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Research Article

Beautiful, sustainable and inclusive cities: How visual attention on urban design can inform modern innovations tailored to promote mental well-being in urban settings

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Abstract: The objective of this study is to analyse visual attention and human-façade engagement with building façades in deprived neighbourhoods in Madrid with the aim of creating beautiful, sustainable, and inclusive neighbourhoods. By utilizing eye tracking technology and participatory design, this study seeks to elucidate how individuals visually engage with building exteriors and how such engagement influences their subjective wellbeing. A lack of symmetry along the vertical axis and a-similar geometrical size of windows, poor maintenance, non-transparency of windows, and non-homogeneity in colour and texture resulted in more reported subjective distress, whereas horizontal/vertical symmetry and same window shape/size resulted in less.

Implications: Incorporating historical urban design principles with modern tools like eye-tracking and participatory design offers new insights into creating environments that support mental well-being. Eye-tracking reveals how individuals visually engage with urban elements, while participatory design ensures inclusive solutions. Together, these methods refine the application of lessons from the past, fostering discourse and developing practical strategies for healthier, more resilient, and aesthetically engaging urban spaces.

Keywords: Building design, environmental health of housing, perception of built environments, subjective reported distress, sustainable built environment

1. Introduction

Mental health is a key component of overall well-being. Mental health issues, such as loneliness, affect 84 million people across Europe (European Commission, 2022a). In the European Union, Spain is identified as one of the 8 countries with the highest levels of loneliness (European Commission, 2022b). Furthermore, the World Health Organization views social isolation as a significant public health threat, leading to higher rates of illness and death, as was strongly illustrated during the COVID-19 lockdowns (Rokach & Boulazreg, 2022). Understanding the characteristics of this vulnerability in urban areas is vital for crafting and implementing policies that promote the well-being and quality of life of city residents.

In this context, the 'Catalogue of Vulnerable Neighbourhoods' (Hernandez, A. et al., 2018) mapped areas of urban deprivation in Spain, using indicators such as 1) the percentage of the population without education, 2) unemployment, and 3) substandard housing. Poor housing conditions and high energy costs exacerbate socio-economic inequality and heighten the vulnerability of neighborhoods to physical and mental health issues (Wilkinson, 2010). In light of this, the Most Energy Vulnerable (MEV) methodology identifies homes in Madrid that are at risk of limited access to sustainable and affordable energy sources during both summer and winter (Martin-Consuegra, F. et al, 2020). This methodology assesses areas affected by the urban heat island (UHI) effect in summer and energy poverty in winter (Figure 1). To fully understand the built environment of these neighborhoods, it is also important to consider the Homogenous Urban Zones (HUZ) classification. Based on Madrid's urban morphology, land cover, and buildings' construction characteristics, the Homogenous Urban Zones (HUZ) methodology aims to classify and identify the most representative built areas in the city of Madrid (Figure 2) (López-Moreno et al., 2022).

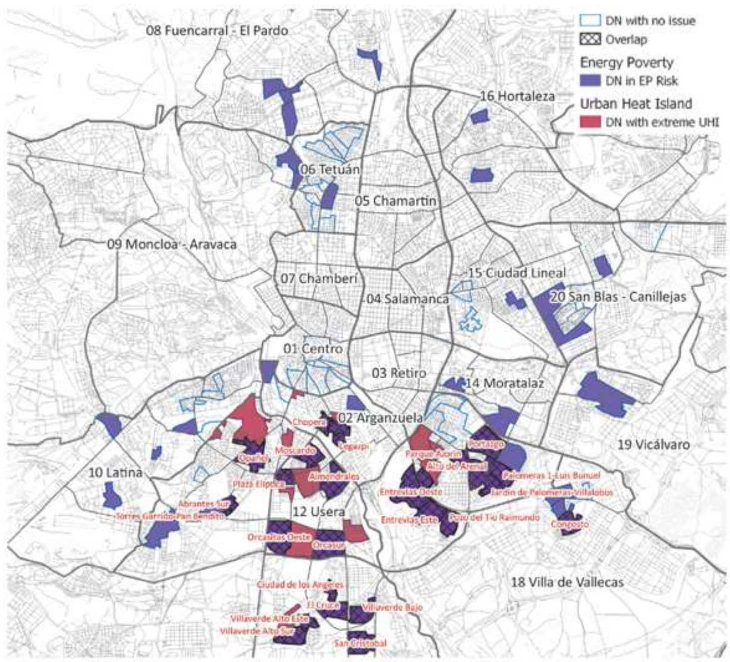

Figure 1. Most Energy Vulnerable Neighborhoods (MEV): Deprived Neighborhoods (DN) with Risk for Energy Poverty (EP) and extreme UHI values in Madrid / Source: own elaboration

