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Eco–Empathic design: how the built environment can affect our brains and behavior.

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Abstract

Eco-empathic design is a new approach to architecture and urban planning that seeks to create built environments that are both sustainable and human-centered. This approach is based on the understanding that the built environment can have a profound impact on our brains and behavior. The research explores the potential of eco-empathic design to improve our health, well-being, and productivity. The paper argues that by incorporating natural elements into the built environment, such as plants, natural light, and views of nature, we can create environments that are more calming, relaxing, and productive. The paper also explores the challenges and opportunities of implementing eco-empathic design in different cultural and environmental contexts. The study discussed examples of eco-empathic design from different areas of the world. These examples demonstrate the potential of eco-empathic design to create built environments that are both sustainable and beneficial to human health and well-being. The paper concludes by calling for more research and adoption of eco-empathic design principles in order to create healthier, happier, and more productive societies.

Keywords

Eco-empathic design, Health and well-being, Biophilic design

1. Introduction

Cities are increasingly disconnected from their natural ecological systems (WWAP, 2023; Semenov, 2020). This is a major problem because nature provides many essential services to cities, such as clean air and water, flood control, and pollination. When cities are disconnected from nature, they become more vulnerable to environmental problems such as climate change, flooding, and air pollution (Baietti et al., 2012). There are many ways that cities are disconnected from nature. For example, rivers are often hidden in pipes underground, wetlands are paved over, and green spaces are replaced with concrete. This lack of green space makes cities hotter and more polluted,

and it also makes it harder for people to connect with nature. The current way we build cities is causing a lot of environmental problems, such as climate change, air pollution, and flooding. These problems are only going to get worse if we don't do something to change our ways. One way to make our cities more sustainable is to "green" them. This means incorporating more vegetation and natural features into our cities. Green buildings are made with sustainable materials and have features that reduce their environmental impact, such as solar panels and rainwater harvesting systems. Green infrastructure is a broader term that refers to any kind of infrastructure that mimics natural systems, such as rain gardens and bioswales. Green buildings and green infrastructure can help to mitigate the urban heat island effect, which is when cities are hotter than the surrounding areas. They can also help to filter and delay stormwater runoff, which can reduce flooding. Green buildings can also reduce building energy use, which can help to reduce greenhouse gas emissions. In addition, green buildings and green infrastructure can provide habitat for wildlife and improve air quality (Semenov, 2020; Grant, Manuel, & Joudrey, 1996; Thurston, 2006; Escobedo & Nowak, 2009; Arnold & Gibbons, 1996). Green infrastructure and sustainable building practices in cities are becoming more common in both the design and construction of new buildings, as well as in the policies and regulations that govern cities. This is due to a number of factors, including the growing awareness of the environmental impacts of cities, the increasing availability of green technologies, and the public demand for more sustainable cities. While there is a growing focus on the environmental performance of buildings and cities, there is a lack of attention to the human experience of these spaces. This is a problem because buildings and cities that are designed for environmental performance alone can be alienating and uninviting. The LEED green rating system, as an example, is a popular green building rating system that awards points for a variety of environmental features, such as energy efficiency, water conservation, and use of recycled materials. However, LEED does not give any points for how well or poorly a building engages its occupants in its green systems. This means that a building could be highly energy efficient and use recycled materials, but still be uninviting and alienating to its occupants (Semenov, 2020). There are a number of reasons why it is important to consider the human experience of buildings and cities. First, people spend a lot of time in buildings and cities. According to the World Health Organization, people spend an average of 90% of their time indoors (Sarigiannis, 2013). This means that the quality of the built environment has a significant impact on our health and well-being. Second, people's experience of buildings and cities can affect their behavior. For example, a building that is inviting and comfortable may encourage people to walk or bike instead of driving. A city that is well-designed and connected may make it easier for people to get around without a car (Roe & McCay, 2021; Kaplan & Kaplan, 1989). Finally, the human experience of buildings and cities can also affect our sense of community. Buildings and cities that are designed to be shared and interactive can help to create a sense of community and belonging (Raymond et al., 2017).

