

Research Article

AI-Simulated Visual Tracking of Structural Order Perception in Urban Facades: A Case Study from Mashhad, Iran

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Abstract

Aims: In urban design, the structural order of building facades plays a pivotal role in shaping human perception and experience. This study investigates the implicit visual recognition of structural order using subliminal visual tracking analysis.

Methodology: Visual Attention Software (VAS) was employed to analyze observers' visual attention patterns toward diverse façade typologies, including historical and contemporary urban facades in Mashhad, Iran.

Findings: Our findings indicate that observers' subliminal perceptions align with the three-part rules of structural order: contrasting elements on a micro-scale, reduced entropy and connection between micro and macro scales, and a hierarchical connection between levels. Here, we show that observers readily perceive structural similarities on a micro-scale and the totality of forms on a macro-scale, but struggle with perceiving the hierarchical connection between these levels.

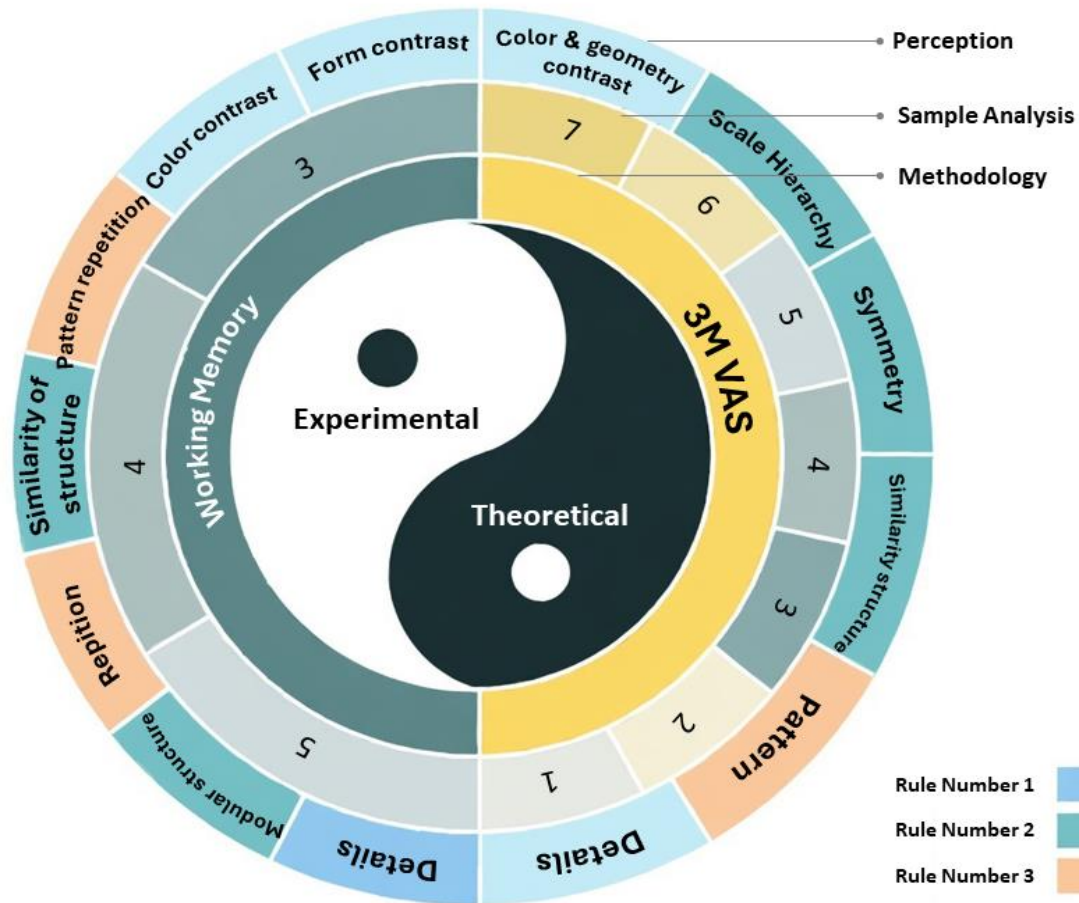
Conclusion: This study underscores the critical role of multi-scale coherence in façade design across scales and provides insights for enhancing the visual quality and coherence of urban facades.

Keywords: structural order, urban façade, subliminal attention, visual attention software (3M VAS), AI-based analysis, structural coherence

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Graphic abstract



1. Introduction

Recent neuroscientific studies suggest that humans prefer to utilize paths that also define a place's spatial sense, and prefer to move along perimeter boundaries and protected edges, a phenomenon called thigmotaxis [1]. This shows the importance of urban façades. Urban façades as the face of a building, especially the principal front that looks onto a street or opens space [2] significantly influence the visual identity and experiential quality of cityscapes and interact with all the people [3]. In their implicit perception of urban façades, people process and store important information in the first few seconds, discarding irrelevant information. According to working memory theory and supported by empirical gaze pattern data, individuals rapidly store visually salient elements within the first few seconds of exposure, prioritizing regions of high geometric and chromatic contrast [4].

Our visual system is developed to select the components involving concentrated information. These components offer optimized perceptual responses within minimal time frames [5]. Corresponding well with 3M VAS [6], the subliminal sensory bias indicates how the neuroscience of

our visual perception system can be used to reveal some of the manners in which the design influences the user [7]. The human eye predominantly focuses on regions with high visual information density, distinctions, contrasts, and curves [5]. The human intrinsic reception of the above results from a coherent totality, called Gestalt [8], as visual structural coherence comes from a kind of structural order in urban façades. This concept of order, operationalized through Salinger's structural rule framework, connects architectural components to perceived coherence by mapping alignment between geometric structures and gaze concentration patterns [5]. The relationship between structural order and Gestalt perception is critical for understanding how design decisions affect human perception.

Gestalt theory explains that humans instinctively perceive patterns and coherent wholes rather than isolated parts. Correspondingly, structural order theory provides the compositional framework through micro–macro scale relationships, binary contrasts, and hierarchical connections that enables such holistic perception to emerge. Alexander's "power of centers" parallels the Gestalt principle of wholeness: each center strengthens the

perception of the whole, while the whole, in turn, enhances the salience of its centers. Thus, structural order can be viewed as the architectural implementation of Gestalt's psychological principles. It is only through structural order that architectural components hold together on visual and physical levels. Order influences human perception because it relies on reducing information through proportions [1]. Despite growing attention to perceptual analysis in urban design, limited studies exist applying AI-based tools to evaluate façade legibility in Iranian urban contexts, justifying the selection of Mashhad as a representative urban landscape.

The question raised in this study is: "What are the main perceived characteristics of urban facades based on the subliminal visual tracking analysis of the facades?" The perception experienced by the user underscores this approach. It shows how Visual Attention Software (VAS) can help optimize urban facade designs as a practical tool to develop human-centered designs [9]. Given the significance of urban facades and the human subliminal reception in his first encounter with urban facades and landscape, VAS was used to comparatively investigate theoretical and experimental approaches to explore the observer's perception by emphasizing principles of structural order of facades to inform evidence-based strategies for enhancing perceptual coherence in urban facade design.

Literature Review: While traditional eye-tracking studies have provided valuable insights into visual attention, they often lack scalability and neutrality, which this study addresses by using AI-based predictive VAS analysis to simulate unconscious perceptual responses.

2. Urban Facades

The design of urban facades [10] and visual appearance of buildings in the architectural landscape of cities is one of the most critical factors [11] in urban design, as urban facades can be seen as the intersection of architectural and urban scale, as well as the interface between buildings and their surrounding environments [12]. In 2015, Sussman and Hollander discussed that the preference of humans for edges (thigmotaxis or wall-hugging) is our evolutionary heritage portion. Here, Wall-hugging refers to the unconscious motivation to maneuver environs the environment with touch and close links to edges or walls. Thigmotaxis has Greek roots meaning shape and touch and has been extensively utilized as a technical phrase for wall-hugging via natural specialists [13]. Urban façades serve as the visual interface between built forms and the public realm of the street environment [14], and are sometimes accused of failing to express the nature of the building's

internal structure [15]. No matter in what terms we choose to interpret the building's façades, they form an important part of our complex urban experiences. Our perception of façades is, among many other things, derived from experiencing symmetry and occasional deviations from symmetry both are important subjects of study, moreover so in recent years we have been aided by new findings provided by some disciplines that previously were beyond the reach of architecture's domain notably complexity theory, biology and biophilia or such interdisciplinary fields as neurasthenics [16].

3. Structural order

Traditional societies embedded enduring design principles associated with structural harmony and visual coherence into architectural forms, which endure across cultures and time, signifying universal "structural order." This order, perceived through smallest geometric and color components, binds artificial and human-scale visual structures, requiring interconnected divisions within a form. Buildings considered perceptually successful based on high user retention scores and consistent gaze mapping demonstrate alignment between structural order principles and attentional focus outcomes. regardless of style, establish natural sensory communication by achieving higher structural order, engaging human perception from micro to macro scales through hierarchically connected communication, ultimately shaping our understanding of the general form [14].

The concept of the hierarchy of orders was derived from the concept of Nested Orders by Boehm and Pitt (1987), who fundamentally demonstrated a hierarchical structure of nested orders used to integrate all existing orders. Each hierarchical level is structured to integrate progressively with adjacent levels, forming an interdependent system. Koestler (1968) developed the concept of interdependence in his term "Holarchy", demonstrating that the hierarchy of orders was the main reason why the resulting combination could be perceived [17].

Four decades ago, architect Christopher Alexander developed the "field of centers" to suggest how physical space is integrated and made coherent through structuring overlapping areas.

He called geometric components "centers", instead of "objects", stressing their interconnection and interdependence in another area [7]. Centers made of objects involve various scales, which are well delimited on a number of surfaces and arranged with certain changes between them.

These scales include: large shopping malls, smaller centers, and very small centers [18].

Comparing architecture with the matter structure, the following three rules about structural order are presented on three micro, intermediate, and macro scales:

3.1. Binary contrast or duality on a micro-scale (rule number 1-Table 1)

Order appears on a smaller scale when contrasting binary elements get balanced in a visual tension (e.g., main units are interwoven in contrasting ground floor facades) (Figure 1).

This contrast results from shape, orientation, color spectrum, and color value [14].

3.2. On a macro scale(rule number 2-Table 2)

Order appears when each component is so connected to all other components that would reduce entropy (Entropy, in

this context, refers to the visual and organizational randomness that undermines perceptual clarity.)

3.3. A micro-scale(rule number 3-Table 3)

Is connected by a hierarchy of intermediate scales to the macro scale (Figure 3 and 4). Its scaling factor from intermediate scales is around $e \approx 2.7$. e is a constant mathematical value underlying natural logarithms.