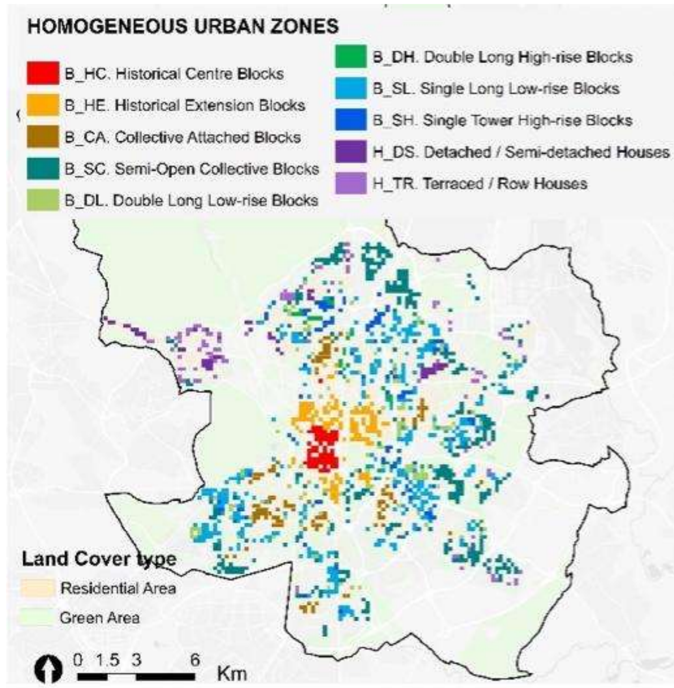

Figure 2 Identified Homogenous Urban Zones (HUZ) in the city of Madrid / Source: own elaboration

Unsustainable housing and social vulnerability of deprived neighbourhoods can have a cumulative negative mental health impact on local population groups. To tackle the socio-economic and climate challenges in Madrid's deprived neighbourhoods, it is imperative to initiate urban renovation. In fact, high quality housing has become more relevant within the context of the current New European Bauhaus (NEB) initiative. This is to say, the European Union (EU) has developed a new instrument that invites all Europeans to collaboratively create sustainable and inclusive cities (European Commission, 2022c). With the NEB initiative the EU intends to bring the European Green Deal to our urban life and living spaces. The NEB initiative not only aims to make our societies more sustainable but also strives to enhance the quality of experience and style, extending beyond functionality to encompass aesthetics and inclusivity (ensuring cities are diverse, accessible, and affordable). The idea behind this vision is that an environment that supports a healthy mental state may create significant psychological and physical benefits (European Commission, 2022d).

This study will focus on the impact of the built environment on human wellbeing in the most energy vulnerable neighbourhoods in Madrid. In this regard, it is essential to understand why there are urban places that encourage happiness, more than others. Some studies have already revealed how the characteristics of the built environment impact our emotions, behaviour and our physical well-being (Bower, Tucker, & Enticott, 2019). Past researchers (Weber et al., 1995) examined, for example, the impact of formal properties, such as size, contrast, symmetry on eye movements and explored the positive effect of various natural and urban settings on the parasympathetic nervous system (Ulrich et al., 1991). Other studies pointed out how the human brain looks for visual coherence in urban settings, as found in nature (Salingaros & Sussman, 2020).

Moreover, software has been developed that can simulate visual attention on building characteristics (Lisińska-Kuśnierz & Krupa, 2020). The advantage of the 3M Visual Attention Simulation Software (3M VAS) is that it simulates human responses to visual stimuli without laboratory set up. The software scans a photo and then predicts where the eye will fixate. A heatmap presents the simulation of the intensity of attention in colour codes. One example of a visual attention simulation to building façades is the study developed by Salingaros & Sussman (2020) where visual attention was simulated on the paintings of 5 different types of building façades: notably a classical/baroque, art deco building, a contemporary building with vertical windows aligned horizontally, and a contemporary building with unaligned vertical slit windows.

In addition to this visual attention simulation, participatory design is useful for exploring the effect of visual attention on humans' subjective levels of distress (Kim et al., 2008; De La Fuente Suarez, 2020). For example, Shapiro (1989) found a change in subjective distress when moving her eyes in a multi saccadic way during a recall of an anxious situation. Moreover, research confirmed that horizontal eye movements may result in increased parasympathetic nervous activation and thus have a relaxing effect (Aubert-Khalfa, Roques, & Blin, 2008).

This study aims to detect visual attention parameters in building façades with the aim of developing an approach to optimize building façades and thus the liveability of deprived neighbourhoods in Madrid. In this view, this study first characterizes and selects representative façades in Madrid according to their vulnerability indicators and urban characteristics, then identifies visual parameters that influence citizens wellbeing via a visual attention simulation, and participatory design, and finally defines positive visual parameters to consider for urban renovation. The methodology will be described in Section 3. The results, followed by a discussion will be addressed in Section 4 and Section 5. Finally, Section 6 will present the conclusions. Suggestions for a follow-up study will be ultimately outlined.

2. Methods

Focusing on energy-vulnerable areas is crucial in the context of the New European Bauhaus (NEB), as the initiative aims to foster beautiful and inclusive building design, while contributing to environmental sustainability and social equity.

Energy vulnerability refers to the inability of individuals or communities to access adequate energy services at an affordable cost, which often stems from poor housing, low income or inadequate infrastructure. In the context of the New European Bauhaus, which focuses on creating beautiful, sustainable, and inclusive living spaces, addressing energy vulnerability is an important element for ensuring the success and impact of the NEB initiative.