The importance of reconnecting urban dwellers with nature is equal to the importance of reconnecting urban infrastructure with living systems. The term "nature deficit disorder" (NDD), which was coined by Richard Louv (2005) in his book "Last Child in the Woods: Saving Our Children from Nature-Deficit Disorder". Children in the United States are spending significantly less time outside than their parents did. In fact, children are now spending an average of less than 30 minutes of unstructured outdoor play per day, and over six hours of screen time per day. This lack of time spent in nature is a major contributing factor to the rise of NDD (Larson, Green, & Cordell, 2011; Roberts, Foehr, & Rideout, 2005; Juster, Ono, & Staford, 2004). Even when children and adults are outside, they are often too focused on their electronic devices to really experience the natural world. This is despite the fact that there are many health and psychological benefits to spending time in nature (Collado et al., 2015; Zhang et al., 2014; Soga, et al., 2016; Kollmuss & Agyeman,

2002).

To further explore the potential of eco-empathic design, the study aims; 1) To explore the potential of eco-empathic design to improve our health and well-being, 2) To identify the specific physiological and psychological benefits of incorporating natural elements into the built environment,3) To investigate how eco-empathic design can be implemented in different cultural and environmental contexts, 4)To develop a set of key principles and guidelines for designing eco-empathic environments that are both sustainable and appealing to people of all backgrounds. The study also highlighted key questions; how eco-empathic design can be used to improve our health and well-being, the specific physiological and psychological benefits of incorporating natural elements into the built environment, how eco-empathic design can be implemented in different cultural and environmental contexts, and what are the economic and social benefits of eco-empathic design. To answer the questions posed in this study, the research will first explore the main concepts and theories of eco-empathic design, and how they can influence human behavior and perceptions. It will then examine a series of international case studies from different cultural contexts that have applied eco-empathic design principles in their urban development plans. Finally, it will synthesize our findings to develop a set of key principles and guidelines for designing eco-empathic environments that are both sustainable and appealing 0 combining a literature review with a series of case studies. The literature review will explore the main concepts and theories of eco-empathic design, as well as the evidence on its benefits for human health and well-being, and its potential to be implemented in different cultural and environmental contexts. The case studies will provide concrete examples of how eco-empathic design principles have been successfully implemented in different urban development projects. Eco-empathic design is a holistic approach that considers the needs of both people and the planet. It seeks to create built environments that are both environmentally friendly and socially beneficial. Eco-empathic design principles can be applied to a wide range of scales, from individual buildings to entire cities. The study's analysis of the literature and case studies will reveal key principles and guidelines for designing eco-empathic environments that are directed to the needs of people and applicable to a wide range of urban development projects.

2. Biophilic design for a more empathic world

Biophilic design, the integration of nature and natural elements into architecture, has become too focused on its concrete benefits, such as improved health outcomes, worker productivity, and student performance. This is in contrast to the more nuanced arguments about human relationships to nature that were made by the early proponents of biophilic design (Kellert & Wilson ,1993). This focus on concrete benefits is reducing biophilic design to a set of superficial guidelines, such as using green walls and organic shapes, biophilic design should be more than just about triggering our feel-good instincts. It should also function as a cultural and emotional communication system that helps us to empathize with nature and with each other (Kellert et al., 2008; Terrapin Bright Green, 2014). Architecture should do more than just make us feel good about nature. It should also function as a cultural and emotional communication system that helps us to appreciate and value nature more. David Orr (2007) argued that architecture and design are "a kind of crystallized pedagogy" that "never fails to inform" us. He believes that the way we design our buildings and landscapes can make us more or less mindful of nature and more or less ecologically competent. For Orr, the ultimate goal of design is to change human minds. He wants us to see ourselves as part of nature, not separate from it. He wants us to value nature for its own sake, not just for its usefulness to us. Our emotions are more powerful than our thoughts when it comes to making decisions. This is supported by neuroscience research, which has shown that the emotional brain, the amygdala, is much faster and more powerful than the thinking brain, the cortex (Salzman & Fusi, 2010; Šimić et

al., 2021). Green architecture can help urban residents develop empathy for the creatures and plants that share their cities. Empathy is the capability of understanding and share the feelings of another being. When we feel empathy for something, we are more likely to care about it and take action to protect it (Sandman et al., 2018). Green architecture can help us to have a visceral connection to the ecology we inhabit. Sullivan (1990) argued that sympathy is a powerful force that can lead to understanding. He said that knowledge is important, but it is not enough. We must also be able to empathize with others in order to truly understand them. As an example of a deep understanding of this reciprocal relationship between humans and nature, Misha Semenov established The Ecoempathy Project as a think tank and platform that explores how architecture and urban design can be used to create a more empathic connection between people and nature. The project aims to do this by highlighting and translating ecological processes and natural features into architectural forms that are both sensually appealing and emotionally resonant. By doing so, the Ecoempathy Project hopes to encourage people to develop a deeper understanding and appreciation of the natural world, and to build healthier relationships with both nature and each other. (Semenov, 2020).