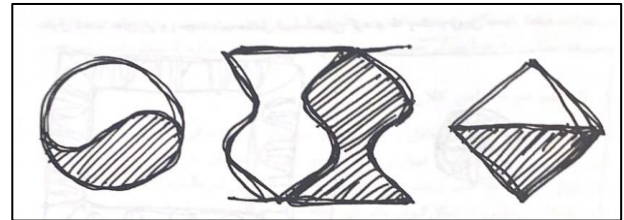


Figure 1. Micro scale including two interwoven contrasting components [14]

Table 1. The first rule of structural order along with its characteristics, components, and outcomes

Rule No. 1				
Scales	Definition	Characteristics	Components	Outcomes
Order on the smallest scale	Balance in the visual tension of contrasting binary elements	Being complementary Keeping same-type units together Duality without overlapping Involving the smallest details Communication with the observer	Color and geometry	Main elements becoming binary Elements interwoven with force Repetition of binary units Combining the most-detailed area with non-detailed area

Table 2. The second rule of structural order along with its characteristics, components, and outcomes

Rule No. 2				
Scales	Definition	Characteristics	Components	Outcomes
Order on a macro scale	Reaction from a distance	Two-way visual interaction Reducing irregularity (Figure 2) Structurally ordered forms contribute to visual stability and psychological comfort in observers. Receiving totality Perceiving lines of communication by the mind	Geometric connection Symmetry Harmony Color	Micro-level configurations of visual areas with similarities and symmetries Main units within symmetrical combination forms Repeated patterns Repetition and harmony of various areas in terms of color, shape, and size (contrast)

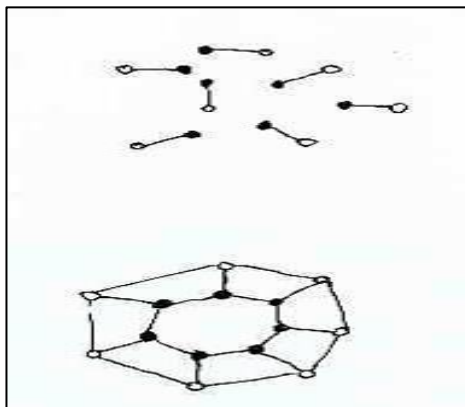


Figure 2. Reduced spatial entropy [19]

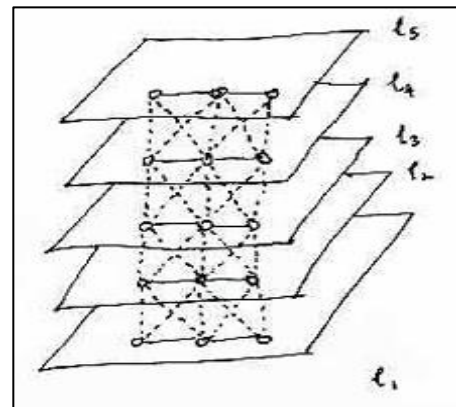


Figure 3. The hierarchy connects the micro scale to the macro scale [19]

Table 3. The third rule of structural order along with its characteristics, components, and outcomes

Rule No. 3				
Scales	Definition	Characteristics	Components	Outcomes
Hierarchy with an intermediate scale	Connection between micro and macro scales	Scaling with a factor of 2.7 Repetition process	Repeated form and pattern Hierarchical connection	Including each unit in a larger unit Repeated pattern or curve on various scales A falling functional scale of focal points Structure of the same size in interaction with the environment

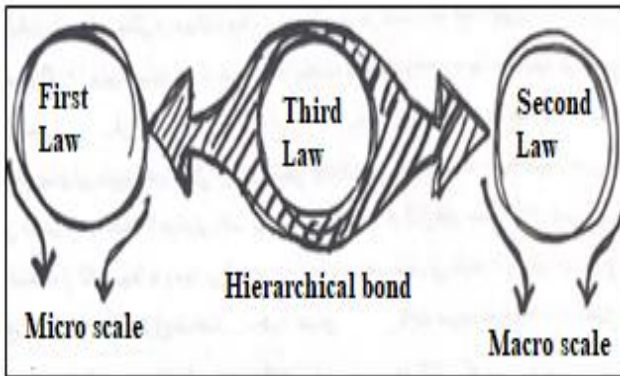


Figure 4. The connection between the three micro, intermediate, and macro scales regulated by structural order rules [14]

Visual information inputs influenced by environmental designs could help create an appropriate biological state in the user.

To reach a stable perceptual engagement state more rapidly, the study operationalized this as consistent gaze fixation patterns on structural centers, validated through eye-tracking heatmap metrics and psychological response indicators, "In addition to the three main structural principles, eight cognitive rules further elaborate the perception mechanics of façades were provided (Table 4). Based on cognitive rules of perception, it is imperative to integrate detailed elements and contrasting curves into façades, as these features consistently draw pre-attentive visual attention, according to VAS heatmap outputs [20].

To meet the above requirements, building designs should incorporate sequential, detail-rich elements that support continuous visual engagement for the human eye to perceive the overall form through tracking, or else the buildings should feature in the middle and corners of combined areas some focal points with details and contrasts [18].

The human eye mostly focuses on parts of an image that features details, distinctions, contrasts, and curves. These regions correspond to high-information visual nodes that guide fixation path.

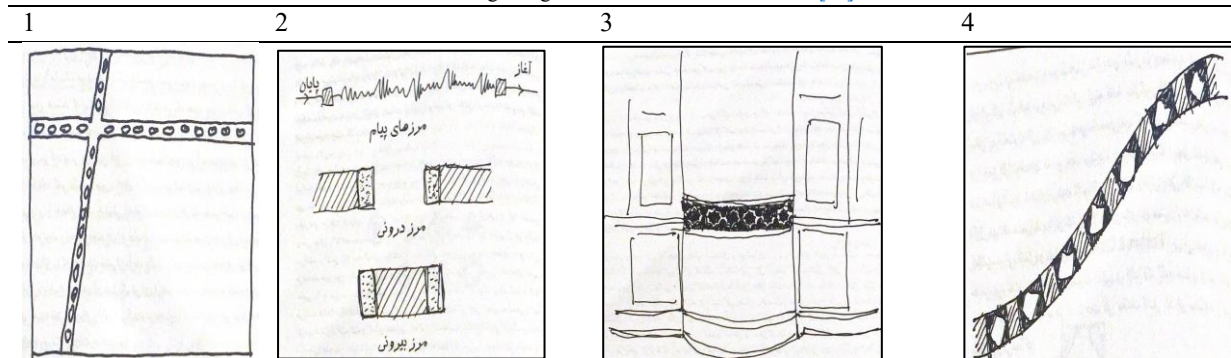
In a visual image, the spots at which the eye gazes create a narrow tracking path on which the eye spends one-third of its time.

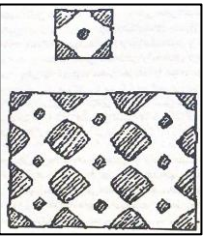
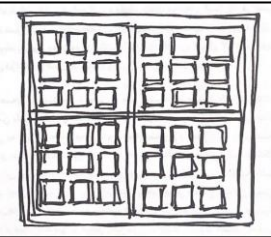
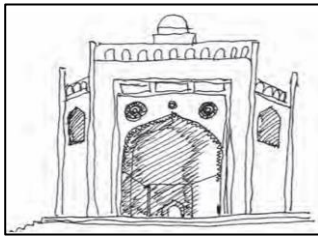

In the meantime, for the remaining two-thirds of the time, the eye turns randomly to other areas that contain less information, i.e., simpler areas. Hence, for the brain to recognize and recall an object, Details such as interlaced forms and complex edge contours were found to attract early gaze fixation.

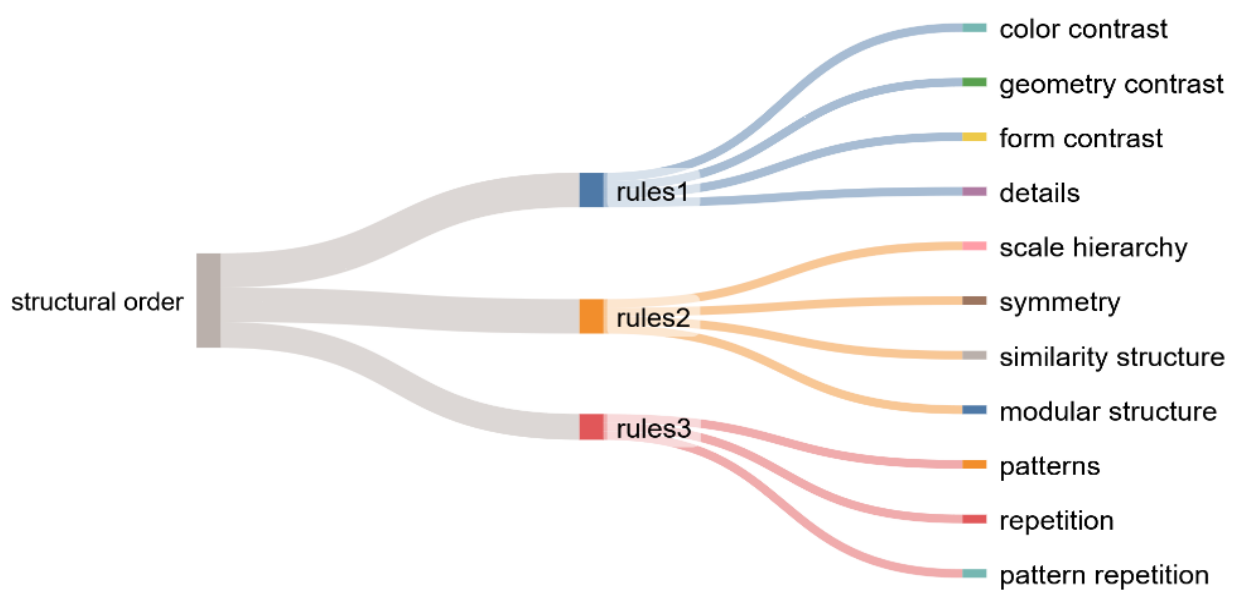
Our visual system is so designed to select the components that hold concentrated information. These components can provide the most complete responses in the shortest time possible [14].

Cone cells in the human retina, responsible for color vision, are essential for detecting fine spatial details [21]. Cone cells facilitate high-resolution color perception, which influences the cognitive mapping of geometric structures.