In line with the New European Bauhaus principle, this study focuses on the optimalisation of building façades in deprived neighbourhoods of Madrid. For the selection of representative buildings, the Most Energy Vulnerable (MEV) methodology was used where 27 deprived neighbourhoods were identified with a risk of urban heat island effect (UHI) in summer as well as energy poverty in winter (Figure 3). This study identified Delicias, Picazo, Orcasur Oeste, Orcasitas as the most vulnerable areas with a high potential for urban renovation (Martin-Consuegra, F. et al, 2022). Within the selected neighbourhoods a representative building was selected based on their most predominant Homogenous Urban Zones (HUZ) classification (López-Moreno, H. et al., 2022). The HUZ method determines representative building blocks considering the land cover, urban morphology and building construction. The methodology has been applied in Madrid, where it identified 10 HUZs. Figure 3 maps the Most Energy Vulnerable Neighbourhoods in the city of Madrid that are selected for this study and presents their HUZ.

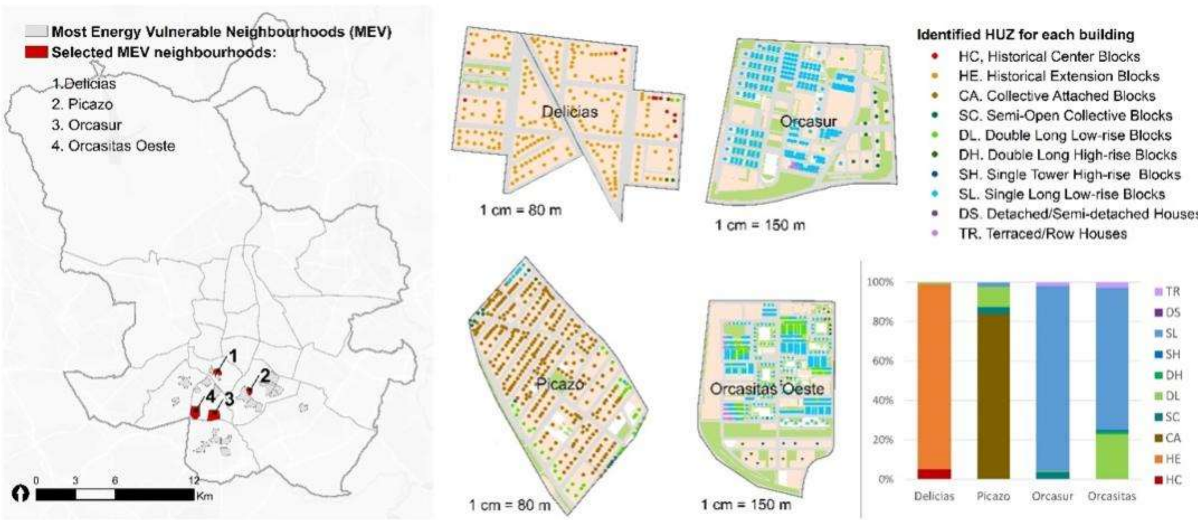

Figure 3. Map of identified and selected MEV neighbourhoods in the city of Madrid (left) HUZ classification and quantification of selected MEV neighbourhoods (right) / Source: own elaboration

The most representative class within Delicias is the Historical Extension Blocks (HE) representing 94% of its buildings, while in Picazo the most repeated HUZ class with an 84% representation is the Collective Attached Blocks (CA). Both HE and CA belong to the compact block areas from the early second half of the 20th century and are characterized by their low ratio of pedestrian and green areas. The HE class, developed near the city center, features higher-rise construction, but its building density is lower compared to the CA class, which has lower-rise built-up areas yet a higher building density.

On the other hand, Orcasur Oeste and Orcasitas are mainly characterized for having sprawl areas, where Single Long Low-rise Blocks (SL) is the predominant HUZ class with 94% and 72% respectively. This class is known for their urban sprawl of mid-to-late 20th-century buildings, marked by their large walkable and public green areas located between the primary and the furthest peripheral city ring. They were constructed in the mid-50s until the late 80s. Specifically SL is one of the most predominant HUZ in Madrid. It is shaped by single longitudinal dwelling rows of approximately 4 to 8 floors height.

For this study, a representative building that belongs to the most predominant HUZ in each of selected neighbourhoods has been determined. This is to say, residential constructions were evaluated and selected based on their proximity to the mean values of the HUZ land cover, urban morphology and building construction indicators. Therefore, in Delicias C. Divino Vallés, 12 (1) was selected, C. Martell, 32 (2) was chosen in Picazo, while Av. Orcasur, 17 (4) and C. de Gainza 11 (5), were defined in Orcasur Oeste and Orcasitas respectively. After verification of the in-person approachability of the building façade a final selection was made. In fact, due to construction at the façade of (4) in April 2022, the preselected case study was replaced by another similar representative building in Orcasitas, notably: (4*) C. de Cestona, 36, Madrid, Spain. Also, an additional representative building type SL was added to the list in view of alternative visual parameters (i.e. window geometry/alignment), notably (5) C. Campotejar, 36, Madrid, Spain.

