Interventions on Cultural Heritage: Architecture and Neuroscience for Mindful Projects

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Interventions on Cultural Heritage: Architecture and Neuroscience for Mindful Projects

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Abstract
The paper aims to investigate the intersections between the disciplines of Architecture and Neuroscience focusing on interventions on cultural heritage. Starting from the assumption that the main objective of architecture is ensuring the well-being of the inhabitants at different scales, and that architecture (with its forms, its proportions, its spatial hierarchies, its relationships) generates behaviors, the authors investigate the terrain of overlap with neuroscience, (particularly in its openings towards the disciplines of psychology, social and behavioral sciences) in order to design meaningful cultural experiences.
The concept of disciplinary contamination regarding cultural heritage is not to be discussed only in physical terms, but also in intangible terms including all social and cultural values of heritage buildings and sites. This is also because values associated with cultural heritage can be protected and enriched by an approach that generates reactions on a cognitive and emotional level, and it needs to be mediated both at the level of architectural interventions and museography.
For this reason, starting from the first intuitions that some designers had during the twentieth century, the paper investigates possible ways of collaboration and experimentation and refers to studies currently underway.

Keywords: perception, emotion, heritage preservation, heritage communication

1. Introduction
The contamination with neurosciences is one of the most recent that have occurred in architecture. They involve a field of reflection with which architecture, naturally with a very different approach, has always had a great affinity.
The awareness that we exist in a way in which mind, body, environment and culture are interconnected at various levels may be obvious to many, but only under the impetus of the extraordinary discoveries and innovations of the biological sciences it has begun to be appreciated in recent years. As Mallgrave acknowledges, we have probably learned much more about our biological and emotional nature in the last quarter century than in all of previous human history [1].
In the 21st century, the material and psychological needs that an architect must meet are very complex. Today he no longer has to respond to the need for survival, but to the quality of life that is made up of aspirations of a cognitive, aesthetic and creative nature [2], and in fact many researches focus on well-being (in response to needs not only physical and ergonomic, but also physiological, social and cultural [3]. The sensory, emotional and cognitive mechanisms on which perceptual experience is based and in particular, as far as architecture is concerned, spatial perception are at the centre of attention in this interdisciplinary dynamic.
It was only at the beginning of the third millennium that the first steps of this contamination were officially taken. Certainly these are disciplines with different approaches, criteria, methods and aims, but neurosciences today can share with designers indications on how humans biologically perceive and experience space, while architecture can offer ideas for experimentation to neurosciences.

In recent years, there have been several contributions from neurosciences that have attracted interest and can create crucial interactions with architecture. First of all, a better understanding of emotions intended in biological sense, i.e. somatic, visceral, electrical and chemical events. In particular, the discovery of mirror neurons also explains why emotions work with such immediacy. These are specialized neurons, through which the subject, on a pre-reflective level, empathizes with the gestures and emotional states of others and the physical environment itself. Thanks to mirror neurons, people who observe works of art "resonate" with the actions connected to them, with a subtle motor activity.
Other crucial discoveries are the neurophysiological mechanisms, through which one perceives one's position in space and orients oneself in it, and finally the notion of neural plasticity, i.e. the brain's ability to alter its neuronal connections in response to environmental conditions (which, among other things, made us realize that the brain does not stop growing in adulthood).
In addition, today we have sophisticated techniques of neurophysiology and neuroimaging, which combined with other methods can evolve the study on how people perceive, imagine and interpret textures, colors, proportions, distances, or the set of physical, sensory and material properties of a room, or an urban landscape. In this way, neurosciences provide food for thought on the emotional reactions and biological constraints of the individual. Studies have also shown that each brain is different and unique. Indeed, it is unique at all times, since it is in a state of perpetual learning and transformation. Neuroscience helps to reconstruct the complexity of the relationships between brain, mind and behaviour.
As a consequence of the extraordinary discoveries in the field of neuroscience, a particular declination of architecture was born: the neuroarchitecture, which studies how the environment modifies the brain and, therefore, behavior. Actually, for some time now architecture has been carrying out similar considerations, but the neuroarchitecture as we know it now was born only 25 years ago and it was inspired by the discovery of neuroplasticity of the brain.
Neuroarchitecture is thus a field of research interested in how the environment modifies brain chemistry and, therefore, emotions, thoughts and behaviour. Certain environmental inputs and spatial properties can trigger mechanisms in the brain that release the hormones necessary for the development of emotions and sensations.
The observations that emerged from neuroarchitecture, which focuses on aesthetic and symbolic aspects, have in some cases been translated into design guidelines, but in this field one must be wary of any form of determinism.