Table 4. Eight cognitive rules for structural order [14]



<p>It is recommended that each built form incorporate visual distinctions such as contrast, detail, and curvature.</p> <p>Frame or framework</p>	<p>It is essential that interior areas or marginal edges of simple surfaces feature details and contrasts.</p> <p>Framing elements emphasize transitions between solid wall masses and open voids, enhancing perceptual contrast.</p>	<p>Visual attention is preferentially directed toward symmetrical decorative elements such as radial patterns, star-shaped shapes, concentric circles, encircled crosses, etc.</p> <p>Decorations</p>	<p>Visual information can be regularized by using linear continuity.</p> <p>Continuity</p>
<p>5</p> 	<p>6</p> 	<p>7</p> 	<p>8</p> 
<p>Symmetries and repetitive patterns decrease cognitive processing load during initial visual recognition stages.</p> <p>Symmetry and pattern</p>	<p>Visual coherence (defined here as the degree of balanced gaze distribution and hotspot connectivity quantified via VAS heatmap analysis) on the micro scale helps establish new structures.</p> <p>Hierarchical connection</p>	<p>The man-environment communication is made through various scales, and the strongest form of communication occurs when the environment is visually coherent and integrated.</p> <p>Unity, spatial integrity, and human perception</p>	<p>Color is key to our comfort.</p> <p>Color (color enrichment, color contrast, and color harmony)</p>



Graph 1. Conceptual framework of structural order

Recent empirical studies employing eye-tracking technology offer valuable insights into visual cognition in urban contexts. For instance, Zhang et al. (2019) utilized VR-based eye-tracking to examine cityscape protection, revealing unconscious attentional biases towards vertical landmarks and high color contrasts [22]. Similarly, Franek et al. (2019) found that urban scenes elicit denser and shorter saccades than natural scenes due to structural and compositional complexity [23]. Moreover, Liao et al. (2022) applied machine learning to eye-movement data to infer spatial familiarity in city districts [24]. While these studies highlight the potential of visual cognition tools, they do not explicitly integrate a theoretical framework of structural order. The present study advances this discourse by combining AI-simulated pre-attentive vision (VAS) with working-memory sketch analysis to evaluate unconscious perception of urban façades, linking empirical gaze data to the multi-scale rules of structural order.

4. Methodology

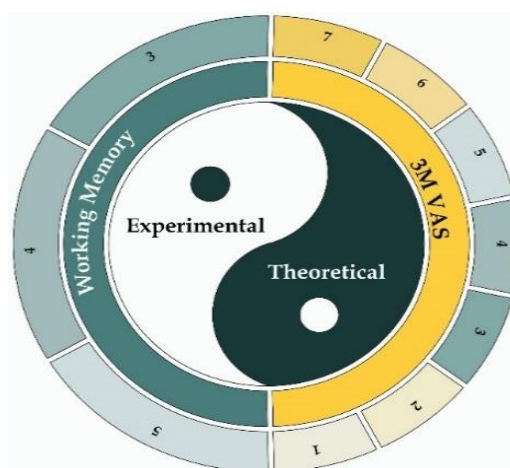
This study applied a comparative investigation method [25]. In this context, the term “comparative” denotes a structured evaluation of façade samples across predefined dimensions: (1) architectural style, (2) urban fabric context, and (3) spatial configuration. To minimize confounding factors, photographic documentation was standardized by maintaining consistent viewing distances, similar lighting conditions, matched illumination/contrast parameters, and uniform image framing. For each façade, analysis proceeded on two parallel tracks: (a) software-based visual attention mapping using 3M-VAS (generating heat maps, hotspot distribution, and gaze sequence data), and (b) expert panel scoring based on the three primary structural order rules binary micro-scale contrast, entropy reduction at macro-scale, and hierarchical scaling between levels. Criteria for comparison included: the number, distribution, and intensity of high-attention hotspots; the degree of visual coherence between micro and macro scales; and the presence and clarity of hierarchical connections. This operationalization enabled controlled, replicable comparison across samples, directly linking perceptual patterns to structural order characteristics. The presented innovative framework is derived from the ancient Chinese philosophical theory, known as the Yin-Yang’s Balance, which is a method to structure materials in a body of knowledge.

The term dualism is utilized in the West and the phrase Yin/Yang [26] is used in Eastern (Japanese and Chinese) philosophies. Hegel, Kant, and others discuss dualism, arguing that there are two heterogeneous and supplementary principles whose intrinsic contradiction in some factors – the idealist school – can be overcome with

synthesis. Yin/Yang states a similar idea in the subsequent sense, but in addition, considers the two poles as masculine and feminine characteristics (not to be mistaken with female and male sex), and frankly assumes multiple collections of Yin/Yang pairs in the world. Thus, in a sense, Yin/Yang is a more specific term [27].

As demonstrated by the graph, the left side concerns the theoretical introduction of the study and the right side concerns the practical problem of how a case study is formulated. The four arrow links on the left concern four types of validity in the study. The four arrow links on the right concern practical domains of the study, associated with each type of validity. External validity was addressed by selecting façade samples from distinct urban zones, enhancing the contextual applicability of results. Its respective practical domain involves the methodology of sampling, which concerns the fabrication of samples under study to make generalizations possible [28].

For the left side of the study, concerning the study theory, 3M VAS was used to analyze seven selected façade images, sampled based on architectural typology and urban texture diversity, with tool reliability confirmed via prior validation literature and expert calibration checks. The reasons for the selection are urban facades, a single building, various urban textures (location in central, middle, and western areas), and various construction periods. For the left side (generalizing the results with a case study), concerning the second test, three standardized façade images were randomly shown to each observer under identical lighting and timing conditions, following a 5-second exposure protocol informed by cognitive psychology standards. This represents a kind of tracking in the tested simulated environment based on reality, in line with the first section’s software analysis. In the end, A cross-modal comparison integrated VAS heatmap hotspots with participant sketches to assess congruence in unconscious and recalled visual focal points. Then matching them with the structural order rules.



Graph 2. Yin-Yang’s philosophical framework

5. Sampling strategy

The sampling protocol was designed to ensure both representativeness and generalizability. Selection of façade images followed three explicit inclusion criteria: (1) clear visibility of the façade in its entirety without significant occlusion, (2) preservation of original architectural integrity without excessive post-construction alterations, and (3) conformity with one of the target façade typologies (Traditional, Modern, Eclectic). Façades failing to meet these criteria such as those with extensive damage, heavy temporary coverings, or extreme photographic distortions were excluded. Observer recruitment involved purposive sampling to capture both academic and professional perspectives on urban design. Ten observers were selected: five university faculty members with over ten years of research in urban design, and five licensed architects with equivalent professional experience. All participants confirmed prior familiarity with structural order principles to ensure informed evaluation. The classification of façade types combined stylistic attributes, contextual placement in the urban fabric (historic core, transitional zone, contemporary district), and spatial configuration (continuous frontage, standalone structure, fragmented façade). This stratified approach ensured variation across both design style and environmental context, supporting broader inference and comparison.

6. Validity and reliability

To enhance the internal validity of the study, a triangulated methodological framework was applied by combining software-based visual attention analysis (3M-VAS outputs) with expert panel evaluations and working memory sketch analyses. The use of multiple, independent data sources allowed patterns to be cross-verified, reducing the likelihood of method-specific bias. Content validity was supported through an a priori operational definition of the three structural order rules, grounded in established literature (Alexander, Salinger, and Gestalt principles), and consistently applied across all samples. Construct validity was maintained by ensuring that the selected façade categories adequately represented the range of styles, contexts, and spatial configurations observed in the study area. Reliability was ensured through standardized photographic documentation protocols and uniform testing procedures for all observers. Inter-rater consistency for expert panel scoring was quantified using Cronbach's alpha ($\alpha = 0.82$), indicating high agreement. For the working memory sketch analysis, two independent raters coded the recalled elements from participants' drawings; Cohen's kappa ($\kappa = 0.79$) demonstrated substantial agreement. Minor coding discrepancies were resolved

through consensus discussion. This combination of reliability checks and methodological triangulation provided a robust basis for the study's analytical outcomes.

7. 3M-VAS Software

Developed by 3M-VAS Company [29, 30]. Visual Attention Software (VAS) is an AI application featuring experimental data from eye-tracking. This software can be used to predict viewer reactions to images, generating fixation point maps and fixation point sequence estimations, thus indicating the pre-attentive or "unconscious" processing of visual stimuli with a very high degree of accuracy [23]. A full report includes visual elements, heat maps, hotspots, and gaze sequences. This report indicates no human bias with visual tracking attention. VAS is developed from 30 years of research by 3M vision scientists. This software is formulated by a large number of eye-tracking recordings. utilized eye-tracking technology to analyze visual attention patterns [31]. The software, claims the 3M Company, represents a higher level of correlation between real eye-tracking studies and simulation. The AI-based simulation will not fully replace eye tracking. If used properly, the simulation can provide a wealth of knowledge about the human eye's unconscious visual attention and the factors influencing it [9]. This study used 3M-VAS to analyze ten types of facades under two original or photographically manipulated states. This software also shows marked differences in the buildings, designed with(out) structural order rules. The ten photographic images were processed using 3M-VAS. The software generally produced four different outcomes of each visualized image as follows [23]:

1. Heat Map: It is a color map that attracts human attention to a specific part of an image within the first 3-5 seconds. This feature is used in all tracking records and serves as the most useful and direct recognition instrument for analysis.
2. Hotspots: It is a simplified version of heat map results, representing spots most likely to be seen within the first 3-5 seconds and is specified by a numerical value representing the priority or order of attention.
3. Gaze sequence: It indicates the sequential gazing of four places in the most probable order of observation.
4. Visual Elements: Visualization helps understand how an algorithm performs by extracting the same features that drive the pre-attentive processing in our visual systems, i.e., edges, intensity, red/green color contrast, blue/yellow color contrast, and faces [14].

In selecting the images and comparing the results, the following should be met to obtain both general practical results and better learn the 3M-VAS software:

1. Framing: In the event the building under study occupies the entire image, a frame may be considered for it.
2. Illumination/contrast/saturation: How these parameters are adjusted will, wholly or partially, affect the way the structures under study are investigated by the software. Distance from the building: To investigate whether proximity to a building will display more details, which would lead to sustainable coherence or cause the coherence to be lost, it is better to record all buildings from the same distance [9, 32].
3. As shown by building images, the frame has only been modified to isolate special features, if necessary. In other cases, no attempt is made to eliminate such elements as people or cars, because real images need to be tested.

8. Data analysis procedure

A standardized coding framework was developed to ensure analytical consistency in interpreting VAS outputs and working-memory sketches. All visual features identified in heatmaps, gaze sequences, and hotspot maps were categorized into predefined variable groups, including: (1) Color contrasts, (2) Geometric forms and curvature, (3) Symmetry, (4) Repetition and pattern regularity, (5) Scaling ratio (≈ 2.7), (6) Hierarchical connections between scales, (7) Presence of powerful centers, (8) Soft and hard landscape elements, and (9) Attached items. Each feature was assigned a binary presence/absence code (10) and, where applicable, an intensity score on a 5-point scale. The same coding scheme was applied to observer sketches, allowing direct comparison with VAS outputs. Cross-checks among three independent coders ensured consistency, with discrepancies resolved by consensus, thus increasing the reliability of the analysis.

