Designing Salutogenic Cities:

The Impact of Façade Design on Emotional Well-Being and Stress Regulation

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Director of the Architectural Design Programme at Universidad Católica del Uruguay, UCU, Punta del Este, and co-founder of Guevara Ottonello Architects, she combines professional practice and research to explore how architectural design can actively enhance health and well-being. Through projects, lectures, and studies in NeuroArchitecture, she promotes a human-centered approach that bridges scientific insight and creative design to shape healthier environments and communities.



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Façade Design, Urban well-being and Stress Regulation

Urban populations spend a significant part of everyday life exposed to building façades through windows and streetscapes, making façade design a central component of the urban visual environment.

While exposure to natural environments has been widely associated with positive effects on well-being, empirical evidence on how façade design influences emotional experience and physiological stress responses remains limited. Advancing this evidence is essential for the development of architectural strategies aimed at creating more salutogenic cities.

Grounded in NeuroArchitecture and human-centered design principles, this study examines how different façade configurations affect emotional responses and stress regulation, evaluating whether façades incorporating human scale, visual complexity, and biophilic integration foster more positive emotional experiences and improve physiological stress coping.

Research Objective

To investigate how the architectural design of building façades affects emotional experience and physiological stress responses, grounded in NeuroArchitecture (Eberhard, 2009; Robinson & Pallasmaa, 2015) and salutogenic design principles (Dilani, 2001, 2011)

Research Question

Ulrich (1984) showed that views of nature reduce stress. But in cities, where windows most often face other buildings, what effect do these buildings facades have on us? How do building façades influence our emotional state and physiological stress response?

Can façade design foster more positive emotional experiences, help regulate stress and promote health?

Hypothesis

A human-centered façade, one that expresses human scale, visual complexity, and biophilic integration, evokes more positive emotional responses, and helps people cope better with stress.
A person under stress can better regulate their stress response when viewing a human-centered façade than a monotonous one.

Methodology: Two-Phase Mixed-Methods Research Design

This study employed a two-phase, mixed-methods research design to investigate how façade design influences emotional experience and physiological stress regulation. The research began with the development of three façade conditions based on an existing residential project by Guevara Ottonello Architects. These conditions constituted a common set of architectural stimuli examined through two complementary empirical phases: a subjective emotional evaluation using photo-elicitation interviews and an objective physiological evaluation using a Virtual Reality stress-induction protocol. The use of the same architectural stimuli across independent methods enabled methodological triangulation by integrating subjective affective evaluations with objective physiological measures.

Emotional Evaluation

Photo-elicitation interviews

+

Physiological Evaluation

VR / Trier Social Stress Test

A within-subject photo-elicitation study exposed 110 participants to all three façade conditions. Valence and arousal were assessed using the Circumplex Model of Affect. Participants also rated each condition and selected their preferred façade, providing complementary measures of emotional experience, perceived quality and preference.

A randomized, between-subjects VR study assigned 48 participants to one of the three façade conditions during a validated Trier Social Stress Test. Heart rate, heart-rate variability and skin conductance were continuously recorded across baseline, stress exposure and recovery to assess autonomic stress reactivity and regulation.

Independent samples and complementary measures strengthened the methodological robustness of the study.

Façade Design Variations

Three façade variations (one control, two human-centered) were developed, all sharing the same building volume, to compare the emotional and physiological impact of viewing each one.



F1. Curtain Wall Façade

Low stimulation control condition

A monotonous, flat, repetitive, boring and sensory-depriving curtain wall. Lacks visual complexity, porosity and human scale, offering no signs of human presence or identity



F2. Dynamic Balcony Façade

Human-centered, creating dynamism

Human-centered façade, it features dynamic, playful balconies arranged non-uniformly to generate rhythm, porosity, and visual complexity. Designed to be sensory stimulating, expressive, identity-rich, welcoming, and scaled to the human body.



F3. Dynamic Biophilic Façade

Human-centered, integrating vegetation

Human-centered, biophilic façade, it features dynamic balconies combined with abundant greenery to create rhythm, porosity, and visual complexity. Designed to be sensory stimulating, alive, biodiverse, inviting, warm, and welcoming, it enhances connection to nature.