2. Cultural heritage and neuroscience: architecture and atmosphere.

As far as architecture and cultural heritage (architectural and not) are concerned, the contributions that can derive from cognitive, behavioral and affective neuroscience are particularly interesting, being “at the centre of brain-mind-behaviour triangulation, questioning how brain systems generate emotions” [2]. Although the field has not yet been specifically investigated, it would be interesting to evaluate the contributions of this contamination. With reference to heritage, it naturally concerns the study of the aesthetic experience but also the communicative mediation needed to enhance and communicate the heritage.
Our evaluations, however 'objective' and rational they may seem, are always influenced by an edonic/affective experience [4]. Juhani Pallasmaa also points out that architecture projects existential meanings into physical space, just as he reminds us that the physical and mental worlds are inextricably intertwined [5].
Now, however, neuroimaging screens can record emotional reactions when we experience an artistic event, so the dividing line between biology and culture is now much more blurred. They confirm that we are constantly evolving and self-organizing in relation to the environment, and this is our way of being in the world.
Among the many discoveries and experimentations carried out, two of them are reported by Canepa as being related to the theme of relations with cultural heritage [2]. First of all, in 2009 some scholars had detected the effects of expectations on neural responses: if people knew that they’re watching a museum piece, rather than one image generated by a computer, different regions of the cerebral cortex were activated. Probably for this reason they considered the first ones to be the most attractive. The neural activities generated suggest that people's expectations draw on memories that affect visual pleasure.
A second very interesting study found that people have different neural responses when told they are looking at an authentic or copied portrait of Rembrandt. These studies show that context and knowledge, beyond the sensory qualities of visual images, demonstrably influence people's neural activity in aesthetic experiences.
In fact, these observations also confirm the concept of "aura" that has long been invoked with regard to original works of art: and among other things it confirms that a virtual visit can never, at the level of biological emotional reaction, really replace physical access, no matter how accurate and high-resolution the reproduction is.

As a result of these studies and the many discoveries of neuroscience, there are at least two strands where the contamination architecture-neurosciences could generate interesting observations.
The first concerns the investigation of the biological dynamics that are triggered when one is in pleasant spaces, therefore more generally during the aesthetic experience as a "natural" phenomenon. Neuroscience could evaluate the weight of the values, personal and cultural, that shape experience, limiting the conditioning given by the contemporary Western aesthetic and cultural canon because today's human being is, at the level of biological structures, the same as thousands of years ago [4].
The second concerns the expedients (in particular, museographic expedients) that are put into practice to enhance the heritage: that is, to preserve it but also to communicate it. Physical interventions are almost always necessary (having an impact on the atmosphere, when it comes to architectural heritage) but also intangible interventions (apps, as well as virtual, augmented or mixed reality) actually affect perception not only from the physical and perceptive but also from the mental and cultural point of view.

2.1 Aesthetics and neuroscience.
Between 1994 and 1995 studies on the correlation between body, brain and art came to the fore: and a few years later, in 2001, Semir Zeki, a pioneer in the investigation of the organization and functioning of the visual brain, coined the neologism 'neuro-aesthetic'. It is a branch that examines the brain when it is in contact with beauty and the artistic imagination, trying to understand if the aesthetic experience is referable to general biological rules.
The pleasure that people derive from looking at beautiful objects automatically triggers a ”recompense” gratification circuit, however, involving different regions of the cerebral cortex in relation to the type of image.
Over time, different approaches have developed, alternative and complementary to the one proposed by Semir Zeki [2]. In the same years, for example, Vilayanur Subramanian Ramachandran, director of the Center for Brain and Cognition in San Diego (CBC), questioned the existence of some universal law delegated to govern the perception of beauty [6]. Ramachandran thinks that there are universal artistic values, despite the infinite variety of artistic styles in time and space.
Other neuroscientists have instead monitored neural reactions in front of artworks and other non-artistic artifacts. Freedberg and Gallese [7] carried some experiments with non-figurative artworks, concluding that even in these cases they induce the empathic involvement of the observer who "feels" the artist's gesture and is biologically induced to relive it by immersing himself in the motion evoked by the work: tears, engravings, scratches, brushstrokes generate in him an activation of the cortical motor system. This did not happen if black lines, without depth, were proposed to him.
This exploration is gradually consolidating thanks also to the growing interest and collaboration of artists. The renewed attention to the corporeity that we see today in architecture helped to shift the focus from the static building to the living body of the individual, from an objective to a subjective vision.