The analysis of the above maps revealed eight cognitive rules of structural order, which are listed in Table 1. The extent to which each facade enjoys structural order can be measured based on the three main rules of the structural order.

9. Results

Using VAS, Table 5 below lists ten photographic images of facades. The initial phase involved documenting 25 building facades through systematic photographic surveys in Mashhad, Iran. Sample selection adhered to three predefined criteria:

1. Architectural Style Variation: Classified as 'Traditional' (Qajar/Pahlavi-era brick facades), 'Modern' (post-2000 glass/steel structures), and 'Eclectic' (hybrid features).
2. Urban Fabric Diversity: Categorized by location: 'Historic Core' (Arg Street), 'Transitional Zones' (Khosravi-Sajjad), and 'Contemporary Areas' (Ahmad Abad).
3. Spatial Configuration: Differentiated as 'Continuous Street Walls' (>3 connected buildings), 'Standalone Structures', and 'Fragmented Facades'.

A panel of 10 experts (5 academics in urban design with 10+ years of research, 5 practicing architects registered with Iran's Engineering Organization) evaluated the samples. Using a 5-point Likert scale (1=low, 5=high), they scored each facade on:

- Representativeness of its architectural style,
- Contextual distinctiveness within its urban fabric category,
- Clarity of spatial configuration.


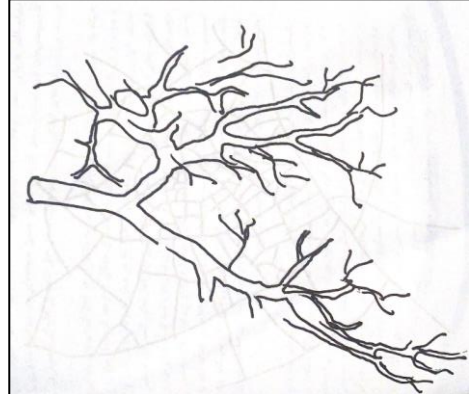
Facades with a mean score ≥ 4 across all criteria were retained (n=10). Inter-rater reliability was confirmed via Cronbach's α ($\alpha=0.82$).

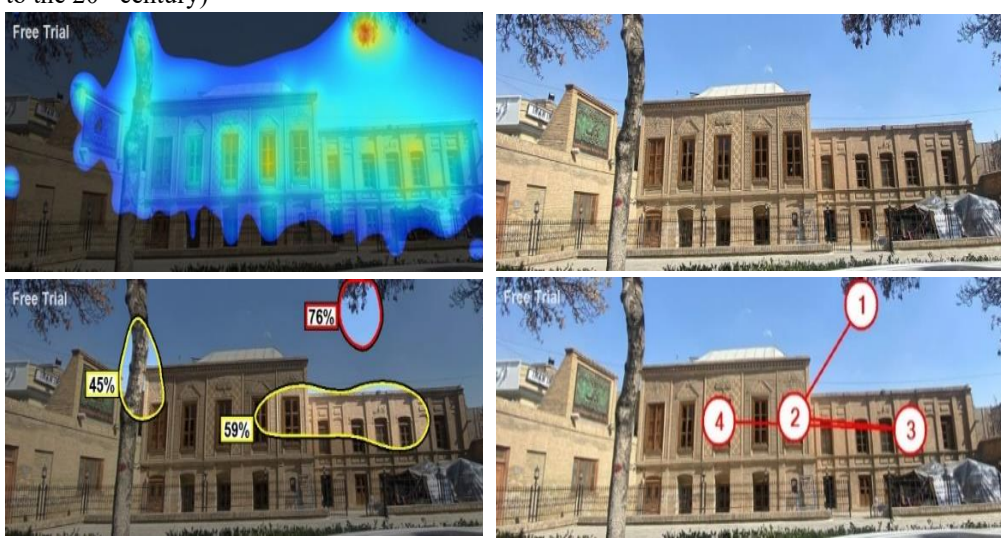
As summarized in Table 5, each façade is described in terms of its physical characteristics, VAS-derived perceptual hotspots, and compliance with structural order rules. This organization allows for cross-comparison between façade types and their perceptual outcomes.

The data indicate that façades with strong compliance to all three rules (e.g., Samples 2 and 4) achieved more balanced gaze sequences and concentrated hotspots, supporting the hypothesis that structural order enhances perceptual coherence.

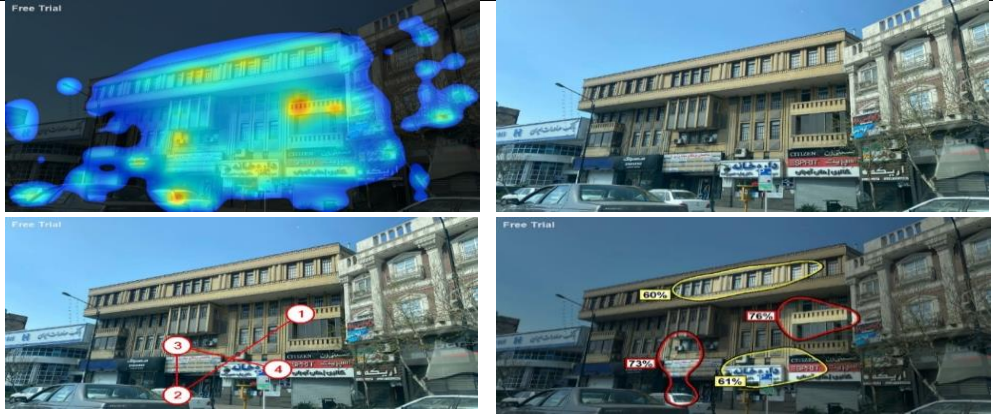
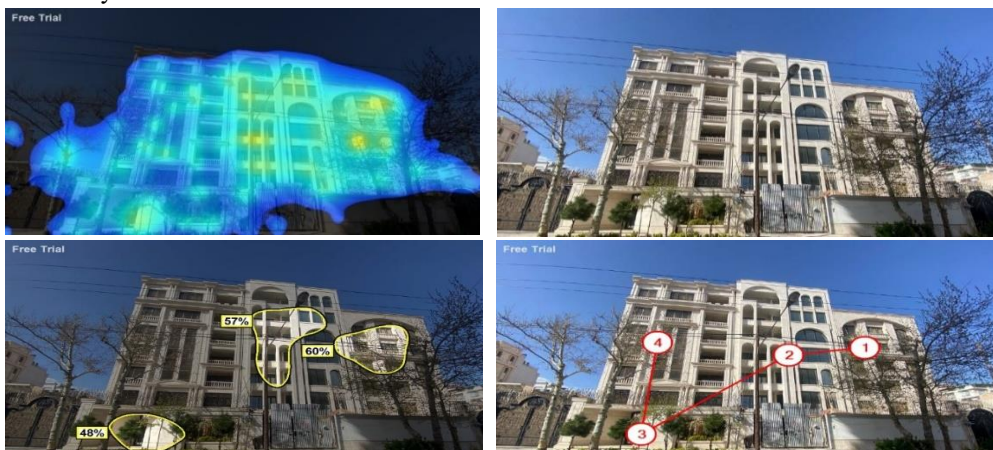
Table 5. Imaged facades along with overall features and perceptions, as well as the analysis of structural order rules

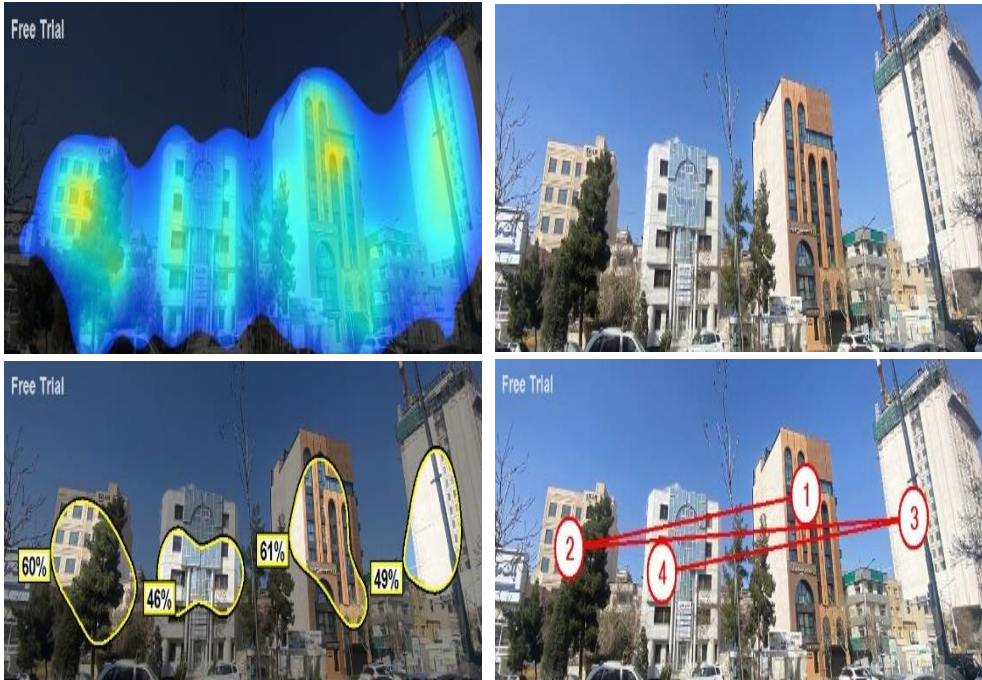
Examples	1. Continuous urban facade
Building's overall features	Pars Hotel Building, Mashhad City, Iran, located in Arg St., dating back to the Qajar era, featuring a brick façade (since 1937)
Hotspots	As analytical findings suggested, parts of the windows featuring geometric modules, signage, and attached items with color contrasts and some shading (less than other factors), as well as sunken spaces and window frames and curved door frame designs constitute the foci of implicit perception. The hotspots, however, lie in areas with greater details and some geometric, color, curved, and order features. The edges are shown by strong contrasts (this software assigns scores to sections with better image light). Since urban facades are investigated in this study, all soft and hard elements alongside each other, including the façade, trees, symbolic elements, and attached items, such as signage and furniture constitute urban facades. This study also considers trees and signage as hotspots.

Examples	1. Continuous urban façade (continued)
Gaze Sequence	The eye's subliminal movement to the side of the street, people, and cars, the skyline edges, and to a lesser extent to some regions with color contrasts such as signage and attached items.
	
