony	-	**3.14**	**0.56**	-	**5.42**
	Scene 20	2.93	0.98	0.57	
	Scene 4	3.01	0.75	0.56	
	Scene 32	3.49	0.81	0.56	
Repetition	-	**3.15**	**0.58**	-	**5.00**
	Scene 3	3.15	0.77	0.6	
	Scene 1	2.01	1.11	0.49	
	Scene 22	3.85	1.07	0.48	
Vertical	-	**2.94**	**0.49**	-	**4.62**
	Scene 26	4.15	0.71	0.7	
	Scene 29	3.06	1.19	0.64	
	Scene 17	1.63	0.83	0.51	

The fourth factor, 'concentrated', with a mean of 2.74, explained variance of 5.73, and 0.4 as a reliability coefficient included five scenes of greenery on facades. The fifth factor, 'symmetry', with a mean of 3.75, explained variance of 5.48, and 0.68 as a reliability coefficient, included three scenes of greenery on facades. The sixth factor, 'greenery in the balcony', with a mean of 3.14, explained a variance of 5.42, and 0.56 as a reliability coefficient, included three scenes of greenery on facades. The seventh factor, 'repetition', with a mean of 3.15, explained a variance of 5.00, and 0.58 as a reliability coefficient included three scenes of green facades. Finally, the eighth factor, 'vertical' with a mean of 2.94, 4.62 as explained variance and 0.49 as a reliability coefficient, included three scenes of green facades (Table 3).

4.1.3. Preference for the 'factors' of the Green Facade

'High value of greenery' has the highest mean (M ¼ 3.87, S.D. ¼ 0.93), followed by 'symmetry' (M ¼ 3.75, S.D. ¼ 0.68), 'stone and cement material' (M ¼ 3.74, S.D. ¼ 0.63), 'repetition' (M¼ 3.15, S.D. ¼ 0.58), 'greenery in the balcony' (M¼ 3.14, S.D. ¼ 0.56), 'vertical' (M¼ 2.94, S.D. ¼ 0.49), 'concentrated' (M¼ 2.74, S.D. ¼ 0.4) and 'one-side' (M¼ 2.45, S.D. ¼ 0.45). High value of greenery has the highest mean and all scenes in this factor show a high and medium value of greenery. Greenery on one side has the lowest mean and all the scenes include greenery on one side of the facade.

4.1.4. Content Analysis of Factors for the Green Façade

Figure 3 shows the architectural design attributes in the facades of the buildings, which includes 28 scenes in eight facade factors. The first factor (high value of greenery) includes three scenes, which have no disturbances and the main feature is the high amount of greenery in the view. The second factor (stone and cement facade material) includes four scenes, because stone and cement materials are used in addition to greenery in the facade. The third factor (one-sided greenery) includes four scenes. In these pictures, greenery is on one side of the view, yet greenery is not visible on the other side. The fourth factor (concentrated greenery) includes five scenes in which greenery is placed in specific points of the view and no linear or integrated pattern can be seen. The fifth factor (symmetrical greenery) includes three scenes, which have relative greenery with a horizontal or vertical line of reference. The sixth factor (greenery in the balcony) consists of three scenes, in which the greenery is in the door of the balcony and less greenery is seen in front of the window. The seventh factor (repetition in greenery) consists of three scenes, in which repeated greenery has a specific pattern without variation. The eighth factor (vertical greenery) includes three scenes, in which greenery is seen in as vertical lines or next to each other on different floors.

The content analysis results of these senses showed that people prefer the green view with a large or medium amount of greenery. Furthermore, facades with repetition in greenery were associated with a higher preference, and the preferred material used next to the greenery in the green facade was stone and cement. The balcony on the facade and the placement of greenery on the balcony of the building is preferred. Concentrated greenery is preferred on the facade. The greenery of a building is better to be designed horizontally, and people seem to prefer something more than greenness that is visible vertically.

Figure 3. Facade scenes based on factor analysis.

