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A COMMON GROUND BETWEEN NEUROSCIENCES AND ARCHITECTURAL DESIGN: EMPATHY, EMBODIMENT, EMOTION

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ABSTRACT

In the last decade, the increasing popularity of neuroscience has involved architecture. Both neuroscientists and architects have endeavoured to understand how the experience of architecture works from the standpoint of cognitive functioning. This has been possible thanks to the neuroimaging techniques such as fMRI and discoveries like mirror neurons. These researches, despite their outstanding quality, are difficult to implement for what concerns the practice of architectural design. However, there is a common ground where architectural theory, phenomenology and neuroscience intersect, represented by empathy, embodiment, and emotion. They are the frame of the awareness of space and the counterpart of the visual perception. The main goal of design is to make the living space but to take a meaning, it has to be the "negative" of the human body. This process comes into existence through "old" tools, i.e. the mentioned empathy, embodiment, and emotion. Still, they can get a new meaning if their traditional hermeneutic is blended with the latest knowledge provided by neurosciences.

Key words: Neuroscience, Empathy, Embodiment, Emotion, Space, Phenomenology.

1. INTRODUCTION

The architectural design combines different intellectual processes based on experience, on knowledge of the history, on technique and on the capacity to be in tune with places and the client. Theoretical studies that have tried to explain the design process are very many and it is relatively easy to explain in rational terms why a certain design choice is made. Some explanations are simple, like those that justify a solution based on compliance with a regulation. Others require more sophisticated tools based on the analysis of spatial models and linguistic codes, analysed and later recreated in the design. Or one can proceed according to the logos, entrusting the epistemological search for the reasons behind a design to language tools. It is still complex, however, to understand the nature of "poetic" choices, the ones that seem to elude the processes of cause and effect. Clearly, all successful architects manage to talk even enthusiastically about what they have built. But what are the real mechanisms that have led to one solution rather than another? Some explanations can be looked for in a possible common ground between architectural design and neurosciences. The latter in recent years, have had certain success even in popular scientific literature, and architecture appears as one of the disciplines they are composed of. Neuroimaging, namely the visualisation of brain activity during superior cognitive processes has made it possible to understand how the brain works during the perception of space and, perhaps, in the future, it will be possible to do so even during the architectural design process. The studies are many and are complex, but we can cite some references that represent the state of the art.

2. DISCUSSION

The discussion about the relationship between neuroscience and architecture is centered around three main subjects: the experience of architectural design performed by practitioners architects, the studies of architects who devoted themself to investigating how architecture interacts with neuroscience and the research carried on by neuroscientists who decided to enter the world of architecture.

Among the innovations conveyed by Modernism there were a change of paradigm as the architects turned their attention from the volumetric to the space. Being aware of the consequences of architectural design on the environment meant managing the atmosphere created by the buildings. Theo Van Doesburg wrote that the man does not live in a building but in the „atmosphere" created by surfaces (Van Doesburg, 1979).

In architectural design theory a trend named „phenomenological" has been pointed out by Paola Gregory (Gregory, 2010, 81-117). It includes architects as Frank Lloyd Wright, Alvar Alto, Richard Neutra and later on Peter Zumthor, Tadao Ando, Alvaro Siza, Giorgio Grassi; although they differ for the historical period, geographical context and cultural experience they conceive the architectural space in terms of bodily experience. The name trend's name is due to the analogy between the meaning of the works built by those architects and and the approach to the reality of phenomenology. The common ground is represented by the effort to grasp the true nature of architecture through the bodily experience and the perception. Kenneth Frampton who is usually considered close to phenomenlogy (Shirazi Reza, M., 2013) spoke of „corporeal metaphor", meaning „the body reconstitutes the world through its tactile appropriation of reality" (Frampton, 1995, 10).

Juhani Pallasmaa wrote mountains of paper about experience and architecture, spanning from the relevance of imaging in architectural design to the state of a close relationship between the drawing hand and the design concept. Consequently, the project is an outcome both of the mind and of the hand that draw it. Pallasmaa playing on the double meaning of „to draw" (representing objects and pulling out) explains that while drawing, mental images and intimate sensations are extracted (Pallasmaa, J. (2009). *The thinking Hand: Existential and Embodied Wisdom in Architecture*, Chichester, Wiley). Whoever have designed something can share this opinion as it's pretty tricky to think of a shape without sketches, mock models and alternating drawings by hand and digital.