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Photo-Elicitation Interviews: Studying Emotional Responses

A within-subject photo-elicitation study was conducted with 110 participants. Each participant viewed the same three façade variations sequentially and evaluated them through a standardized procedure. Participants were instructed to respond intuitively according to their immediate impression of each image. The assessment captured three complementary dimensions: emotional response, overall design rating and comparative preference.

Valence and Arousal / Circumplex Model of Affect

For each façade, participants evaluated their emotional response along two independent dimensions derived from the Circumplex Model of Affect (Russell, 1980).

How pleasant or unpleasant does this façade feel to you?



How calming or activating does this façade feel to you?



After viewing all three façades, participants provided an overall rating and selected their preferred design.



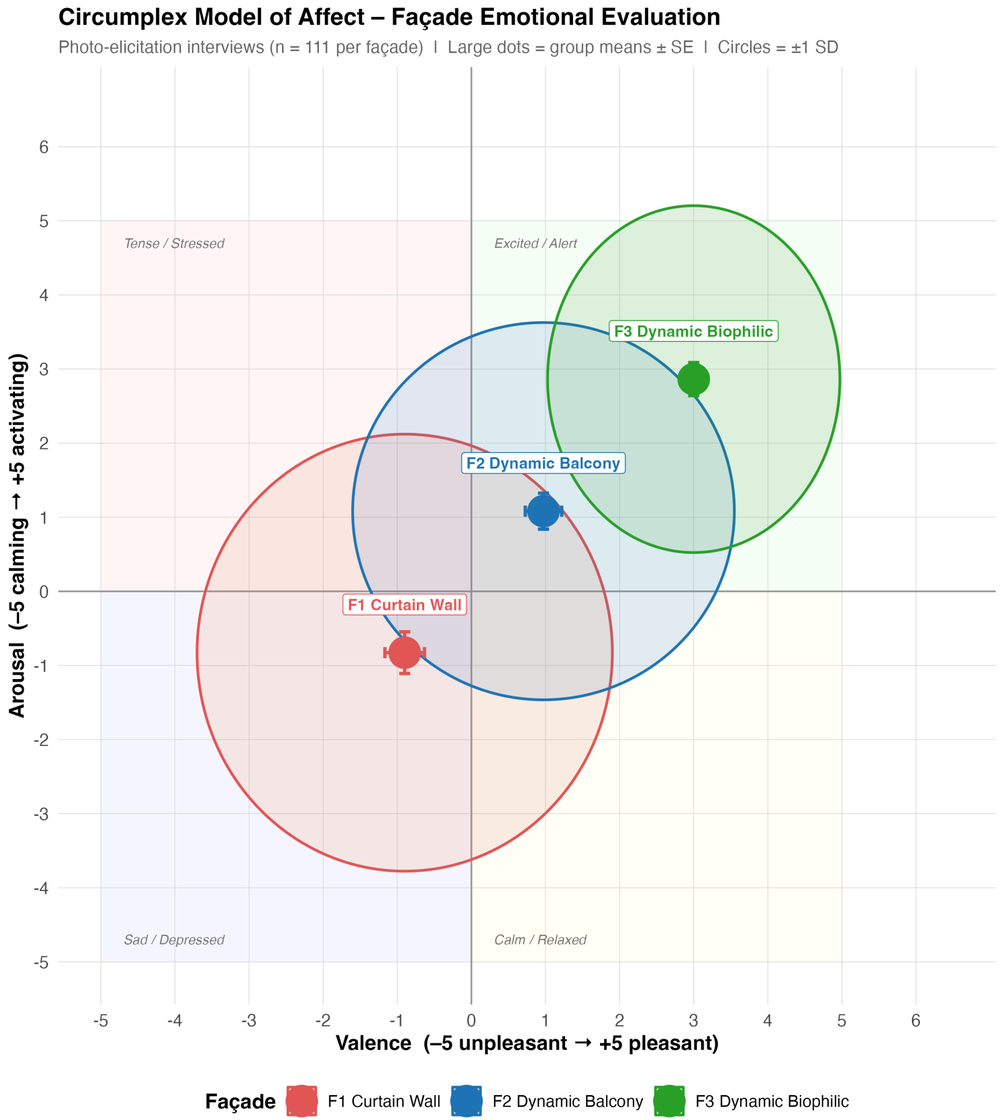




Results: Emotional Evaluation | Biophilic Façade Received the Most Positive Response

