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The Urban Territory between Emotion and Architecture: Freehand Drawing as an Investigative Tool

By Gaia Leandri[*]

This paper presents a methodological proof-of-concept study investigating freehand drawing as a tool for analysing emotional responses to urban environments. The primary aim is propose and experiment an interdisciplinary framework that combines representation, image analysis, perceptual testing, and neurophysiological measures. In contemporary urban studies, emotional and perceptual dimensions are increasingly recognized as essential components of territorial identity. The interdisciplinary research project P.A.T.H.O.S. (Perception of Architecture, Territory and Heritage. Observation and Sensation) explores the potential of freehand drawing as a cognitive and affective tool for interpreting urban space. Moving beyond its traditional illustrative role, drawing is approached as a relational act capable of revealing the emotional resonance of places through lived experience. The study involved over 150 students from the University of Genoa, combining artistic practice, semantic and photometric image analysis and neurophysiological testing. Participants were assigned four emotions (Joy, Sadness, Anxiety, Calmness) and asked to select urban sites that embodied one of those feelings, producing on site drawings guided by their emotional responses. The results show strong correlations between visual characteristics and emotional intensity. The study support the hypothesis that drawing can serve as a critical and interpretive medium, capable of mapping the emotional geography of cities. This approach may open new perspectives for participatory urban design, where the emotional map of a place can inform architectural and planning decisions grounded in human experience.

Keywords: *city, drawing, emotion, perception, urbanism*

Introduction

A Project to Decode the Urban Environment

In the contemporary urban context, the concept of territorial identity has acquired a strong relational dimension. It no longer depends solely on geographical or historical characteristics, but also on how places are experienced and remembered. Studies in environmental psychology, human geography, and affective urbanism have highlighted the central role of emotions in the construction of territorial identity. The landscape, therefore, is not only what is seen, but also what is lived and felt (Zumthor, 2006).

In 2018, 55% of the world's population lived in urban areas, surpassing the share residing in rural regions. Projections indicate that by 2050 this figure will rise to 68%. With almost 5% of its territory built up, Europe ranks among the most urbanised

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[*] Tenure Track Researcher, University of Genoa, Italy.

regions globally (United Nations, 2018). In this context, the way urban areas are planned and developed will play a decisive role in shaping sustainable growth and quality of life.

Urban design has profound implications for mental health, social cohesion, and overall well-being (Lednova, 2024). Yet, despite decades of research in architecture, planning, and neurourbanism (Elsayed et al., 2025), the tools available to capture and quantify these effects in real urban contexts remain limited. Moreover, existing methods tend to focus either on physiological measurements or subjective assessments, without integrating them into a unified protocol. As a result, many approaches are difficult to replicate across different cultural and environmental contexts, limiting their usefulness.

This paper means to address such limitations by presenting the preliminary results of an interdisciplinary project endorsed by the Department of Architecture at the University of Genoa, provisionally named PATHOS. (Perception of Architecture, Territory and Heritage. Observation and Sensation). The core characteristic of PATHOS lies in its attempt to merge the inherently subjective dimensions of perception and emotion elicited by the urban environment with the objective experimental methods of deterministic science, as far as possible. In essence, the project aims to decode the extreme complexity of the built environment into quantifiable entities grounded in their effects on human experience.

By categorising psychological and neurophysiological responses to urban stimuli, PATHOS seeks to extract objective data that can be translated into analytical tools. These tools are intended to support the systematic analysis of how form, proportion, color, light, and other artificial or natural elements influence emotional perception and the liveability of urban environments.

The primary contribution of this paper is the proposal and preliminary validation of a transferable methodological framework in which freehand drawing operates as an interface between lived urban experience and quantitative analysis. The empirical results should therefore be interpreted as proof-of-concept evidence supporting the feasibility of the method.

Literature Review

Foreword

The investigation of the current state of interdisciplinary research on the urban environment is essential to identify the theoretical, methodological, and experimental gaps that persist across psychology, urban studies, and neuroscience. Although a growing body of literature acknowledges the emotional dimension of urban experience, these contributions remain fragmented across disciplinary boundaries, often adopting incompatible epistemological assumptions and experimental frameworks.

In parallel, architectural and urban studies have explored how cities are perceived, emphasising the role of atmosphere, memory, and everyday experience. More recently, neuroscience has provided tools to measure neural and autonomic correlates of emotional perception, offering the promise of objective indicators of affective states, though much of the experimental literature, particularly in neuroscience, relies on controlled laboratory settings or virtual simulations, which significantly reduce the multisensory and situational complexity of lived urban environments. As a result, the ecological validity of many findings remains limited, and their applicability to real, inhabited spaces is still uncertain.

This literature review is structured into five thematic sections: (1) psychological approaches to environmental and urban experience; (2) studies addressing the representation of the urban environment as a means to understand its emotional effects; (3) neuropsychological research on central nervous system responses to visual and spatial stimuli; (4) investigations of autonomic physiological correlates of environmental affect; and (5) virtual reality-based approaches.

Psychological Approaches to Environmental and Urban Experience

Psychological research has long demonstrated that the built environment plays an active role in shaping emotional states, cognitive functioning, and behavioural patterns. Within environmental psychology, urban space is understood not as a neutral container of activity, but as a dynamic set of stimuli that continuously interacts with perception, affect, and appraisal processes (Rapoport, 2013). Early studies established that spatial features such as density, scale, enclosure, and legibility influence stress levels, mood, and perceived comfort, particularly in everyday, repeatedly experienced settings.

A central contribution of psychological literature concerns the development of constructs such as place attachment, place identity, and sense of place, which describe the affective bonds formed through sustained interaction with environments. These bonds are not merely symbolic or cognitive, but emerge from embodied experience and emotional engagement with familiar surroundings (Lynch, 1960). Empirical studies conducted in real urban contexts have shown consistent associations between environmental characteristics and mental wellbeing, including perceived safety, emotional regulation, and restorative potential (Asgarzadeh et al., 2012; Pelgrims et al., 2021; Xu et al., 2023).

From a psychological standpoint, emotions are conceptualized as relational processes arising from the interaction between individuals and their environments. Several theories suggest that urban stimuli acquire emotional significance through rapid evaluations of relevance, predictability, and threat or affordance, often occurring below the level of conscious awareness (Zadra and Clore, 2011; Brosch et al., 2013). In densely inhabited urban settings, such affective appraisals are continuous and cumulative, influencing attention, movement, and decision-making, and contributing to perduring emotional states such as chronic stress or comfort (Morgan and Mall, 2019; Ostinelli et al., 2021).

Despite the robustness of these findings, psychological investigations of urban affect have relied predominantly on self-report questionnaires, interviews, and behavioural observation. While these methods are essential for capturing subjective experience, they are limited by introspective bias, linguistic mediation, and reduced comparability across contexts. Consequently, although psychology has clearly established the emotional relevance of urban environments, it has struggled to develop standardized and transferable tools capable of systematically linking specific environmental features to measurable affective responses in real-world settings.

Representation of the Urban Environment as a Tool for Affective Understanding

Within architectural and urban studies, representation has long been understood not merely as a descriptive practice, but as a cognitive and interpretative act through which spatial experience is selected, structured, and emotionally charged. Visual representations of the city, like maps, sketches, diagrams, and photographs do not passively reproduce urban reality; rather, they mediate perception and contribute to the construction of meaning and atmosphere (Lynch, 1960; Dutoit, 2007).

Drawing, in particular, occupies a privileged position in the exploration of urban experience. In contrast to automated or photographic forms of representation, hand drawing requires active engagement with space and time, compelling the observer to make interpretative choices regarding scale, framing, emphasis, and omission. Several authors have argued that this process fosters heightened attention to spatial relationships, rhythms, and tensions, allowing affective qualities of places, such as comfort, unease, attraction, or monotony, to emerge through visual form (Amistaldi, 2021; Bradecki and Stangel, 2014). Recent cognitive research has also emphasized the role of drawing and diagrammatic representation as fundamental tools of spatial reasoning and conceptual structuring. According to Tversky (2019), the act of drawing externalizes internal cognitive processes, enabling complex spatial relations and experiences to be organized into interpretable visual structures.

Research in urban studies and visual culture suggests that representation plays a crucial role in articulating the emotional dimension of everyday environments. The city functions as a "daily landscape" that is experienced repeatedly and often unconsciously. Drawing and mapping practices make this familiarity visible, enabling reflection on how ordinary urban spaces are perceived and felt (La Cecla, 2011). In this sense, representation acts as a bridge between lived experience and analytical understanding, translating emotional impressions into communicable visual artifacts.

Beyond its exploratory function, drawing also serves as a medium of emotional communication. Visual elements such as line density, contrast, spatial compression, and compositional balance have been shown to influence emotional interpretation, even in the absence of explicit narrative content (Stanischewski, 2020; Sahyun, 2024). Participatory mapping and emotional cartography further demonstrate that visual representations can externalize subjective affect and reveal shared emotional patterns within urban environments (Panek and Benediktsson, 2017).

Despite this growing body of work, the affective dimension of urban representation has been addressed primarily through qualitative analysis, interpretative readings, and participatory methods. While these approaches provide rich insights into the experiential qualities of places, they rarely establish systematic links between formal characteristics of representations and measurable emotional responses. This methodological gap limits the transferability of findings and hinders dialogue with empirical psychological and physiological research, underscoring the need for integrative approaches capable of connecting visual representation, emotional experience, and objective measurement in real urban contexts.