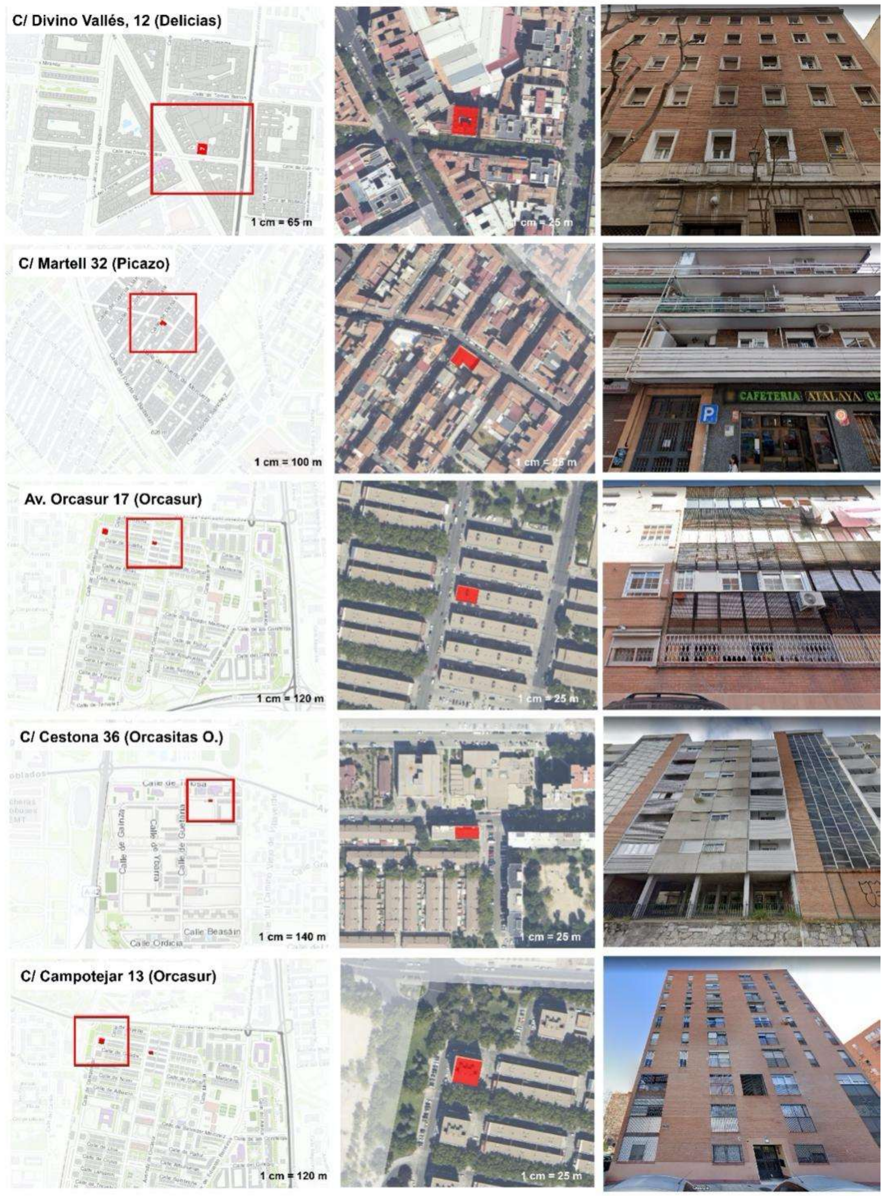

Figure 4. Map and google streetview of the selected building façades in MEV neighbourhoods of Madrid / Source: own elaboration

Façade design is often the first thing a person notices when they encounter a building. As underlined in the New European Bauhaus, the visual aesthetics of a building have a profound impact on mood and perception of space. In energy-vulnerable areas where people may already face social, economic, and environmental stressors, a well-designed, attractive façade can help foster a sense of pride, belonging, and community identity. Aesthetic quality can enhance well-being by reducing feelings of stress and anxiety. Well-designed façades that incorporate elements like natural light, greenery, or locally resonant architectural styles can elevate the quality of life by creating spaces that are perceived as welcoming, calming, and comfortable.

The methodology of this study is based on the idea that the design elements of a building façade can significantly influence how individuals visually engage with the environment and how this engagement impacts their psychological state. The methodology considers that more eye movements are indicative of better visual engagement with the façade. If we assume that the aim of sustainable architecture is to ensure that design choices contribute positively to the wellbeing of people, then these choices are intended to create environments that prioritize comfort, safety, and a sense of security. The psychological concept of the "Window of Tolerance" is central to this methodology (Figure 5). Within this window, the psychological response to the building environment is balanced, leading to a more comfortable and relaxed experience for the observer. The window of tolerance represents a range of emotional states in which an individual is able to effectively cope with and respond to stressors without becoming overwhelmed or emotionally dysregulated.