Based on the literature review and result of CIM, seven variables were selected for use in DCM (Table 4). The CIM method was used based on the research background, which emphasized the importance of high value, a large amount of greenery and symmetrical greenery of the facade. Furthermore, people prefer green facades with stone and cement materials and the presence of greenery on the balcony, while facades with concentrated greenery are the least preferred. Moreover, a green facade of a building is better to be designed horizontally, and people prefer something more than greenery that is visible vertically. Therefore, according to the obtained results, the proposed theoretical model is presented (Figure 4).

Table 4. Architectural design attributes used in DCM on green facades.

Attributes	Levels	References
Value	Low, Medium, High	[14,34–37,72–74]
Symmetry	Exist, Non exist	[39,40,46]
Material	Brick, Cement, Stone	[46,47]
Balcony	Exist, Non exist	[2,21,47]
Variety	Exist, Non exist	[75,76]
Configuration	Concentrated, Scattered	[43,44]
Shape	Vertical, Horizontal	[43,44]

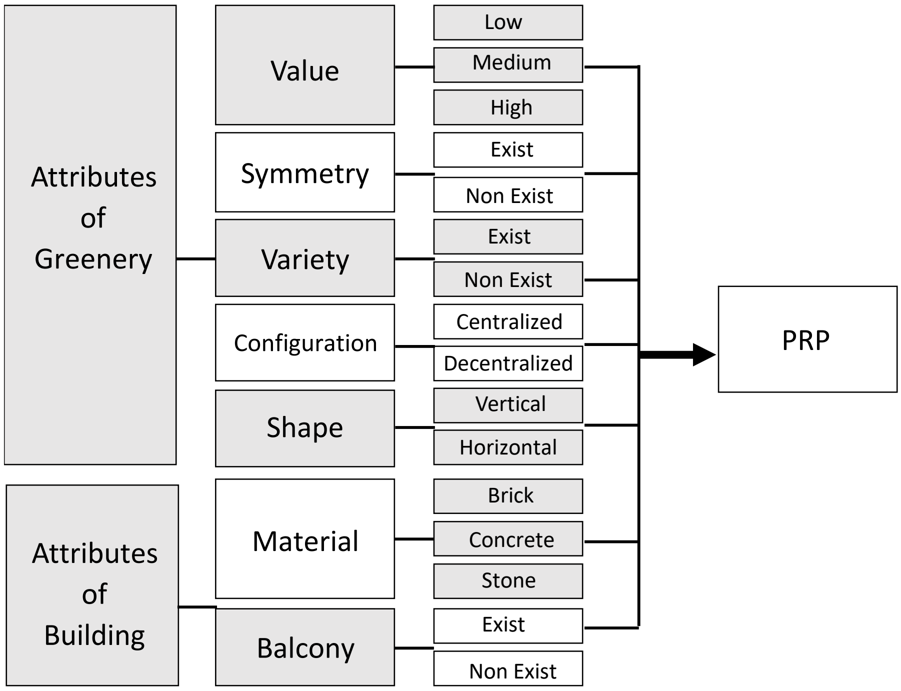


Figure 4. Theoretical model.

According to the results of the literature review and CIM, the following model was suggested:

4.2. Discrete Choice Method

In the Discrete Choice Method, seven attributes where utilized as independent variables, as outlined in Table 4. To ensure optimal results from the data, the test design is critical [77], and a complete factorial design would require all possible combinations of levels and components ($3 \times 2 \times 3 \times 2 \times 2 \times 2 = 228$). However, due to the complexity of the variables and levels involved, a fractional factorial design was employed using SAS 9.2 SAS/QC ADX Interface software to reduce the number of scenarios to 72 in six blocks, each comprising six sets with three options (option one, option two, and none). Images were generated using Photoshop and SketchUp software for each option, with the base view selected from the top five views in the CIM test. The design was produced according to the results of SAS 9.2 software, with the building facade attributes fixed except for the variables used in the design. Figure 5 provides an example of a choice task with seven variables in a discrete choice experiment.

set	alternative	value	symmetry	material	balcony	variety	configuration	shape
1	Picture1	2	2	2	2	1	1	1
	Picture2	3	1	1	1	2	2	2

Figure 5. Overview of different levels for two images: (**left image**) medium value, symmetrical, cement material, presence of balcony, variability, concentrated and horizontal greenery. (**right image**) high value, no symmetrical, brick material, absence of balcony, no variability, scattered and vertical greenery.