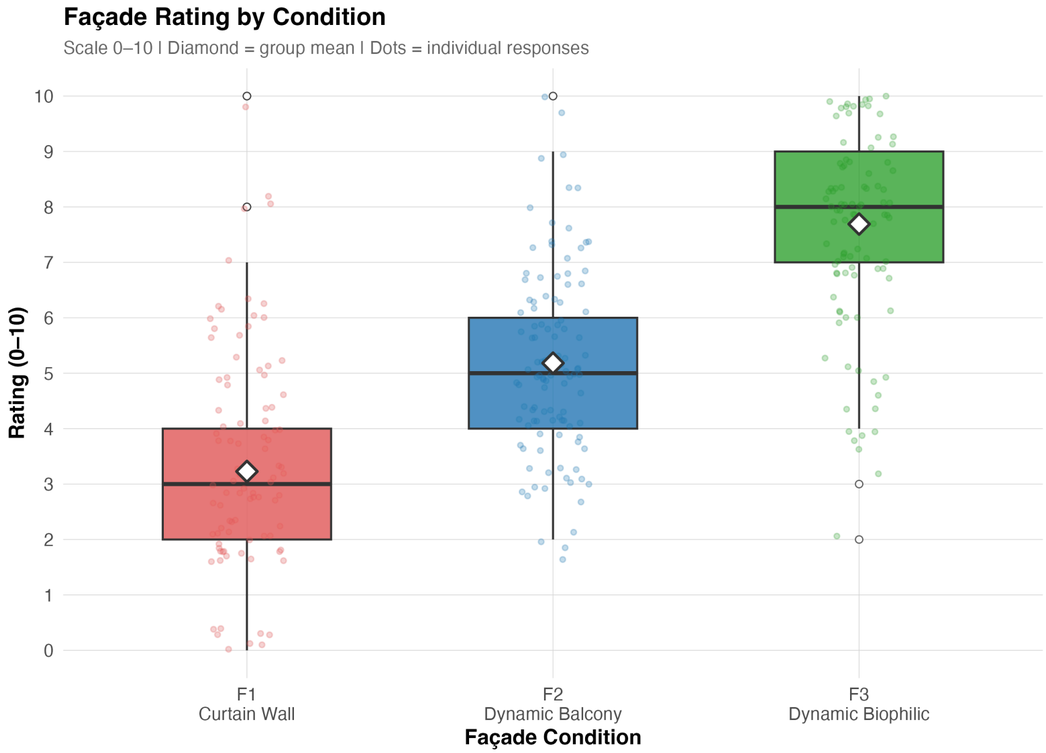
Valence and Arousal

Emotional responses differed significantly across the three façade conditions. F1 was associated with low valence and low arousal, reflecting disengagement and boredom (M = −0.90 and −0.83). F2 elicited moderate positive valence and arousal (M = 0.97 and 1.08), while F3 produced the highest scores (M = 3.00 and 2.86), corresponding to excitement, happiness and positive engagement. One-way ANOVAs confirmed significant differences in valence and arousal, with all pairwise comparisons reaching p < .001.