First rule Perceptions	<p>Contrasting elements on a micro-scale</p> <p>Ground floor facing: contrasting window forms</p> <p>Landscape: Spots with structural order such as tree leaves (Figure 5) and branches full of life and fractal order [30 , 33], with signage details capturing the gaze.</p> <p>The entire façade: Contrasting component colors after being perceived, the edges capture the gaze.</p>
Analysis Second rule	<p>Contrasting elements are hotspots.</p>
	
Figure 5.	Hierarchy of scales in nature/self-similar (human lings) [14]
Perceptions	<p>Reduced entropy and irregularity with the establishment of the connection between elements of the micro and macro scales</p> <p>The first floor features a micro scale, showing a weaker structural order.</p> <p>The sunken window's wooden frames feature the connection between the hierarchy and smaller square frame patterns.</p> <p>Linear continuity and order in repeated upper window details markedly determine the tracking path needed for the eye to gain information.</p>
Analysis Third rule	<p>Repeated patterns and the scaling connection in the modules constitute the hotspots.</p> <p>The scaling factor, details, symmetry</p>
Perceptions	<p>Upper window details</p> <p>Symmetrical window divisions</p>
Analysis	<p>Hotspots are seen in the integrity of upper window details and their symmetry.</p>

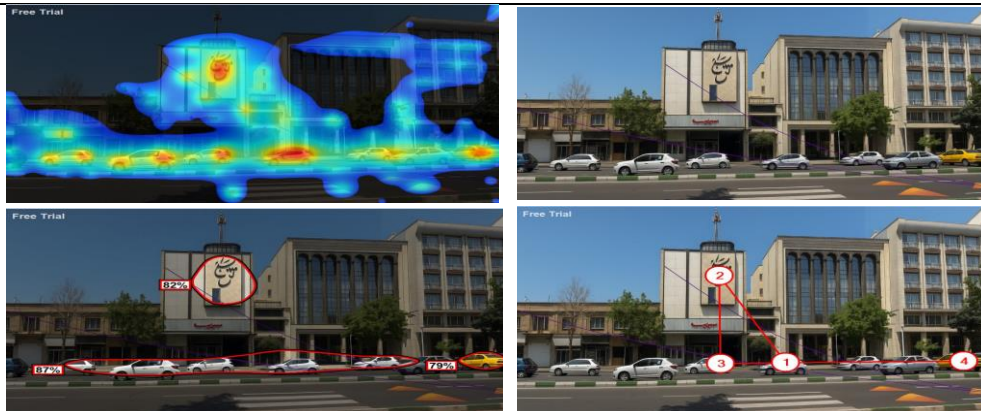
Example	2. The façade is more transparent without soft landscape elements
	
First rule	First rule: On the (micro) scale, areas with details are distinguished from areas with simple areas.
Perceptions	This area involves window divisions and entrance details. Contrasting scales
Analysis	Organized repetitions and symmetrical window details
Second rule	Hotspots are organized by symmetries, contrasts, and organized complexities. Interaction between facade elements and their organization leads to greater order and reduced entropy (irregularity).
Perceptions	Visual enrichment on two facings of the building (action from a distance) that appear symmetrically, capturing 61 and 54% of the subliminal visual attention.
Analysis	Hotspots have a balanced distribution on the entire façade.
Third rule	To connect the structures of two micro and macro scales
Perceptions	Structural similarities such as repeated windows' forms and patterns
Analysis	Relatively balanced distribution of view sequence
Example	3. A single façade and an ordinary state are seen on a real scene of the street.
Building's overall features	Malek Mansion, located in the city of Mashhad, Iran on the Arg St., on the eastern angle of the street. This mansion dates back to the Qajar era and features a brick façade (dating back to the 20 th century)
	
First rule	Smaller elements including brickwork on the upper parts of the windows (simple surface margins, details, and contrasts)

Example	3. A single façade and an ordinary state are seen on a real scene of the street.(continued)
Perceptions	Contrasts and interconnection are balanced via a sequence of columns next to the windows.
Analysis	Contrasting elements constitute the hotspots.
Second rule	Organizing visual information and the connection between micro and macro scales The connection between the micro and macro scales is based on windows' modular structures that have created a hierarchy of scales.
Perceptions	In the symmetry of upper windows' patterns on the right-side facades Linear continuity is featured in the repetition of windows' rhythm and patterns Coherence Modular structures of windows
Analysis	The hierarchy of scales in the repetition of the windows' modular patterns constitute the hotspots.
Third rule	Lack of a hierarchical connection
Perceptions	Failure to understand the connection between façade elements and the attraction of the gaze toward edges, such as tree leaves on the upper corner of the image and tree trunks on the other corner of the image
Analysis	Weakness in the third rule and lack of sequence in rational view/gaze saccade
Example	4. Street landscape
Building's overall features	Mashhad City, Iran, located on Arg St., Khosravi Intersection, the beginning of Modarres St., close to Kafsh-e-Melli Building, dating back to the Qajar era, and featuring a brick façade (1960s)
First rule	Contrasting proportions
Perceptions	Vertical elements of small columns have captured visual attention for featuring contrasts in attached items and vertical-horizontal directions, as well as color contrasts in the signage of the ground floor. Color contrasts between yellow (materials) and blue (the sky-nature) in the skyline.
Analysis	Spots with color contrasts constitute the hotspots.
Second rule	Connection between micro and macro scales
Perceptions	There is no coherence in the visual continuity.
Analysis	The lack of connection between scales and saccades of gaze
Third rule	Proportions
Perceptions	Understanding proportions at a factor of 2.7
Analysis	Appropriate proportions on the scale constitute hotspots.
Example	5. Facades
Building's overall features	Mashhad City, Iran - located on Ahmad Abad Street, the Pezeshkan (physicians) building, dating back to the contemporary period and being made of brick materials.

Example	5. Facades (continued)
<p>First rule Perceptions</p> <p>Analysis</p> <p>Second rule Perceptions</p> <p>Analysis</p> <p>Third rule perceptions</p> <p>Analysis</p>	 <p>Contrasting colors and proportions</p> <p>Vertical elements of smaller columns featuring contrasting attached items and vertical and horizontal directions</p> <p>Color contrasts in the blue color reflected on the glass and the ochre color of the bricks.</p> <p>Color contrasts constitute hotspots.</p> <p>Connection between micro and macro scales in divisions</p> <p>Modular division of the upper-level windows</p> <p>There is no structural coherence in the totality of the facades.</p> <p>Detached and incoherent facades, imbalanced sequence of gazes</p> <p>Lack of a hierarchical connection</p> <p>The patterns created in the repetition of rectangular forms</p> <p>The lack of connectivity between scales and gaze saccades</p>
Example	6. Street landscape
Building's overall features	<p>Mashhad, Iran, located on Sajjad St., a contemporary residential building made of stone. This building helps analyze structural order in a perfect façade (i.e., highest compliance with visual perception efficiency measures according to VAS outputs), measuring coherence and visual continuity in the facade.</p>
<p>First rule</p> <p>Perceptions</p>	 <p>On the two facades of the right side, the curves in the openings have brought about contrast and order in the façade's structure.</p> <p>The white color has been used in the façade without any contrasts, featuring a minimalist and empty facing in terms of color.</p> <p>The symmetrical elements on the right-side of the façade such as columns have created hotspots, with the symmetries and patterns of openings in the middle of the façade and the right-side façade revealing a cognitive fabric between man and the facade.</p> <p>The left façade is the only place featuring structural order and a sunken balcony, representing the ratio of vertical (smaller columns) to vertical (openings) elements.</p>

Example	6. Street landscape (continued)
Analysis	No color contrasts Vertical proportions and symmetries have created hotspots. Sunken volumes have created hotspots.
Second rule	Structural coherence/micro and macro scale connection
Perceptions	Three-part repetition of opening modules in the middle of the façade has created visual continuity, causing structural coherence in the façade. Visual coherence is also viewed by the connection between two facades on the right.
Analysis	Three-part repetition has created structural coherence.
Third rule	Lack of hierarchical connection in totality
Perceptions	The left-side façade has no visual connection and scale-based connection with the other two facades.
Analysis	Minimalism on the left side and gaze saccades and discontinuity of view
Example	7. Comparing four different buildings next to each other, located in a facade isolated from each other in a discontinuous way
Building's overall features	Marginal facade of Sajjad Str., (one of the axes in the middle-western textures of Mashhad), Mashhad, Iran
	
First rule	Contrasting proportions and details
Perception	The façade capturing the first tracking features include curves, contrasts, and greater details than other facades.
Analysis	Curves and details are hotspots.
Second rule	Structural coherence
Perceptions	Lack of coherence between the facade and a coherent view
Analysis	View discontinuity and gaze saccades
Third rule	Hierarchical connection
Perception	Non-perception
Analysis	Unbalanced gaze sequence
Example	8. A heterogeneous urban façade that has undergone construction across various historical periods, characterized by the juxtaposition of architectural styles ranging from traditional to contemporary, with buildings constructed alongside one another using diverse materials and techniques.
Building's overall features	Iran, Mashhad, Khosravi Str.

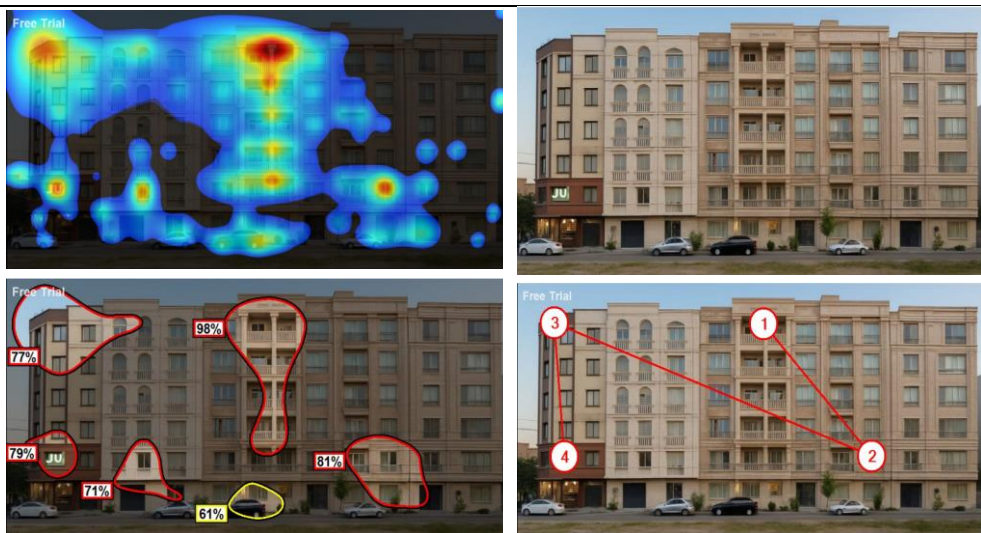
Example 8. A heterogeneous urban façade that has undergone construction across various historical periods, characterized by the juxtaposition of architectural styles ranging from traditional to contemporary, with buildings constructed alongside one another using diverse materials and techniques (continued)