Neurophysiological Correlates of Visual and Spatial Emotion: Central Nervous System Measures

Neurophysiological research has provided extensive evidence that emotional perception modulates early and late stages of visual and attentional processing in the human brain. Electroencephalography (EEG) and Event Related Potentials (ERPs) have been widely employed to investigate how affective significance influences sensory encoding, attentional allocation, and motivational relevance of visual stimuli. Foundational studies have demonstrated that emotionally salient stimuli elicit enhanced neural responses at multiple temporal stages, including early visual components and later evaluative processes (Cuthbert et al., 2000; Schupp et al., 2006).

Visual evoked potentials (VEPs) and early ERP components have been shown to reflect rapid, automatic modulation of sensory processing by affective content (Pourtois and Vuilleumier, 2006; Zadra and Clore, 2011). These effects are particularly pronounced for stimuli associated with threat or uncertainty, suggesting that emotional relevance alters spatial attention and perceptual organization at early processing stages. Later ERP components, as well as slow cortical potentials such as Contingent Negative Variation (CNV), have been linked to anticipatory attention, expectancy, and motivational engagement (Schupp et al., 2006; Harmon-Jones and Gable, 2018). The recorded potentials that are related to a visual event are usually addressed as Visual Event Related Potentials (VERPs), the acronym that will be used in this paper.

Within this literature, affective processing has been most frequently investigated using standardized visual stimuli, including photographs drawn from validated image databases such as the International Affective Picture System (IAPS) and the Nencki Affective Picture System (Lang et al., 2008; Marchewka et al., 2014). These paradigms offer high experimental control and reproducibility, but the stimuli typically depict isolated objects, animals, or emotionally explicit scenes, rather than complex spatial environments, and are presented under highly constrained laboratory conditions.

As a result, although EEG and ERP studies have convincingly demonstrated neural sensitivity to affective visual information, their application to urban and architectural contexts remains limited. The perceptual and emotional experience of real urban environments unfolds through sustained exposure, multisensory integration, and embodied movement. These conditions are difficult to replicate in conventional experimental settings. Recent work in neurourbanism has begun to address this limitation, yet many studies continue to rely on virtual simulations or simplified visual proxies rather than direct engagement with real, inhabited spaces (Elsayed et al., 2024; Elsayed et al., 2025).

Consequently, a critical gap persists between the well-established neural markers of affective perception identified in laboratory research and their application to the study of everyday urban environments. In particular, the relationship between complex spatial representations, such as drawings or depictions of lived places, and central nervous system responses has not yet been systematically explored. This gap highlights the need for experimental frameworks capable of preserving ecological validity while leveraging the temporal sensitivity of EEG-based measures to investigate affective responses to urban experience.

Functional Neuroimaging Approaches and Their Methodological Constraints

Functional magnetic resonance imaging (fMRI) has been widely employed to investigate neural processing enabling the localization of brain regions associated with affective appraisal, reward, threat detection, and spatial cognition (Etkin and Wager, 2007; Kringelbach and Berridge, 2010). Owing to the constraints of the imaging environment, however, such studies necessarily rely on highly controlled experimental paradigms and, in the context of urban research, predominantly employ photographs or virtual reality simulations rather than real, embodied exposure.

From a methodological standpoint, fMRI presents two critical limitations for the investigation of affective urban experience. First, its temporal resolution is insufficient to capture the rapid dynamics of emotional and perceptual processing, which unfold on the scale milliseconds (Pessoa and Ungerleider, 2005). Second, its morphological results are just an indirect proxy of neuronal activity, sometimes leading to overrating its performance with possible ambiguous interpretations (Poldrack, 2012).

While fMRI has undoubtedly contributed to the identification of large-scale neural networks involved in emotion and spatial cognition, these limitations reduce its suitability for studying the temporal structure and modulation of emotional responses elicited by complex urban environments.

Autonomic Correlates of Emotional Experience in Urban Environments

In parallel with central nervous system measures, psychophysiological research has extensively documented the role of the autonomic nervous system (ANS) in emotional processing. Autonomic responses, including heart rate, heart rate variability (HRV), electrodermal activity (EDA), and respiration, are closely linked to arousal, stress, and affective intensity, providing objective indicators of emotional engagement that operate largely outside conscious control (Benson, 1975; Panksepp, 1998).

From a psychological and psychophysiological perspective, autonomic activity reflects the organism's continuous adaptation to environmental demands. Urban environments, characterized by high sensory load, social density, and spatial complexity, have been shown to elicit measurable autonomic responses associated with stress, vigilance, and emotional regulation. Field studies conducted in real urban contexts indicate that exposure to crowded, noisy, or visually disordered settings is associated with increased sympathetic activation, whereas environments perceived as coherent or restorative tend to support parasympathetic regulation and physiological recovery (Asgarzadeh et al., 2012; Pelgrims et al., 2021).

Autonomic measures have also been employed to investigate rapid affective reactions to environmental stimuli, capturing contingent fluctuations in emotional arousal that are not reliably accessible through self report. Electrodermal responses, in particular, have been widely used as indicators of emotional salience and orienting responses, while cardiac measures have been linked to stress, attentional engagement, and emotional valence (Cuthbert et al., 2000; Fredrickson, 2001). These measures are especially valuable in ecological settings, as they can be recorded continuously during real-world exposure with minimal interference to behaviour.

Despite their sensitivity and ecological potential, autonomic indicators are inherently non-specific: similar physiological patterns may correspond to different emotional states depending on context and individual appraisal. For this reason, autonomic measures alone cannot fully characterize the qualitative nature of emotional experience. In urban research, they have most often been employed either as standalone indicators of stress or as complementary measures alongside subjective reports, rather than as components of integrated affective models.

Consequently, while autonomic responses provide a crucial physiological window onto emotional experience in real environments, their interpretative power depends on integration with other levels of analysis. The absence of frameworks linking autonomic dynamics to specific spatial features or to higher-order perceptual and representational processes remains a significant limitation in current urban affect research, further motivating interdisciplinary approaches capable of combining physiological sensitivity with contextual and perceptual specificity.

Virtual Reality in the Study of Urban Emotion

Virtual reality (VR) has emerged in recent years as a prominent tool for investigating emotional and cognitive responses to urban environments. By enabling immersive, controllable, and repeatable exposure to simulated spaces, VR offers clear methodological advantages, particularly in experimental settings where precise manipulation of visual and spatial parameters is required. In the context of urban research, VR has been employed to study restorative environments, neighbourhood preferences, and affective responses to architectural features, often in combination with neurophysiological measurements (Elsayed et al., 2024; Galleguillos-Torres and Grêt-Regamey, 2025).

The principal strength of VR lies in its ability to balance ecological richness with experimental control. Compared to static images, virtual environments allow dynamic navigation and perspective changes, facilitating the investigation of spatial experience beyond purely pictorial stimuli. This has led to a growing body of work within neurourbanism that adopts VR as a proxy for real urban exposure, particularly when investigating neural and autonomic correlates of environmental perception (Elsayed et al., 2025).

However, despite these advantages, approaches based on VR present intrinsic limitations that are especially relevant when the objective is to understand emotional experience in real, inhabited environments. Virtual simulations remain primarily visual and auditory, offering a reduced multisensory spectrum that excludes tactile, thermal, olfactory, and social cues that play a critical role in everyday urban perception. Moreover, the knowledge of being in an artificial and consequence-free environment alters emotional appraisal, risk perception, and behavioural engagement, potentially attenuating or distorting affective responses.

Empirical comparisons suggest that emotional and physiological reactions elicited in virtual settings do not fully replicate those observed during real world exposure, particularly for affective states linked to uncertainty, threat, or embodied movement (Huang et al., 2025). As a result, while VR provides valuable insights into stimulus-driven emotional responses and allows for systematic parameter control, its capacity to capture the complexity and intensity of lived urban affect remains limited.

For these reasons, VR should be regarded as a complementary methodological tool rather than a substitute for research conducted in real environments. Studies that rely exclusively on virtual simulations risk overlooking critical dimensions of urban experience that emerge only through direct, embodied interaction with physical space. This distinction is particularly important for research aiming to develop transferable and ecologically valid protocols for assessing emotional responses to urban environments.

Identified Gaps and Positioning of PATHOS

To integrate the heterogeneous strands of research reviewed above, it is necessary to clarify the epistemological role assigned to the human observer within the present study. The lived urban environment is inherently complex, multisensory, and dynamic, resisting direct reduction into discrete variables without substantial loss of experiential meaning. Visual, auditory, tactile, thermal, olfactory, and social cues are continuously integrated through perception and emotion, producing a form of environmental experience that cannot be exhaustively parameterized at the source. Within this context, the human subject should not be regarded as a source of noise or bias to be eliminated, but as an active interface capable of translating environmental complexity into structured, analyzable forms.

Human perception already performs a continuous process of selection, compression, and affective weighting, transforming the analogue continuity of the real environment into salient spatial and emotional representations. Freehand drawing is understood here as an externalized trace of this process: a visual artifact that encodes attentional priorities, spatial relationships, and emotional salience through formal choices such as framing, scale, density, and emphasis. The resulting representation is neither a direct depiction of the environment nor a purely subjective expression, but a mediated construct shaped by perceptual, cognitive, and emotional constraints. This human-mediated transformation enables a principled reduction of complexity, preserving experiential structure while rendering it accessible to subsequent analysis.