2.2 Cultural heritage and neuroscience
Architecture as a spatial and aesthetic experience generates emotional reactions, adaptations and behaviors, and this is a very important point as far as the enhancement of cultural heritage is concerned, a field in which so far no real contamination with neuroscience has been experienced.
In addition to the other mechanisms of spatial perception studied by neurosciences, the reference to cultural heritage overwhelmingly calls into question the experiential and mental sphere, and in particular the "atmosphere", which becomes an occasion generating experience: its perception is a condition of resonance and identification (sensorimotor, emotional and cognitive) between the individual and the surrounding architectural space [2].
Perception captures the atmosphere before any other element or detail [8]. "An artwork or an architecture", Pallasmaa states, "is a real mental image-object, a complete microcosm that is placed directly in our existential consciousness and experience" [7]. These microcosms catalyze poetic images, conscious or unconscious, linked to experience and memory while the stimuli are already perceived on a neurophysiological level. Canepa defines them as 'neurocosms' [2].
This also influences, albeit in a much less conspicuous way, the attitude towards the architectural cultural heritage. The atmosphere generates a response on a physiological level that we can define as mood: events and environmental factors produce sensory inputs that influence us [9].
It is immediately obvious that there are many factors that contribute to compose architectural atmospheres. From geometric shapes to proportions, from rhythm to masses, from details to materials, from light to sound climate, from temperatures to olfactory qualities. Although they can be defined as generators of atmosphere, the atmosphere is a result that goes beyond the simple sum of them [2].
The environment around us is an immersive sensorial sounding board, which exerts a profound influence on our unconscious. The atmosphere is complex, fuzzy, multisensory, kinaesthetic and haptic, instinctive and immediate [10] [2]
As we know, this idea of an all-encompassing, and not fragmented, perception was first formulated at the beginning of the 20th century by members of the Gestalt school; as well as we know that the human

organism is not only endowed with the five classical senses. There are also the somatic senses of pain, temperature, itching and proprioception (which controls posture and body segments) and the vestibular sense of balance. Above all, however, the sensory qualities flow into a unified perceptual act [11].
Despite the supremacy of sight, even closing the eyes it is possible to feel the atmosphere of a room, and someone argues that "an atmosphere, above all, can be sniffed, aspired to" [12]
Emotions, biologically understood, play a crucial role in this process. Generally, in the past, there has been a tendency to underestimate their perceptive role in architectural space, preferring rational knowledge. "But actually their effect on the actions of men is immense," said Giedion [13].
On the neurobiological nature of emotions, it should be clear that they arise from a specific event, including behavioural and physiological changes that are not always conscious, and that they specifically facilitate social interactions [2]. Therefore, when you enter a new atmosphere, it is the body that first feels the stimuli coming from its surroundings and, after a temporary disorientation, you "perceive" how you feel, reaching a new balance [14]. This process is particularly evident when one comes into contact with, for example, an exhibition atmosphere, which precisely aims to make one perceive with greater acuity and attention.
This is the case of the incredible atmosphere created by the experimental, responsive architecture "Hylozoic Ground" by Philip Beesley for the Canadian pavilion at the 12th International Architecture Biennale of Venice in 2010 (fig.1). An artificial forest, made of an intricate lattice, digitally-fabricated, was fitted with microprocessors and proximity sensors that reacted to human presence. This responsive environment functions like a “giant lung that breathes in and out around its occupants”. This mythical and fragile forest of light creates a sort of “empathic motion, affecting people on an emotional and poetic level, linking the animate and the inanimate” [15].
In order to ensure the appropriate adaptive plasticity required by an ever-changing environment, emotions have a very compressed duration, which usually dissolves within a few moments, or a few minutes at most, but especially in the memory, these are decisive moments that influence all the permanence in that space.
The question that can be asked, and to which neurosciences cannot answer but can certainly contribute to elaborate, is whether it is possible, and how, to "preserve" the architectural atmospheres of heritage. Since it is the unity of details that generates the atmosphere, "take one away, everything changes" [16]. Or, vice versa, as despite their physical and material conservation they evolve with time and society. In fact, it is probably impossible preserving and handing down atmospheres, even if Canepa wonders whether they are irreversible intrinsic qualities of architecture, or vice versa they are "volatile" and can be irremediably lost [2].
Each historical period is unique and characterized by complex elements, including its atmospheres [17] that reflect the values of the society that created them, values that find in the communicative power of architecture a means of resonance. But that's not all: the way they are perceived also changes over time. determinism.