An MNL was run the investigate the relationship between attributes of design green facades and PRP. The results of Table 5 show that all the attributes significantly affect the utility of green facades except for materials and architectural style (traditional). A positive sign of the coefficients throughout the model means that a higher value of the variable increases the probability of choosing a visual attribute compared to the reference level. Based on the results in Table 5 regarding greenery attributes, the respondents preferred asymmetry over symmetry in green facades (β = 0.75, $p < 0.00$). In terms of shape attributes, due to the negative effect coefficients, participants preferred vertical over horizontal green facades (β = −0.26, $p < 0.003$). A variety of greenery was also found to be significant (β = −0.48, $p < 0.00$). That is, the more variety, the lower the perceived restorative potential. The result of the value attribute showed that participants preferred high value over low value (β = 0.63, $p < 0.00$); however a medium effect value of variability in greenery was also found to be significant (β = 0.224, $p < 0.051$). In addition, they also preferred scattered greenery on the facades over concentrated greenery on the facades (β= 0.559, $p < 0.0001$). Regarding facade attributes, stone and cement material were preferred over greenery attributes (β Stone = 0.995, β cement = 1.792, $p < 0.00$). The result for the balcony was not found to be significant at $p < 0.05$. Table 5 shows that the stone and cement material for facades were preferred over greenery attributes. Stone had the most positive influence on preference, followed by cement. Among greenery attributes, no symmetry and high value had the most effect, followed by no variation in greenery. Vertical, medium value and scattered had the lowest values (Figure 6).

Table 5. Relationship between attributes of design green facades and PRP.

	Attributes	Base Level	Coef.	Std. Err.	z	p	[95% Conf.-Interval]	
Greenery	**Symmetry**							
	No choice		0.237	0.171	1.39	0.165	−0.098	0.574
	No Exist	Exist	0.747	0.091	8.17	0.00	0.568	0.927
	Shape							
	Vertical	Horizontal	-0.262	0.089	2.92	0.003	−0.438	−0.086
	Value							
	Medium	Low	0.224	0.115	1.95	0.051	−0.001	0.45
	High		0.633	0.11	5.75	0.00	0.417	0.85
	Variety							
	Exist	No exist	0.483	0.9	5.32	0.00	0.661	0.304
	Position							
	Scattered	Concentrated	0.188	0.089	2.1	0.036	0.0125	0.365
Facade	**Material**							
	cement	Brick	0.995	0.115	8.63	0.00	0.769	1.222
	Stone		1.792	0.114	15.68	0.00	1.568	2.017
	Balcony							
	presence	absence	0.17	0.9	1.88	0.06	−0.007	0.348
	Model specification							

Number of obs = 3672, LR chi2 (10) = 633.25, Prob > chi2 = 0.000, Pseudo R^2 = 0.1355, Log likelihood = −2020.6572.