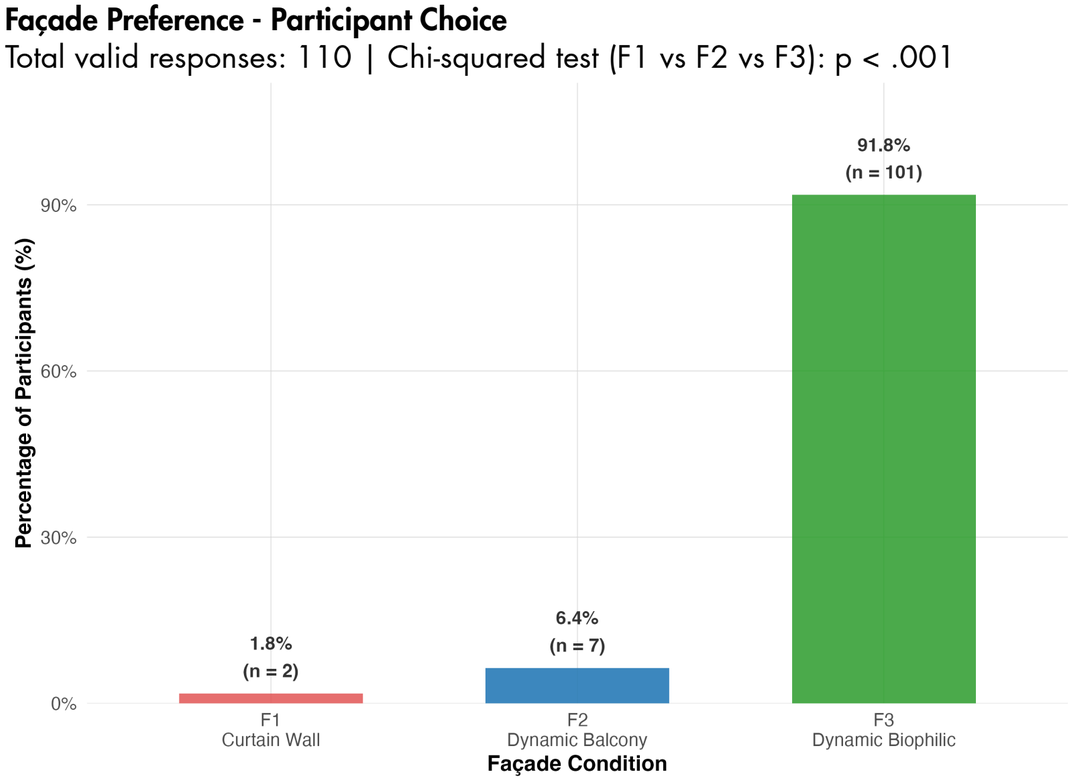
Design Ratings

Façade design had a highly significant impact on participants' ratings. The Dynamic Biophilic façade received the highest mean rating (F3: M = 7.69/10), followed by the Dynamic Balcony façade (F2: M = 5.18/10), while the Curtain Wall received the lowest rating (F1: M = 3.23/10). A one-way ANOVA confirmed significant differences across façade conditions ($F(2, 327) = 133.74$, $p < .001$), and post-hoc comparisons showed that each façade differed significantly from the other two (all $p < .001$).



Façade Preference

Preference was strongly concentrated in the biophilic condition. Of the 110 valid responses, 91.8% of participants selected F3, compared with 6.4% for F2 and 1.8% for F1. A chi-squared test confirmed that this distribution was significantly different from chance ($\chi^2(2) = 153.94$, $p < .001$), indicating a near-unanimous preference for the Dynamic Biophilic façade.



Physiological Evaluation through the VR-TSST

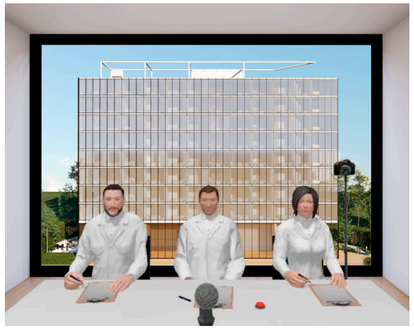
Virtual Reality version / Trier Social Stress Test (VR- TSST)

48 healthy adults were randomly assigned to one façade condition, between-subjects (F1: n = 14, F2: n = 18, F3: n = 16). Each was immersed in a neutral apartment facing the Promenade Building, with the assigned façade visible through a large dominant window throughout, delivered via the Open TSST-VR platform (Linnig et al., 2024).

Stressor
with virtual panel

Recovery
panel gone, façade remain

Group 1 / Variation 1:
Curtain Wall Façade



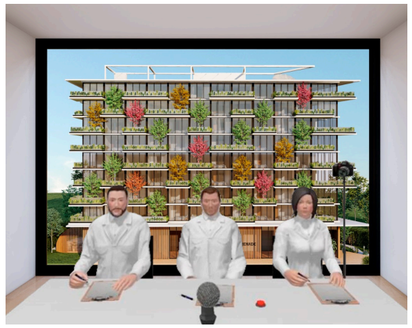


Group 2 / Variation 2:
Dynamic Balcony Façade





Group 3 / Variation 3:
Dynamic Biophilic Façade





Physiological Evaluation through the VR-TSST

Virtual Reality version / Trier Social Stress Test (VR- TSST)



Results: Physiological Evaluation | Biophilic Façade Showed the Most Favorable Physiological Response

The Dynamic Biophilic façade showed the strongest and most sustained stress regulation pattern, while the Dynamic Balcony façade also reduced sympathetic activation during acute stress compared with the Curtain Wall control.

