The P.A.T.H.O.S. project. Drawing Human Perception of the Environment

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Abstract

The P.A.T.H.O.S. project (*Perception of Architecture, Territory and Heritage. Observation and Sensation*) explores the intersection between emotional perception, artistic expression, and the urban environment through the medium of drawing. Architecture students were invited to depict selected areas of the cities of Genoa and Pisa, guided by specific emotions assigned to them — such as joy, sadness, anxiety, and calmness. These hand-drawn representations served as the foundation for a multidisciplinary study aimed at understanding how emotions can be expressed and interpreted through artistic depictions of urban space.

The project unfolded across multiple research phases: an online perception test involving over 200 participants, laboratory sessions utilizing electroencephalogram (EEG) recordings to measure neurological responses to the drawings, and experimental investigations employing artificial intelligence to analyze visual patterns and emotional content.

Findings indicate that drawing is a particularly powerful medium for emotional communication, capable of conveying complex affective states with clarity and nuance. The study also highlights recurring spatial elements — such as tunnels and wide-open areas — as being consistently associated with specific emotional tones. While the current study represents a pilot, its promising results lay the groundwork for future

iterations and a broader exploration of how the emotional reading of cities can inform both artistic practice and urban design. P.A.T.H.O.S. opens up new perspectives on the role of subjective perception in shaping our experience of place, suggesting that emotion-based approaches can contribute meaningfully to architectural and urban discourse.

1. Drawing as a tool for urban experience

The *P.A.T.H.O.S. project - Perception of Architecture, Territory, and Heritage. Observation and Sensation* aims to study the human emotional response to built heritage by using drawing as a tool for investigating and representing human perception .

Drawing has long been explored in the fields of art history, pedagogy, and psychology as an extremely direct and effective means of communicating emotion (Bartoli, 2017; Bonoti *et al.*, 2006; Brechet *et al.*, 2022; Drake *et al.*, 2012; Rechichi *et al.*, 2023; Ricci Sindoni, 2014). At the same time, it is widely recognized that sketching and drawing are intrinsic to the architect's profession, as architects use pencils both as a creative tool and as a means of exploring the reality that surrounds them (Cook, 2014). However, when it comes to healthy adults, the relationship between drawing and emotion, as well as between emotion and the investigation of territory, remains largely unexplored — both in scientific research and in university education.

This research aims to move beyond the traditional frameworks of architectural technical drawing and city studies conducted in a conventional academic manner. Instead, it proposes a more personal approach, where human emotions take the center stage. The architecture that surrounds us, even unconsciously, contributes to shaping our everyday reality (Buttazzoni, 2022; Pallasmaa, 2014; Shu *et al.*, 2022; Zumthor, 2006), with its built environment and empty spaces, in a play of forms, lights, and shadows that creates an image rich in intrinsic meaning. The best tool to investigate this phenomenon is, therefore, spontaneous drawing — free from judgments of “beauty,” or “technical accuracy”— but rather an artistic expression capable of conveying a sense of lived experience, engaging in the most direct possible dialogue with any observer.

[1] The study is conducted in collaboration between the Department of Architecture and Design (UNIGE), the Department of Neuroscience, Rehabilitation, Ophthalmology, Genetics, and Maternal-Infant Sciences (UNIGE), the Department of Energy, Systems, Territory, and Construction Engineering (UNIPI), and the Department of Architecture and Design (POLITO) (fig. 22).

2. The structure of the research: from live drawing to laboratory

The research was structured in several phases, some of which were carried out in parallel.

The initial phase, in September 2024, consisted of two workshop days during which 18 students – 7 second-year Engineering students from the University of Pisa and 11 first-year Architecture students from the University of Genoa produced the drawings and photographs that were later used, at least in part, in subsequent phases of the research (figs. 1,2).

The students were assigned either a positive or a negative emotion. If a student received a negative emotion on the first day, they were assigned a positive emotion on the following day, and vice versa. The emotions were chosen in antithetical pairs: *joy* and *sadness*, *calmness* and *anxiety*. Considering that there is no validated category of emotions in psychology for the perception of urban environments, the basic emotions theory (Ekman, 1992) was utilized. The chosen emotions are therefore considered to be as broad as possible to allow the students greater familiarity with the concept of emotion and its interpretation. Each student was asked to write three additional adjectives or emotions related to the location selected for the drawing, thereby expanding the textual description that might otherwise have been limited to a single assigned term.

For both the drawing day in Pisa and that in Genoa, maps showing three urban areas were provided for free choice following a brief site visit. The three zones were selected based on the architectural and spatial elements they featured, In order to offer an ample inside variety. The urban areas selected in Pisa were: Navicelli, Borgo Stretto, and Lungarno Pacinotti; the areas chosen for Genoa were: Porto Antico, Giardini Baltimora, and Via dei Giustiniani (and the surrounding alleys). For each area, parameters regarding climatic and light conditions, sounds, and the presence of people or vehicles were taken into account.

At the end of the two workshop days, a total of 36 drawings had been produced.

In the second phase of the research — which took place between October 2024 and December 2024 — 20 drawings were selected for the creation of an online quiz. For the electroencephalogram study, two drawings and two photographs were chosen instead.

2.1 Cognitive Assessment

Prior to the drawing sessions, the students were evaluated from a cognitive perspective. Specifically, the following tests were administered.

Figure 1 – The students during the two days of the workshop. On the left, the first day in Genoa; on the right, the second day in Pisa. Pictures by Martina Castaldi.

1- *Mini Mental State Examination* (Folstein *et al.*, 1975) : by screening for general cognitive abilities, it is possible rule out significant impairments that might hinder the complex process of drawing or the nuanced interpretation of emotions. This initial assessment helps focus the study on individuals whose creative output is not hampered by broader cognitive deficits.

2- *Visual search* (attention) (Spinnler & Tognoni, 1987): attention is critical when engaging in drawing tasks, as it involves the ability to selectively process relevant visual details. The visual search test measures how efficiently a subject can locate and focus on specific elements within a complex visual field.

3- *Benton Visual Retention Test* (perception and visual memory) (Sivan *et al.*, 2014) : the process of drawing is deeply intertwined with the ability to accurately perceive, retain, and reproduce visual information. The Benton Visual Retention Test evaluates how well subjects can encode and recall visual stimuli, which is crucial for translating mental images into drawings. A robust visual memory ensures that key elements — especially those that convey emotion — are accurately reflected in the final artwork, enhancing both fidelity and expressiveness.

4- *Eyes Test* (executive functions, emotion and mood recognition) (Serafin, 2004) : executive functions encompass higher-order processes such

Figure 2 – The students were free to complete their drawings in the classroom. Pictures by Enrico Pupi.

as emotion recognition and mood interpretation. The Eyes Test specifically assesses the ability to discern subtle emotional cues from facial expressions.

5- *Raven's progressive matrices*, 1947 (logical reasoning and intelligence) (Basso *et al.*, 1987) : logical reasoning and abstract problem-solving skills are fundamental in synthesizing complex visual and emotional information into coherent artistic representations. This nonverbal test gauges an individual's capacity to identify patterns and relationships.

Assessing these cognitive capacities not only provides a well-rounded profile of a subject's mental functions but also sheds light on how these skills collectively contribute to the artistic process. By understanding the interplay between attention, perception, memory, executive functioning, and reasoning, researchers can better appreciate how individuals translate emotional experiences into compelling visual narratives.

The sample was identified as cognitively healthy thus allowing for reliable and generalizable results.

3. Questionnaire and participants

The second phase of the research involved creating a test distributed online to a broad and diverse audience. The goal was to gather feedback on the drawings, both in terms of graphic elements and content, from a non-specialist audience of varying backgrounds and ages.