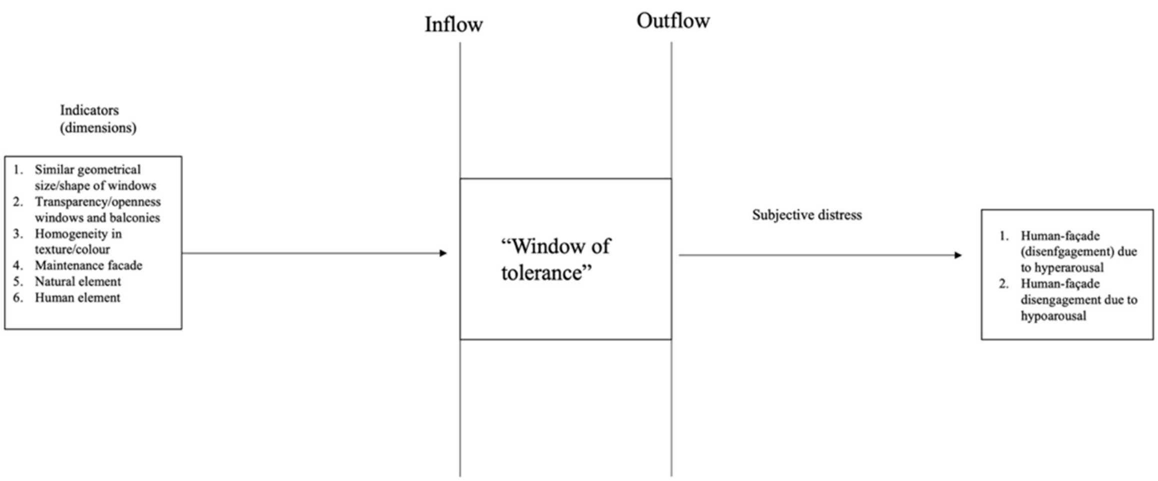

Figure 5. Concept to measure / Source: own elaboration.

The goal of architectural interventions is to maximize the time spent in optimal level of arousal, and/or to help individuals (Table 1) expand their window of tolerance (Figure 6). This means increasing their capacity to manage stressors and emotional experiences without entering states of hyperarousal or hypoarousal. In other words, designing spaces that not only embody beauty and functionality but also offer solace, empowerment, and feelings of comfort and emotional safety.

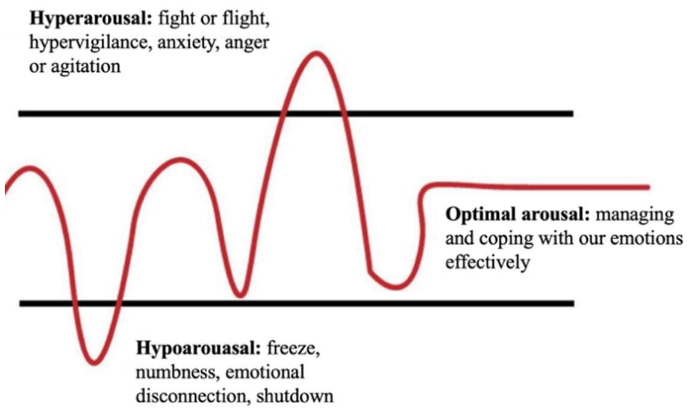

Figure 6. Window of tolerance / Source: own elaboration.

Participants were engaged through focus sessions, where their insights and feedback were gathered to inform the design process. In this study, three different approaches were compared: participatory design, where participants actively contributed to the creation of design concepts, and visual attention simulation combined with eye tracking, which provided data on how users visually engaged with different design elements. These methods were evaluated in tandem.

Table 1. Method for measuring visual attention / Source: own elaboration

Method	Experimental set-up
Visual attention simulation	Following the Salingaros & Sussman study (2020), this study uses the 3M VAS tool as an instrument to analyse the first 3-5 seconds of visual attention on the 5 selected building façades in the city of Madrid. Visual attention software was complemented by participatory design. A written informed consent was obtained by the participants in advance.
Eye tracking	To understand how the participants engage with building façade, raw gaze data was collected by the Tobii eye tracker. Once calibrated, the Tobii eye tracker tracked the movement of the eyes on the screen, including fixations (periods of stable gaze) and saccades (rapid eye movements between fixations). Eye tracking calibration with Tobii devices involves the user focusing on a series of calibration points displayed on the screen, typically in different areas like the corners and center. The system uses infrared light to detect the position of the eyes as they fixate on each target, mapping this data to corresponding screen locations. If the system detects any inaccuracy, it prompts the user to adjust their gaze or

	position. This process ensures that the eye tracker can accurately determine where the user is looking, with real-time adjustments to account for eye drift or changes during use.
Participatory design	Participatory design focuses on participants providing direct input into the design process. This was done in bilateral focus sessions. It is valuable for understanding user needs, preferences, and experiences, which can lead to more inclusive and relevant designs. Participants viewed the image of the building facade either on A3-sized paper in a university classroom or through the Miro digital platform. Eye-tracking provides data based on actual behaviour, while participatory design captures user opinions, preferences, and context that may not be visible through eye movements alone.
Participants	The participants for this study were recruited in the Universidad Politécnica de Madrid (UPM) and the University of Antwerp (UA) based on the snowball sampling method.

3. Results

Visual attention towards the HE, CA, SL building façades of the Most Energy Vulnerable Neighbourhoods was simulated with the 3M Visual Attention Software (VAS). This was followed by participatory design exploring conscious visual attention of the building façades and their subjective reported distress.