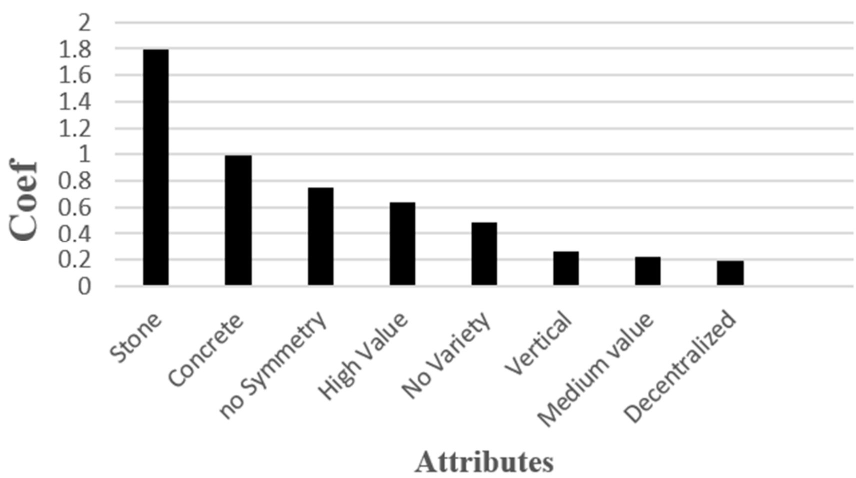


Figure 6. Preference for architectural design attributes of green façades.

5. Discussion

This study aimed to investigate which architectural attributes of green facades improve people's perceived restorative potential. Knowledge of this can be used by practitioners in architecture and urban planning to increase people's opportunities for recovery from high stress levels and attention fatigue as well as promote people's mental well-being in urban landscapes.

First, the results show that *a medium to high amount of greenery* on facades can improve people's perceived restorative potential. The amount of greenery is the most critical variable in people's preferences, and this is in line with previous studies. There are several examples, such as higher levels of greenery in streets lead to an increased preference for cycling [34] and willingness to pay for residences on those streets [35]. Furthermore, the element "many trees" has a more significant effect than "some trees" on preferences [34,36] Similarly, Zhang et al. (2017) found preferences for greenery in different parts of a residential block, with a greater preference for a higher value of greenery [37]. In addition, studies show that greenery in the workplace, for example greenery visible through windows, significantly affects workers' recovery potential from stress levels [73]. A study also revealed that a high value of greenery on the facade contributes to higher PRP [14]. Research has shown that increased vegetation has a more restorative effect, and people generally prefer natural environments to urban settings, highlighting the need for nature in human lives [74].

Furthermore, the study found that *asymmetric greenery* positively affects people's perceived restorative potential. This finding was unexpected. While studies have shown a general preference for symmetry in shapes and faces, natural images without complete symmetry are preferred for landscapes [39]. Symmetrical greenery may be perceived as unnatural, and according to our results, does not positively affect perceived restoration. The result may also be influenced by education and background, where artists and architects may have different preferences than nonexperts [40]. The aesthetic experience of building facades is influenced by people's expertise, with symmetrical facades corresponding to the taste of nonexperts. Asymmetry may not necessarily lead to equal preferences for expert and nonexpert groups in eye movements in face images [40], and nonartistic individuals may find symmetrical and complex stimuli more beautiful [46]. Despite this, most studies have shown that visual qualities such as symmetry are influential in the visual preferences of architectural views. While symmetry may not necessarily enhance the beauty of natural landscapes, it can be a positive quality in artificial landscapes as they are treated like patterns or objects [39].

A third finding that was initially unexpected was that a *low variation* in greenery led to a high perceived restorative potential. However, research shows that stressed and tired people like to visit areas with low diversity in order to recover. The more stressed and tired a person is, the more evident this becomes [75]. Studies have also shown that complex and varied urban environments are tiring, while a less complex and varied green structure in cities leads to cognitive recovery [76]. In that context, it is interesting that our subjects rate green walls against a background of *stone and cement* as more restorative compared to if the greenery instead has a background of a complex and varied brick wall. According to some studies on materials, *stone materials and white cement* have the most significant effect on green facades. Consistent with Ghomeshi et al. (2013), architects preferred brick and cement facades more, and nonarchitects preferred stone façades [45]. Some studies have stated that materials can show the identity of the façade. However, others have considered them one of the most important visual elements that depict images and recall history or perspectives, including materials, especially modern materials, for shaping people's appreciation of beauty [46].