The awareness of the designed space is grounded both on the embodied simulation and the empathy that, in turn, represents the common ground between architectural design neurosciences.

In fact these last provide tools to understand why the embodied simulation occurs and how it works in the architectural design process.

Michael Arbib, theoretical neuroscientist and computer scientist who investigate the relationships between language and brain (Arbib, 2012), has given a seminal contribute in endeavouring the connections among neuroscience and architecture. His most recent book *When Brains Meet Buildings* examines how neuroscience can influence design through action-oriented perception, memory and imagination (Arbib, 2021). In previous studies he has traced fundamental lines separating the different fields of research, by speaking of “neurosciences of the Experience of Architecture”, of “neuromorphic architecture” and of “the neuroscience of design progress” (Arbib, 2015, 75-98). Moreover, referring to Peter Zumthor, he has highlighted the strength of Architectural expression in influencing human mood and that architecture needs to be understood as a whole. Neurosciences knowledge helps in understanding how that whole works.

No research about Neuroscience and Architecture would have been possible without the highly inffluential work of Harry Francis Mallgrave. Starting from a PhD dissertation about Gottfried Semper dated to 1983 he devoted prominent part of his research work to investigating connections and mutual interactions among Empathy, Form and Space. What is relevant is the comparative work that includes aestethic, neuroscience and architecture. His books *Architecture and Embodiment* (2013), quoted several times in this paper and *The Architect’s Brain: Neuroscience, Creativity and Architecture* are his outstanding publications: the last surfes the architextural thoughts considering the relationship between neuroscience and architecture (Mallgrave, 2009).

3. MATERIALS AND METHODS

In the most general sense, we can separate the research developed following a method close to the scientific root of neuroscientists namely medicine, biology and psychiatry from the one carried on with an approach similar to the one of architectural theory. Among the first there are the work of Vittorio Gallese and Giacomo Rizzolatti who discovered the mirror neurons or Jaak Pankseep and Antonio Damasio. The second area of interest was explored by professional architects as Juhanii Pallasmaa or architects who devoted a large part of their activity to neuroscience as John Paul Eberhard and the above mentioned Henry Francis Mallgrave.

The present paper has been informed by an inductive research method aimed to focus what drives the decision making in architectural design taking into account the aspects that seem to run away from a rational explanation concerning the relationship between the perception and the awareness of the sense of design. The key to understanding these relationships lies in the interaction between the body and the environment, meaning phenomenology and gestalt have addressed the research line.

The progress in architectural design goes on through the research by design and /or the content analysis. The first involves extracting data from professional experience turning them into theoretical statements. The more common working method is the thematic analysis of books and papers. The vast amount of the information collected in this way needs to be sifted through to get the correct goal. In pure sciences, the new usually overcome the old, while in architectural theory, the prior knowledge keeps an active role. This is the core of the typological thought for which in whatever issue we have a permanent part and a variable one. The type is a product of the human mind, and it is an epistemological tool that lets us circumscribe specific ideas. The common ground where such ideas have been found out is represented by Phenomenology and Gestaltpsycologie. Both in Italy and Spain they have affected the architectural theory in the revision of modernism that occurred since WW2 and they share with neurosciences some issues as empathy, corporeality, the experience of space and the interest for emotions and memory. It is also necessary to remark another difference with pure sciences: researchers do experiments before writing a paper that is the translation in words of what has been tested or discovered. In architectural theory, the text is a sort of “live matter” which interact empathetically with the author: so, this paper is not just a report of what has been searched but an essay aimed to spark new ideas.

4. EXPERIENCE AND BRAIN

To introduce the core topic that is to say empathy, embodiment, emotion, we need to recall Arbib's fundamental research lines. The "neurosciences of the Experience of Architecture" (Arbib, 2015, 75). regards the functioning of the brain in the moment in which the architectural space is experienced. The various parts of the brain work together through connection networks that start from a "simple" level, the synapses between neurons, to arrive at complex combinations called "schemas" (Arbib, 2015, 78). Of these, the hippocampus plays a fundamental role in the control of spatial movement and in orientation.