Fig. 1: "Hylozoic Ground" by Philip Beesley for the Canadian pavilion at the 12th International Architecture Biennale of Venice, 2010

3. Museography and neuroscience.

More than a hundred years have passed since Dalcroze's first experiments introducing eurythmy into music teaching, but only recently are we beginning to appreciate the role that body movements, postures, homeostasis and emotional responses play in all the processes of our thinking. We now know that we are very dynamic, responding biologically to the stimuli of the environment with an intense and continuous electrical and chemical activity: and this is important for the arts, and for design disciplines in particular. The typical distinction body-mind is therefore no longer valid, the body and emotions give shape to our way of thinking and acting, from which they are inseparable, and therefore also in our architecture and cities. Therefore, organism and environment are complementary and interconnected [2].

In particular, as explained above, aesthetic experiences emerge from interactions between different neural systems involving sensory-motor circuits, evaluation of emotions and knowledge of meaning: these sensory areas classify visual elements and evaluate them, albeit with mechanisms that are still under investigation.

However, architecture does not only involve issues of an aesthetic and emotional nature, but also affects experience in the broadest sense. It was precisely the notion of neuroplasticity of the brain that made Fred Gage, a neuroscientist at the Salk Institute interested in the effects on the brain caused by environmental changes, say that environmental changes modify the brain and therefore modify our behavior. This was already clear to Klaus Maria Koenig [18], who stated that architecture is composed of “signs” promoting behaviour. Very interesting reflections can therefore be generated by the overlap between semiotic considerations and the most recent discoveries of neuroscience.

More specifically, this overlap could bear very interesting fruit in the discipline of museography, which aims to reconcile the conservation and study of heritage with its exhibition, enhancement and communication. The interest of a contamination with neuroscience can certainly be aimed, in the first instance, at verifying how affordable a single exhibition tool is. But probably, also following what has been said so far, the matter is much broader. In the case of an exhibition environment, there is a double track of stimuli: those sent by the architectural environment and the museum setting, therefore the atmosphere they create, and those generated by the artworks and objects on display in the museum. This complex mechanism is further complicated by the fact that each visitor has different expectations, different background, different sensibilities - in short, a different brain.

Here neuroscience can again support us precisely in relation to the observations about the atmosphere and emotions mentioned above. The preservation and above all the dissemination of heritage must therefore be adapted to the nature of an "aesthetic" experience that is actually all-encompassing, i.e. dynamic and global, immersive, that goes beyond visual input alone.

It is almost obvious that the architectural environment and the way it is set up can strongly influence the visitor's interpretation of the works and objects he sees. Much less clear, although there are guidelines and studies on the subject, how the designer can really communicate with the space, direct behaviour, generate "coherent" emotions with the very nature of the heritage.

For a long time museography had had intuitions - theoretical and practical - about emotional and behavioural reactions to spaces that seemed to occur in the majority of visitors, as well as the need to interact with other disciplines, including psychology. Neuroscience confirmed the common basis of biological responses to spaces, forms and atmospheres.

Reference to the German architect Manfred Lehmbruck is a must [19]: he stated that museography is that field of interior architecture where the architect must necessarily have psychological knowledge, and where he can try to manage and direct not only conscious but also unconscious reactions of visitors. His reflections refer to the factors that attract and guide the movement of a visitor in a room (the micro-path): e.g. the role of the eye as a pre-programmer of movements, motor reactions to environmental stimuli, or the instinctive positioning of the body to accommodate the entire artwork in its visual field.