This approach aimed to assess the perception of emotions in relation to artistic expression and the urban environment, which are hypothesized to be universally shared perception mechanisms among all human beings.

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 — 10 from Genoa and 10 from Pisa — depicting open and enclosed spaces, natural and artificial elements, modern and historical architecture, as well as scenes featuring people or empty landscapes.

The test reached a total of 212 participants across Italy, collecting responses over a period of 30 days.

3.1 Basic demographic information

The first part of the quiz was designed to collect demographic data from participants, with a particular focus on their familiarity with the

cities under study, their demographic group, and their familiarity with architectural images.

The results (figs. 3-5) show a predominance of participants aged between 20 and 29 years and a majority whose professional occupation or field of study is not related to architecture or design.

Regarding the cities, no significant differences emerged, with a familiarity rate of 39.62% for Pisa and 43.40% for Genoa (fig. 6).

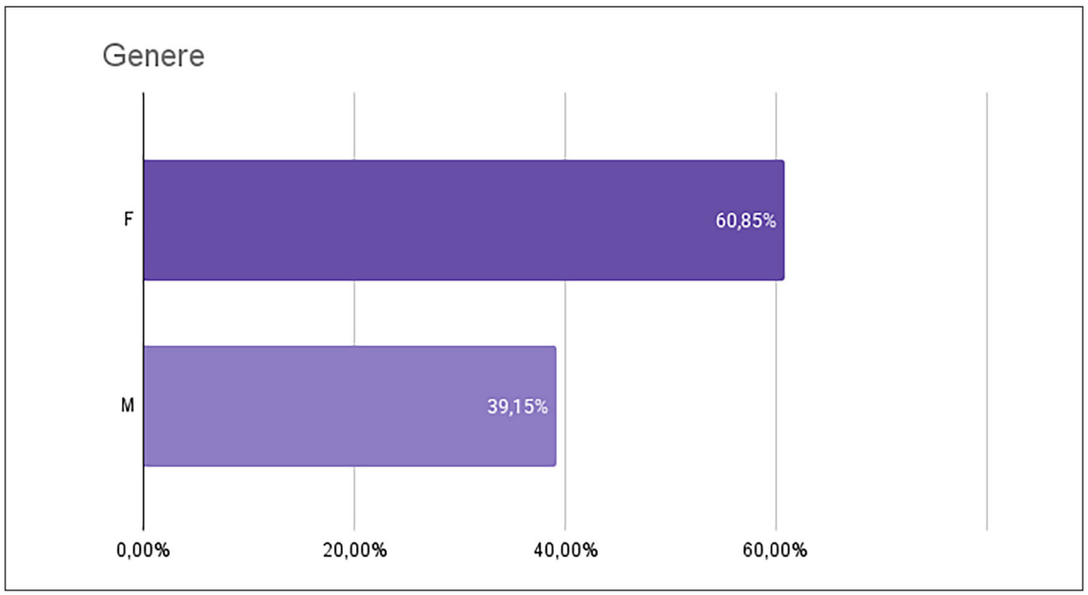


Figure 3 – The first question shows that 60.85% of the online quiz participants were female, while 39.15% were male. The "other" option was not selected by anyone.

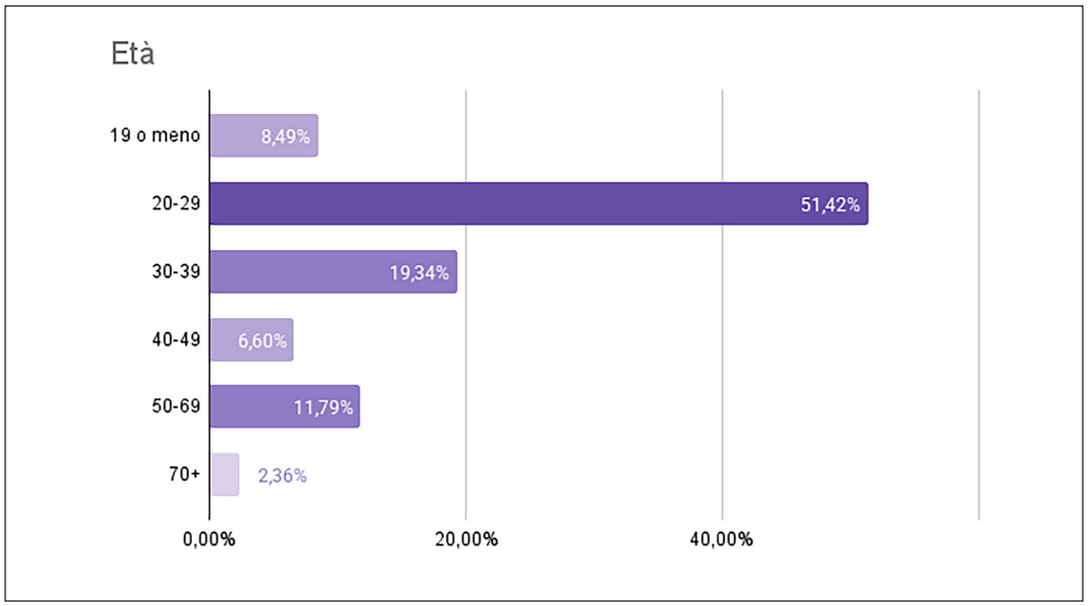


Figure 4 – The results of the age-related question show that the majority of test participants fall within the 20–29 age group.

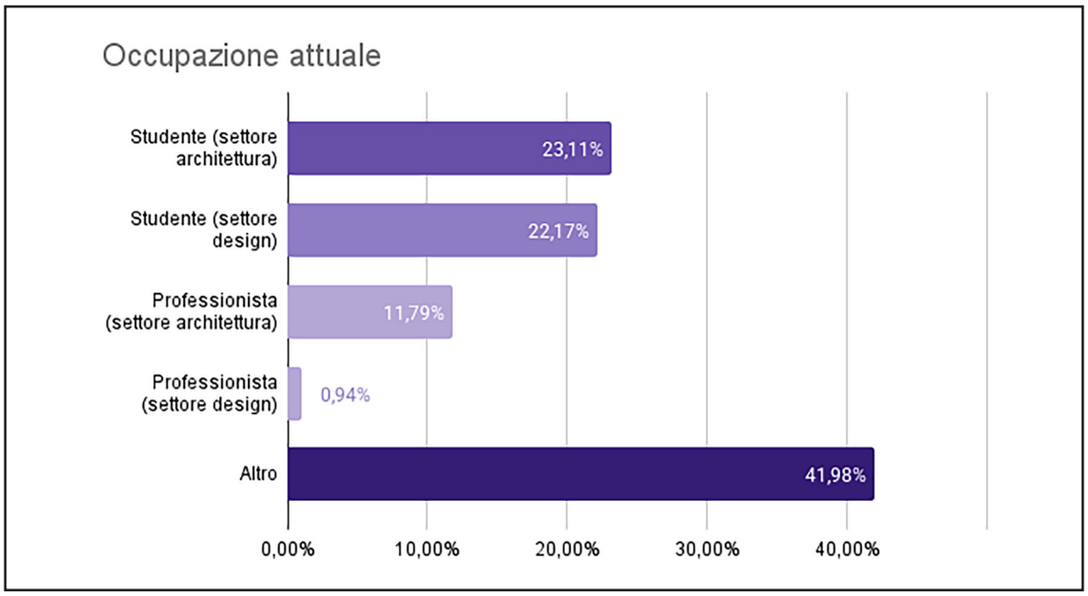


Figure 5 – Results of the question on current occupation. About half of the participants were design or architecture students.