Fourth, our results showed that *horizontal greenery* on facades, as well as *scattered greenery*, has a clearly greater positive effect on people's perceived restorative potential than vertical greenery and more concentrated greenery on facades. In line with results of the study by Dongen et al. (2019), vertical greenery has a more negligible impact on residential streets than horizontal greenery, and low preference values were found for all designs with concentric configurations [43]. This study showed that horizontal and scattered greenery have a positive effect and significant coefficients on revitalization. In other words, linear and scattered greenery on facades encourage people to go straight and offer a powerful perspective [44]. Hypothetically, scattered greenery on facades is also perceived to be greener than concentrated greenery.

Another important variable that affects people's preferences and PRP when visiting green facades is the presence of balconies. Researchers have found that private outdoor spaces, such as terraces and balconies, are highly desirable features of apartment buildings, as they contribute to residents' perception of livability and provide additional living space for daily activities [47]. Moreover, these outdoor spaces can also be potential contributors to PRP through the introduction of appropriate greenery, especially in inner-city areas with reduced vegetation and densification [21]. The lack of a balcony or garden has been directly linked to decreased life satisfaction and may stimulate the desire to move [2]. However, the presence of a balcony was not significantly associated with PRP in this study ($p = 0.06$).

Some of our results were unexpected, where the qualities of green facades in terms of aesthetic preference and support for recovery from high stress levels and attention fatigue differed markedly. However, several studies show that high preferences for certain qualities in green areas by the general public and high restoration potential do not correspond. This applies, for example, to species richness and variety as well as social meeting places [78,79].

6. Conclusions

It is important to recognize the significance of nature and visual landscapes, as well as the positive impact of green facades, on people's health. Identifying the elements of green facades that contribute to PRP is a crucial step towards improving the mental well-being of individuals in urban environments. Urban naturalization and enhancing green facades should be prioritized. This study highlights how the design of residential building green facades can impact the mental restoration of citizens. A green facade with a high amount of greenery, asymmetric greenery, stone and cement materials, horizontal greenery, scattered greenery, and a low level of variation in greenery attributes is effective in promoting mental restoration among citizens. Several of these results are somewhat unexpected, but must be considered from the perspective of being able to support recovery from high stress levels and attention fatigue, and not from aesthetic preference and stimulation. This means that cities need to offer a range of qualities, for both stimulation and recovery. Based on that function, the results support the ART and CCT theories.

In this study we have included many types of greenery on facades. This way, we were able to identify many types of architectural attributes that are important for recovery from high stress levels and attention fatigue. It is crucial to conduct studies on the demands of citizens and users of urban spaces and building facades. These studies can assist building designers in implementing more suitable designs that meet the needs of users. By prioritizing this issue, we can improve the quality of urban living environments and positively impact people's perceptions of the city's image for their mental rejuvenation. Neglecting to conduct such studies can lead to a gap between users' wishes and designers' preferences for plans, resulting in poorly designed spaces that do not meet users' needs.

However, it is important to acknowledge the limitations of this study when interpreting the results. Firstly, the survey was exploratory, and the budget was limited, which may have affected the representativeness of the sample size of 204 respondents in relation to the demographics of the study area. People with different demographic attributes and ethnic backgrounds may have different opinions. The subjects in this study mainly consisted of young academics. Future studies should include a larger and more representative sample of subjects, especially regarding age, ethnic background and education. Secondly, the selection and arrangement of components and their levels in the design of images have influenced the results, due to the limitation in the number of components associated with the discrete selection method, which should be considered in future studies. The number of alternatives in the selection set was reduced to save time and money and generate the most reliable results. Thirdly, considering the limitations of time, money, and facilities, the facades studied in this research are of residential buildings, and photographic surrogates were used instead of real environments. In future studies, it is suggested that realistically simulated projects be investigated and that more diverse landscapes, such as green facades of offices and commercial buildings and different residential buildings, be used to obtain more acceptable results.

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