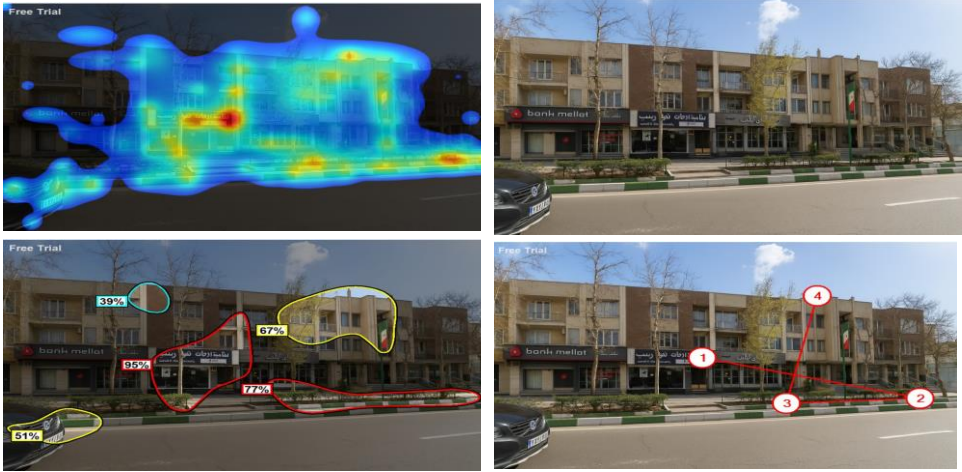
First rule Color contrast
 Perception Understanding color contrast in cars
 Analysis Hot spots are only located on cars
 Second rule Formal Similarities
 Perceptions There is no perception of the building's facade other than the hotel's name.
 Analysis Formal Similarities of cars are hotspots
 Third rule Lack of a hierarchical connection
 Perception Failure to understand the connection between façade
 Analysis Weakness in the third rule and lack of sequence in rational view/gaze saccade

Building's overall features Iran, Mashhad Sayyad shirazi Str.

N. 9



First rule The facade's areas of porosity, produce opposing light and shadow, thereby generating visual tension.
 Perception light and shadow are hotspot
 Analysis Elements interwoven with force,
 Second rule Similarity in form of balconies
 Perceptions Similarity
 Analysis visual areas with similarities and symmetries
 Third rule Repetition of balconies
 Perception Repeated form and pattern
 Analysis Repeated pattern on various scales

Building's overall features	Iran, Mashhad Imam khomeini Str.
N. 10	
First rule Perception	Color contrast and light and shadow of balconies
Analysis	Understanding color contrast in sign and sidewalk table and facade's areas of porosity
Second rule Perception	Contrasting elements are hotspots- light and shadow are hotspot
Analysis	Formal Similarities
Third rule Perception	There is no perception of the building's facade other than formal similarities in sidewalk table
Analysis	Formal Similarities of sidewalk table are hotspots
Third rule Perception	Lack of a hierarchical connection
Analysis	Failure to understand the connection between façade
Third rule Perception	Weakness in the third rule and lack of sequence in rational view/gaze saccade

9.1. The second section: the underlying theory; Baddeley's model of working memory (1974)


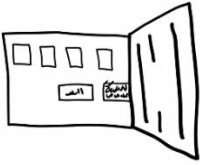
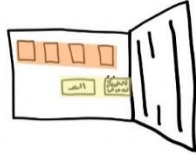


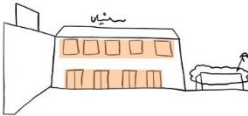


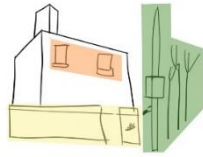

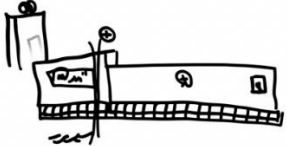
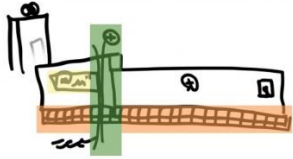

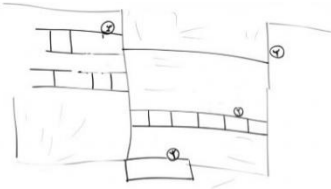
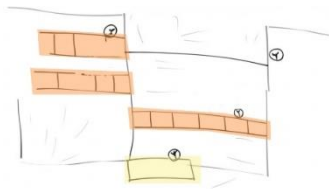
The concept of working memory proposes that a dedicated system maintains and stores information in the short term, and that this system underlies human thought processes [4]. The working memory is responsible for the temporary storage and simultaneous processing of information [34]. One of the leading models of working memory is the multi-component model; a three-component model that involves two-store components called an audio-phonological loop and a spatial-visual sketchpad, as well as an executive component called central executive [35]. The spatial-visual sketchpad stores visual images for a short period. Working memory is a complicated cognitive system with a limited capacity which processes and stores information simultaneously [35].


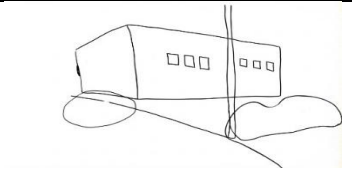
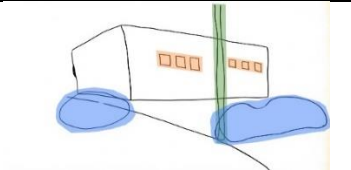

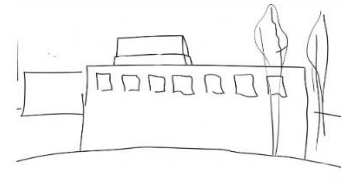
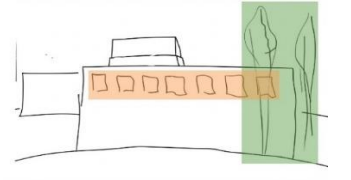

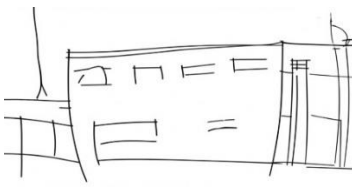
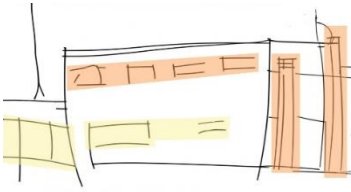

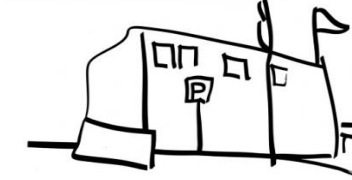
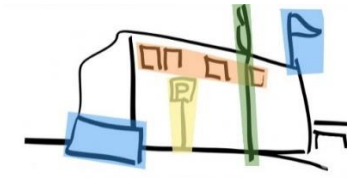

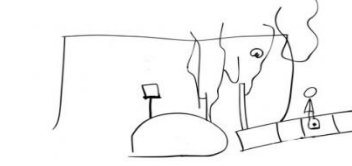
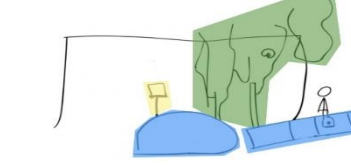
This enables people to process and store the main information, discard irrelevant information, and take steps to achieve their intended goals. According to Baddeley's model of working memory, the visual-spatial sketchpad temporarily stores and processes the main visual and spatial information, which includes such characteristics as shape, color, location, and the spatial order of objects. This is critical for the activities that need to simultaneously process visual data, such as movement, orientation, and pattern visualization [14,36].


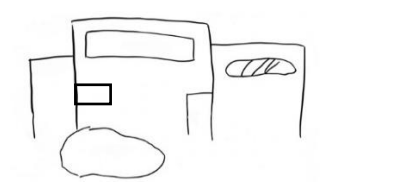
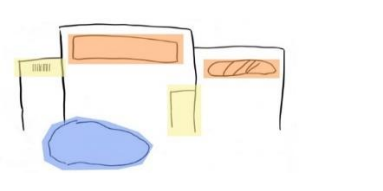

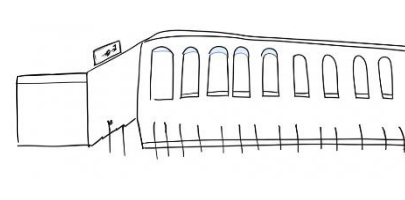
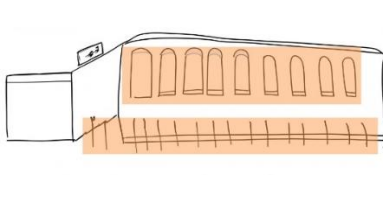





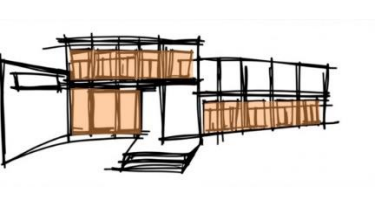



This test is associated with Baddeley's model of working memory (1974) in psychology and neuroscience domains. This theory states that humans are capable of storing and recalling visual information for a short period of time (usually less than 1 second). After this, most of the details disappear, with only the key spots remaining in the mind. In the second section of the study, three images were selected.



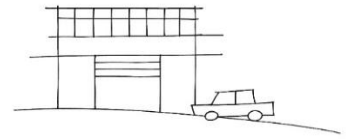
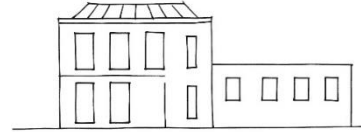
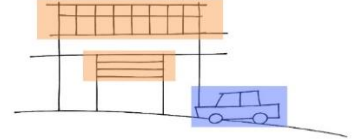
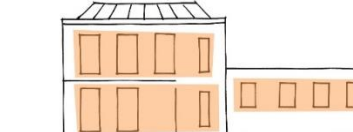


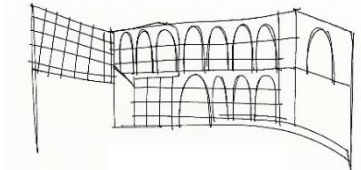
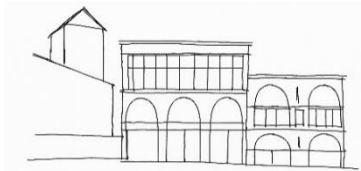
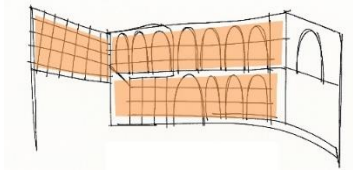
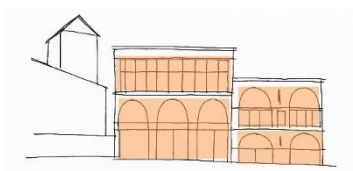
The reason why these images were selected was that they were examined practically in real-time experience and held low structural order as shown by the software environment of the first section (Table 5). After the images were displayed for a few seconds and were then cut, the participants were asked to describe what they saw. The description could be in the form of sketching on a whiteboard. Ten participants trained in architecture and urban planning were selected and were shown three images randomly. The observers started sketching the images on the whiteboard, and the key spots in the mind of the observer were extracted into a table. In the table below, the sketches are drawn by the trained observer and the images are real. According to Baddeley's theory of working memory, a test was designed in which the observer had 3-5 seconds to gaze at the image. The image was then cut and the observer started sketching what he had already stored in his mind. The table below (Table 6) gives the key spots that remain in the observer's mind.