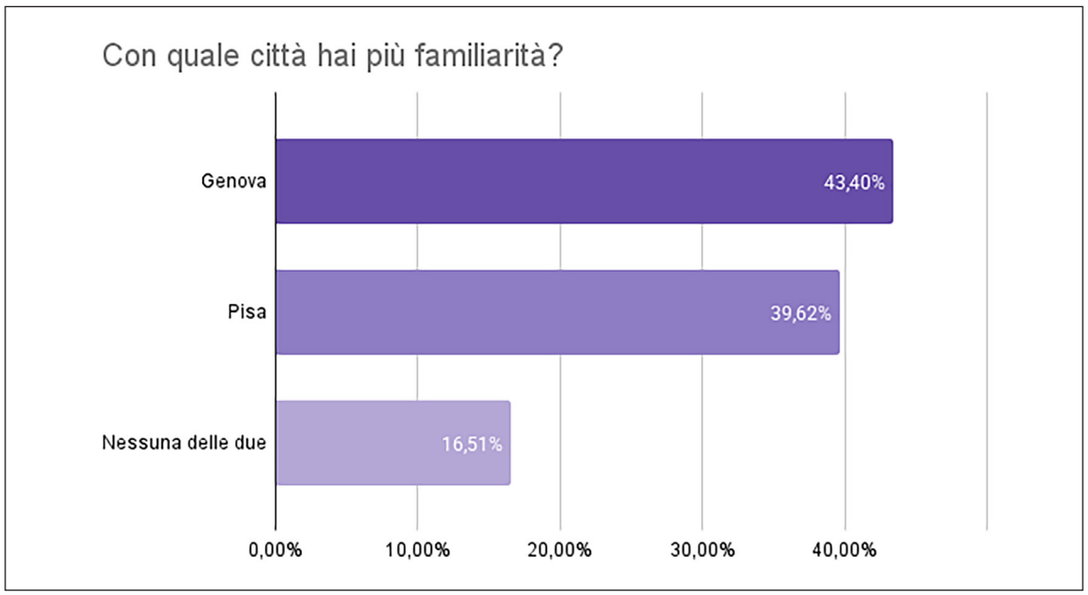


Figure 6 – Results of the question "Which city are you most familiar with?"

3.2 Exploring the relationship between emotions and drawings

The main part of the test involved matching the correct emotion to the student's drawing, choosing one from the four emotions assigned during the workshops — joy, sadness, calmness, and anxiety.

A selection of 20 drawings was performed based on the following criteria: presence or absence of color, use of vibrant or muted colors,

presence or absence of human figures, representation technique, and the depicted location.

The selection aimed to offer the widest possible stylistic variety, ensuring that all locations were represented in at least one drawing. Nine drawings depict negative emotions, while eleven represent positive emotions.

The 212 responses were analyzed in terms of accuracy for each individual emotion (fig. 7) and then for the overall distinction between positive and negative emotions.

The first chart (fig. 8) presents the results for individual emotions: 70% of participants correctly matched the exact emotion to the drawing.

The second chart (fig. 9) illustrates the error rate in distinguishing between positive and negative emotions: 90% of participants answered correctly. Only in two images were the emotions reversed — in both cases, a positive emotion was associated with an image intended to depict anxiety or sadness.

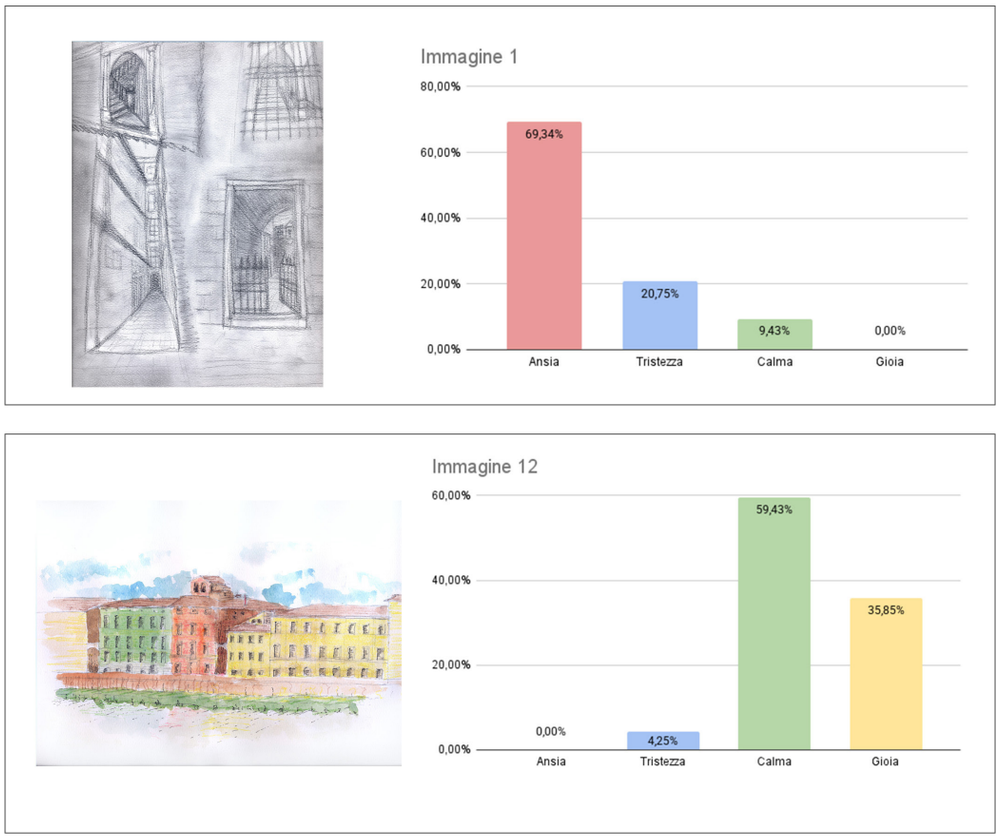


Figure 7 – Examples of drawings shown in the online test and the average responses for each emotion. First drawing of the vicoli area in Genoa, representing “anxiety” by Dimitri Tollot (Unige); second drawing of the Lungarno in Pisa, representing “joy” by Fabio Mazzeo (Unipi).

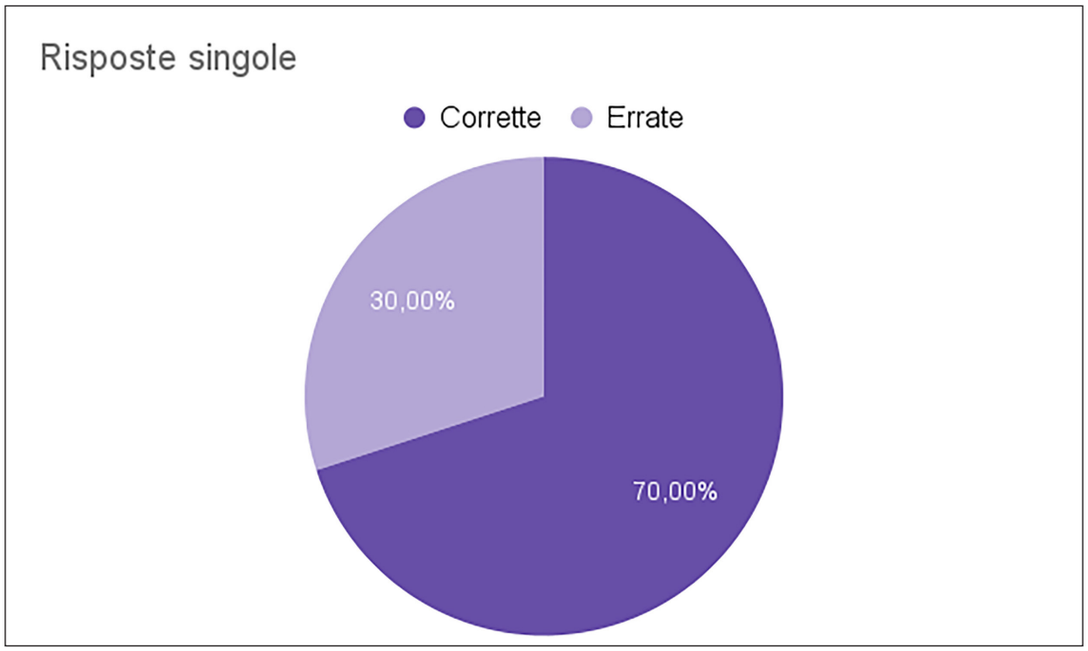


Figure 8 – 70% of the test takers correctly identified the specific emotion associated with the drawing.

