The Qualities Affecting Human Perception of the Architectural Environment

Aubrey Truebenbach

Commonwealth Governor's School

Culminating 11

Ms. Asselanis

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Introduction

Popular architectural philosophy has, for at least the past century and a half, been dominated in nearly all respects by the oft repeated phrase ‘form follows function’. The truistic nature of this saying has led to its extreme dominance in the world of contemporary architecture, as it is indeed no simple task to argue that the form of a structure ought to be conformed to anything but its function. New architectural design has thus, for the most part, been consigned to the world either of strict practicality or arbitrary design choice. Recently however, researchers involved in fields ranging from design to neuroscience have begun to question the impact of this form of architectural thought. Especially with the present crisis of mental illness, a crisis which is significantly more pronounced in urban areas, the idea that buildings themselves may have an impact on the mental health of their occupants is being seriously considered. It is not so much the validity of form following function which is under consideration, but rather if and how the function of a building extends further than, as architect Le Corbusier famously stated, “a machine for living in”. In light of recent findings, a great deal of human history, biology, and neurology have been examined in order to determine the factors in both interior and exterior architectural design (henceforth referred to as the built environment), which impact the way a building is perceived and processed, and from this to determine how said features affect individuals. Overarchingly, the focus in this up and coming field of study, (which will be further referred to as cognitive architecture) is to determine the way in which the built environment can be most effectively designed in order to maximize its positive impact, both mentally and, as some studies suggest, physically. Although the goal is identical, the various architectural elements which have been identified as having possible physiological benefits are numerous, though much of the research is focused on the themes of biophilic design, specifically designs involving fractal patterns, general architectural principles such as coherence and complexity, as well as a final more simultaneously broad and central question of the role of beauty or vitality in design. This work aims to synthesize the current research on cognitive architecture in order to provide for a nuanced and comprehensive view of the topic and how it can be applied in the broader world.

The Incorporation of Biophilic Design

Across centuries and nations it has been noticed that human beings have a natural inclination towards nature, and likewise that their architectural design tends towards including elements which mimic the natural world (Ruggles, 2017, p. 24). Such elements may be external to the physical structure of the building, such as a potted plant or fish tank, or they may be internal, for example, columns made to resemble trees or a window built in the likeness of a flower (Ruggles, 2017, p. 24 ; Evans & McCoy, 1998, p. 92). Biophilic design in architecture refers to architectural design which seeks to purposefully integrate these elements of the natural world into the built environment, often in an attempt to improve the experience of a space (Joye, 2007, p. 318). It has been suggested that this biophilic design has a strongly positive impact on the wellbeing of occupants when applied on both the external and structural levels.

Research suggests that non-structural elements of the built environment, such as the above-mentioned plant or fish tank, have a notable positive impact on the mental wellbeing of those exposed to them, specifically in the area of fascination (Evans & McCoy, 1998, p. 91, 92). Included in this category of non-structural elements is windows as the examined impact comes not from the window but rather the view it provides (Evans & McCoy, 1998, p. 92). It has been observed that extended periods of focused or voluntary attention tend to induce mental fatigue, and that a period of unfocused attention is beneficial in the “restoration” of the mind from this fatigued state (Evans & McCoy, 1998, p. 91, 92). This unfocused attention, otherwise known as “soft fascination” refers to periods in which the mind is drawn unintentionally to a particular object or area (Ellard, 2020, p. 91, 92). Soft fascination is distinguished from other types of fatigue inducing focus in that it is an unconscious response, it is a natural activity of the mind which does not tire, but rather restores and refreshes it (Ellard, 2020, p. 91, 92). Biological elements, which have already been noted for their positive psychological impacts, are effective ways by which this ‘soft fascination’ may be induced (Ellard, 2020 p.12 ;Evans & McCoy 1998, p. 91, 92). They draw the notice of a viewer without the strenuous mental demands of prolonged focused attention. A view of nature as provided by windows has likewise been demonstrated, in a 2004 study, to decrease diastolic blood pressure in patients when compared to those in a windowless room (Hagerhall et al., 2004, as cited in Joye, 2007, p. 318). Views of nature have also been shown to increase both mood as well as provide for increases in “holistic and innovative thinking styles” (Leong, Fischer, & McClure, 2014, as cited in Abboushi et al., 2019 p. 58). Such evidence has served to further solidify a scholarly belief in the restorative effect of nature, and likewise the importance of incorporating natural elements into the built environment.