Table 6. Description of the image by a trained observer

No	Real image	Observer's sketch	Sketch analysis Guide façade elements Building signage and attached items Green spaces/greenery Cars and moving items	Key spots
1				<p>Pattern repetition Organized repetition Systematic sequence Modular structure Attached items with colors contrasting from the background</p>
				<p>Receiving totality Pattern repetition Organized repetition Systematic sequence Modular structure Connection between repeating elements</p>
				<p>Pattern repetition Color-contrasting attached items and signage Structural similarity Organized repetition Trees and cars with colors contrasting from the background, e.g., yellow cars (emphasizing color) Receiving totality of volume</p>
				<p>Pattern repetition Structural similarity Organized repetition Natural elements such as trees Receiving totality</p>
2				<p>Pattern repetition Structural similarity Organized repetition Connection between repeating elements in a connected network Cars Receiving totality</p>

No	Real image	Observer's sketch	Sketch analysis Guide façade elements Building signage and attached items Green spaces/greenery Cars and moving items	Key spots
				Car traffic jams Natural elements such as trees Emphasizing car colors Receiving totality of volume
3				Pattern repetition Structural similarity Organized repetition Ceiling elements on the edge Natural elements (trees) Emphasizing traditional materials Receiving totality Vertical elements
				Pattern repetition Structural similarity Organized repetition Signage and attached items Emphasizing colors Receiving totality
				Pattern repetition Structural similarity Organized repetition Signage Natural element (tree) Cars (emphasizing color) Receiving a totality of volume
4				Natural elements (trees) Signage Cars Emphasizing colors

No	Real image	Observer's sketch	Sketch analysis Guide façade elements Building signage and attached items Green spaces/greenery Cars and moving items	Key spots
5				<p>Repeated patterns in an interconnected network Signage Cars Emphasizing colors</p>
				<p>Pattern repetition Organized repetition Systematic sequence Modular structure Attached items with colors contrasting from the background</p>
				<p>Pattern repetition Organized repetition Systematic sequence Modular structure Attached items with colors contrasting from the background</p>
				<p>Receiving totality Pattern repetition Organized repetition Systematic sequence Modular structure Connection between repeating elements</p>
				<p>Pattern repetition Structural similarity Organized repetition</p>

No	Real image	Observer's sketch	Sketch analysis Guide façade elements Building signage and attached items Green spaces/greenery Cars and moving items	Key spots
6	 	 	 	<p>Repeated patterns in an interconnected network Cars</p> <p>Pattern repetition Structural similarity Organized repetition Modular structure</p>
7	 	 	 	<p>Repeated patterns in an interconnected network</p> <p>Pattern repetition Structural similarity Organized repetition Modular structure</p>

No	Real image	Observer's sketch	Sketch analysis Guide façade elements Building signage and attached items Green spaces/greenery Cars and moving items	Key spots
8			<p>Sketch analysis Guide façade elements Building signage and attached items Green spaces/greenery Cars and moving items</p>	<p>Pattern repetition Structural similarity Organized repetition</p> <p>Cars</p> <p>Pattern repetition</p> <p>Attached items with colors contrasting from the background Cars Natural elements (trees)</p> <p>Pattern repetition Natural elements (trees)</p>
9			<p>Sketch analysis Guide façade elements Building signage and attached items Green spaces/greenery Cars and moving items</p>	<p>Attached items with colors contrasting from the background Cars Natural elements (trees)</p> <p>Pattern repetition Natural elements (trees)</p>


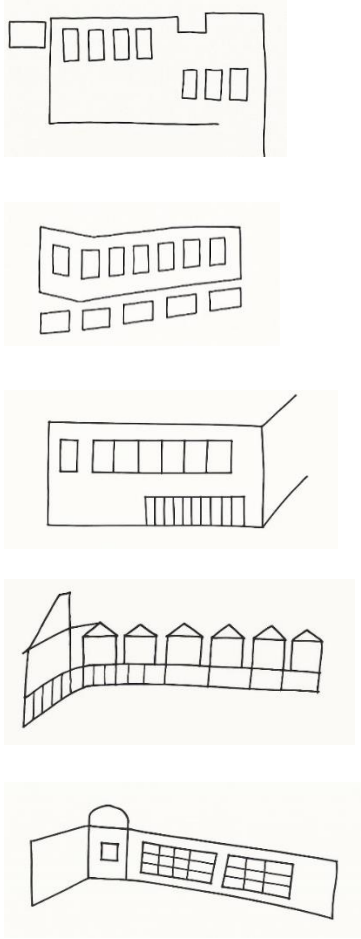
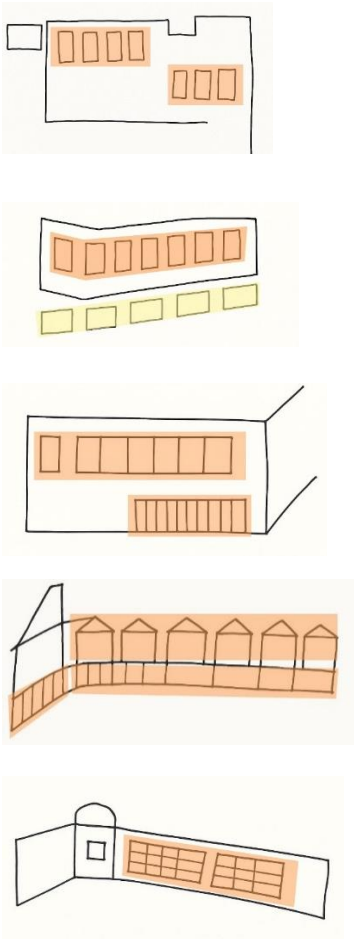
No	Real image	Observer's sketch	Sketch analysis Guide façade elements Building signage and attached items Green spaces/greenery Cars and moving items	Key spots
10				<p>Pattern repetition</p> <p>Pattern repetition Cars</p> <p>Pattern repetition</p> <p>Pattern repetition</p> <p>Pattern repetition</p>

Table 7. Analyzing the received facades using cognitive rules of structural order and VAS software outputs

Sample No.	Rule 1		Rule 2		Rule 3		No. of hotspots	Scattered hotspots toward the edges (non-reception)	Balanced gaze sequence	Balanced totality	Unorganized soft elements in landscape
	Color	Form geometry (curve)	Symmetry	Fractal geometry	Patterns	2.7 ratio in proportions					
1	✓	-	✓	-	✓	-	8	-	-	-	✓
2	✓	✓	✓	✓	✓	-	10	-	✓	✓	-
3	-	✓	✓	-	✓	-	7	-	-	-	-
4	✓	✓	✓	-	✓	✓	11	✓	-	-	✓
5	✓	-	✓	-	✓	-	9	✓	-	-	✓
6	-	✓	✓	✓	✓	-	7	-	✓	✓	-
7	✓	✓	✓	✓	-	-	4	✓	-	-	-
8	✓	-	-	-	-	-	8	-	-	-	✓
9	-	-	-	-	✓	-	12	✓	-	-	-
10	✓	-	-	-	✓	-	14	✓	-	-	✓

Table 8. Mapping of Empirical Design Variables to Theoretical Constructs in Structural Order and Gestalt Frameworks

Design Variable (Empirical Test)	Theoretical Construct	Corresponding Structural Order Rule	Related Gestalt Principle(s)
Hotspot concentration on detailed façade areas (VAS)	Visual salience through micro-scale contrasts	Rule 1 – Binary contrast (micro scale)	Figure–Ground, Similarity
Contrast in colors, geometry, or forms (VAS & Sketch)	Micro-level duality enhancing perception	Rule 1 – Binary contrast (micro scale)	Contrast, Figure–Ground
Hotspot clustering stability & balanced gaze sequence (VAS)	Macro-scale coherence via entropy reduction	Rule 2 – Macro-scale order	Closure, Continuity
Repetition & symmetry in façade modules (VAS & Sketch)	Harmonious structural patterns reducing visual entropy	Rule 2 – Macro-scale order	Symmetry, Repetition
Identification of “powerful centers” (VAS & Sketch)	Central spatial nodes integrating perception	Rule 3 – Hierarchical connection	Centrality, Gestalt Wholeness
Perception of proportional ratios (e.g., 2.7 scaling) (Sketch)	Scaling laws as structural connectors	Rule 3 – Hierarchical connection	Proportion, Scale Invariance
Recall of micro-to-macro connections (Sketch)	Inter-scale linkage through nested orders	Rule 3 – Hierarchical connection	Continuity, Part–Whole Relationship
Attention shifts to peripheral or unrelated areas (VAS)	Breakdown in structural order reducing coherence	Deviation from Rules 1–3	Disruption of Gestalt Whole
Rapid recall of attached or natural elements (Sketch)	External visual attractors affecting façade perception	Outside structural order scope; contextual interference	Figure–Ground (External Objects)

Notes:

1. Key spots = Observable features retained in short-term visual memory (e.g., repeated patterns, symmetry, attached items, greenery, moving elements).
2. Sketch analysis guide = Coded interpretation of façade elements according to structural order rules (color contrast, geometry, hierarchical connection).

3. The number in the last column corresponds to the sample ID from the VAS analysis (Table 5), enabling cross-referencing between the two tests.
4. Receiving totality = The observer perceived the façade as a coherent whole rather than as isolated details.

The comparison of sketches to real façade images shows that key structural order features such as pattern repetition and symmetry are more likely to be retained in memory,

while weaker hierarchical connections or fractal patterns are less consistently recalled.

This supports the earlier VAS findings (Table 5), indicating that organized complexity enhances visual memorability.

10. Discussion

10.1. General analysis of the first section

The table (Table 7) compares the examples under study to help understand the structural order- inferred rules in analytical images.

To clarify the theoretical alignment, the following table maps each empirical design variable assessed through VAS outputs and working memory sketch analysis to its corresponding theoretical construct (Table 8).