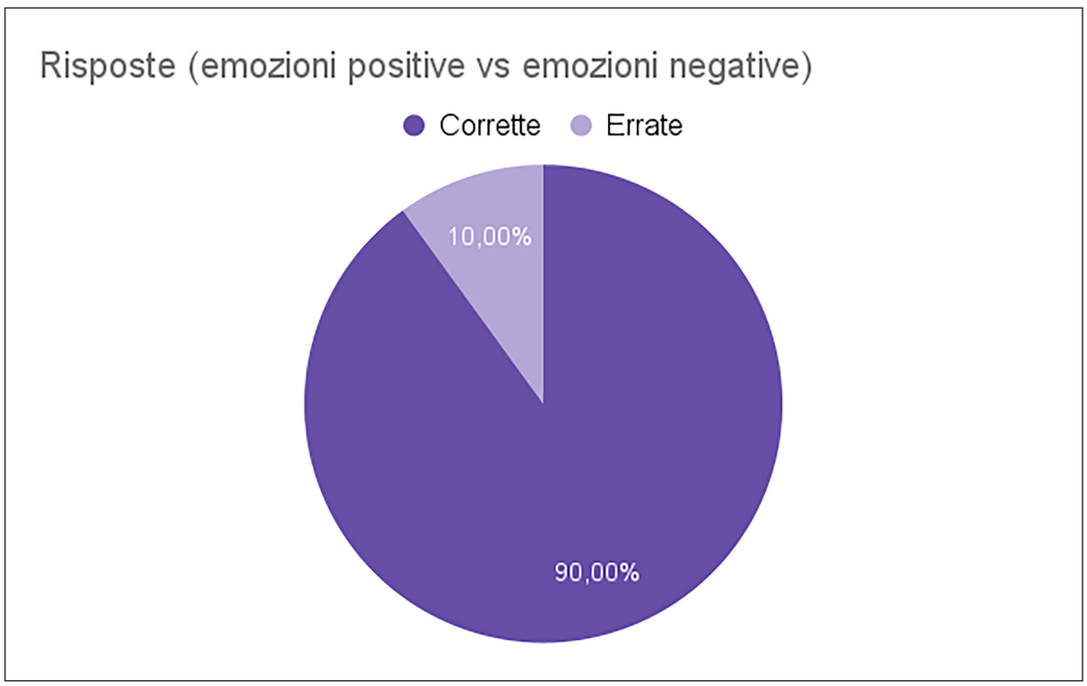


Figure 9 – If we analyze the distinction between negative and positive emotions, 90% of the test takers correctly identified the correct option.

3.3 Images evaluation and commentary

The last section, consisting of two multiple-choice questions and one open-ended question, aimed to gather participants' opinions on the choices made and comments on the test or research.

When comparing graphic elements (stylistic choices), represented elements, and experience of the place, there is a clear preference for the first category (88%), while prior knowledge of the place does not seem to have influenced the choice for many participants (20.7%) (fig. 10).

The graphic element that appears to have most influenced the choice of emotion was color, particularly the contrast between bright and dark colors (57% of preferences), followed by the choice of framing (43%). The presence or absence of graphic details was not considered determining factor (18.4%) (fig. 11)

The comment section served as a platform for sharing opinions and suggestions, demonstrating that quiz participants from diverse age groups and professions found the topic engaging and reflective on the often-overlooked human connection to the city (fig. 12).

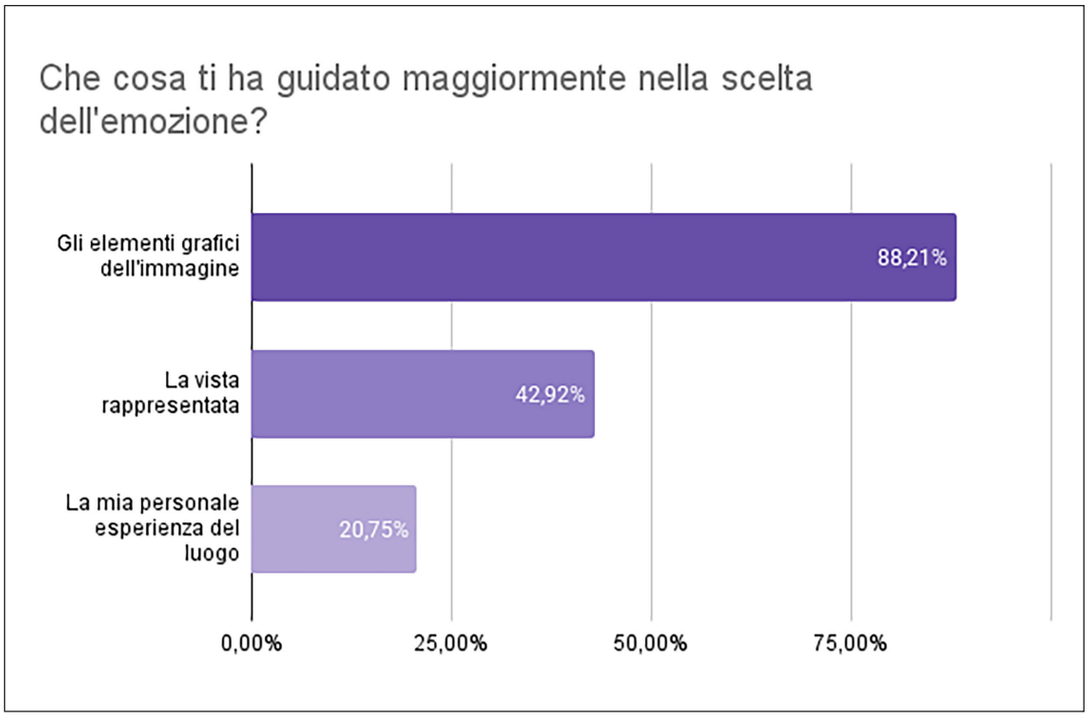


Figure 10 – For the question "What guided you the most in choosing the emotion?", the majority of responses were based on graphical aspects.