Biophilic design is not limited to elements exterior from a building's structure, and has been found to have positive mental benefits when applied even to the foundational elements of a design. As was mentioned previously, the human mind demonstrates a strong aesthetic preference for natural scenes, specifically scenes which involve lush vegetation or savannas (Ulrich, 1993 as cited in Joye, 2007, p. 318). Subjects also display a decrease in both psychological and physiological stress when exposed to these environments (Ulrich et al., 1991, as cited in Joye, 2007, p. 318). Such responses are not merely subjective to the individual, but rather have their roots in reactions which take place in the unconscious autonomic nervous system (Ruggles, 2017, p. 12). These unconscious reactions relate to both the sympathetic and parasympathetic parts of the autonomic nervous system, with the parasympathetic relating to the release of so-called, ‘feel-good’ hormones such as endorphins and serotonin (Ruggles, 2017, p. 13). The parasympathetic mode of the autonomic system is activated in response to pleasure, and is critical in not only the mind's perception of happiness or well being, but also the proper functioning of the immune system (Ruggles, 2017, p. 12). It has also been demonstrated that the parasympathetic autonomic system is activated in accordance with viewing the natural world, providing the mind and immune system with restoration (Brown et al., 2013 ; Ruggles, 2017, p. 12). Given this positive response, researchers have sought to discover the specific qualities in nature which induce our minds' positive response to them, and thus incorporate these qualities into architecture.

Research has overwhelmingly suggested that it is fractals which underline the human brain's positive response both to nature and the architecture which resembles it. A fractal, put simply, is a geometric pattern which repeats at different scales; for example, a tree whose branches are a reflection of its own form, or a sunflower whose spiraling seed pattern can be noticed whether all or only the middle-most seeds are visible (Ruggles, 2017, p. 12). A significant amount of research has been done which has demonstrated the fractal character of the natural world, a phenomenon which is noticeable both at the level of the individual organism as well as entire landscapes (Ruggles, 2017, p. 12 ; Joye, 2007, p. 318). Evidence has since been put forward to suggest that it is this very fractal character which drives humanity’s perception of these environments; as one writer put it, “...it is not the tree that causes these emotional responses, but the fractal mathematics of the tree" (Joye, 2007, p. 318). The results of one study demonstrated that the emotional responses of participants towards natural scenes could be predicted based on the dimensions of the fractals which formed the image, specifically that it was images which contained underlying fractal dimensions of around 1.3 to 1.5 that produced the most positive responses (Aks and Sprott 1996; Abraham et al. 2003; Spehar et al. 2003, as cited in Joye, 2007, p. 318). The presence of these dimensions in fractals was also shown in a 2002 study to reduce stress in viewers (Wise and Taylor, 2002, as cited in Joye, 2007, p. 318). Similar results were found in a 2006 study measuring skin conductance which demonstrated that human stress levels were reduced by 60% in the presence of fractals with the dimensions 1.3 to 1.5 (Abboushi et al., 2019 p. 58). Noteworthy is the fact that these same dimensions correspond to the fractal dimensions of savanna environments, a fact which suggests that the human response to nature finds its origins in our earliest ancestors, who first viewed the savanna as a place of plentitude and safety (Joye, 2007, p. 318). In total the research suggests that the presence of fractals in nature is what initiates our positive responses to these environments, and thus that similar fractal structures may be applied to architectural design in order to produce these same responses (Joye, 2007, p. 318). It has likewise been considered that the modern architectural emphasis on so-called simple Euclidean forms may increase stress level over time, impacting health negatively (Joye, 2007, p. 319).