The literature just reviewed reveals a series of persistent and interconnected gaps. Psychological research has convincingly demonstrated that urban environments influence emotional wellbeing, but has struggled to move beyond self-report and observational methods towards standardized, transferable measures. Studies on urban representation and drawing have shown that affective qualities of place can be externalized and communicated visually, yet have remained largely qualitative and interpretative. Neurophysiological research has identified neural markers of affective perception, but has applied them predominantly to simplified or standardized stimuli, rarely addressing complex spatial environments. Autonomic measures offer ecologically valid indicators of emotional arousal, yet lack specificity. Finally, approaches based on virtual reality provide experimental control but reduce multisensory richness and embodied engagement, limiting their capacity to capture lived urban experience.

PATHOS is positioned at the intersection of these gaps. Rather than attempting to directly quantify the urban environment itself, the project adopts the human observer as a necessary transducer between environmental complexity and scientific measurement. The core methodological strategy consists in using freehand drawing as a structured means through which individuals encode their perceptual and emotional experience of real, inhabited urban environments. These drawings constitute a reduced but meaningful representation of environmental affect, which can then be subjected to systematic analysis.

Crucially, PATHOS does not treat drawings solely as qualitative artifacts. Their semantic and formal properties can be investigated through psychological decision-making frameworks and, in parallel, through the assessment of neurophysiological responses elicited during their visualization. VEPs and ERPs are thus employed not to measure the city directly, but to probe the neural and physiological correlates of human-translated environmental experience (the produced drawing). In this way, the project links the analogue domain of lived urban perception to the digital domain of quantifiable scientific evidence through an explicit, human-mediated step.

The present contribution reports preliminary results aimed at testing the feasibility and coherence of this approach. Rather than offering definitive conclusions about specific urban features or emotional outcomes, PATHOS seeks to establish a transferable methodological framework capable of integrating subjective experience, visual representation, and objective measurement within real environmental contexts. Future work will be directed toward expanding sample sizes, refining analytical protocols, and systematically validating the relationships between representational features, psychological judgments, and neurophysiological responses. Within this perspective, subjectivity is not treated as an obstacle to scientific rigor, but as a necessary and structured component in the study of emotionally meaningful urban environments.

Methods

First of all, it is important to highlight that this is a proof of concept work, to study and possibly improve its framework, in a field so far unexplored. Most procedures are applied in experimental manner, and necessarily their interconnections must be subject to preliminary testing.

General Plan, Aims and Steps

The conceptual framework of the PATHOS project, with its aims and steps, is summarized in Figure 1, where it is made clear that the course aimed at quantifying the emotional features of the urban environment hinges on the human experience and creativity. The complex multisensory urban environment is first experienced and interpreted by a human observer, who encodes this experience through freehand drawing. The resulting representations are analysed at three complementary levels:

photometric/chromatic image statistics, semantic scene descriptors, and representational drawing features. The freehand drawings can then be used to measure neurophysiological responses, enabling the extraction of quantifiable emotional signatures associated with architectural and urban environments. Also, they can be submitted as a simple online test to assess their communicability.

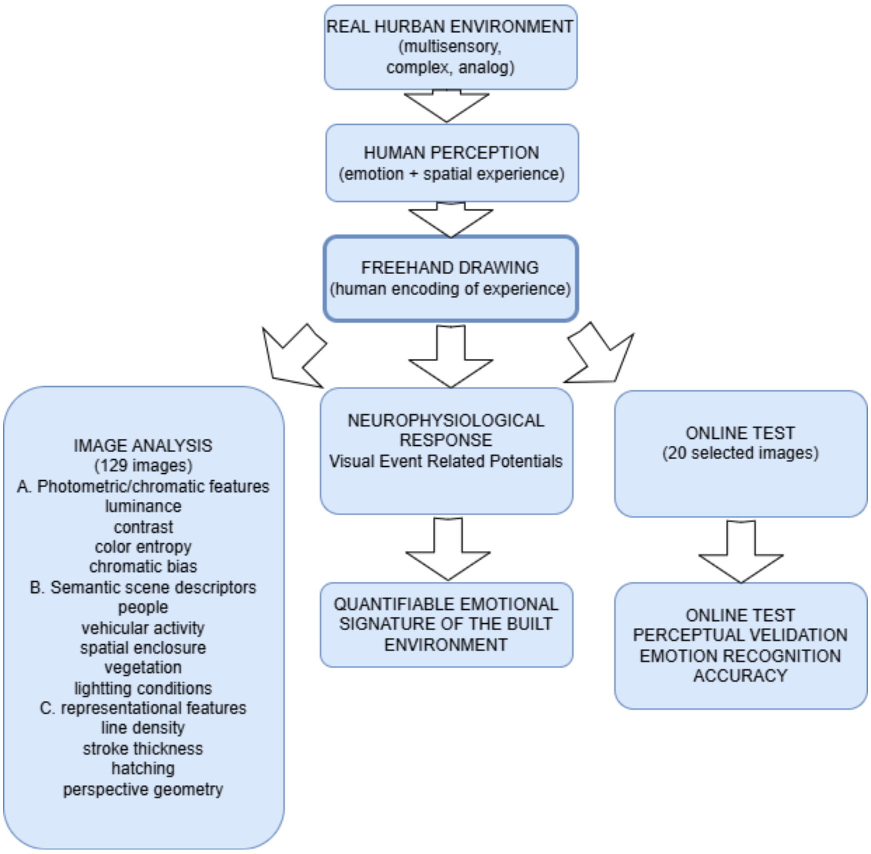


Figure 1. *Conceptual Framework of the PATHOS method*
Source: image by the author

Subjects

All subjects involved in this study, either as drawing authors or observers or undergoing neurophysiology testing gave their informed consent to the procedures and use of anonymized data.

Students, authors of drawings: a total of 150 students (age details in table 1) participated in the first phase of the study: the making of freehand drawings. They were all students at various Bachelor and Master courses of the Department of Architecture at the University of Genoa. Regardless of their experience in freehand drawings, they were asked to depict in their own style and method a site linked to a definite emotion (see the following “Emotion representation” subsection for the proposed list of emotions)

Table 1. *Age and Gender of drawing Crafters*

Age range	Female	Male
18-19	8	4
20-29	86	18
30-39	25	7
40-49	2	0

Observers participant to the online test: the online test was taken by 212 participants, whose age and gender are shown in Table 2. Their occupation was: Student=97; Professional architect=26 and Other 89

Table 2. *Age and Gender of Participants to the Online Test*

Age range	Female	Male
18-19	11	7
20-29	64	45
30-39	23	18
40-49	8	6
50-69	20	5
70_79	3	2

Seven subjects underwent the Visual Event Related Potentials (VERPs). They were female students, aged 19-28 years, of the second year of the Bachelor course in Architecture at the University of Genova. All of them were in good health, with no history of alcohol or drug consumption.

Emotion Representation

Since there is no official classification in the literature of emotions associated with urban landscape and architecture, four basic emotions were selected: Joy, Sadness, Anxiety and Calmness, in order to establish two positive and two negatively contrasting pairs (Ekman, 1992). So we had two positive and two negative paired emotions.

These emotions served as a guide throughout the experiment, influencing both the choice of location and the graphic style of representation.

All students were asked to choose an area of the city of Genoa based on the emotion assigned to them. The survey drawing sessions took place in July and September 2024 and 2025.

The Online Test Procedure

To evaluate whether freehand drawings of urban locations communicate the intended emotional character of place, a perception test was conducted using an online questionnaire. Participants (N = 212) were shown a series of 20 freehand drawings depicting specific urban sites. Each drawing had been produced by its author with the explicit intention of conveying one of four emotional states associated with the place: calmness, anxiety, joy, or sadness.

The online test started when only part of the final amount of drawings were available. The selection of the 20 drawings was based on both formal and content-related considerations. A variety of drawings was chosen to include both black and white and color works, created using different techniques such as pen, pencil, watercolor, markers, and acrylics, with both vertical and horizontal orientations. At the same time, a diverse range of scenarios was presented depicting open and enclosed spaces, natural and artificial elements, modern and historical architecture, as well as scenes featuring people or empty landscapes

For each image, participants selected which of the four emotions they believed the drawing expressed. The task therefore constituted a four-alternative forced-choice judgment. Responses were considered correct when the selected emotion corresponded to the emotion originally assigned to the drawing by its author. All participants evaluated all 20 images. Because the task involved four response options, the chance level of correct identification was 25%. The analysis therefore compared the observed proportion of correct responses with this baseline. Accuracy was calculated per image and across all responses. Statistical significance was assessed using exact binomial tests against the 25% chance level. Confidence intervals for proportions were calculated using the Wilson method, which provides stable interval estimates for binomial data (Wilson, 1927; Brown et al., 2001).

Semantic and Representational Annotation of Drawings and Related Statistical Analysis

In addition to photometric and chromatic image statistics (see the following subsection), each drawing was annotated using a set of semantic and representational descriptors designed to capture contextual and graphic characteristics of the depicted urban scenes. Semantic scene annotation is commonly employed in studies of visual emotion and environmental perception to complement low level image statistics with higher level contextual information (Lang et al., 2008; Marchewka et al., 2014; Redies et al., 2020).