3. Architecture and the embodied mind

Architects have been designing buildings to evoke certain emotions in people for centuries, but we are only just beginning to understand the neuroscience behind how our brains respond to architecture. This understanding is important because it can help architects design buildings that are more emotionally engaging and effective. Studies from neuroscience focus on the way that architects design and assess buildings. This is because neuroscience can help us to identify the specific features of architecture that trigger certain emotions (Sussman & Hollander, 2015). The parts of an organism that depend on the perception and emotion of other beings are designed to create a particular relationship with those beings. This relationship can be beneficial to both the organism and the other beings, or it can be harmful. For example, the bright, juicy berries are designed to attract birds that will eat them and spread the seeds. This is a beneficial relationship for both the berries and the birds. The berries get to reproduce, and the birds get to eat a nutritious meal. The venomous snakes, on the other hand, use their flashy patterns to warn predators away (Semenov, 2020). This is a harmful relationship for the predators, but it is beneficial for the snakes. The snakes avoid being eaten, and they can continue to reproduce. organisms that engage in this kind of signalling use their form to communicate a specific message to other organisms. This message can be either positive or negative, and it can be either simple or complex. In the case of the Ophrys apifera (Figure 1) orchid, the message is "do this." The orchid has evolved to look and smell like an attractive bee in order to lure male bees into pseudocopulation. When the male bee lands on the orchid, it gets pollen stuck to its body. When the bee flies away to find a real female bee, it will pollinate the next orchid it visits. The orchid's form is essential for this signaling to work. The orchid has to look and smell like a real bee in order to fool the male bee. The orchid also has to be shaped in a way that guides the male bee to the spot where it can pick up pollen (Semenov, 2020). Humans have evolved alongside nature, and our brains have developed preferences for certain visual cues that are found in nature. These preferences are still present today. Even though we live in a world that is increasingly artificial, our

Figure 1.The Ophrys apifera deceives male bees by mimicking the appearance and scent of a female bee (Source: Vereecken &Francisco, 2014).

innate design preferences, shaped by evolution, influence our interactions with the world around us. We are drawn to bright berries, repelled by slimy creatures, and emotionally connected to patterns that resemble faces. These preferences, studied by biophilia experts like Stephen Kellert (2008), have influenced the evolution of species from toy dogs to tulips, and shaped the built environment, from Gothic cathedrals to traditional buildings. Green buildings should be more than just functional machines. They should also be aesthetically pleasing and communicate with their users. However, many green buildings are designed with a focus on mechanical systems and energy efficiency, while neglecting aesthetic and communicative considerations. This is a missed opportunity, as green buildings can play an important role in shaping our relationship with the natural world and promoting sustainable living (Kellert, 2008). These systems provide great opportunities for us to mimic and be inspired by nature. We can learn how to interact with them, like the story of the Ophrys apifera orchid, which deceives bees. The orchid's plan of creating a false advertisement in the form of a bee is an excellent point to start. The theory of empathy has invariably illustrated that people pay attention to buildings that reflect their own bodies and faces. Brain research and studies are beginning to discuss these phenomena.