Basic Architectural Principles Which Induce Positive Human Response

Along with the incorporation of nature into design, several more general architectural principals have been put forth which demonstrate positive impacts on human wellbeing. One of these principles, heavily expounded upon by University of Texas at San Antonio mathematics professor Nikos Salingaros, is complexity, specifically organized complexity (2014, p. 19). Complexity, according to Salingaros represents “intricacy of structure” and to define complexity level, he puts forth the rubric of Kolmogorov-Chaitin complexity, a system which defines something’s complexity based on the number of words needed to give a decently accurate description of that particular thing (object, building, etc); more words representing a higher level of complexity and visa versa (2014, p. 18). Salingaros also specifies that only what he calls organized complexity, as opposed to disorganized complexity, has a beneficial effect on the human mind; he uses simple drawings to illustrate the difference in these complexities, though for a verbal description one could consider the seeds within a sunflowers versus those same seeds scattered randomly on a table, the former being an organized complexity and the latter disorganized (2014, p. 19). Organization allows the mind to process complexity in an environment while avoiding “information overload” (Salingaros, 2014, p. 19). This relates to the concept of over stimulation (stimulation defined as “the amount of information a setting or object impinges upon the human user”), a phenomena shown to induce distraction and a lack of ability to concentrate (Evans & McCoy, 1998, p. 86). Several principles are put forth which may be used to establish the organized complexity which is necessary to produce an “emotionally nourishing state” and avoid the anxiety created by perceived randomness (disorganized complexity) (Salingaros, 2014, p. 18).

One of these principles is the use of symmetry breaking; research has established that the human mind demonstrates a preference for symmetry, though Salingaros makes the distinction that a “careless use of symmetries" on a large scale can lead to what he calls “informational collapse” leading the mind to perceive a space as dull, depressing, or even oppressive (Salingaros, 2014, p. 20 ; Alasmar, 2019, p. 127). In essence, when everything looks exactly the same on a large enough scale, the mind is unable to make sense of a space. Instead it is recommended that a variety of small "symmetry breaking" details be used in order to prevent informational collapse (Salingaros, 2014 p. 20). For an illustrated example see Salingaros's own drawings below (Figures 1 and 2). Figure 1 shows a design which incorporates symmetry breaking, small variation in detail or form, while figure 2 presents a design which does not, being completely uniform throughout.

Figure 1

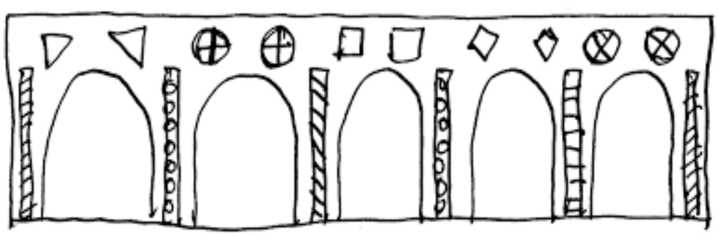

Figure 1. Symmetry Breaking. From "Complexity in Architecture and Design", by Salingaros, N. (2014). *Oz Journal*, *36*, 18-25.

Figure 2

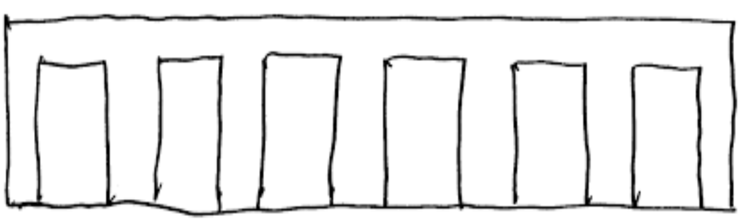

Figure 2. Informational Collapse. From "Complexity in Architecture and Design", by Salingaros, N. (2014). *Oz Journal*, *36*, 18-25

The concept of scaling symmetry is also proposed as a tool to be employed in creating organized complexity (2014, p. 22). Scaling symmetry is defined as the presence of forms which repeat on larger or smaller scales, creating a sense of cohesion in the whole design (Salingaros, 2014, p. 19). These scales, when both sufficiently numerous and well defined in their structure, create a design which is both complex and organized (Salingaros, 2014, p. 22). The distinction is also made that the jump in scale should not be too great or too little least the scale difference becomes either disorientingly large or unnoticeably small; the mathematical constant $e \approx 2.7$ is given as a general rule for scale distribution (Salingaros, 2015, p. 10). Interestingly, Salingaros notes the presence of structurally defined scales on the microscopic level which are present in many of the natural materials, for example stone and wood, which imbue many traditional structures with an organized complexity on the most basic levels (2014, p. 22). He also notes that this microscopic organization is not present in more modern materials such as steel or concrete (Salingaros, 2014, p. 19).