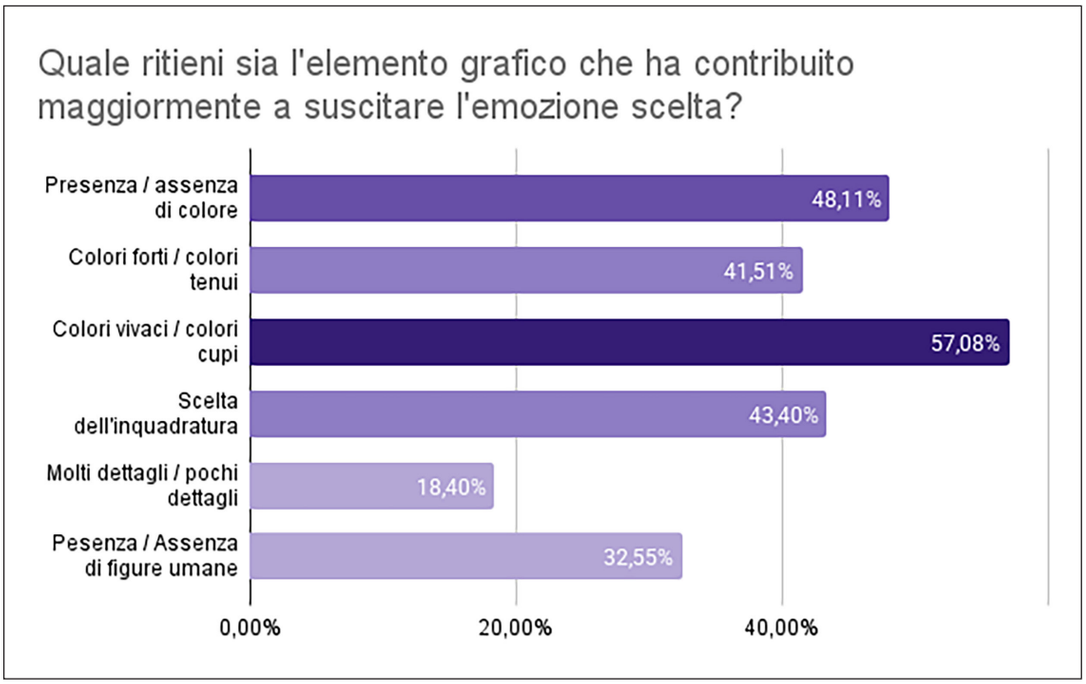


Figure 11 – For the question "Which graphic element do you think most influenced your choice?", the contrast between bright and dark colors was the most selected option.

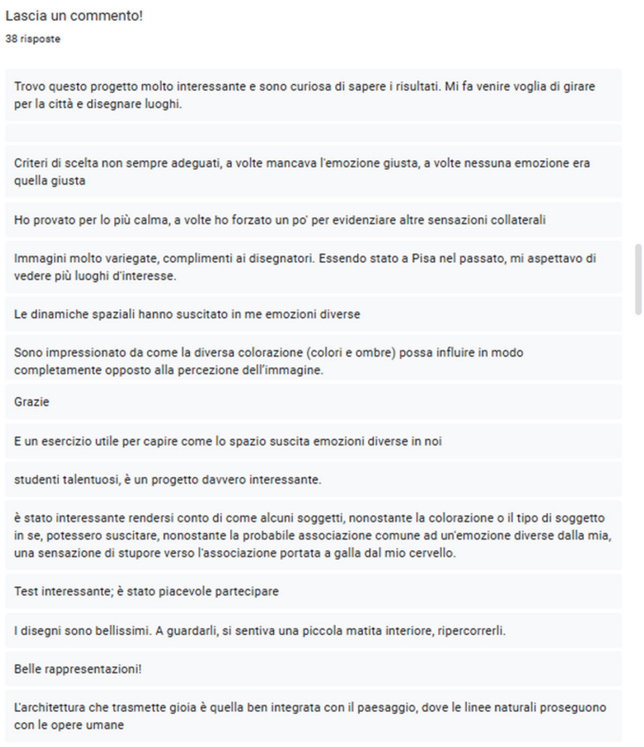


Figure 11 – For the question "Which graphic element do you think most influenced your choice?", the contrast between bright and dark colors was the most selected option.

4. Image Evaluation Through Electroencephalography

One of the aims of the project was to seek objective, instrumental evidence of some of the biological mechanisms set forward by the observation of a salient drawing from an architectural scene compared to a photograph. To do so, we resorted to recording the electroencephalogram as an ideal instrument for the exploration of the neuronal function. The specific technique that we used was the Visual Event Related Potentials (VERPs).

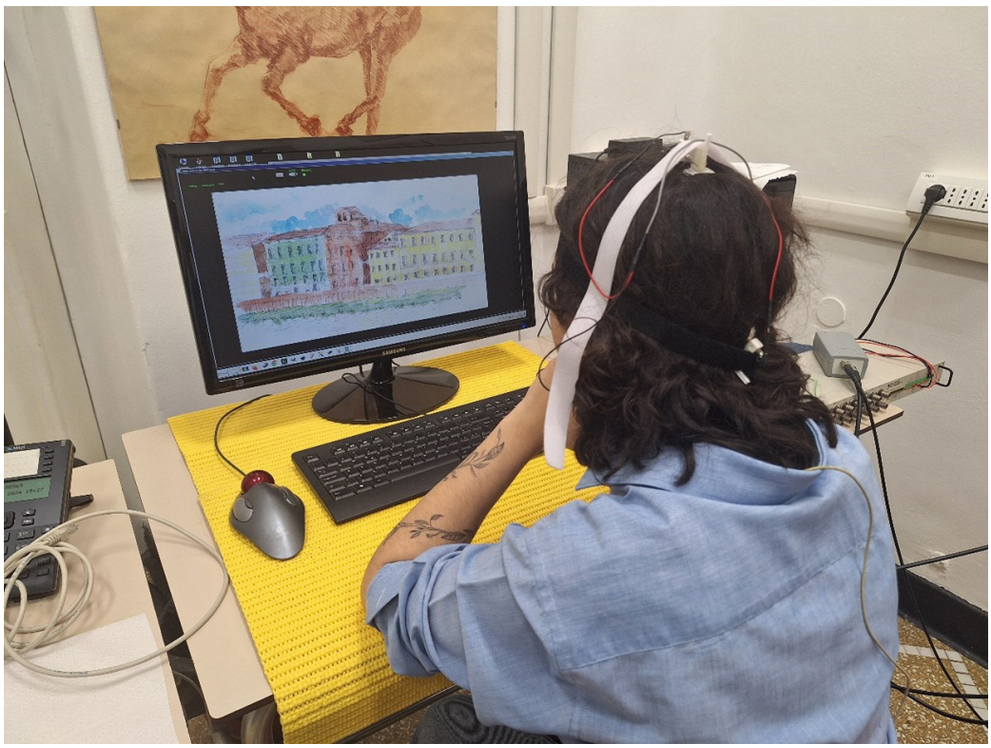


Figure 13 – One of the students during the EEG recording session. Picture by Gaia Leandri.

4.1 Method

VERPs are so called because the electroencephalogram is not recorded continuously but only for short time epochs in synchronism with the presentation of an image (“visual event” stimulus), which is “related” to a response of the neurons, recorded as an electric “potential” over the observer’s scalp . They are dedicated to the study of visual perception, and it is known that emotional or cognitively salient visual stimuli do evoke electric potentials recorded over the vertex area of the head in

the range of time between 150 and 600 ms after the stimulus (Luck, 2014). We studied these responses in three of the students who took part in the drawing experiment (fig. 13). They were presented with two kinds of visual stimuli: the “D” stimulus was a freehand drawing as an artist’s interpretation of an architectural scene, and the “Ph” stimulus was the photograph of the same spot. Both images were presented interspersed in a random fashion several times so that two sets of separate responses for D and Ph stimuli could be stored and the average of each one calculated to enhance the signal to noise ratio, where signal is the neuronal response to the stimulus, and noise is the random spontaneous neuronal activity not linked to the stimulus.