The museographic project, intended as a set of spatial, material and lighting devices, is able to communicate (without speaking), and in particular to suggest paths, relationships between the pieces, hierarchies, as well as to suggest contents and interpretations and also evoke contexts. It must master the environment in its totality, foreseeing the so-called immersive effect, and the consequent behaviour of the visitor. We know that colours generate emotional reactions that are also reflected in physical parameters that influence emotional states (we know that red accelerates heartbeats, blue slows them down; the first transmits energy and movement, the second relaxation and rest; the first communicates warmth, the second a sense of cold). These notions are taken into account to evoke contexts and emotions.

One example seems particularly appropriate in this regard. The great designer Carlo Scarpa, a sensitive connoisseur of art and master of interior architecture, has put into practice the use of the mechanism of "mirror neurons" (even though they hadn't been discovered yet...) in one of his museum installations. In the museum of Palazzo Abatellis, in Palermo, Scarpa had to insert the valuable marble bust of Eleonora of Aragon. He wanted the visitor to appreciate not only the frontal view of her face, but also her profile.



Fig. 2 and fig. 3 (left): the first sight, in profile, of the marble bust of Eleanor of Aragon by Francesco Laurana, Palazzo Abatellis, Palermo
Fig. 4 (right): the second sight, from the front, of Eleanor of Aragon

He therefore put in place a system that, with little need for words, let alone obligatory routes, actually induced the vast majority of visitors to make precisely the movements that he had foreseen. At a certain point in the museum's path the view opens up, through a door, on the bust, which is framed in profile, standing out against a green background that makes one appreciate its features (fig. 2, fig. 3).
The Eleanor bust seems to point in the direction the visitor should follow: he should not yet enter, but go straight ahead. Actually, the mirror neurons invite the visitor to follow the gaze and the direction indicated by Eleanor: imitating her unconsciously, the visitor goes straight on. He will then enter the next room, and while he's observing the objects on display, his memory involuntarily pushes him to look in the direction they know Eleanor is observing him. And in fact she is framed centrally in another passage, and her frontal position, again emerging on a green background, this time seems to invite the visitor to come closer (fig. 4): and he accepts "invitation", he "imitates" her by guiding his steps towards her.
On the other hand, let us think of an intervention on an archaeological area: its covering, made necessary for reasons of material and formal conservation, in fact creates a space with a precise atmosphere that is certainly not the original one (which, moreover, had already been irreparably destroyed by the maimings of time).
A very significant example is the Kolumba Museum designed, not surprisingly, by Peter Zumthor. Inside, in the area where the Roman and Gothic remains are located, the double height space is illuminated by the natural light coming from the brick gray perforations (fig.5, fig.6). The atmosphere, very suggestive, induces an aesthetic experience that can resonate with the great Gothic sacred spaces, less with the archetype of Roman architecture. Precisely the theme of the archetype, referring to the atmosphere, could be another field of investigation on which to test this interdisciplinary contamination.
Conversely, the choice of the Archaeological Museum of Pointe-à-Callière in Montéal is to generate an atmosphere evoking color and movement, in other words evoking not so much the aesthetic experience as the multiform life that animated those places, now in a state of ruins (fig. 7, fig.8). Certainly, when faced with objects that belong to very similar aesthetic categories, the atmosphere is able to generate very different emotional, motor and cognitive responses.
Even inside a museum, the verifications and experiments in collaboration with neurosciences could lead to significant observations. How much does an exhibition space encourage stopping or movement, as well as contemplation and understanding?
It is worth remembering that atmospheres depend both from the objects or environments and from the subjects who live in them. In fact, one cannot think of an eternally preserved object equal to itself to face a relationship with a subject eternally in motion. It is the relationship between the two that constitutes the atmosphere and consequently the experience.


Fig. 5 and fig. 6: interior of Kolumba Museum, by Peter Zumthor


Fig. 7 and fig. 8 : interior of archaeological museum of Pointe-à-Callière, Montréal

Probably these reflections, far from appearing tautological, could develop very interesting reflections and experiments. After all, the perception of the atmosphere is the first, decisive link with which the heritage presents itself and therefore the first link in the mutual communication between the two.

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