Arbib cites the studies of John O'Keefe on the hippocampus of rats in 1971 and those of Maguire on people, conducted in 1997 (Arbib, 2015, 83). The latter have shown that the right-hand side of the hippocampus can create a topographical memory, working together with other areas of the brain. Similar research conducted by Russel Epstein using PET and fMRI (functional magnetic resonance imaging) has identified two areas involved in the conscious perception of space: the first, called parahippocampal place area (PPA), is capable of "codifying the geometry of the surrounding environment" (Arbib, 2015, 84); the second, known as the "retrosplenial cortex (RSC)" and complementary to the PPA, enable us to navigate through a space and head for objects even if they are not visible (Epstein, 2008).

Studies of the hippocampus have generally improved knowledge about the way in which this part of the cerebral cortex constructs mental maps of environments. Different types of cells have been discovered - head direction cells, grid cells, boundary cells, conjunctive cells - each one providing different information processed by a coding process capable of assessing complex variables like the speed and change in position of obstacles. The data gathered from studies of mice have been useful for studying the hippocampus of humans and for understanding what parts contribute to the recognition of and learning about a spatial configuration. Some hippocampal areas are activated both when experienced environments are remembered as well as when another person's viewpoint is assumed (Hartley, Lever, Burgess, Keefe, 2014). These mental operations occur when a building is studied through the analysis of its layout. Awareness, which forms the basis of critical thinking, of the morphological qualities of the space requires both recalling the experience of places already seen as well as putting oneself into the mind of the designer.

The field of „neuromorphic architecture" supposes, however, that buildings can have a brain or a nervous system actively interacting with people and redesign itself according to changes in human emotions. Arbib talks about a building that is no longer static but with "intelligent" technological devices capable of responding in real time to a stimulus from people, especially with regard to furnishings or technological devices for controlling the lighting, sound and climate of interiors (Arbib, 2015, 84). This subject has been considered a real innovation in architectural design and hailed as the new frontier of design (Rinaudo, 2019).

For example, one can cite the architectural firm Lombardini22 in Milan which has been conducting, since 2017, under the direction of Davide Ruzzon, research into the relations between neurosciences and architecture. One first result was the "Tuned" design tool for defining guidelines for the preliminary design phases, and with the goal of creating a building capable of reacting to people's needs by interacting with their emotions. In 2019, NuArch research was launched in collaboration with the CNR (Central Research Institute) Institute of Neurosciences in Parma, exploring the relationships between the form of space and "cerebral, physical and emotional representations"(Pizzolante, 2021). The data from the perception of space are mapped and used to design constructions, capable of interacting with the neurological process at the basis of the users' state of psycho-physical wellbeing. A similar approach has been used by the company Sensoimmersive in the creation of the Plaza Sensory Pool in the Plaza hotel in Abano Terme (Italy), designed by Mick Odelli and Umberto Carraro, which uses a systems of lights to arouse emotional reactions in its users.

These orientations exploit a typical logic of the interaction between man and machine, namely feedback. It is a signal or information that represents the state of a machine or of an environment and allows to act in order to change that very state. One example is that software, like pedometers,

that measures exercise and stimulates its user to do more exercise to improve their physical shape (Gallina, 2019, 156). In the case of tuned or Abano Terme the opposite occurs: the feedback comes from the person and it is the machine to react and control the state of humans. Although the real impact of this type of technological development is yet to be evaluated, it is more than valid in the case of people with temporary or permanent disabilities who can achieve considerable improvement of quality of life from these technologies.