All semantic and representational variables were coded manually by the author using predefined ordinal categorical scales designed to allow simple quantification of scene characteristics; their list is shown in Table 3. Such semantic scene descriptors have been widely employed in studies of visual affect and environmental perception to capture the contextual meaning of images beyond low-level visual statistics (Lang et al., 2008; Redies et al., 2020). The resulting coded variables allow qualitative and quantitative comparisons between emotional stimulus categories.

To capture representational characteristics of the drawings themselves, additional variables describing graphic execution were recorded; they are listed in Table 4. These descriptors provide a simplified representation of drawing style and allow the graphic encoding of spatial perception to be examined alongside the semantic characteristics of the depicted environment.

Table 3. *Semantic Variables*

Variable	Scale
People presence	0–2
Vehicular activity	0–1
Spatial openness	1–3
Street width	1–3
Building height	1–3
Vegetation presence	0–1
Sky visibility	0–1
Perspective convergence	0–2

Table 4. *Representational Variables*

Variable	Scale
Line thickness	0–2
Line density	0–2
Hatching intensity	0–2
Line grouping	0–2

All variables were recorded as ordinal scores to allow descriptive and non-parametric statistical comparisons between emotional categories. Differences between emotional groups were evaluated using the Kruskal-Wallis non-parametric test (Kruskal and Wallis, 1952), which assesses whether the distribution of a variable differs across multiple independent groups. Effect sizes were estimated using eta-squared (η^2) statistics. For visualization purposes, category means of selected variables were normalized to a 0-1 range and represented using radar plots to illustrate the multidimensional spatial signatures associated with the different emotional categories.

Image Global Photometric and Chromatic Statistics

To quantify the global visual properties of the stimulus images, summary statistics describing luminance, contrast, and chromatic bias were computed. These image features are known to influence perceptual processing and emotional appraisal of visual scenes (Palmer & Schloss, 2010; Valdez & Mehrabian, 1994).

All images were stored in JPEG format and decoded into the standard sRGB color space. Pixel values were normalized to the range 0-1 prior to further processing. To obtain physically meaningful luminance values, sRGB values were converted to linear RGB by applying the inverse gamma correction defined by the sRGB standard (IEC 61966-2-1).

All computations were performed using LabVIEW® (National Instruments) with the Vision Development Module, which provides built-in color space conversion utilities (e.g., RGB to CIE L*a*b*). When required, additional routines were executed through the LabVIEW Python Node.

To ensure comparability across stimuli, all images were processed using the same decoding, normalization, and color/space conversion prior to statistical analysis.

Luminance Computation

Perceived luminance Y was computed for each pixel using the standard linear transformation from RGB to the CIE XYZ tristimulus space:

$$Y = 0.2126R + 0.7152G + 0.0722B$$

where R, G, and B represent linear red, green, and blue intensities. These coefficients correspond to the photometric sensitivity of the human visual system and are defined by the CIE colorimetric standard (CIE, 1931; Wyszecki & Stiles, 1982).

For each image, mean luminance was calculated as:

$$Y_{mean} = \frac{1}{N}\sum_{i=1}^{N} Y_i$$

where N denotes the total number of pixels in the image. Mean luminance provides a measure of the overall brightness of the stimulus.

Contrast Estimation

Global contrast was quantified using the standard deviation of luminance:

$$\sigma_Y = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(Y_i - Y_{mean})^2}$$

This measure corresponds to root mean square (RMS) contrast, which is widely used in vision science as a global descriptor of luminance variability (Peli, 1990). RMS contrast captures the dispersion of luminance values around the mean and provides a compact estimate of global visual contrast within the stimulus image.

Chromatic Statistics

To quantify chromatic properties, images were converted from RGB to the CIE L*a*b* color space using a D65 reference white (CIE, 1976). The L*a*b* color space is approximately perceptually uniform and separates lightness from chromatic components.

For each image, mean chromatic coordinates were computed as:

$$a^*_{mean} = \frac{1}{N}\sum_{i=1}^{N} a^*_i$$

$$b^*_{mean} = \frac{1}{N}\sum_{i=1}^{N} b^*_i$$

The a^*axis represents the green–red chromatic dimension, whereas the b^*axis represents the blue-yellow chromatic dimension. These parameters provide a quantitative estimate of the global color bias of each stimulus.

Previous studies have shown that chromatic characteristics can influence emotional perception of visual stimuli, with systematic associations reported between color distributions and affective dimensions such as valence and arousal (Valdez & Mehrabian, 1994; Palmer & Schloss, 2010). In particular, variations along the blue-yellow chromatic axis have been linked to differences in perceived emotional tone and affective appraisal.

Global Image Descriptor

Each stimulus image was therefore characterized by a four dimensional feature vector:

$$(Y_{mean}, \sigma_Y, a^*_{mean}, b^*_{mean})$$

These parameters respectively quantify overall brightness, global contrast, and chromatic bias along the red/green and blue/yellow perceptual axes. Such global image statistics provide a compact quantitative description of the visual properties of the experimental stimuli while preserving perceptually relevant luminance and color information.

Image Distributional Statistics: Color Entropy

To quantify the diversity of color distributions within each stimulus image, color entropy was computed as a distributional image statistic derived from the color histogram. Entropy-based descriptors are widely used in image analysis as indicators of visual complexity and information content and have been shown to correlate with perceptual judgments of image richness and aesthetic or emotional response (Redies et al., 2020; Sahyun, 2024).

Images were represented in the standard sRGB color space and quantized into a fixed number of color bins to obtain a stable estimate of the color distribution. The relative frequency $p_i$of pixels in each color bin was then used to compute Shannon entropy (Shannon, 1948):

$$H = -\sum_{i=1}^{K} p_i \log_2 p_i$$

where $p_i$represents the probability associated with the i-th color bin and K is the total number of bins in the color histogram.

Higher entropy values indicate a diverse or more complex color distribution, whereas lower values correspond to images dominated by a smaller set of colors. Color entropy therefore provides a quantitative measure of the distributional complexity of chromatic information in the stimulus images, complementing the global photometric-chromatic descriptors computed for luminance and mean color values. The theoretical entropy range depends on the number of histogram bins used in the quantization procedure. When N bins are used, entropy ranges between 0 and $\log_2 N$, with the maximum value occurring when all bins are equally populated.

Visual Event Related Potentials

Working hypothesis: the handmade drawing of a urban setting could be more salient than a mechanical reproduction (photograph), because of the artist's "filter" perceived by the observer.

Visual Event Related Potentials (VERPs) are a well established method to investigate the effect of salient images upon the brain cortical functions (Luck, 2014).

VERPs Stimulation

Brain responses to visual stimuli were measured using visual event related potentials (VERPs), a non invasive electrophysiological method that records stimulus locked changes in scalp electrical potentials reflecting cortical processing of sensory information.

Participants viewed visual stimuli representing the same architectural objects in two formats: Photograph (Ph) and freehand Drawing (D).

Each stimulus presentation constituted a trial. For each trial the EEG signal was recorded from 1000 ms before stimulus onset to 1000 ms after stimulus onset, yielding a 2-second recording window centred on the stimulus. Stimuli were presented at random times (range 4-8 seconds) and alternate (Ph or D) in random order. A digital tag was sent to the data acquisition board so that the EEG responses could be assigned to the pertaining Ph or D stimulus.

The screen was kept 1 meter from the subject. Effective picture size on the screen surface was 415x220mm (pixel size 1500x800). Subjects were asked to pay attention to the stimuli by counting presentations.

VERPs Recording

Only one scalp derivation with two surface electrodes (Cz-Au1-2) was used, since the object of the research was timing and area under curve of the signal (see next paragraph for details) and not its scalp distribution, already very well known (Luck, 2014)

The two electrodes were held in place by two headbands which could be worn for a long time far more comfortably than the usual multi-electrode headcaps.

The electric signal was acquired with an isolated battery powered preamplifier (gain 8k, bandpass 0.1-500 Hz, 3dB points), then digitally converted via a 16bit A/D board (National Instruments NI PCIe-6320), with 5KHz rate. No further frequency filtering was applied. The presentation of the visual stimulus generated the digital trigger that synchronized acquisition which extended from 1s before to 1s after trigger (the trigger event being labelled as time 0 in the abscissae axis).

Signal Storage and Analysis

All trials (each trial consisting of a 2s EEG time epoch that contained the 1s prestimulus neutral activity and the 1s response to the single visual stimulus) were permanently stored on a datalog and kept available for further analysis. First, a selection was performed to delete artifact contaminated trials. The mean voltage in the -1000 to 0 ms interval preceding stimulus onset was subtracted from the entire signal to obtain a common baseline reference.

The primary analysis window was set 100-800 ms after stimulus onset, which includes several well known stages of higher order visual processing, including perceptual evaluation and semantic interpretation (Luck, 2014). Rather than relying only on peak amplitudes of individual VERP components, neural activity was quantified using the Area Under the Curve (AUC) of the absolute signal:

$$AUC = \int_{100}^{800} \mid V(t) \mid \, dt$$

where V(t) = instantaneous EEG voltage at time t.

This measure represents the total magnitude of neural activity during the selected interval. Using AUC has several advantages: it is independent of signal polarity, it is robust to baseline shifts, it is less sensitive to latency variability, it captures overall cortical processing effort. This approach has been recommended in ERP and VERP studies when multiple overlapping components are present (Luck 2014; Pernet et al. 2015)

VERPs Statistical Analysis

Two complementary statistical approaches were used: subject-level analysis and trial-level mixed-effects analysis.