3.1. Visual attention simulation

The visual attention simulation shows in a heatmap the intensity of pre-attentive fixation spots over the first 3-5 seconds of visual gazing, in which the intensity of attention was color-coded: black (none), blue (low), green (medium), red (considerable), dark red (maximum) (Figure 7). The heatmaps indicate that windows and human/natural elements are the most important indicators for pre-attentive fixation in all building façades. Especially those elements that break the planned harmony of the façade such as ventilators, decorative plants' pots as well as opened windows or those ones that have shutters drawn. HE and CA typologies (image 1 & 2) show more homogeneous intensity of attention for all the façade, while in SL buildings differences in the heat map are more remarkable.

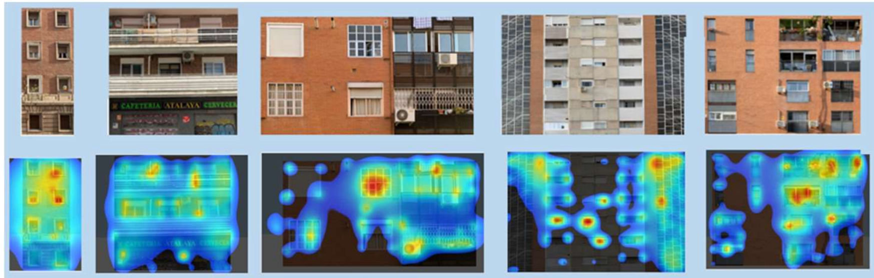

Figure 7. Simulated visual attention towards different types of building facade in deprived neighbourhoods in Madrid. C. Divino Vallés, 12 (HE), C. Martell, 32 (CA), Av. Orcasur, 17 (SL), C. de Cestona, 36 (SL), C. Campotejar, 13 (SL) (from left to right) / Source: own elaboration.

3.2. Eyetracking

3.2.1. Fixations

One way of visualizing real eye tracking data in Tobii Pro Lab is by creating Heat maps. These maps can reveal if participants are focusing on specific visual elements within the stimulus. Heat maps display areas of higher and lower visual attention. The distribution of the data is represented in areas with more intense colors (e.g., red or orange) representing regions of high visual attention, while areas with less intense colors (e.g., green) indicate lower attention. The color scale usually corresponds to the frequency and duration of eye fixations in each area. The regions with the most intense colors are often referred to as "hotspots" or "areas of interest" (AOIs). These are the areas that draw the most visual attention from participants. The regions with less intense colors are known as "cold spots" or "areas of low interest." Cold spots may indicate areas that are being ignored or skipped by participants. These areas may be less engaging or relevant to the participants' task.

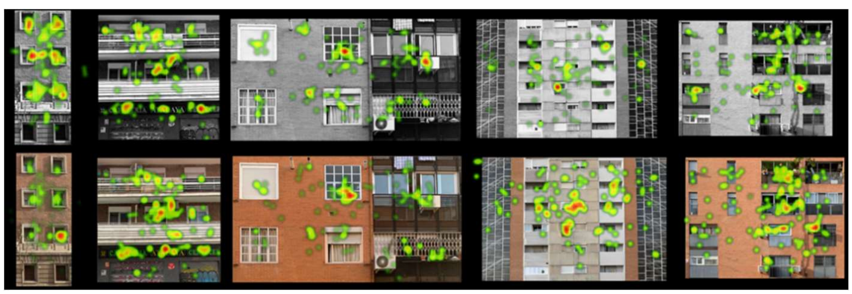

Figure 8. Heatmaps casestudies. Fixations or gaze data samples on black/white versus coloured pictures. C. Divino Vallés, 12 (HE), C. Martell, 32 (CA), Av. Orcasur, 17 (SL), C. de Cestona, 36 (SL), C. Campotejar, 13 (SL) (from left to right) / Source: own elaboration.

As illustrated in Figure 8, coloured pictures often have more visual saliency and complexity compared to black/white pictures. Participants might spend more time fixating on coloured pictures due to the presence of multiple colours, contrasts, and visually distinctive elements. It should also be noted that people may have different preferences or biases when it comes to processing black versus coloured pictures. Also, it is important to remember that interpreting heat maps should not be done in isolation. Combining heat maps with qualitative observations, and participant feedback provides a more comprehensive understanding of participants' visual attention and behavior (for this reason participatory design was conducted).

3.2.2 Saccades

It is essential to consider not only the number of fixations but also other eye movement metrics such as scan path, among others. Saccades are rapid eye movements between fixations. Visual sequence data can indicate shifts in attention or points where participants reorient their gaze to different areas of interest. Interpreting visual sequence data is a valuable step in understanding participants' dynamic visual attention and behavior. Interpreting subjective reported distress can vary over participants but horizontal eye movements, such as those used in certain eye movement techniques like Eye Movement Desensitization and Reprocessing (EMDR) have been associated with various therapeutic benefits and improvements in wellbeing. Horizontal eye movements have been hypothesized to facilitate the processing of traumatic memories and emotions. During EMDR therapy, for example, bilateral eye movements are believed to help individuals reprocess distressing memories and reduce emotional reactivity, leading to emotional healing and wellbeing.

Figure 9. Scanpaths casestudies eye tracker (Tobii) versus visual attention simulation (3M VAS). C. Divino Vallés, 12 (HE), C. Martell, 32 (CA), Av. Orcasur, 17 (SL), C. de Cestona, 36 (SL), C. Campotejar, 13 (SL) (from left to right) / Source: own elaboration.