5. EMPATHY, CORPOREALITY, EXPERIENCE OF SPACE

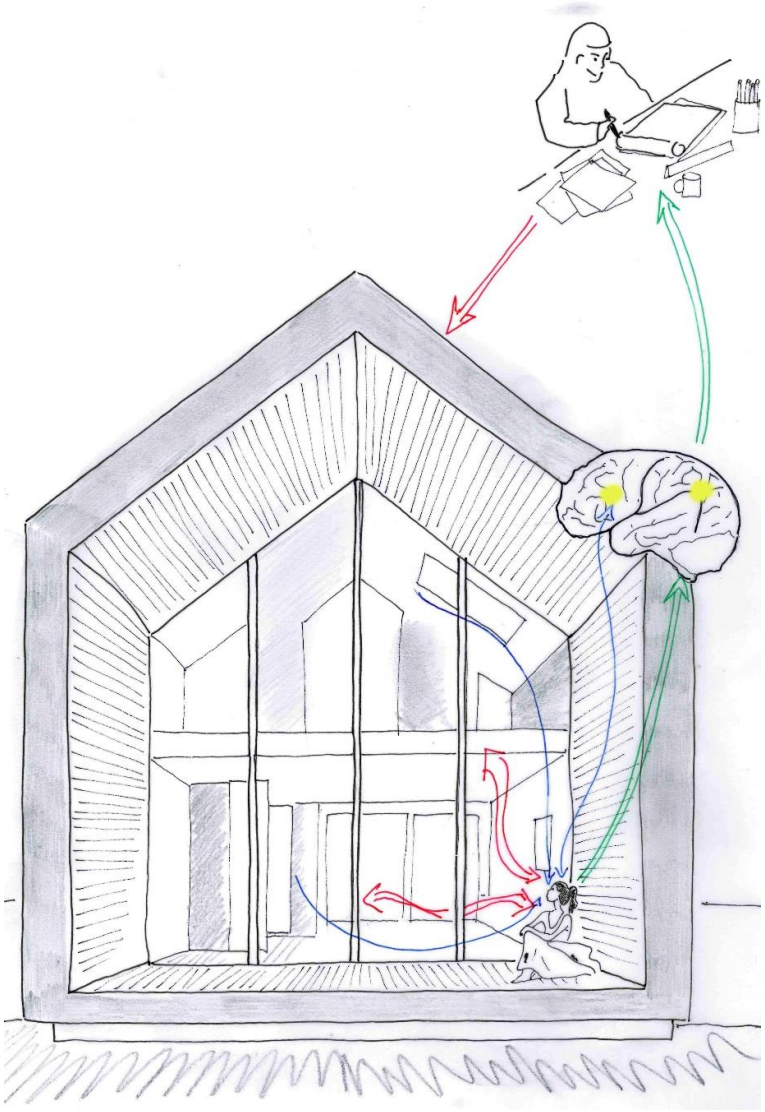
The neuroscience of design progress explores the design process. Arbeit expresses reasonable doubts about the efficacy of real interactions between neurosciences and architecture. Knowing which neural circuits an architect activates during the design process does not have much theoretical not practical interest (Arbeit, 86). It could, however, be more important to understand what abilities an architect uses to make a design important and meaningful. But even here, Arbeit does not fully clarify, at least from the viewpoint of design techniques, the real contribution of neuroscience. So Vittorio Gallese and Alessandro Gattara come to our aid, having identified three fields in which neuroscience interacts with architecture, namely: the relationships between empathy and perception, the relationships between the real world and the imaginary one, the subject of embodied simulation and its links with aesthetics (Gallese, Gattara, 2015, 163-164).

Empathy, whose etymology comes from the Greek *en* (within) + *pathos* (emotion) corresponds to the German term *Einfuhlung* (identification) and, in general, regards the understanding of a reality empathy. In simple terms, empathy enables a work of architecture to be recognised, through the "as if" structure: the viewer who looks at it perceives the architecture "as if "he himself were its designer. This phenomenon gives objects "a soul" but it is not a filling up with intellectual and emotional content by the subject. Instead, a correspondence is activated based on a liking between the human body and the architectural body, even if the latter bears no resemblance to the former.

On the one hand, this correspondence, as understood by August Schmarsow, is physical and perceptive in nature since the human body moves and lives according to a rhythm of stasis and movement similar to the heartbeat (Schamrsow, 1915), the interior space of a building establishing a form of exchange and communication with it (De Fusco, 1967). It is, on the other hand, intellectual since it is based on the ability to reflect the self in the object built on the basis of the "as if" theory: "it gives soul to inanimate things, forgetting it has done so" (Pinotti, 2011).

Empathy is scientifically explained by Giacomo Rizzolatti's discovery of mirror neurons in the beginning of the 1990s at the Institute of Physiology of the University of Parma, which make embodied simulation possible, so that "we internally simulate aspects of a building in a multisensory and emotional way" (Mallgrave, 2013 14). Mirror neurons are placed within the evolution of psychoanalysis and of a considerable review with the shift away from Freudian theories to relational psychoanalysis, with a new way of thinking about inter-object relationships as "intrapsychic representations" (Gallese, 2006, 547).