Finally, Salingaros concludes with a warning against an attempt to introduce complexity into a design without consideration for the "normal forces of the situation" (2014, p. 24). Such attempts, he warns, distress the mind as it searches for a meaning which is not present, and can introduce axial imbalances in a structure which, due to the working of the inner ear mechanism, have to potential to induce "nausea, alarm, and physiological distress" (Salingaros, 2014, p. 24). For a concrete example see again Salingaros's illustration (Figure 3).

Figure 3

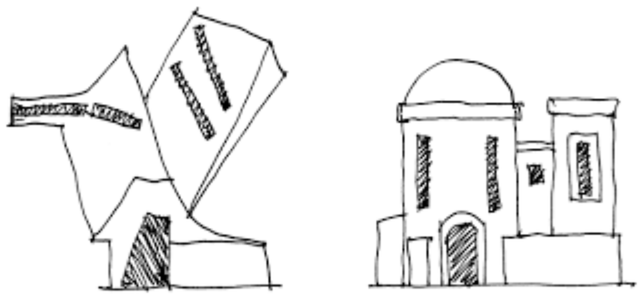

Figure 3. Good and Bad Complexity. From "Complexity in Architecture and Design", by Salingaros, N. (2014). *Oz Journal*, *36*, 18-25

The structure on the left represents a design which has introduced complexity that ignores the normal situational forces, defined as "structural integrity, activities, and sustainability of the form" and is therefore confusing and unbalanced, whereas the structure on the right follows these principals creating a balanced mix of both complexity and coherence (Salingaros, 2014, p. 24).

Alongside complexity there exists another series of design principles which provide for positive human response, such principles are numerous but may all be categorized together under the name logical or coherent design. Neurology professor Anjan Chatterjee defines architectural coherence as "the degree to which a scene is organized" and puts it forward as one of the three most important factors that influence a person's perception of the built environment (the other factors being fascination and hominess) (2020). Another paper in the Journal of Environmental Psychology gives coherence the definition of "clarity or comprehensibility of building elements and form" and expounds upon several of the factors which lead to an increase or decrease in a space's coherence, as well as the effects which are brought about by incoherency in design (Evans & McCoy, 1998, p. 87). Coherence is what allows the mind to make logical deductions about the purpose of a space, as well as about how said space is organized (Evans & McCoy, 1998, p. 87). When this ability is impaired, that is, the space becomes incoherent, stress may occur as the mind is unable to understand the forms surrounding it (Evans & McCoy, 1998, p.

87). Conflicting or abruptly changing visual information as well as high levels of ambiguity both contribute to incoherence in the built environment and have the potential to increase stress levels (Evans & McCoy, 1998, p. 87). Essentially, both too little and too much information prevent the brain from understanding the space it is occupying, which may cause it distress as it tries to make sense of a space which cannot be understood.

Legibility, or "the ease with which one can comprehend the spatial configuration of an interior space" is proposed as a factor which increases design coherence, and may be achieved by the inclusion of elements such as regular "geometric shapes" and "distinctive interior markings as well as "views of the external environment " (Weisman, 1982 ; Evans, 1980 ; Garling et al., 1986, as cited in Evans & McCoy, 1998, p.87). Helpful in avoiding incoherence are also the use of properties such as repetitive features and the presence of underlying expressions of rules (Lynch, 1960; Kaplan & Kaplan, 1982, as cited in Evans & McCoy, 1998, p. 87).