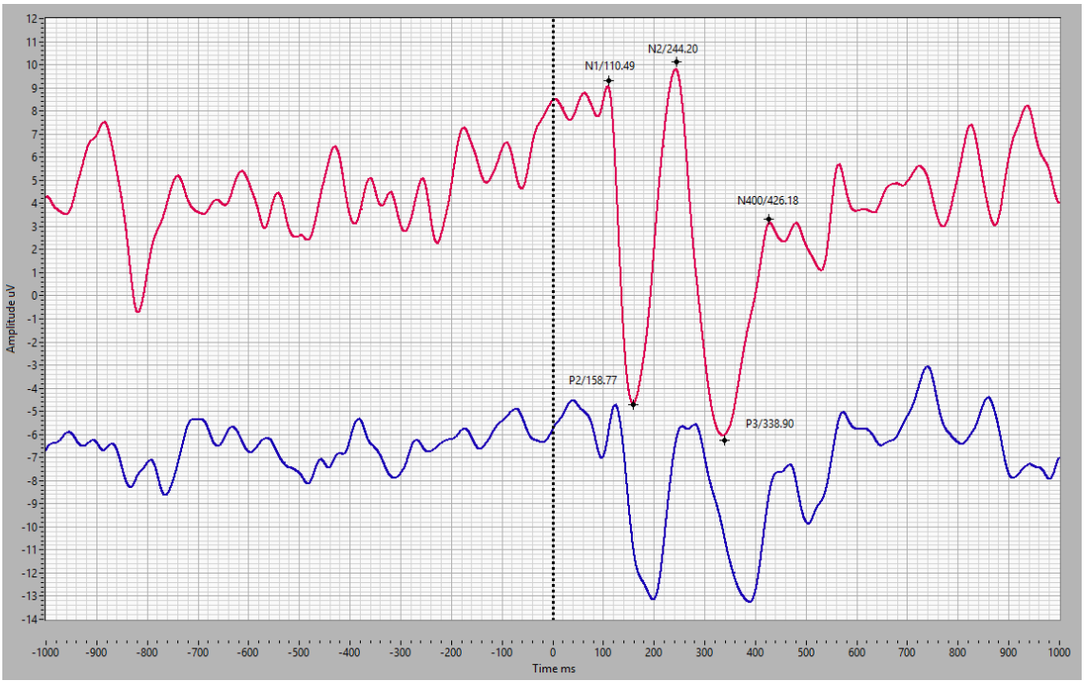


Figure 14 – An example of VERPs after presentation of D (red) or Ph (blue) stimulus.

	N1	P2	N2	P3	N400
Latency D	41.78 ms	160.63 ms	240.48 ms	340.76 ms	428.04 ms
D stimulus	4.54 μV	4.93 μV	8.62 μV	11.62 μV	2.84 μV
Ph stimulus	2.20 μV	5.99 μV	1.32 μV	6.10 μV	1.24 μV

Table 1 - Amplitudes of main peaks of VERPs.

	Area μV.ms
D stimulus	2315.76
Ph stimulus	1721.17

Table 2 - Areas under signal in the time domain 150-600 ms after the stimulus.

These results suggest that a far larger number of neurons, presumably pertaining to the association areas devoted to processing visual signals, are being activated by the more emotionally salient drawings compared to photographs. The phenomenon has so far only been observed in the three examined cases and of course needs to be confirmed by further experiments. Nevertheless, the feasibility of the technique has been demonstrated and it is expected that similar results will be obtained in a short time.

5. Hand-drawings and generative AI. A comparative analysis of emotional reproduction

Continuing the investigation into hand drawing as a privileged tool for exploring the emotional dimension in response to built heritage, the P.A.T.H.O.S. project integrates Generative Artificial Intelligence (GenAI), specifically open-weight diffusion models, into its methodological framework. This extension aligns with the most recent international research (Rapp *et al.*, 2025; Zhang *et al.*, 2024) regarding the transformative potential of these technologies in image generation, capable of emulating and reinterpreting the perceptual and emotional qualities intrinsic to human works.

Visual imagination is a key technique in various therapeutic approaches to help patients imagine a place or confront memories. The literature already contains several studies investigating emotional and/or physiological responses to immersive images or videos. These studies, aimed at examining the patients' emotional states about different types of environments, increasingly rely on GenAI images. In this context, it is deemed essential to deepen the study of the image's effectiveness through systematic evaluation and comparison between different open-source GenAI systems for image creation.

It is important to emphasise that the generation process is not exclusively based on conventional textual prompts. To preserve compositional and structural coherence with the original manual drawings, the inference is

conditioned by implementing ControlNet preprocessors. Simultaneously, to ensure prompt standardisation, open-weight Large Language Models (LLMs) are employed for automated prompt generation based on descriptive adjectives associated by students with manual drawings.

In this early stage of the research, the diffusion models used are not subject to fine-tuning processes; this methodological choice responds to the need to evaluate these models' intrinsic capacity to interpret and reproduce the emotional nuances conveyed by hand drawing before considering potential adaptations or customisations.

Through rigorous comparative analysis, the aim is to evaluate the native capacity of open-weight diffusion models to interpret and reproduce emotions conveyed through hand drawing while simultaneously opening a critical reflection on the ethical implications and practical perspectives of such tools in the context of architectural heritage.

6. The study of the drawings in light of the findings

The analysis of the 20 drawings selected for the test—and thus submitted to public evaluation—was conducted on both a formal and a semantic level. From a graphical standpoint, the parameters were useful in assessing which elements might have influenced visual perception, and consequently, neurological and psychological responses. Meanwhile, a statistical analysis of the depicted views allowed us to identify which urban elements, as experienced and represented, convey various emotions, thereby contributing to the shaping of our perception of that environment.

6.1 Formal analysis

To analyze the graphical characteristics of the images, the following software were used: ImageJ, Photoshop, and ImageToColor. Additionally, software devlepoed in LabView language is being utilized for the ongoing study of image entropy. The focus was on the elements that, according to responses from the online quiz, most significantly guided the selections — namely, contrast and color. Averages were computed for drawings corresponding to each emotion category (five per emotion).

Drawings representing negative emotions (anxiety and sadness) exhibit higher contrast compared to those representing positive emotions (calmness and joy), likely reflecting a tendency to portray these negative states using more defined strokes, bolder colors, and less gradation (fig. 15).

In terms of warm and cool color distribution, joy features the highest

proportion of warm colors (59%), while sadness shows the lowest (3%). Conversely, sadness exhibits the highest percentage of cool colors, averaging 96.88%, with joy displaying the lowest (40.6%) (figs. 16-17). Overall, cool colors dominate in images linked to negative emotions; however, drawings depicting anxiety contain a higher percentage of warm colors (15.6%) compared to those representing calm (12.5%). This discrepancy is likely attributable to the inclusion of natural elements—such as the sea, river, and vegetation—in calm drawings, which are typically rendered in cool hues.

The "joy" category exhibits the largest number of color points—exceeding 500,000—significantly higher than the other three categories, which average approximately 130,000 (fig. 18).

Finally, a consolidated color palette was generated for each emotion by averaging the percentage of color points in each drawing. Arranged from left to right—from the most prevalent to the least prevalent color—the palette showcases the most frequently used hues. This arrangement clearly demonstrates an overall preference for cool colors and a broader variation of hues in positive emotions, regardless of the representation method employed.