Mirror neurons and embodied simulation allow for the simulation of an intention, that is, what we could do with objects. These are activated following a perceptive and sensory act: in the case of architecture, when we experience the space of a building or of a place. Embodied simulation thus offers us the condition of corporeality and of architecture in different terms. Remember that the relationship between the body and architecture is one of the most long-lasting and consolidated foundations of design theory, rooted in the theories of Plato and Pythagoras and in their rediscovery in the Renaissance. Francesco di Giorgio Martini found proportional correspondences between the human body and architecture, while Leon Battista Alberti in his De Re Aedificatoria, established that architecture is a body (Choay, 1986, 148*)*. This identity was the foundation of beauty (*concinnitas)* the bearer, in turn, of pleasure (*voluptas*).



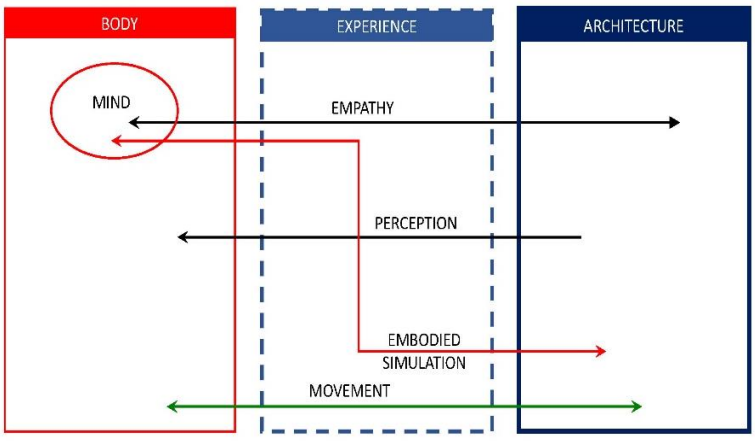


Fig. 1. The process of embodiment. The girl perceive the architecture both visually (red arrows) and bodily (blu arrows). Her mirror neurons (yellow point) activate and they make her feel as she were the Architect, who in turn communicate through the house. Source: author’s draw.

Frampton's corporeal metaphor is a mechanism through which human beings become aware of the environment (Frampton, 1995, 10). It is not a deterministic but a metaphorical process by which the languages, beliefs, histories and physical characteristics of a place settle and form a knowledge that influences the design. Architecture and space are "frozen" design actions in which the designer reflects himself thanks to embodied simulation. Empathy activates a intersubjective dimension that puts us in relation to the psychic life of the work, constituted precisely by the design actions and by that "sense of life" condensed in the construction and in the way of living it (Pallasmaa 2015, 4).

The subject of the corporeal comprehension of space cuts across different ideas of modern and contemporary architecture: the modern movement rethinks living spaces according to the dimensions of the interior space, of the furnishing elements. His detractors are often called to a return to the human scale of urban space even if the masters of Italian modernity like Ernesto Nathan Rogers have based their theoretical thinking right on the consistency between human and architectural dimensions. A strong thematic core regards Gestalt psychologies and their ramifications in typological thinking. Gestalt, as known, is a basis technique for ordering (and understanding) formal elements in space according to recurring principles such as proximity, similarity, enclosure, continuity, focal point, figure-ground and common ground (Kohler,1961). In many architectural designs, there are recurring rules in the organisation of space, such as juxtaposition, combination, superimposition, inversion and joining. They are the foundation of the typological structure (Martí Arís 2021) insofar as they are the same as the form corresponding to consolidated practices in the use of space. In a home (be it a detached house or a flat in a block), the space on the plan can be classified as directional, central or a hybrid of the two. If we consider instead its three-dimensionality, we can have the subdivision into separate levels or the cross-contamination of those so as to have a raumplan. Understanding of the sense of the qualities of these spaces and as a result their correct use by the designer is based on an interrelation between perception and thought, where the former provides "the material" (namely the experience of the space) necessary for the functioning of the latter.