Another principle which may be brought under the label of coherent or logical design is that of affordance, or the ease with which the proper use of an object of space may be determined (Evans & McCoy, 1998, p. 87). Misaffordance can occur both when there is a sudden or dramatic change in visual information as well as when the visual information present is ambiguous or confusing, similarly to incoherency (Evans & McCoy, 1998, p. 87). For example, changes in visual access as brought on by movement across a sharp barrier or the obscuring of depth of space are inhibitors of affordance in a space (Evans & McCoy, 1998, p. 87). When too much or too little information is presented such that the mind cannot deduce how to ought to interact with the environment around it, it responds negatively, producing responses ranging from annoyance and frustration to hostility or helplessness (Norman, 1989, as cited in Evans & McCoy, 1998, p. 87). Perhaps the textbook example of misaffordance in design is a door wherein the question of ‘push or pull’ remains unanswered until a choice is first made. Summarily, the design of a space should both make sense from a logical standpoint, balancing coherence and complexity, and should be able to be quickly understood by its occupants, preventing stress and frustration.

Life and Beauty in Architecture

As well as the more specific elements of biophilic design and the incorporation of factors such as coherency and complexity, there exists a another set of standards being considered as a means of positively affecting the human response to the built environment; such standards may be categorized as elements which produce the experience of beauty or life in architecture.

The first of these factors finds its origin in the phenomena of pareidolia, or the tendency of the human mind to perceive human faces even in inanimate objects. Researchers have observed the presence of a ‘facial’ pattern in both a significant portion of traditional human architecture, as well as in basic childrens illustrations of houses (Ruggles 2017, p. 79 ; Green, 2021). In its most basic form this pattern consists of a square divided into nine parts, the top-most right and left sections and the bottom-most middle sections being darkened; this pattern corresponding to the pattern of windows and doors as found in architecture (both designed professionally and drawn by children) as well as to the darkened areas of the human face, specifically the eyes and nose/mouth (Ruggles, 2017, p. 79, 81, 85). One basic explanation for the near ubiquitous presence of this facial pattern in architecture states that the presence of this pattern allows for a human viewer to perceive something of a story behind the building, giving it a greater depth than a mere structure (Green, 2021). Another explanation, explored heavily by author and architect Donald Ruggles in his book *Beauty, Neuroscience & Architecture*, presents a more fundamental reason for the presence of the facial pattern in architecture. Ruggles begins by examining the limited visual capabilities of infants, and explaining that, although human beings are born with very limited vision, being able to recognize only vague light and dark areas, newborns nevertheless possess the ability to recognize faces (Ruggles, 2017 p. 81). He also cites the research done by John Morton and Mark H. Johnson for the Cognitive Development Unit in London, England as well as Robert Franz which suggest that children are born with the ability to recognize faces, that it is something innate to human biology (Ruggles, 2017 p. 81). Essentially, human beings are born possessing an inherent connection in their minds between a simple light and dark pattern and the faces of other people. This research finds its connection to architecture in the fact that, not only do infants possess the ability to recognize the form of the human face, they also prefer them (Ruggles, 2017 p. 80, 82, 81, 83). As Ruggles states “The facial pattern recognition beginning from birth elicits a response of love, nurturing, survival, protection and empathy, the general sense of bonding. This bonding generates neuronal pathways in our brain which last a lifetime, ready to be activated upon viewing a facial pattern” (Ruggles, 2017 p .82). In short, the love and pleasure experienced by young babies being cared for by their parents creates a strong positive association between the basic pattern they have been able to recognize since birth, as perceived in the faces of their parents, and the comfort and care they have received from said parents. Therefore, the reason for man's cross cultural and cross national use of the facial pattern in everything from professional architecture to the drawings of young children, comes not from a coincidental design choice, but rather the universal experience of parental care (Ruggles, 2017 p. 84). The vague light and dark pattern which is first in a child’s mind as the shape of a face and then imbued with further positive associations as they grow becomes the foundational pattern of the buildings they create and enjoy.

In creating a building with facial characteristics man is likewise able to see himself present in the built environment, eliciting responses of empathy and the pleasure associated therein (Ruggles, 2017 p. 86). The reason thus, that humanity perceives certain buildings or types of buildings as beautiful is not the result of arbitrary preference, but rather innate biological realities; as Ruggles states quoting Professor Harry Francis Mallgrave "...we judge certain forms to be beautiful because they in fact mirror the basic conditions of organic life" (Ruggles, 2017 p. 84).