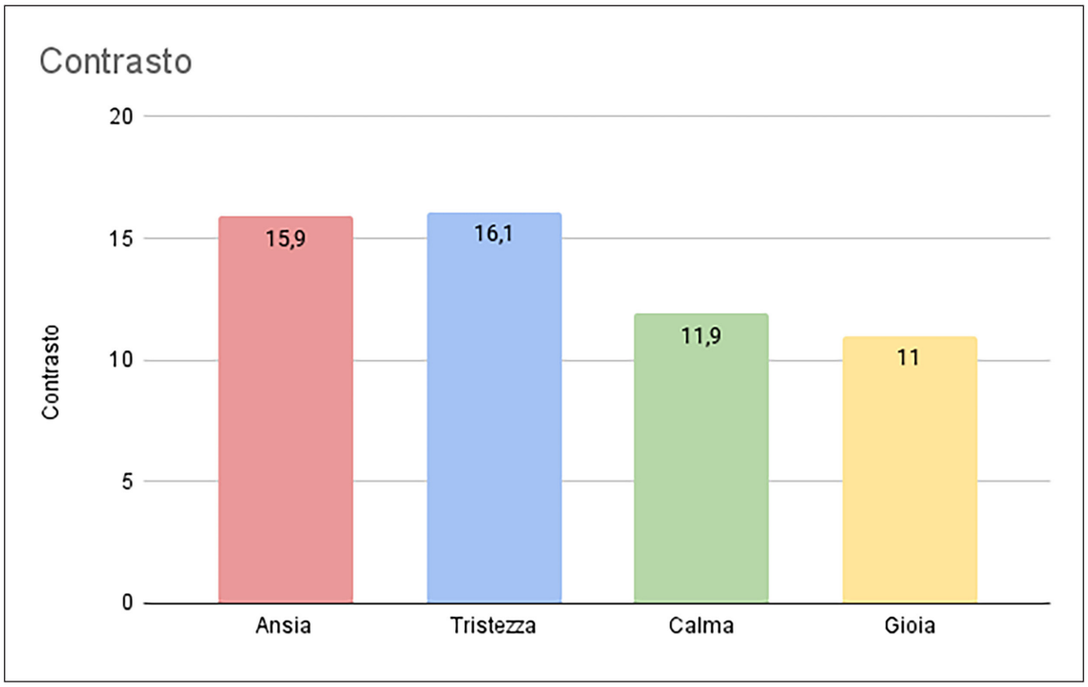


Figure 15 – Contrast analysis for each emotion.

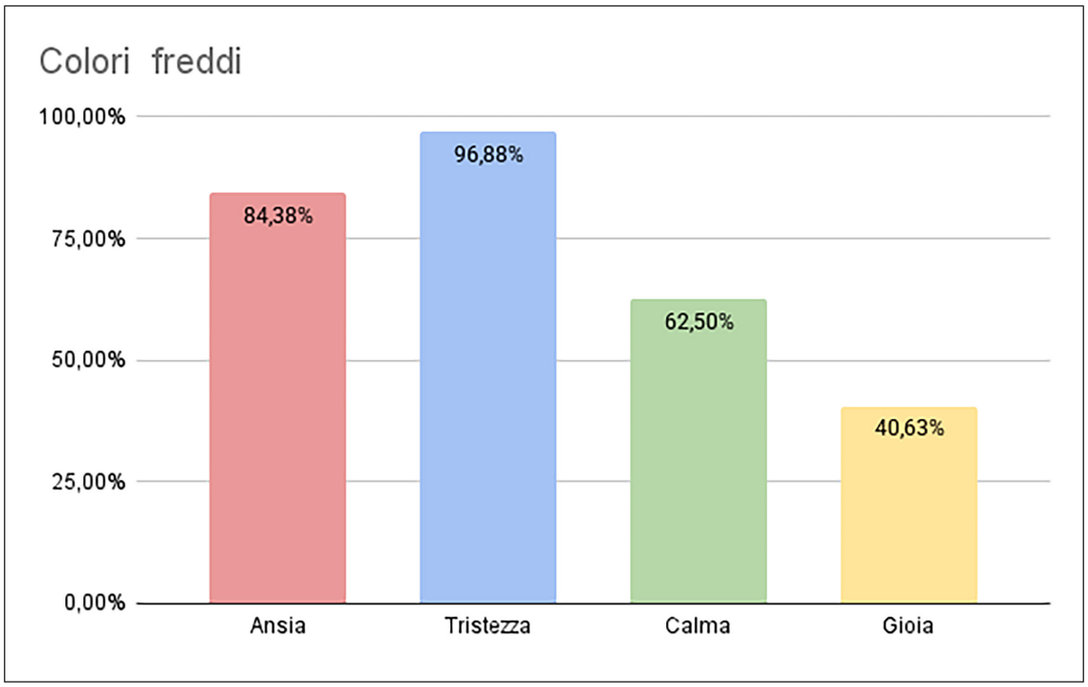


Figure 16 – Analysis of cold colors.

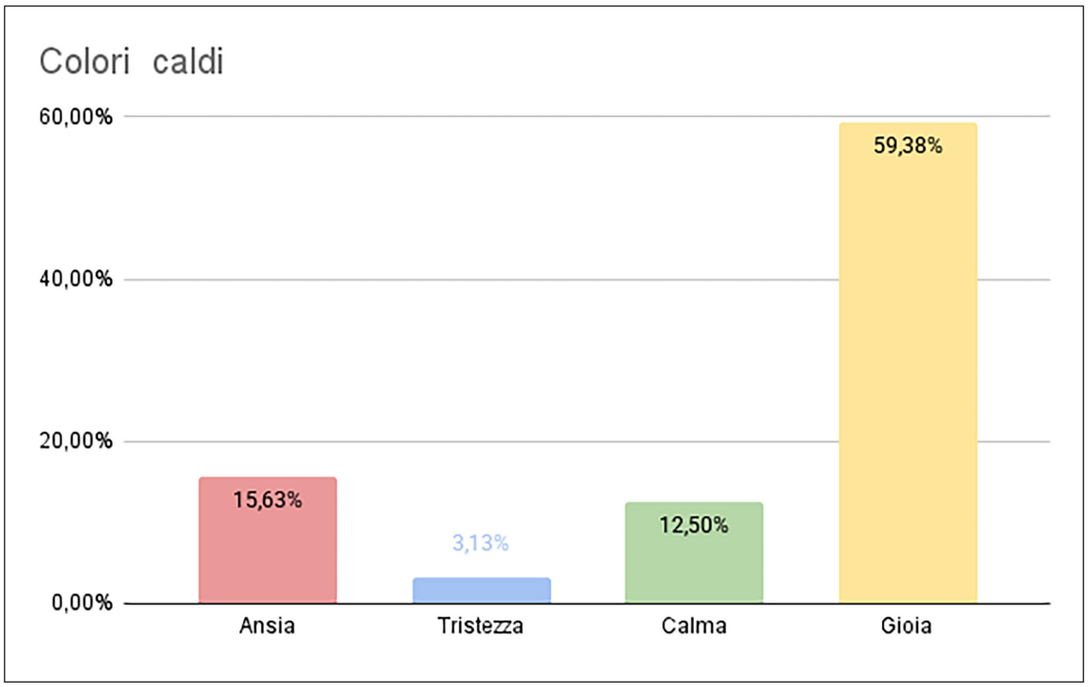


Figure 17 – Analysis of warm colors.

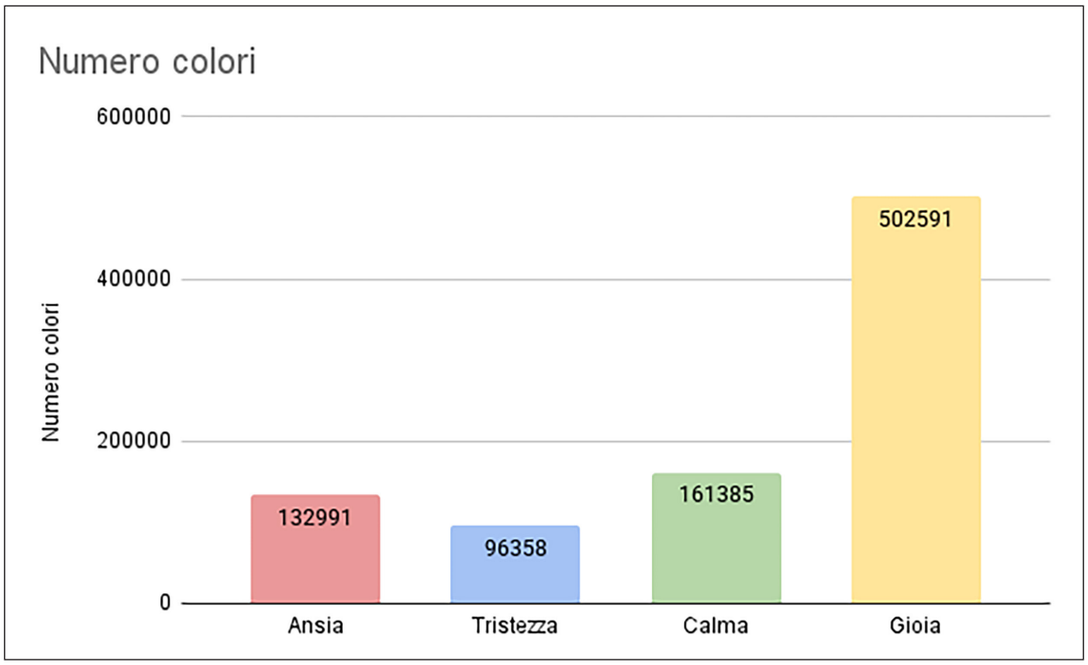


Figure 18 – Number of colors analysis.