Fig. 2. Residential unit Moduli 225, Helsinki. This project for a summer home designed by Kristian Gullichsen and Juhani Pallasmaa in 1971 was considered an effort to enhance the corporeal relationship between people and nature. Source: Eba, 2013

Design, corporeality and experience of architecture "travel" through the body in the exact way in which it was explained by neurosciences when speaking of radical embodiment, because "the nervous system, the body, and the environment are interwoven and highly dynamic, structured, integrated with respect to one another at various levels both internally and externally" (Mallgrave, 2013, 64).

6. EMOTIONS AND MEMORY

The driving force of empathy is represented by emotion (the word empathy concerns pathos, as we have seen) a system of powerful forces, preconscious capable of orienting our volition. In the past, it was believed that emotions were a sort of animal instinct triggered by sensory stimuli, subordinate to the more reliable reason. According to Jaak Panksepp researches (Panskepp, 1988) they are part of an inner process and outcome of a long neurological evolution based on the primordial and instinctive behaviours linked, in turn, to chemical factors of the nervous system. Emotion is therefore when an initial reaction to a perceptual stimulus that activates neuron circuits to which certain behaviour corresponds. Some are indispensable to the design: one of these, identified by Jaak Panksepp, is research. Without that, no design exists. It requires the combination of an enormous quantity of different elements. Research is a stimulus for testing out design solutions which, by accumulation, lead to an acceptable structure for the designer. At the basis is what is known as a "dopaminergic or hedonic reward" process according to which the achievement of an aesthetic goal provokes pleasure, generating stimuli capable of keeping the work going (Panskepp, 1988, 144).

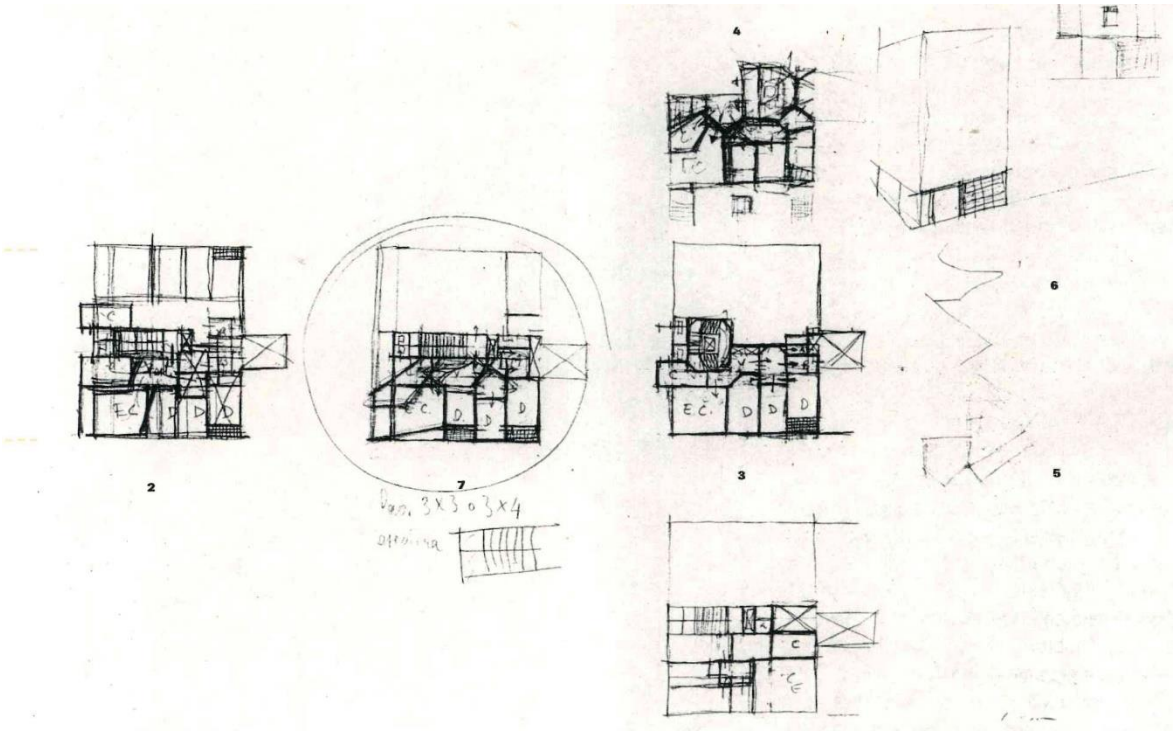


Fig. 3. Sequence of Coderch's sketches where he is shifting the floor plan from an orthogonal pattern to one with inclined geometries. Source: Coderch, Fochs (1996).