4. Ecoempathy design

Empathy is the ability to see the world through another person's eyes and feel what they feel (Stephan, 2023). It is a complex process that involves both thinking and feeling. Thinking empathy is understanding another person's perspective, while feeling empathy is sharing their emotions. Empathy is essential for building and maintaining strong relationships. When we can empathize with others, we can better understand their needs and respond to them in a meaningful way. This leads to more supportive and fulfilling relationships. Empathy also plays a critical role in society as a whole. It helps to promote cooperation, trust, and understanding between people. It also motivates us to help others and volunteer (Riess, 2017). Once thought to be innate, empathy has been shown to be a teachable skill, even for healthcare providers (Riess et al., 2011). The idea of empathy in design has its roots in 19th-century Germany, where philosophers like Kant and Lipps began to think about how we understand and appreciate art and architecture. They argued that we must first empathize with the physical and emotional experience of the user. This means trying to understand how the user feels and what they need, in order to create spaces and objects that are responsive to those needs (Wagner & Blower, 2014). As humans, we are aware of the mechanical forces acting on our bodies. This awareness allows us to perceive objects beyond their physical form. Prominent art historian Heinrich Wölfflin developed a theory of embodiment, which suggests that we judge every object we see by analogy to our own bodies. He believed that even objects completely dissimilar to ourselves will transform themselves immediately into a creature, with head and foot, back and front. Wölfflin also argued that we experience the spiritual condition and contentment or discontent expressed by any configuration, however different from ourselves. This is because we see every physical form as the manifestation of an internal process. As a result, we experience a recurrence of the emotion that we would feel with our own bodies if we were in the same configuration (Wölfin, 1964). The physical form of architecture can evoke strong emotional responses in humans, which can influence our cognitive processes, including memory. As Geofrey Scott (1914) argues in his book The Architecture of Humanism, architectural features such as soaring spires, springing arches, and swelling domes can "stir our physical memory," allowing us to empathize with the perceived state of the structure. In other words, we can project ourselves onto the architecture, identifying our own emotions and experiences with the physical features of the space. During the 20th century, the study of the embodied experience of art and architecture was pioneered by phenomenologists, such as Edmund Husserl and Maurice Merleau-Ponty. Their work was later absorbed by a generation of postwar American architects, including Kent Bloomer and Charles Moore,

whose book Body, Memory, and Architecture is a seminal exploration of architecture's relationship to the human body (Bloomer & Moore, 1977). Recent neuroscientific advances have provided experimental evidence for some of the ideas first proposed by empathy theorists and phenomenologists. For example, David Freedberg and Vittorio Gallese (a co-discoverer of mirror neurons in monkeys) have written in their article "Motion, Emotion, and Empathy in Esthetic Experience" that multiple studies have confirmed the existence of a mirror neuron system (MNS) in the human ventral premotor cortex and posterior parietal cortex. The MNS is a network of neurons that fire when an individual performs an action, as well as when they observe another individual performing the same action. This suggests that the MNS plays a role in understanding and responding to the actions of others (Freedberg & Gallese, 2007). The MNS is a network of brain regions that is activated when an individual performs an action or observes another individual performing the same action. The MNS was first discovered in macaque monkeys, but it has since been shown to be present in humans as well. One of the most interesting properties of the MNS is that it can be activated by implied actions. For example, if you see a person reaching for a cup of coffee, your MNS will be activated, even if the person doesn't actually grab the cup. This is because the MNS is able to infer the intended action from the observed movement. Another interesting property of the MNS is that it can be activated by tactile stimulation. For example, if someone touches your hand, your MNS will be activated, even if you cannot see the person who touched you. This is because the MNS is able to integrate information from different sensory modalities, including vision and touch (Freedberg & Gallese, 2007). These findings suggest that (MNS) may play a role in our appreciation of art. When we view images of people performing actions, such as the poking of flesh or the reaching of hands, our MNS is activated, allowing us to experience those actions vicariously. This may help to explain why we are so drawn to such images, and why they can evoke such strong emotional responses. An example of this state is the image of Caravaggio's Incredulity of Saint Thomas (Figure 2).

Another example of the activation of the mirror neuron system (MNS) can be seen in responses to scenes from Goya's Desastres de la Guerra. Viewers not only experience bodily empathy for the many unbalanced figures in these scenes, but also for the frequently horrific representations of lacerated and punctured flesh as indicated in Figure 3. It is thought that MNS plays a crucial role in social interactions, including empathy, imitation, and understanding the intentions of others. One of the most important functions of the MNS is embodied simulation. This is the process of mapping the actions, emotions, and sensations of others onto our own internal representations. This allows us to understand the experiences of others without having to directly experience them ourselves. The MNS is also involved in imitation and understanding the intentions of others. When we observe someone performing an action, our own motor neurons are activated, allow-

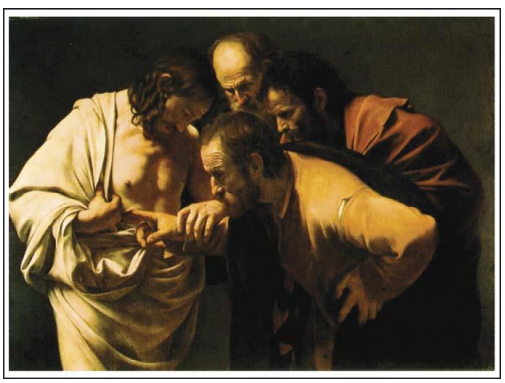

Figure 2. Caravaggio's Incredulity of Saint Thomas (Source: Freedberg & Gallese, 2007).