Subject-level Analysis

For each participant, the EEG recordings from individual trials were first averaged within each stimulus condition and the mean values of AUC_Ph, AUC_D (Photograph and Drawing) calculated. Each participant contributed approximately 100 trials per condition. Averaging across trials is standard practice in event-related potential analysis because it improves the signal-to-noise ratio by cancelling the free running background EEG activity while preserving stimulus-locked neural responses (Luck, 2014). The resulting averaged waveforms therefore represent the typical brain response of each participant to the two stimulus conditions. From these averaged responses, neural activity in the 100-800 ms post-stimulus interval was quantified using the area under the curve (AUC) of the module of the signal, providing a measure of the overall magnitude of cortical activity during late visual processing. These participant level measures were used to visualize inter-individual variability in neural responses. However, statistical comparisons based only on participant means would substantially reduce statistical power because each participant would contribute only a single value per condition. Therefore, inferential statistics were performed using a trial level mixed-effects model, which incorporates all individual trials while accounting for variability between participants.

Trial-level mixed-effects Analysis

To fully exploit the dataset while accounting for subject variability, a linear mixed-effects model was applied, as the following:

$$AUC_{ij} = \beta_0 + \beta_1\, Condition_{ij} + u_i + \varepsilon_{ij}$$

where
i = participant
j = trial
β_0 = baseline neural activity
β_1 = effect of stimulus condition
u_i = subject-specific deviation from the population mean
ε_{ij} = residual trial-level noise

This hierarchical model accounts for the fact that multiple trials from the same participant are not statistically independent (Baayen et al. 2008).

The analysis included 1824 trials across 7 participants.

Mixed-effects modelling is widely recommended for EEG datasets with repeated observations per participant because it increases statistical power while preserving valid inference (Pernet et al. 2015).

Results

Results of Online Test

Across the 20 drawings and 212 participants, the dataset comprised 4,240 individual responses. The overall proportion of correct responses was 46.3% (95% CI: 44.8–47.8%), substantially exceeding the 25% chance level expected from random guessing (exact binomial test, $p < 0.001$). This indicates that viewers were generally able to infer the intended emotional character of the depicted urban scenes from the drawings. Recognition accuracy varied across individual drawings, and the most successful images were correctly interpreted by approximately 70–72% of participants, while the least successful images produced accuracies of roughly 18–

36%. Most drawings therefore communicated their intended emotional content reliably, although recognition performance varied across individual images.

Performance also varied by emotion category. Drawings intended to convey anxiety (56.6%) and calmness (53.5%) were recognized most accurately, followed by joy (43.9%), while sadness (37.9%) showed the lowest recognition rate. Despite this variation, all emotion categories were identified above the 25% chance level.

Analysis of response patterns revealed systematic confusions between certain emotional categories. In particular, drawings intended to convey joy were frequently interpreted as calmness, and anxiety drawings were often interpreted as sadness. Such confusions suggest that viewers may rely on broader positive or negative affective dimensions when interpreting drawn urban atmospheres.

Overall, the results indicate that freehand drawings can communicate the emotional atmosphere of urban places with reliability well above chance, supporting their potential as a representational tool for conveying experiential qualities of urban space. These findings suggest that freehand drawing may function not only as a descriptive tool for urban form, but also as an effective medium for communicating the affective atmosphere of specific places, allowing viewers to recognize intended emotional qualities with reliability substantially above chance.

Semantic and Representational Annotation of Drawings and Statistical Analysis

Statistical comparisons revealed significant differences across emotional categories for most of the semantic and representational variables extracted from the drawings. A summary is shown in Table 5. Differences between emotional groups were evaluated using the Kruskal-Wallis non-parametric test, which assesses whether the distribution of an ordinal variable differs across multiple independent groups.

The strongest effects were observed for spatial openness and street width. These large effect sizes indicate that the emotional interpretation of the urban environment is strongly associated with the degree of spatial enclosure represented in the drawings. In particular, drawings associated with calmness and joy tended to depict more open spatial configurations, whereas anxiety and sadness drawings more frequently represented narrow or enclosed environments.

Additional significant differences were observed for sky visibility, perspective convergence, vegetation presence, and building height. These variables suggest that environmental elements such as natural components, vertical enclosure, and spatial depth contribute to the emotional interpretation of urban scenes.

Representational features of the drawings also varied significantly across emotional categories. Line density, line thickness, hatching intensity, and line grouping all showed statistically significant differences between groups. These results suggest that the graphic execution of the drawings reflects aspects of the emotional interpretation of the environment, with certain emotions associated with denser line work, stronger contrast, or more structured compositional organization.

In contrast, the presence of human figures did not show significant differences between emotional categories, suggesting that emotional interpretation in this dataset was driven primarily by spatial and environmental characteristics rather than by the depiction of social activity. Together, these findings indicate that both the spatial configuration of the depicted environments and the graphic strategies used in the drawings contribute to the visual encoding of emotional interpretation.

Table 5. *Statistical Comparison of Semantic and Representational Variables across Emotional Categories. H Represents the Kruskal–Wallis Test Statistic, which Evaluates whether the Distribution of a Variable Differs between the Four Emotional Groups. p-value Indicates the Probability that the observed Differences occurred by Chance. η^2 (eta squared) Represents the Effect Size, Estimating the Proportion of Variance explained by the Emotional Category*

Variable	H	p-value	η^2	Interpretation
People presence	3.14	0.37	0.001	not significant
Vehicular activity	13.59	0.003	0.085	small–medium effect
Spatial openness	64.05	$<10^{-13}$	0.49	extremely strong effect
Street width	60.28	$<10^{-12}$	0.46	extremely strong effect
Building height	29.33	$<10^{-6}$	0.21	strong effect
Vegetation presence	22.49	$<10^{-4}$	0.16	moderate effect
Sky visibility	38.78	$<10^{-8}$	0.29	strong effect
Perspective convergence	35.68	$<10^{-7}$	0.26	strong effect
Line thickness	19.77	$<10^{-4}$	0.13	moderate effect
Line density	25.42	$<10^{-5}$	0.18	moderate effect
Hatching intensity	38.26	$<10^{-8}$	0.28	strong effect
Line grouping	32.53	$<10^{-6}$	0.24	strong effect

A radar representation of the relationships between emotions and semantic/ representational variables is shown in Figure 2. Here values represent normalized category means of selected spatial and graphic descriptors extracted from the drawings. Distinct profiles emerge for anxiety, calmness, joy, and sadness, reflecting differences in spatial openness, perspective structure, environmental elements, and drawing execution. The strongest effects were associated with spatial openness ($H = 64.05$, $p < 0.001$, $\eta^2 = 0.49$) and street width ($H = 60.28$, $p < 0.001$, $\eta^2 = 0.46$), indicating that emotional perception is strongly related to the degree of spatial enclosure of the depicted environment. Additional significant differences were observed for sky visibility, perspective convergence, vegetation presence, building height, and vehicular activity. Graphic execution also varied systematically across emotional categories. Line density, line thickness, hatching intensity, and line grouping all showed significant differences between groups, indicating that drawing style reflects perceptual and emotional interpretation of the environment

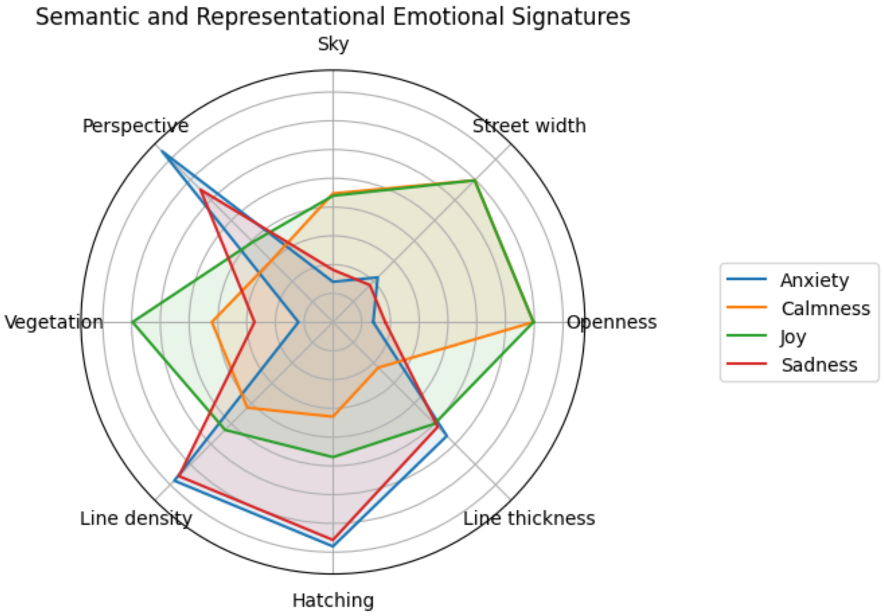


Figure 2. *Radar Representation of Semantic and Representational Features across Emotional Categories*
Source: Image by the author

Photometric Descriptors of the Drawings

The calculated photometric descriptors of the 129 drawings related to emotional category are summarized in the graph shown in Figure 3. Photometric analysis of the drawings revealed systematic differences across emotional categories. Mean luminance (abscissae axis) did not differ significantly between groups (Kruskal-Wallis H = 5.36, p = 0.147), although calmness scenes showed slightly higher brightness values on average. On the other hand, global contrast (ordinate axis) differed significantly across emotions (Kruskal-Wallis H = 9.10, p = 0.028, η^2 = 0.049), with anxiety (red A centroid) drawings relating to the highest and calmness (green C centroid) the lowest contrast levels.