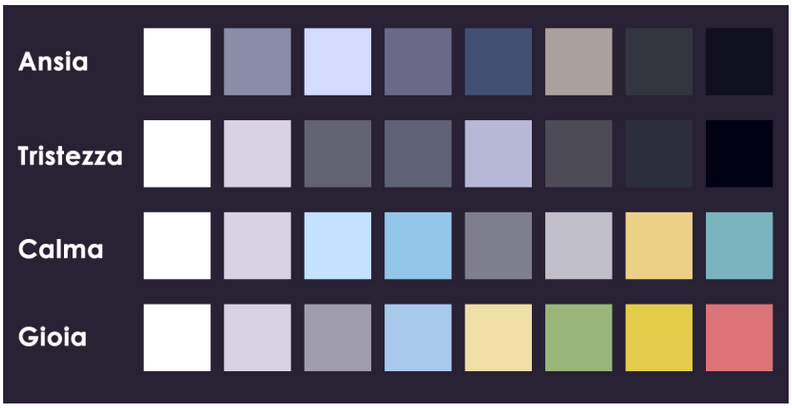


Figure 19 – The average of the most prevalent colors, from the highest percentage (left) to the lowest percentage (right).

6.2 Content analysis

The analysis of the image content, as well as that of the adjectives associated with the selected views, is still ongoing. However, some preliminary results have already emerged. First, based on the students' choices regarding the association of a given emotion with the location they selected to represent that emotion, Tables 3 and 4 show that, in both cities, two locations were predominantly linked to negative emotions,

while one location received mixed evaluations.

The reasons behind these choices can be traced back to the preliminary assessments conducted to identify the three locations: Baltimora Gardens and Borgo Stretto are the two areas that feature the greatest variety of elements — ranging from transitions between enclosed and open spaces to a mix of human-made and natural features, as well as diverse architectural forms. In contrast, Via dei Giustiniani, Porto Antico, Lungarno, and Navicelli, although differing greatly in various parameters, display a higher uniformity of elements within the designated area.

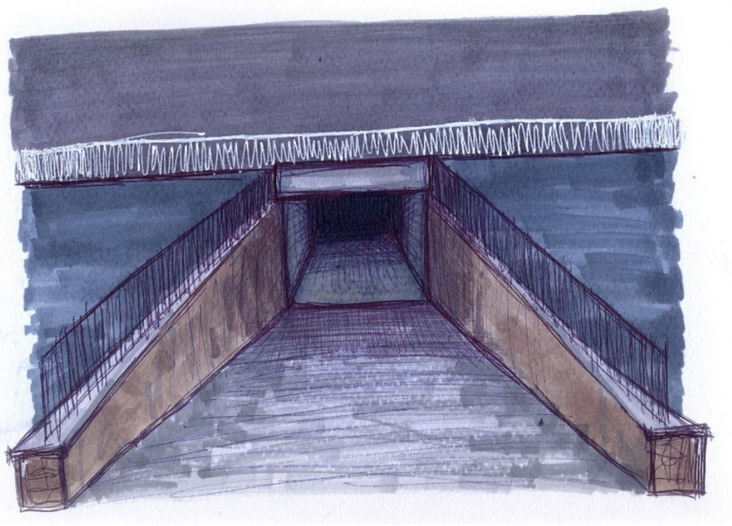
Moreover, there is a clear correlation between the depiction of enclosed environments (narrow streets, arcades, gates, tunnels) and negative emotions, versus the preference for more open spaces (views of the sea or river, port, and promenades) associated with positive emotions. Additionally, modern architecture appears to be linked with the emotion "anxiety," whereas historical architecture is more frequently associated with "sadness" or "calmness."

Genova	Giardini Baltimora	Via dei Giustiniani	Porto Antico
CALMA	▲		▲▲▲▲
GIOIA			▲▲▲▲
ANSIA	▲▲▲	▲▲▲	
TRISTEZZA	▲	▲▲▲	

Table 3 – The selection of areas based on emotions in Genoa.

Pisa	Borgo Stretto	Navicelli	Lungarno
CALMA	▲		▲▲
GIOIA	▲		▲▲▲▲
ANSIA	▲	▲▲▲	
TRISTEZZA	▲▲▲	▲	▲

Table 4 – The selection of areas based on emotions in Pisa.



Fiure 20 - A view of Pisa chosen for the emotion of “anxiety”. Drawing by Asia Xeka (Unige).

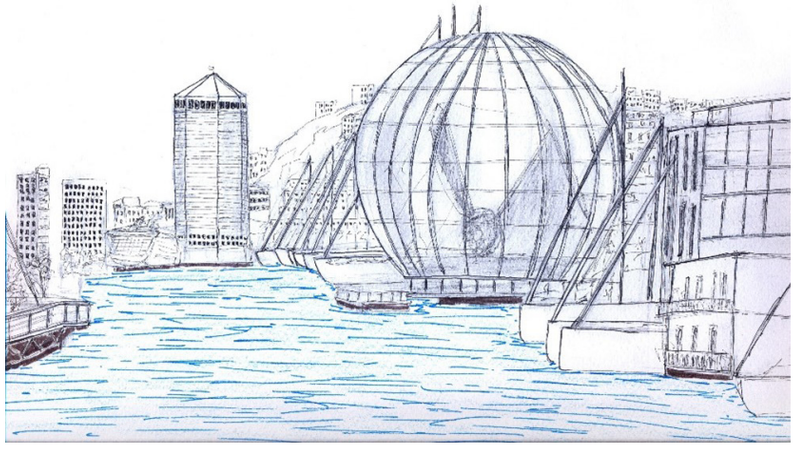


Figure 21 – A drawing of the port of Genoa chosen for the emotion of “calmness”. Drawing by Antonella Batistini (Unipi).

7. Conclusions

From a scientific standpoint, the implications are numerous. Firstly, it will be possible to assess which parameters of graphic expression most significantly influence the human psyche. Furthermore, by examining the selected views, we can determine which characteristics of places contribute to eliciting various emotions. Finally, through analyzing the descriptive words used, new terms related to the emotional reception

of physical spaces may be identified, thereby helping to bridge a current gap in psychological literature.

The project is still under development, but it has already shown significant results in both research and teaching. Its methodology makes it replicable across different university courses and in any city, indicating substantial potential for growth. In the future, the research will be expanded to include a study of the sounds perceived during live urban experiences and during electroencephalogram recordings. The insights obtained from this research are diverse and span multiple levels — from graphic expression to urban and psychological aspects. Simultaneously, incorporating the study of emotions in university drawing courses may prove to be a valuable tool in enhancing the perception of built environments and fostering artistic expressiveness.

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Figure 22 – The research group and the students who took part in the project. Picture by Martina Castaldi.

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