The number of saccades (Figure 9) can reflect how participants explore the visual scene. In colored pictures, saccades might be driven by the need to identify objects based on their colors and shapes and participants may make more saccades as they move their gaze between different objects or regions of interest.

3.3. Participatory design

In both the 3M visual attention simulation and participatory design process, certain elements consistently drew the eyes of the participants across five different case studies (Figure 10).

3.3.1. C. Divino Vallés, 12. Historical Extension Blocks (HE)

In the first case study, attention was drawn to window shutters, the presence of human figures, and areas of high contrast. Shutters, being distinct structural elements, naturally captured attention, while the human decorative element provided a focal point of interaction. The contrast between different elements (such as light and dark areas) further emphasized these points of interest. As presented in Figure 9, both the simulated as the self-reported fixation spots indicated that the horizontal/vertical symmetry as well as the same size and shape of the windows resulted in cognitive entanglement. The windows of this historical extension block were perceived as a coherent aligned structure, which increased human-façade engagement and reduced reported subjective distress. However, contrary to the visual attention simulation, the maintenance and non-transparency of some windows (closed window shutters) and non-homogeneity in colour and texture between upper and lower part of the façade were reported as causing sadness and disengagement. On the other hand, the human element, placed in the (right) window frame on the first floor, was reported as a relaxing, engaging visual cue.

3.3.2. C. Martell, 32. Collective Attached Blocks (CA)

The second case study revealed that the eyes were drawn to the ventilator, the non-transparent (or opaque) balustrade, and graffiti. The ventilators, likely due to its mechanical and functional appearance, stood out as a point of interest. The opacity of the balustrade created a barrier that drew attention, and graffiti added a layer of visual intrigue due to its bold and irregular patterns. In photo 2, C. Martell, 32 (Figure 9) the windows are not aligned vertically. The fact that sub-symmetries are missing in this collective attached block, resulted in cognitive disentanglement and more self-reported subjective distress. This is to say, the participants reported disengagement with the building façade as result of the lack of symmetry along the vertical axis and size/geometry of windows. However, contrary to the visual attention simulation, the aluminium balustrade, coloured letters and graffiti in the lower part of the building strongly attracted the visual attention of the participants but were reported as uncomfortable and classified as disgust. In summary, the maintenance of the façade, the transparency (closed window shutters) and ventilators were reported as disengaging elements.

3.3.3. Av. Orcasur, 17. Single Long Low-rise Blocks (SL)

In the third case study, attention was captured by the non-transparency of the balcony's raster (grid structure), the transparency or partial transparency of windows (whether open or with curtains), and the human element represented by a towel. The contrast between transparent and opaque surfaces created a dynamic visual field, while the towel, as a personal item, introduced a human element that naturally attracted the eye. Contrary to the visual attention simulation, visual attention towards this single long low-rise block was also drawn to the vertical axis between the two types of materials in the left/right side of the building. The fact that sub-symmetries were missing resulted in cognitive disentanglement. Participants reported mostly surprise and in little quantity anger when looking at the difference in colour/material, window grid, its maintenance, non-transparency (closed windows shutters), ventilators, and a-similar window size/shape. The human elements (drying towels) were perceived as positive engaging, breaking the non-transparency of the largely present window grid.

3.3.4. C. de Cestona, 36. Single Long Low-rise Blocks (SL)

The fourth case study highlighted how the eye was drawn to areas of contrasting textures, the transparency of both stairs and windows, shutters, and a ventilator. Contrasting textures provided a tactile visual experience, while transparency in architectural elements like stairs and windows invited curiosity about the spaces beyond. Shutters and ventilators, being functional yet prominent elements, also held attention. In photo 4, C. de Cestona, 36 the windows have the same shape/size and are aligned horizontally and vertically. This single long low-rise block was scored by most as (at least slightly) engaging. The participants reported reduced subjective distress when looking at the façade due to the symmetrical organization of the material and the transparency of the stair hall. This is the result of visual coherence. However, the non-transparency of certain windows (deep terraces/stair hall raster) and texture of the middle part of the façade (concrete) were reported as slightly disengaging.

3.3.5. C. Campotejar, 13. Single Long Low-rise Blocks (SL)

In the fifth case study, transparency of the windows, plants, and a ventilator were the primary attractors. Transparency created a sense of openness and continuity, plants added a natural and vibrant element, and the ventilator, as seen in previous cases, remained a visually significant feature. In photo 5 the windows do not have the same shape and size and are not aligned vertically. The fact that sub-symmetries are missing in this single long low-rise block resulted in cognitive disentanglement. In addition, comparable with the simulated fixation, self-reported fixation spots were drawn towards human and natural elements, hence this façade was scored as (at least slightly) engaging. Non-transparent visual cues, such as window shutters/rasters were reported as disengaging, increasing reported subjective distress.

Figure 10. Comparison 1. simulated visual attention (3M VAS) versus 2. self-reported fixation spots towards different types of building façade in deprived neighbourhoods in Madrid. C. Divino Vallés, 12 (HE), C. Martell, 32 (CA), Av. Orcasur, 17 (SL), C. de Cestona, 36 (SL), C. Campotejar, 13 (SL) (from left to right) / Source: own elaboration.