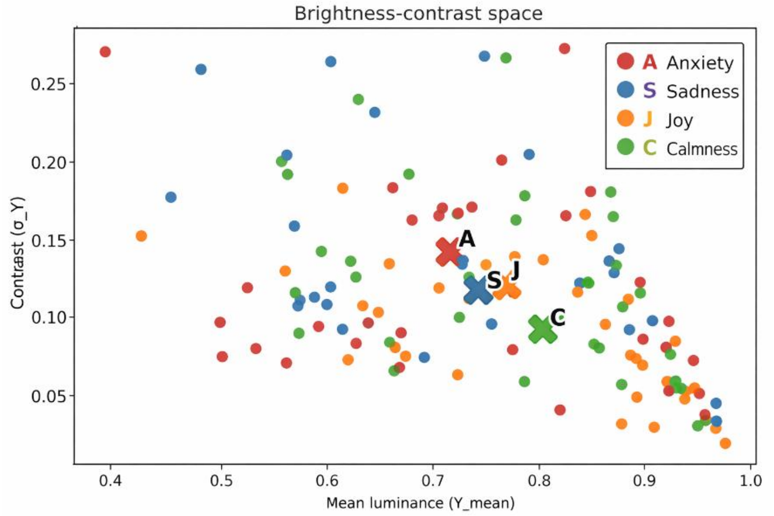


Figure 3. *Brightness–contrast Distribution of the Drawings. Each Point Represents a Single Drawing. The Centroid of each Emotional Category is indicated by a cross labelled with its initial (J = Joy, A = Anxiety, S = Sadness, C = Calmness)*
Source: Image by the author

Chromatic Descriptors of the Drawings

The chromatic characteristics of the drawings were further examined through the average values of the CIE L*a*b* chromatic coordinates. The a* axis represents the green–red chromatic dimension, while the b* axis represents the blue–yellow dimension. When the distributions of the drawings were projected into the chromatic space defined by these two axes, the four emotional categories occupied partially distinct regions of the diagram.

Drawings associated with joy tended to show positive values on both the a* and b* axes, corresponding to warmer chromatic tones located in the red–yellow region of the chromatic plane. Calmness drawings were generally positioned closer to the neutral region of the diagram, with moderate values along both axes and relatively balanced chromatic compositions. Anxiety drawings showed a tendency toward slightly positive a* values but lower or near-neutral b* values, indicating the presence of more muted or less saturated chromatic components. In contrast, drawings representing sadness clustered around the central or slightly negative regions of the chromatic axes, corresponding to cooler and less chromatically saturated tonalities.

These tendencies are illustrated in the chromatic space diagram (Figure 4), where individual drawings are plotted together with the centroid of each emotional category. Although considerable dispersion exists within each group, the centroids reveal a gradual chromatic shift from cooler and more neutral palettes for sadness toward warmer and more saturated chromatic compositions for joy.

Color entropy also showed significant variation between emotional categories ($H = 12.77$, $p = 0.005$, $\eta^2 = 0.078$). Joy drawings displayed the highest entropy values, indicating greater chromatic diversity and visual richness.

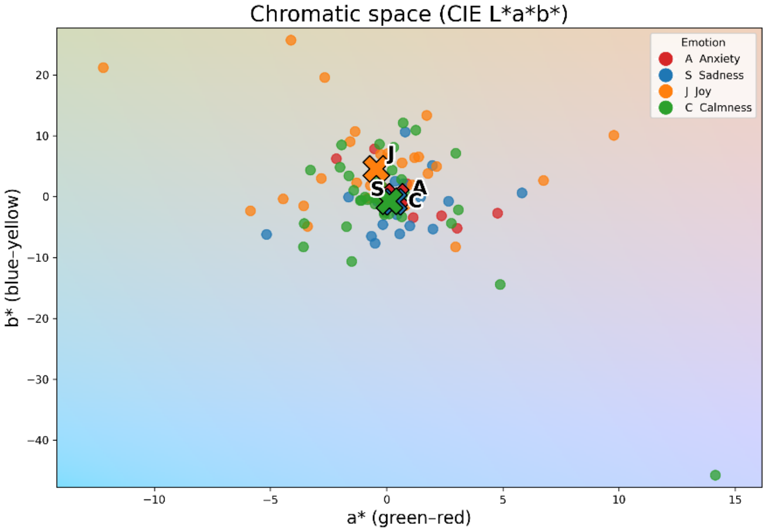


Figure 4. *Distribution of Drawings in Chromatic Space (CIE L*a*b*). Points Represent Individual Drawings; Crosses Indicate Category Centroids*
Source: Image by the author

Combined Photometric and Chromatic Descriptors

Drawings associated with calmness were characterized by higher average luminance and relatively low contrast, reflecting visually brighter and more homogeneous scenes. Anxiety drawings tended to occupy intermediate luminance levels but exhibited moderately higher contrast. Sadness images generally showed lower brightness and reduced chromatic variability, resulting in more subdued visual compositions. In contrast, drawings representing joy displayed the highest levels of chromatic diversity and a tendency toward warmer color distributions in the positive region of the a* and b* axes. These tendencies are summarized in Table 6, which shows the statistical comparison (Kruskal-Wallis test) of photometric and chromatic variables across emotional categories.

Table 6. *Photometric and Chromatic Variables as Determinants of Four Emotions; p-value Indicates the Probability that the observed Differences occurred by Chance; η^2 (eta squared) Represents the Effect Size, estimating the Proportion of Variance explained by the Emotional Category*

Variable	H	p-value	η^2	Interpretation
Mean luminance (Ymean)	5.36	0.147	0.021	not significant
RMS contrast (σY)	9.10	0.028	0.049	small effect
Color entropy	12.77	0.005	0.078	small–moderate effect
Mean chromatic coordinate a*	8.41	0.038	0.045	small effect
Mean chromatic coordinate b*	10.53	0.015	0.059	small–moderate effect

The General Picture of Visual Characteristics

In general, distinct profiles emerge across both semantic and photometric variables, suggesting that emotional perception of urban environments is encoded simultaneously in spatial structure, visual composition, and graphic representation. In Figure 5, the radar diagram shows the combined semantic, photometric and chromatic emotional signatures of the analyzed drawings. The diagram shows how emotional perception of urban environments is associated with the most relevant physical image properties, spatial structure, and graphic representation.

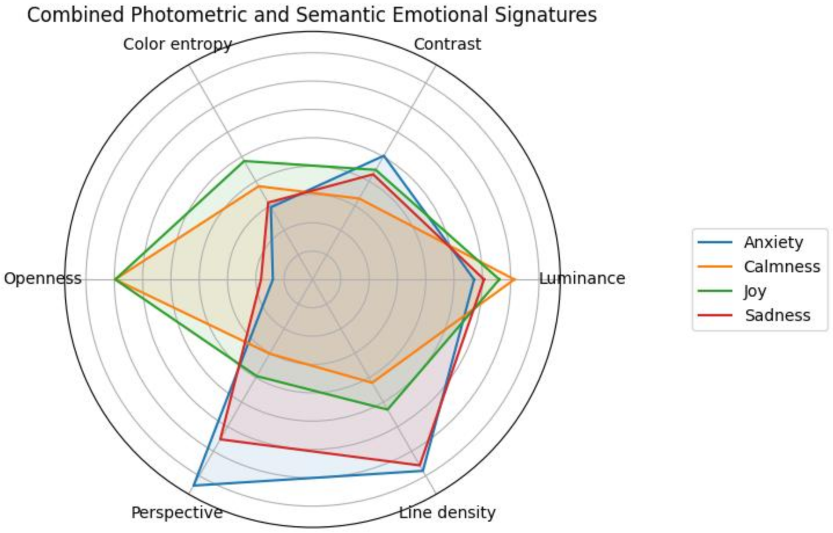


Figure 5. *Radar Representation of normalized Mean Values for selected Photometric and Semantic Variables across Emotional Categories*
Source: Image by the author

Results of VERPs recordings

This test was added as an exploratory neurophysiological module within the PATHOS framework, in order to test the possibility of providing a biological indicator of perceived affection in a limited sample of subjects.

It was kept as simple as possible in this preliminary phase. The two images to compare, as specified in the Methods section, were the photograph of a urban site and its freehand drawing version. It may be useful to remind that neurophysiological tests related to cognitive activity have rather ample margin of variability, being influenced by several attitudes that the subject may be experiencing at the moment of recording. This test, therefore, though being likely better representative of emotional reaction than autonomic reflexes, cannot be deemed as entirely objective. Increasing the number of subjects will likely improve its statistical validity.