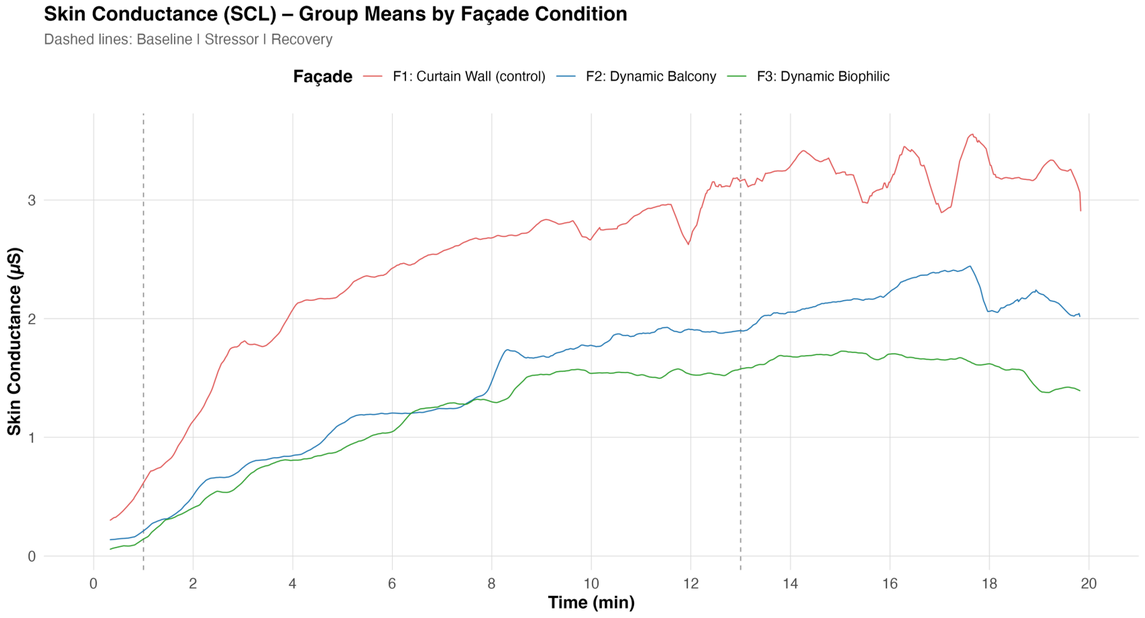
Heart rate was significantly lower in F3 than in F1 during both stress exposure and recovery ($p = .003$ and $p = .006$, respectively), with F3 maintaining consistently lower cardiovascular activation while F1 showed no meaningful recovery after the stressor.

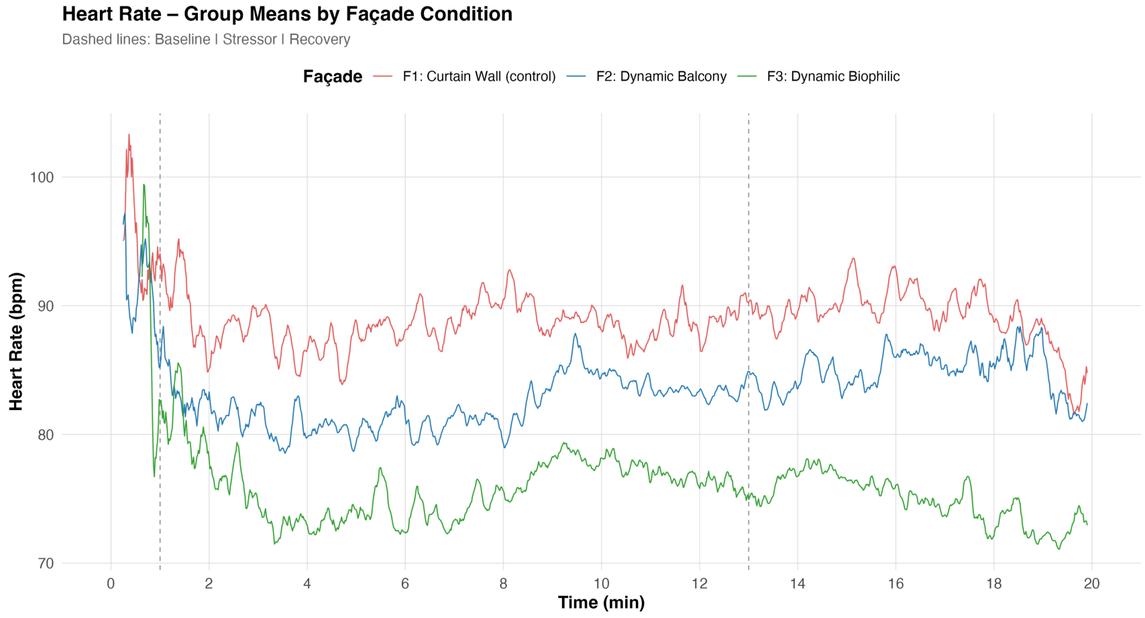
Skin conductance was also significantly lower during stress in both human centered conditions compared with F1 (F2: $p = .039$; F3: $p = .018$), and F3 maintained this significant advantage through recovery ($p = .034$).