By analyzing visual attention data collected through simulation, eye tracking, and participatory design processes, several key elements were identified as critical for fostering positive cognitive, emotional, and physical experiences in urban environments.

The study highlights four primary design features of building façades that significantly impact visual attention and, in turn, subjective well-being outcomes:

1. Size, shape, and arrangement of windows: The configuration of windows on a building façade plays a crucial role in directing visual attention. Larger, well-proportioned, and strategically arranged windows create a sense of openness and connectivity between the interior and exterior environments. This promotes

engagement with the space and enhances the emotional well-being of occupants and passersby.

2. Interior-exterior transparency of materials: The transparency of materials that connect interior and exterior spaces, such as open window shutters, contributes to a feeling of visual accessibility and openness. This transparency helps reduce physical and psychological barriers, making spaces feel more inviting and fostering a sense of safety and well-being for individuals in public spaces.
3. Homogeneity in colour and texture: A consistent use of colour and texture across building façades contributes to visual coherence, which is crucial for creating a harmonious environment. High levels of homogeneity help in reducing cognitive load and provide a more pleasant and easily navigable visual experience, fostering positive emotional states and encouraging longer stays in public areas.
4. Maintenance of building façades: Well-maintained façades instill trust and comfort, while deteriorating or neglected buildings may evoke negative emotions and deter engagement. Regular maintenance is essential for promoting not only visual appeal but also physical and emotional engagement with the urban space.

These design features collectively enhance the likelihood of human-façade engagement and contribute to positive cognitive, emotional, and physical awareness in public spaces, particularly in settings such as Historical Extensions, Collective Attached, and Single Long Low-Rise Blocks.

Based on the study's findings, urban designers and architects should prioritize the following principles when planning and designing public spaces and building façades:

1. Prioritize visual permeability by incorporating appropriately sized windows and transparent materials that foster a sense of connection between indoor and outdoor environments.
2. Design with coherence in mind, ensuring that the façade features (color, texture, materials) work in harmony to create a unified visual experience that is easy to navigate and mentally comforting.
3. Focus on the human scale in façade composition, balancing larger architectural features with more intimate, human-centered elements like windows and doors, which encourage engagement and attention.
4. Ensure regular façade maintenance to maintain visual appeal and instill a sense of safety and care, which contributes to a higher level of engagement and well-being.

These principles may not only enhance visual attention but also improve subjective well-being outcomes for individuals interacting with the built environment, ultimately fostering healthier, more engaging public spaces.

Finally, results show, in general terms, there were no discernible patterns across the variables describing demographic characteristics such as age, level of education or field of study. While it was initially assumed that age might influence respondents' perspectives, with younger individuals potentially illustrating different attitudes compared to older participants, the findings did not support this hypothesis. Similarly, the assumption that varying levels of education (bachelor's, master's, pre-doctorate, doctorate) might lead to diverse viewpoints was not confirmed, as the data did not reveal any significant trends. Furthermore, this study initially expected that individuals' fields of study could impact their responses, but this did not emerge as a defining factor either.

Despite the lack of clear patterns, it is essential to acknowledge the limitations and advantages of this analysis (see below). In general terms, this study outlines the diversity and complexity of human experiences and viewpoints. The results highlight the importance of considering individual perspectives rather than relying solely on broad generalizations based on demographics or field expertise.

4. Discussion

Limited attention has been given to the specific role of visual attention and memory recall in mediating the relationship between environmental aesthetics and wellbeing. Besides, blinking rate or pupil dilation, can change during moments of emotional arousal which could be explored in future research as well.

It is also important to note that snowball sampling has some limitations. Since participants are recruited based on referrals from existing participants (convenient sampling method) (Noy, 2008), there is a risk of bias and homogeneity within the sample, as individuals tend to refer to others who have a similar background as themselves. Additionally, the method may not result in a representative sample of local case study population, making it challenging to generalize findings to a broader context. Despite these limitations, snowball sampling remains a valuable tool in qualitative research for generating rich, in-depth insights when population groups are difficult to reach.

Findings from selected neighborhoods and building types in Madrid may not apply to other urban contexts. Madrid's unique combination of narrow historical streets, modern architecture, and hot climate influences building design and urban behaviour in ways that may not align with other cities, where factors like density, local preferences, and environmental challenges differ. Additionally, the economic and regulatory landscape in Madrid, including zoning laws and real estate dynamics, may shape urban development in ways that are specific to the city, limiting the applicability of these findings to regions with distinct socio-political or economic conditions.

Visual attention simulation tools like the 3M VAS provide useful insights into where people might focus their gaze, but they do not fully capture the complexity of real-world interactions with façades. These simulations often overlook factors such as environmental context (e.g., lighting, weather), behavioural variability (e.g., multitasking, distractions), and the dynamic nature of human movement through space. Additionally, they typically focus solely on visual cues, ignoring other sensory experiences like sound or touch, which also influence engagement with architectural elements. As a result, while these tools offer valuable predictions, they should be complemented with field studies and real-world observations for a more accurate understanding of how façades are experienced.

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