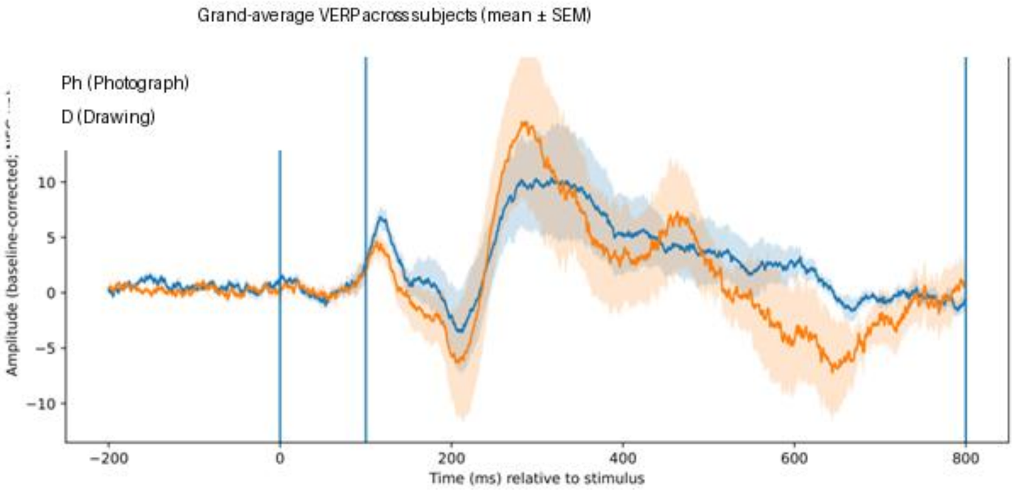


Figure 6. *Shows the averaged Brain Responses for both Conditions; The Shaded Area represents the Standard Error of the mean (SEM). The Vertical Lines Mark the Onset of the Visual Stimulus, the Start and the End of the area under Curve Calculation (AUC)*
Source: Image by the author

The grand-average (i.e. cumulative inter-subject average) VERP waveforms showed two temporal tendencies. The drawing based stimuli yielded their largest responses in the time epoch around 200–300 ms, whilst the photographs tended to evoke stronger responses in the time range 500–700 ms. However, the timing of these effects varied across individuals. Consequently, the integrated AUC measure provided a more reliable statistical indicator than peak-based component analyses.

The mixed-effects statistical model revealed a significant effect of stimulus type. Within this exploratory sample, neural activity in the 100-800 ms interval was significantly greater for drawings than for photographs ($\beta=-1.50$; $p=8.6\times10^{\wedge}(-5)$), indicating a preliminary tendency for drawings to evoke stronger sustained responses during late visual processing.

Neural activity in the 100–800 ms interval was significantly greater for drawings than for photographs, suggesting that drawings elicited greater sustained neural activity during late visual processing. The visual processing occurring in the investigated time window is typically linked to cognitive effects (Luck, 2014).

Subject-level analyses showed that most participants exhibited higher neural energy for drawings than photographs, although the magnitude of the effect varied between individuals.

This variability explains why subject-level comparisons alone produced weaker statistical significance, whereas the mixed-effects model, which incorporates trial-level information, revealed a robust effect.

Within this exploratory sample, neural activity in the 100-800 ms interval was significantly greater for drawings than for photographs, indicating a preliminary tendency for drawings to evoke stronger sustained responses during late visual processing.

Discussion

This study's principal contribution is methodological: it introduces and tests the PATHOS framework as an integrative protocol for investigating emotional responses to urban environments.

The results support the central hypothesis of the PATHOS framework: emotional perception of urban environments can be captured through measurable characteristics of visual representation. Significant differences were observed not only in semantic descriptors of spatial structure, such as openness, street width, and perspective convergence, but also in graphic properties of the drawings and in selected photometric image statistics. This convergence suggests that the emotional interpretation of an environment is reflected simultaneously in spatial configuration, visual composition, and the graphic strategies used to represent it. In this sense, the human observer acts as a mediating analytical instrument, translating the complex and multisensory experience of the urban environment into simplified visual forms that can subsequently be quantified. The proposed approach therefore may provide a methodological bridge between subjective perception and objective analysis of urban space.

Semantic Spatial Structure and Emotional Interpretation

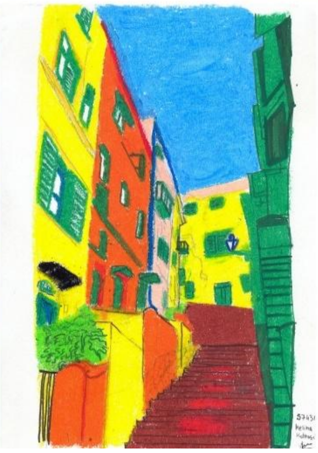
The semantic analysis of the drawings revealed that emotional interpretations of urban environments were strongly associated with spatial configuration. Variables describing the degree of enclosure of the urban scene, particularly spatial openness and street width, showed the strongest statistical effects across emotional categories. These results suggest that the emotional reading of urban environments is closely related to fundamental spatial characteristics such as enclosure, visibility, and depth.

Drawings associated with calmness and joy tended to depict more open spatial configurations, wider streets, and greater visibility of the sky. In contrast, drawings representing anxiety or sadness more frequently portrayed narrower streets, stronger spatial compression, or pronounced perspective convergence. These patterns are consistent with long-standing observations in environmental psychology asserting that spatial enclosure and limited visibility are associated with increased perceptual tension and reduced perceived safety, whereas open spatial configurations are often linked to feelings of comfort and freedom of movement (Appleton 1975, Kaplan & Kaplan 1989, Gehl 2010).

Additional variables, including vegetation presence and building height, also differed significantly between emotional categories. Scenes containing natural elements were more frequently associated with positive emotional states, while more rigidly built environments tended to appear in anxiety or sadness representations. Although the present dataset does not allow causal conclusions regarding specific urban elements, the results indicate that emotional interpretation of urban space is reflected in the structural organization of the represented environment. The tables show, for each emotion, the variety of elements represented (Figures 7-10).

These findings support the premise that the human observer acts as a perceptual filter, translating complex multisensory urban experience into simplified spatial structures that retain the essential emotional characteristics of the place.


Via Felice Romani
Genova Italy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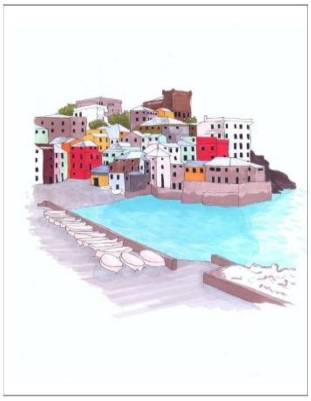

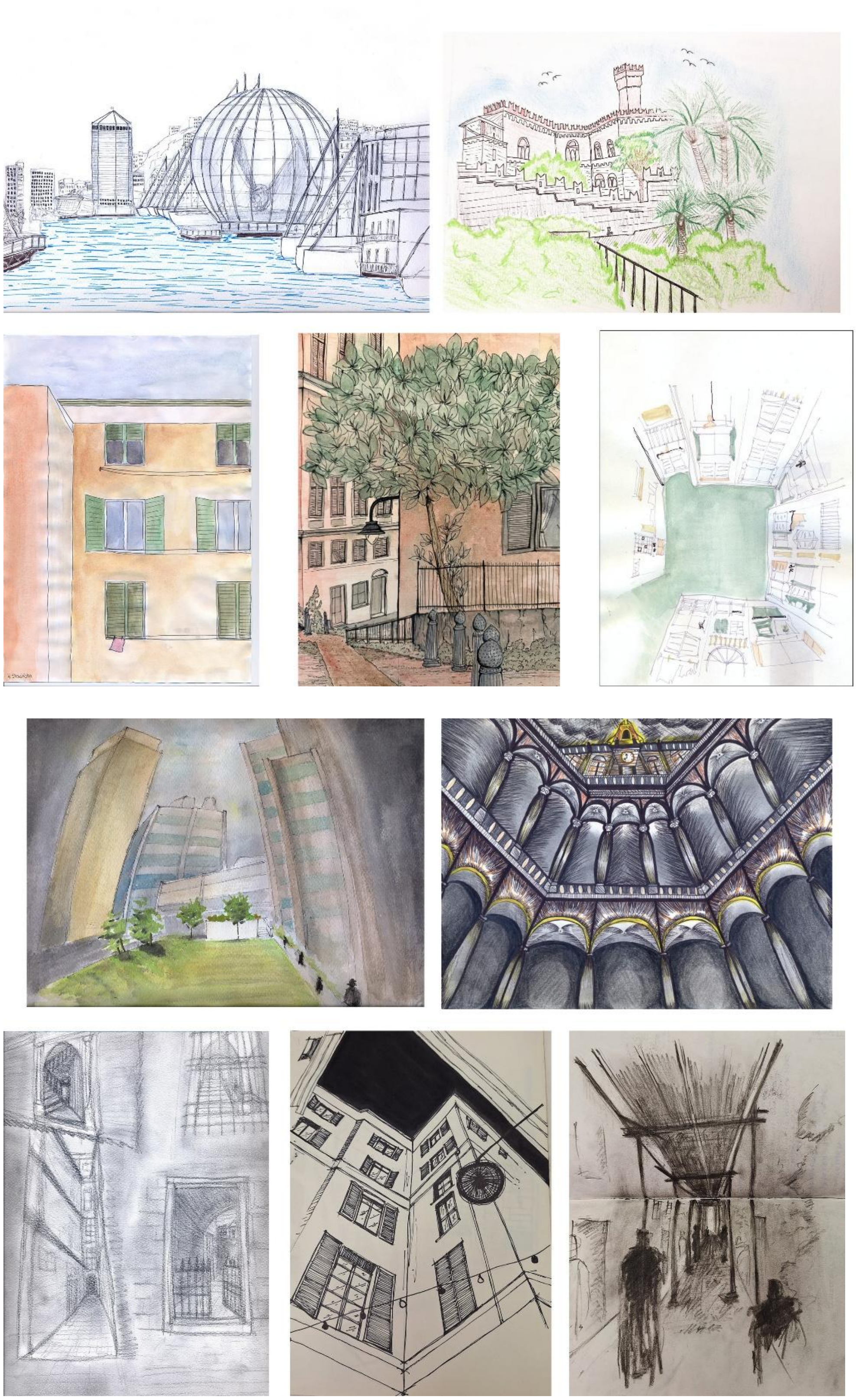

Figures 7-10. *Examples of Representations for Each Emotion. From Top to Bottom Joy, Sadness, Calm, Anxiety*
Source: Image by the author

Representational Features of the Drawings

In addition to the semantic characteristics of the depicted environments, significant differences were observed in the graphic execution of the drawings themselves. Variables describing drawing style, including line density, line thickness, hatching intensity, and stroke grouping, varied systematically across emotional categories.