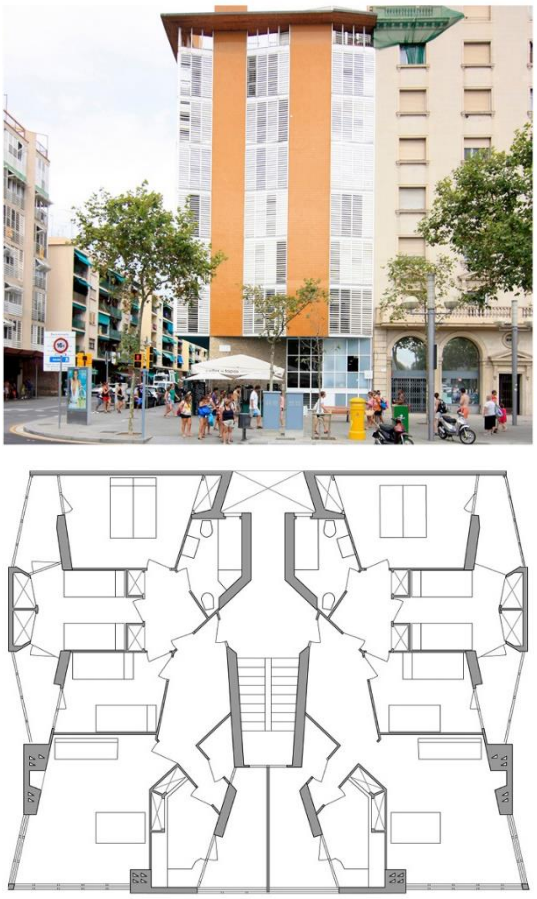


Fig. 4. José Antoni Coderch: Fishermen's house or casa de la Barceloneta, Barcelona 1952. Source: phot and floor plan redraw by the author

A practical example helps to understand better. Let's consider the famous Fishermen's house by Antoni Coderch de Sentmenat in Barcelona, built in 1952 and regarded as an icon of modern post-war architecture. Coderch initially developed a design based on the H-shaped plan widespread in Barcelona[1]. The supporting walls are, as usual, perpendicular to the perimeter of the parcel but, over the course of the design, he distorted the plan by introducing diagonal attitudes that involve both the central nucleus of the building as well as the enclosure (Armesto, 1996, 31-54). It is likely that Coderch was not satisfied with the normal orthogonal wall design scheme, so, working on his sketches, he progressively reached the final solution. And it is unlikely he made this decision for practical reasons alone. However, it is possible that he intuitively went with the "organic" form already tried out in previous designs, like the Ugalde house designed with a mix of curvilinear and polygonal forms so as to harmonise the design with the landscape. This too is a form of empathy developed from the personal sensibility of the architect, given that no predefined rules exist to achieve effective integration between architecture and landscape. Coderch, thanks to inclined geometries, achieves good fluidity in the inner circulation of the apartments for which the relationships between the spaces are more dynamic compared to homes with perpendicular walls. Furthermore, the living spaces are not compartmentalised into rooms but are linked by an organic flow: the relationships between them go from "closed and rigid" to "open and fluid" (Cornoldi, 1988, 56). Whoever visits the Casa Marina today is emotionally engaged: empathy allows us to enter into the spirit of

[1] H-shaped floor plan takes on this name since it is shaped in a similar way to a H steel profile, where the web is the stair volume and the flanges the dwellings. This kind of plan has a central symmetry with a relevant thickness spanning from 15 to 27 metres. The H-shaped plan is recognisable in buildings of different scale and urban meaning ranging from stand-alone buildings to perimeter block ones located in the Barcelona Ensanche or the outermost neighbourhoods.

Coderch, appreciating more intensely the façade punctuated into slightly rotated vertical planes where the perforations are interruptions in the wall screened by the slat façade with Llambì louvres.