The table also indicates which structural order rule and related Gestalt principle(s) each variable operationally represents, thereby making explicit the link between the conceptual framework and its practical application.

Subliminal Sensory Bias: 3M-VAS demonstrates how the neuroscience of the visual perception system can be used to reveal some of the ways in which the design influences the user.

This strong instrument demonstrates how people tend to have an intrinsic formative bias that directs us unconsciously and is out of our control [37].

Visual Coherence: Subliminal visual attention functions remarkably in a highly coherent structure because the designs featuring these characteristics, being full of contrasts and details, and as “fields of centers” resulting from a higher degree of organized complexity could lead to extreme yet balanced visual attention. Designs or structures will become increasingly coherent when they tend toward a greater degree of structural order. This empirical outcome underlies understanding fractal-based human cognition (geometric structure arranged in a hierarchy of scales [32].

Featuring a crowded scene of the street landscape, Images 4 and 5 involve numerous hotspots existing in a traffic jam of cars, and irregular traffic signage, and trees, with the human gaze directed at the edges due to the lack of visual coherence in the facade landscape in some spots.

Contrast in Colors and Structures: Our gaze is attracted by details, colors, and structures formed by contrasts. Subliminal eye tracking is directed at the entrance which indicates entrance readability. Following the analysis of structural order rules, this readability is formed by contrasting geometric structures on a micro scale, as curved and rectangular shapes produce an interwoven contrasting pair, e.g., color contrasts of traffic signage.

Hierarchy of Scales: A higher degree of organized complexity is defined through the symmetric and repeated forms and patterns and a 2.7 ratio of proportions in the facade elements attract the subliminal observer’s attention. In an urban facade, the visual continuity of the facade elements and openings, as well as the scale-based harmony and connection between the facades follow the principles of facade designs.

This continuity and sequence are represented by the repeated rhythm of elements, the connection between the scales, the harmony or contrast of colors, and geometric order and symmetry.

In some analyzed facades, however, these factors are separately considered in each façade, regardless of whether they are designed in harmony with each other.

The eye also receives some coherent spots within the first 3-5 seconds, then moves toward other edges. This test provides the following:

1. The visual sequence is uniformly distributed across a structurally ordered combination.
As a result, in a structurally ordered facade, there are fewer gaps and saccades between hotspots, with fewer hotspots identified in the image.
2. In a heat map of a successful facade, hotspots correspond to the specific components of a façade, such as the main entrance or projected windows.
3. An unsuccessful facade shows hotspots in unrelated places such as corners or edges of a building, or totally far from the building.
4. The most successful samples demonstrate the scaling rule, i.e., organized complexity, thereby helping to maintain the interaction between the elements of the facade.
5. Simplicity and uniform repetition do not engage the observer’s subliminal perception, which results in a heat map with large empty areas.
An empty and minimalist facade that lacks structural order could lead to a fragmented heat map with gaps, which causes the observer to lose his attention.
6. Certain powerful centers are defined that help perceive totality (Rule 3).

Quantitative Analysis of VAS Outputs:

To measure perceptual efficiency, we calculated:

1. Compliance: Number of criteria adapted in the three laws,
2. %: Number of criteria adapted in the three laws compared to the total criteria (Table 9)

Quantitative analysis confirms that Samples 2 and 4 demonstrated superior compliance with the tripartite structural order framework, Conversely, Samples 8 and 9 exhibited minimal conformance with the tripartite structural order principles.

Table 9. Quantitative Analysis of VAS Outputs

Sample	Compliance	%	Compliance rate
1	3/6	50	
2	5/6	83	High-compliance facades
3	3/6	50	
4	5/6	83	High-compliance facades
5	3/6	50	
6	4/6	66	
7	4/6	66	
8	1/6	16	low-compliance
9	1/6	16	low-compliance
10	2/6	33	

10.2. General Analysis of the Second Section

The test was conducted to investigate people's reactions to visual stimuli. This test aimed to indicate the connection between visual subjects and the observer's cognitive responses. This section concerned the designed sketches to help identify perceptual patterns and the key spots received by the observer's working memory. The test findings are categorized into three categories of structural order rules as follows:

1. Order on a micro scale: Contrasting colors and structural similarities in micro-scale elements;
2. Order on a macro scale: Receiving powerful centers, and
3. Order on an intermediate scale: Lack of a hierarchical connection between powerful centers and the micro and macro scales

As tested, the key spots received by the trained observer within the first 3-5 seconds and remained in the working memory are subjects on a micro scale, as color and the totality of volume (building's form and shape) have led to sketching the totality of ratio to each powerful center. This test provides the following:

1. On the micro scale, a contrast in forms, colors, and geometry provides a relatively perfect reception, indicating the significance of façade details on the micro scale.
2. On the macro scale, most powerful centers achieve an overall reception, with totality almost sketched, indicating the significance of powerful centers.
3. On the intermediate scale, where the patterns are repeated, organized sequences, modular elements, and structural similarities will remain in the memory when they are first received; there is, however, a weakness in receiving the hierarchical connection between them.
4. Attached items, cars, and natural elements are also received as transparent elements rapidly. The rapid reception of the attached items, not falling under the

main components of the façade and the facade, could have a major impact on receiving the landscape. For this, it is critical to control and manage them to better receive the landscape and have a clear view, and finally to remove any visual errors.

11. Conclusion

A comparison of VAS results and the experimental test (Table 10): 1) The extent to which structural order rules are used, and 2) The most important spots to be used in designs for creating a structural order.

Eye tracking tests using AI-based powerful VAS enable us to perform pre-attentive processing of facades and buildings. This article provided designers with some conceptual and practical considerations to access pre-attentive process information., which could affect their primary reactions to buildings. This unconscious reception significantly corresponds to Salinger's structural order, which had been conceptualized decades ago before this kind of visualization could ever be made possible. VAS helps to see the human hidden experience (defined here as unconscious perceptual patterns detected through pre-attentive processing in VAS) of buildings and predict how elements of a building could be remembered in the mind because the visual perception system ignores one part of the building facades completely and instead emphasizes other parts specifically. VAS allows designers to "see" the world we usually experience unconsciously.

As shown by the analyses, structural order rules on three micro, intermediate, and macro scales could help the observer rapidly receive, store, and perceive images. The factors of the first rule consisted of balanced visual contrasts, including contrasting colors, forms, geometry, and using details in the facades appropriately. If applied, this rule could help the observer receive the factors well. The factors of the second rule, which concern actions from a distance, consisted of geometric symmetry and connection and harmony in shapes, and colors, as well as the perception of connection lines by the mind. This also helps receive powerful centers, which connect together on a macro scale. If applied, major centers and totality in the facade will be unconsciously received by the observer. The factors of the third rule, which constitute the scale-based hierarchy, consisted of patterns and how they were repeated, as well as using a 2.7 ratio in proportions. This rule aimed to connect the micro and macro scales, resulting in the perception of the façade in a coherent and structured form in a way interconnected with other facades. According to the theoretical and experimental tests conducted in the VAS environment, the first rule is fully received and indicates the presence of the first rule factors in the facade.

Table 10. A comparison of VAS results and the experimental test (WM)

Rule	Scale	VAS factors		VAS	WM	Comparison
Rule No. 1	Micro	Hotspots in the heat map		Receiving contrasts in forms	Perceiving contrast in forms	+
		Hotspots in the heat map		Receiving contrasts in geometry	Perceiving contrast in geometry	+
		Hotspots in the heat map		Receiving contrasts in color	Perceiving emphasis on forms	+
		Hotspots in the heat map		Receiving details	Perceiving details	+
Rule No. 2	Intermediate	Gaze sequence		Receiving symmetry	Perceiving symmetry	+
		Gaze sequence	Hotspots in the heat map	Non-reception of fractal geometry	Non-perception of fractal geometry	-
		Hotspots with a higher percentage		Heat spots indicating powerful centers	Perceiving powerful centers	+
		Gaze sequence		Receiving pattern	Perceiving patterns	+
Rule No. 3	Macro	Gaze sequence		Receiving repetition	Perceiving repetition	+
		Gaze sequence		Non-reception of 2.7 ratio	Non-perception of 2.7 ratio	-
		Gaze sequence		Non-reception of the connection between micro and macro scale	Non-perception of the connection between micro and macro scale	-
		Gaze sequence		indicating a balanced gaze sequence	indicating a balanced gaze sequence	-

On the other hand, it represents the significance of design on the observer's side.

In the second rule, the factors of symmetry and powerful centers are rapidly received, but fractals may not be perceived in the working memory, thus suggesting a weak fractal design in the façades.

In the third rule, the factors of patterns and how they are repeated are well received; however, this rule, whose primary goal was to connect the micro and macro scales with a ratio of 2.7, provided no perception neither in the software environment nor in the real test environment.

This rule indicates the significance of the third rule, i.e., connecting the hierarchy of micro and macro scales, scaling, and the interconnection of various levels in design. These findings help to construct better places and strengthen the quality of urban façades in public domains. Evaluating prior experiences could lead to better designs. This will encourage architects to value building façades, as evaluation is useful for comparative studies in architecture. This helps architects to provide more sophisticated planning programs.

12. Practical Design Recommendations

Based on the findings of this study, several actionable guidelines are proposed for architects and urban designers aiming to enhance façade vitality and structural order:

1. Micro scale – façade detail design
 - Incorporate balanced color and geometric contrasts to create strong visual hotspots without overwhelming the viewer.
 - Avoid excessive minimalism that results in large “empty” gaze areas and reduced perceptual engagement.
2. Macro scale – urban coherence
 - Strengthen symmetry and establish powerful centers that provide a coherent “whole” perception of the façade.
 - Connect adjacent façades through shared proportions, rhythms, or material palettes to promote visual continuity.
3. Intermediate scale – hierarchical connection

- Apply proportional systems such as the 2.7 scaling ratio to link micro and macro elements effectively.
 - Integrate rhythmic repetition of modules to reinforce perceptual hierarchy and gaze stability.
4. Design testing with visual cognition tools
- Incorporate AI-based visual attention simulations (e.g., 3M-VAS) during the design review stage to predict hotspot distribution and gaze sequences, allowing for targeted design adjustments before implementation.

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Authors Contribution

The authors confirm the study conception and design: In this research, Maryam Motamedinezhad & Maryam Ostadi was responsible for collecting data and preparing the manuscript; Maryam Motamedinezhad & Maryam Ostadi was responsible for checking the accuracy of the data and evaluating the results, and Fatemeh Mohammadniai gharaei and Zahra Sadat Saeideh Zarabadi were responsible for selecting and reviewing the research method through written reviews.

Availability of data and materials:

The data supporting the findings of this study are included within the article and its supplementary materials.

Conflict of interests

The authors declare no conflicts of interest.

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