These representational features can be interpreted as indicators of how observers translate their emotional experience of urban space into visual form. Drawings associated with anxiety or sadness tended to display denser line work, stronger hatching, and more pronounced grouping of strokes, suggesting a graphic encoding of visual tension or spatial compression. In contrast, drawings associated with calmness or joy often exhibited lighter line structures, lower hatching intensity, and more open graphic compositions.

The importance of these findings lies in the fact that emotional interpretation is not expressed only through the selection of spatial features, but also through the manner in which those features are graphically rendered. In other words, the representational language of drawing itself becomes part of the emotional encoding process.

This observation is consistent with theories of drawing as a cognitive and interpretative practice rather than a purely descriptive technique (Tversky 2019; Goldschmidt 2014). Freehand drawing requires the observer to actively select, emphasize, and organize visual information, and these choices inevitably reflect perceptual and emotional priorities. The graphic structure of the drawing therefore provides an indirect record of how the observer has interpreted the spatial atmosphere of the environment.

Photometric and Chromatic Image Signatures

The photometric analysis of the drawings revealed additional differences between emotional categories at the level of global image properties. Although mean luminance did not differ significantly between groups, systematic variations were observed for global contrast and color entropy.

Drawings associated with anxiety exhibited higher contrast values, reflecting stronger luminance variability and sharper visual transitions within the image. This tendency is consistent with the increased use of dense line work and hatching observed in the representational analysis. Conversely, drawings associated with calmness were characterized by relatively lower contrast and more homogeneous brightness distributions.

Color entropy, which measures the diversity of color distributions within an image, also varied significantly between emotional categories. Drawings associated with joy exhibited the highest entropy values, indicating greater chromatic variability and visual richness, while sadness drawings showed lower chromatic diversity. These findings suggest that chromatic complexity may play a role in the visual communication of emotional tone.

Together, these photometric and chromatic descriptors may provide a compact quantitative representation of the visual structure of the drawings. Importantly, these measures are rather independent of semantic interpretation and therefore could offer an objective way to characterize the visual properties of the images used in the experiment.

Neurophysiological Responses to Drawings and Photographs

VERP findings should be interpreted as exploratory evidence within the broader methodological aims of the PATHOS framework. In this limited sample of just 7 subjects, drawings elicited higher neural activity than photographs in the selected post-stimulus interval of 100-800 ms. This time window is typically associated with higher order stages of visual processing, including perceptual evaluation, semantic interpretation, and attentional engagement. The increased neural activity observed for drawings therefore suggests that this form of representation may require greater perceptual and cognitive processing than photographic images of the same architectural scenes.

One possible explanation of this behavior is that drawings present a simplified and interpretative representation of the environment, requiring observers to reconstruct spatial relations and environmental meaning from a reduced set of visual cues. This process may increase perceptual and cognitive effort during visual interpretation. Photographs, by contrast, provide a dense and mechanically recorded representation of the visual scene. As a result, the cognitive effort required to interpret the image may be lower.

From the perspective of architectural representation, this result suggests the view that drawings function not merely as descriptive depictions of space but as cognitive artifacts that actively structure perception. This notion would be consistent with the idea that the viewer is not simply observing a scene but is engaging with the interpretative filtering performed by the author of the drawing.

Although these results are preliminary and based on a limited number of participants, they make it possible to hypothesize the feasibility of using electrophysiological measures to investigate perceptual responses to different modes of architectural representation within the PATHOS methodological framework. Because the neurophysiological experiment involved a small participant sample, these findings should be considered preliminary and require replication in larger cohorts before broader conclusions can be drawn.

Online Perceptual Validation of Emotional Communicability

An additional element of validation for the PATHOS methodology was provided by the online perceptual evaluation experiment. In this test, independent participants were asked to classify a subset of drawings according to the emotional categories considered in the study. Although the number of stimuli used in the test was limited (five drawings per emotional category), the results indicate that observers were generally able to recognize the intended emotional content of the drawings at rates above chance level.

Because of the small sample of stimuli, the statistical strength of this result is limited and does not allow definitive conclusions regarding the discriminability of all emotional categories. Nevertheless, the experiment provides an important proof of concept indication that the drawings produced within the PATHOS framework retain communicable emotional information that can be interpreted by external observers.

This finding supports the central assumption of the method: that freehand drawings generated by observers can act as condensed representations of the emotional perception of urban environments. If the drawings did not communicate emotional meaning to independent viewers, the subsequent semantic, photometric, and neurophysiological analyses would have limited interpretative value.

In this sense, the perceptual validation experiment represents a complementary step linking the subjective act of drawing to the objective analytical framework proposed by the PATHOS methodology.

Integration within the PATHOS Framework

Taken together, the results of the semantic, representational, photometric, and neurophysiological analyses seem to be consistent with the central methodological premise of the PATHOS framework. Emotional interpretation of urban environments appears to be reflected simultaneously in multiple levels of representation: the spatial structure of the depicted environment, the graphic strategies used in the drawing, the global photometric properties of the image, and the neural responses elicited during visual perception.

According to the hypotheses on which this framework is based, the human observer would act as an intermediate analytical interface capable of translating the complexity of the real urban environment into structured visual representations. Freehand drawings may be considered to encode perceptual selection, spatial organization, and emotional interpretation into a simplified visual artifact that coould subsequently be analyzed using quantitative methods.

Rather than attempting to measure the urban environment directly, PATHOS therefore focuses on the human mediated representation of that environment. This approach would allow the complexity of lived urban experience to be reduced in a principled way while preserving the perceptual and emotional structures that shape how environments are experienced.

Limits of the Study and Future Research

The present study should be interpreted as a methodological feasibility demonstration rather than a definitive empirical investigation of emotional responses to urban environments. Several aspects of the experimental design reflect this exploratory objective. First, the number of drawings and stimuli used in some experimental steps, particularly the online perceptual validation and the electrophysiological experiment, remains limited and therefore does not allow strong statistical generalization. Second, semantic annotation of drawings was performed by a single evaluator using predefined criteria, which may introduce subjective bias despite the structured coding scheme adopted. Finally, the present dataset focuses on hand-drawn representations produced under controlled conditions and therefore does not yet capture the full variability of drawing styles or urban contexts that would be expected in larger studies.

Nevertheless, the objective of this work was to demonstrate the methodological viability of integrating perceptual representation, image statistics, and neurophysiological measurements within a unified analytical framework. The results indicate that such integration is feasible and can generate coherent quantitative descriptors of emotional perception in urban environments.

Although the present work represents an initial proof of concept, the results suggest that the integration of perceptual representation, image statistics, and neurophysiological measurement may provide a promising methodological framework for studying emotional responses to architecture and urban space.

Future research will need to extend this approach by expanding the dataset of drawings, refining the semantic annotation protocols, and exploring the relationships between representational features, perceptual judgments, and physiological responses in larger participant samples.

Conclusion

The EEG/VERP results are best interpreted as an exploratory demonstration that neurophysiological methods can be integrated into the PATHOS framework, rather than as definitive evidence about neural responses to architectural representations.

This study introduced the PATHOS framework as a methodological approach for investigating emotional responses to urban environments through the integration of freehand drawing, quantitative image analysis, perceptual validation, and exploratory neurophysiological measures. The principal contribution of the paper is therefore methodological: to propose a transferable protocol through which subjective urban experience may be translated into analyzable visual and experimental data.

The results provide preliminary evidence that emotionally guided drawings contain recurring semantic, representational, and photometric patterns associated with different affective categories. In particular, variables related to spatial openness, street morphology, sky visibility, line treatment, and chromatic diversity showed systematic differences across emotions. The online perceptual test further suggested that several drawings communicated their intended emotional content to independent observers. The exploratory VERP recordings also indicated that different visual representation modes may engage neural processing in distinguishable ways.

At the same time, the findings should be interpreted within the limits of a proof-of-concept study. The dataset was context-specific, semantic coding involved interpretative judgment, and the neurophysiological sample was limited in size. Consequently, the present work should not be read as providing definitive generalizations about urban emotion, but as establishing the feasibility and potential usefulness of the proposed framework.

Future research may extend the method to larger and more diverse populations, multiple cities and cultural contexts, automated image-analysis pipelines, and expanded physiological protocols. Within this perspective, PATHOS may contribute to future forms of evidence-informed architectural design, urban regeneration, and teaching grounded in lived human experience.

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