After pareidolia, there exist several other factors being analyzed as providers of beauty and life in architecture. One such principle is symmetry, a factor related strongly both to our perception of both beauty and aliveness (Ruggles, 2017 p. 85). Studies have indicated that facial symmetry is related directly to perceptions of beauty in faces, a response likely correlated with the base need to determine biological fitness in a potential partner (Jacobsen, Schubotz, Höfel, & Cramon, 2006; Ramachandran & Hirstein, 1999; Rhodes, Proffitt, Grady, & Sumich, 1998; Frith & Nias, 1974, as cited in Coburn et al., 2017, p. 1523). Likewise, the presence of symmetry is crucial in distinguishing a living organism from a nonliving object, symmetry being associated with life and vice versa (Ruggles, 2017 p. 85). This combination of factors indicates that architectural symmetry may play a role in human perception of the built environment as beautiful or alive.

Aliveness as a critical quality in architecture finds further explanation in the writings of architect Christoper Alexander who outlines 15 architectural principles which give the built environment 'life' (Salingaros, 2015). He defines the properties as: levels of scale, strong centers, thick boundaries, alternating repetition, positive space, good shape, local symmetries, deep interlock and ambiguity, contrast, gradients, roughness, echoes, the void, simplicity and inner calm, and not-separateness (Alexander, 2001, as cited in Salingaros, 2015). Alexander explains these principles in depth in his book *The Nature of Order,* though together they are most essentially aimed at creating a space which mimics the harmony and coherence of nature Salingaros, 2015). According to Alexander, life like design incorporates both symmetry and roughness or variety in fine details, it utilizes both transitional areas whilst also makings use of clear unambiguous distinctions, it is at once contrasting and cohesive; each part blends together in a seamless whole, much in the same way natures itself maintains harmony even whilst balancing a great variety of factors (Salingaros, 2015). When these properties are ignored however, the coherent balance they provide disappears, resulting in alarm and physiological anxiety (Salingaros, 2015).

The research of this section in totality suggests that the perception of beauty, more specifically the beauty we recognize in ourselves and other human beings, as well as the perception of life as defined by those seemingly contrasting qualities which make up the natural world strongly influenced man's experience of the architectural world. It proposes that when looking at the world around him, man wants to see himself, his family, and his first biological home reflected to him.

Conclusion

Artist and designer Jay Dee Dearness makes an attempt at the famously difficult definition of beauty, calling it, in an architectural context, "...the melding of functionality and aesthetics in just the right proportions to achieve the desired result" (Keim, 2018). Such a definition has credence given the research which has been done in the area of cognitive architecture, demonstrating that there exists, or at least ought to exist another aspect to the design process apart from considerations of simple functionality or arbitrary design, an aspect which appeals to the most fundamental parts of the human person. Research indicates that poor architectural design has the potential to decrease human well-being overtime, producing feelings of anxiety, stress, and frustration; whereas good architectural design is able to reduce these factors and even promote mental and physical wellness. These factors together establish the designing of good or positive architecture to be crucial in the physiological, and not merely aesthetic, sphere. Existing literature is extensive in its exploration of the specific qualities of positive cognitive architecture, though more research is needed to explain how the examined qualities of biophilia, coherence and complexity, and beauty and life are to be most effectively combined and utilized in the practical realm. One possible way in which the information thus collected may be furthered would be in the design and/or creation of an architectural model which incorporates the above mentioned qualities. A product designed in this way would allow for insight to be gained, both on how all of the qualities mentioned can work together and build upon one another, as well as on the possible challenges of bringing them all together in an actual design. Given the established importance as well as the relative novelty of this line of study and design work, more research is needed on the effects and creation of good cognitive architecture, and examples of the principles of said architecture which achieve the “melding of functionality and aesthetics in just the right proportions to achieve the desired result” being put into place in a tangible model of design would certainly contribute to this research (Keim, 2018).

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