Fig. 5. OAB architecture, Casa Vertex, Barcelona 2007: photo and floor plan redraw by the author

The awareness and consciousness of what is being observed is activated by the memory which, in some senses, can be considered a design tool. The satisfaction created by the dopaminergic circuit of pleasure is greater if the visitor has already studied the buildings by Coderch. The Fishermen's house is difficult to visit inside as it is private, but the knowledge of the plans and the old photos of its interiors triggers the imagination thanks to which the interior space can be experienced without ever being there. This is already a design act in itself. Perceiving a building and imagining designing it activates the same neural resources (Robinson, Gallese 2018, 80). If we were to instead design a new building and decide to take Coderch's house as a reference, the imagination would be complementary to the comparison between what we are thinking and Coderch's example. The comparison works by finding the similar in the different. A similar process probably marked the design of the Vertix house by OAB (Office of Architecture in Barcelona, headed by Carlos, Borja, Lucia Ferrater and Xavier Martì Galì) in Barcelona (2009). There are clear analogies with Coderch's house since the geometries, in the plan, of the facade and the screening elements are morphologically similar, their being based, respectively, on a broken line and on the presence of louvres.

This type of comparison is based on the memory which besides being an obvious basis for any knowledge, it is also the main source of the imagination in designing architecture. The explanation of the role of the memory in design can be found in the studies of John Paul Eberhard, (Eberhard, 2009). He identified an important relationship between memory (short-term) and the experience of perception. Things observed (and listened to, heard, smelled) are not always memorised by the brain in the same way, but categorised based on a comparison with past events. This process takes the name "re-entry" (Eberhard, 2009, 33) and is based on neuroplasticity and the synaptic connections between neurons, thus establishing an awareness of the experience. Edelman and Tononi believe that the interaction between certain neural activity patterns, due to the synergy between body and mind, play a fundamental role. Memory is plastic, not limited to storing but processing and is, thus, one of the key elements in the ability to imagine; without imagination, there is no design.

Of the tools through which the imagination becomes perspicuous, metaphor has considerable importance. The role of metaphor in architecture and its relationships with the world of language have been explored elsewhere (Lucchini, 2009). As regards neurosciences, metaphor allows things to be other than what they really are, based on references that link together space and material/matter, intellect and body. When I spoke about fluid space, I used a metaphor activating neurological feedback in the reader, which associates the image of fluidity with an experience of movement without obstacles. The metaphor seems to be a reflection of a neuronal ability to link areas of the brain designated to carry out different tasks. This ability is called by neurologists "synaesthesia" (Mallgrave, 2013, 57) and is the basis of creative activity. If we read *Towards a New Architecture* by Le Corbusier we can find an impressive quantity of linguistic metaphors, but this is no surprise, considering that Le Corbusier made extensive use of the metaphor during his career as an architect.

7. CONCLUSIONS

Neurosciences provide a rational explanation to the creative processes common to art, architecture, like other fields of knowledge. It is not an essential discipline for architectural design and it is not said that its application, through sophisticated technologies, can actually lead to an improvement in the configuration of living spaces. It is not even said that it is wholly ethical to "scan" the mind with fMRI techniques to understand what users like. A good architect achieves the same goals with experience. It can instead be a useful tool for learning and theoretical purposes. Explaining the reasons behind design choices also from a neurological viewpoint helps to better understand their grounds, activates more neuronal connections and improves the ability to understand things. Empathy and emotions are not however the only tools for enriching the expressive power of architecture. We need to bear in mind reason too. The relationships between empathy and reason are far from simple and in many ways contentious. Some believe that empathic circuits are alternative to rational ones but that they can work together in some situations (Jack et al. 2013) Other

believe instead that reason and empathy are always active but that one balances the other, so as to achieve relative objectivity (Slote, 2010).

In architectural design, thought moves both in an analogical as well as in a logical dimension. The former is structured on a network of correspondences that link examples and solutions already tried out over the years with the new ones. This is the ground where empathy finds more space, and modifies, thanks to emotional tensions, the connections between real facts and ideas and images. To achieve a consistent whole, it is necessary to proceed also on an analytical level that tends to take apart and put together the parts according to syntactic principles that establish hierarchies and constraints. What is suggested is that architecture and neuroscience belong to different fields of knowledge in spite of the trend which is attaching the prefix „neuro" to whatever discipline. Anyway, is possible to focus on the relationship between them for what concerns the role of the mind in the architectural design process. Architecture and neuroscience are like two field of energy: they may interact being complementary, but they can't be superimposed

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