Heart rate variability, assessed through RMSSD, followed the same directional pattern, with F3 showing the highest parasympathetic activity, followed by F2 and F1, although these differences did not reach statistical significance.

Baseline measurements showed no significant differences between groups, indicating comparable physiological levels before stress induction.

Together, these findings indicate that human scale, visual complexity and integrated vegetation can support more effective physiological regulation during acute stress.





Key Findings: Converging Evidence

Across emotional responses, design ratings, preference and physiological regulation, the results consistently identified F3 as the most favorable condition, F2 as intermediate and F1 as the least favorable, highlighting the value of human scale, visual complexity and integrated vegetation.

Façade Variations	Design Characteristics	Emotional Response & Preference	Physiological Response	Salutogenic Design Relevance
F1 Curtain Wall Façade	Monotonous repetition, flatness and low stimulation; no human scale, visual complexity or vegetation.	Low valence and low arousal, reflecting disengagement and boredom. Lowest rating: 3.23/10. Preferred by 1.8%.	Least favorable physiological profile. Highest heart rate and skin conductance during stress and recovery, with no meaningful cardiovascular recovery after the stressor.	Least supportive of salutogenic design. Monotony, low stimulation and the absence of human scale were associated with boredom, heightened physiological activation and limited cardiovascular recovery.
F2 Dynamic Balcony Facade	Human scale, rhythm, porosity, visual complexity and signs of habitation and human presence.	Moderate positive valence and arousal. Intermediate rating: 5.18/10. Preferred by 6.4%.	Significantly lower skin conductance than F1 during stress, with an intermediate heart rate response.	Supportive of salutogenic design. Human scale, rhythm and coherent visual complexity were associated with more positive emotional responses and reduced sympathetic activation during acute stress.
F3 Dynamic Biophilic Façade	**Human scale, rhythm, porosity, visual complexity and abundant integrated vegetation, with biodiversity and natural color variation.**	**Highest valence and arousal, corresponding to excitement, happiness and positive engagement. Highest rating: 7.69/10. Preferred by 91.8%.**	**Most favorable physiological profile. Significantly lower heart rate and skin conductance than F1 during both stress and recovery, showing the strongest and most sustained physiological regulation.**	**Strongest support for salutogenic design. The integration of vegetation with human scale and visual complexity was associated with the most positive emotional experience and the most favorable and sustained physiological regulation.**

Conclusion: Façade Design as an Active Component of Urban Health

This research demonstrates that façade design can influence emotional experience and physiological stress regulation in urban environments. Across two complementary empirical phases, human-centered façades were associated with more positive emotional responses and more favorable stress regulation than the monotonous Curtain Wall. The Dynamic Biophilic Façade produced the most positive emotional experience and the strongest and most sustained physiological regulation.

Human scale, coherent visual complexity and integrated vegetation emerged as architectural qualities with clear health-supporting potential. Their consistent effects across subjective and physiological measures position façade design as a meaningful resource within salutogenic urbanism and provide practical, evidence-based guidance for architects, developers and urban policymakers.

Façades form part of the shared visual environment experienced every day through windows and streetscapes. By integrating health promotion into this everyday layer of architecture, façade design can support emotional well-being, reduce stress and contribute to the creation of healthier, more resilient and more salutogenic cities.