Figure 3. The Disasters of War by Francisco Goya (Source: Freedberg & Gallese, 2007).

ing us to learn new skills and behaviors by watching others. Additionally, we can use our MNS to understand what the other person is trying to do, which allows us to coordinate our actions with others and to engage in social cooperation. Overall, the MNS is an essential system for social interactions. Studies have shown that people with autism spectrum disorder (ASD) have reduced MNS activity, which is thought to contribute to the social difficulties that are characteristic of ASD (Freedberg & Gallese, 2007; Semenov, 2020). Our empathetic processing capacities are not limited to other humans. We are also prewired to perceive other entities in the world as expressive and sentient, or as products of processes we can empathize with. For example, we may experience an embodied simulation of reaching and stretching when we see a plant stem striving towards a light source. This is because the plant stem's movement is similar to our own movements when we reach for something. Michael Arbib (2015) has argued that there are limits to our ability to empathize with other species and subjects. For example, a dog barking does not trigger the same neural networks associated with speech production in humans. However, even inanimate objects, such as buildings, can potentially trigger the same neural pathways involved in social interaction. If enough neurons fire in response to a building, this may trigger a related population of neurons that corresponds to our interactions with other people. We are also capable of empathizing with other entities in the world, including plants, animals, and even inanimate objects (Arbib, 2015). Buildings are not merely utilitarian structures that provide shelter for our daily lives; they are also interlocutors and companions that constantly trigger neural responses corresponding to our own bodies and minds. Although mirror neurons are present in other social primate species, it is useful to consider why the empathetic systems of Homo sapiens are particularly well-developed. Robin Dunbar's social brain hypothesis proposes that the expansion of social networks and the evolution of the social brain worked in a positive feedback cycle: as humans became more social, their brains evolved to be better wired for embodied simulation and empathy (Mallgrave, 2015). In summary, our ability to empathize is not limited to other humans. We are also capable of empathizing with other entities in the world, including plants, animals, and even inanimate objects including the physical world of the built environment.

4.1. Building connections: faces in architecture

Sussman and Hollander (2019) investigated the influence of evolved neurological mechanisms on human responses to visual stimuli, particularly in the context of architecture and urban planning. They used sensors to track eye movements, facial expressions, and neural activity in trial subjects as they viewed buildings and cities for the first few seconds, before conscious and rational processing began (Hollander et al., 2019; Hollander & Foster, 2016). Sussman and Hollander's (2021) research demonstrates that humans are not only more stimulated by and drawn to buildings with facial features, but our eyes also naturally gravitate towards the most human-like elements of a façade in the first few seconds of viewing a building. This is evident in the heat map (Figure 4). of Sussman's (2015) eye-tracking study of a New England carriage house, which shows that participants' eyes focused most on the windows and doorway, which resemble human eyes and a mouth, respectively.

Sussman and Hollander's (2021) proposed that a greater proportion of our brain is dedicated to facial recognition than to any other visual object recognition task. In fact, Shakeshaft and Plomin (2015) suggested that we may even have a gene for facial recognition. However, in a modern glass building (Figure 5), our eyes tend to be drawn to other features of the environment, such as trees with their fractal patterns, people on the street, and areas with their fractal patterns, people on the street, and areas of contrast, rather than the building itself. Humans are a

Figure 4. Heat map of eye tracking data reveals viewers' focus on facial features of a building façade (Source: Sussman & Hollander, 2021).

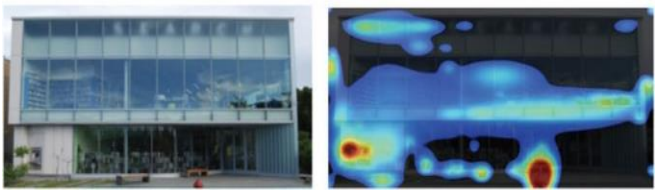

Figure 5. Heatmap of eye gaze on modern glass building (Source:Hollander, et al. 2020).

social species, and our brains are wired to be attracted to faces. This is because faces are important for social communication and bonding. Product designers exploit this innate human trait by incorporating face-like features into their designs. For example, car makers design cars with "faces" that are attractive to customers, and companies like Apple use faces in their advertisements to draw attention to specific products (Sussman & Ward, 2019). In short, mirror neuron studies and empathy theory have shown that our brains are wired to respond to the actions and emotions of others. This suggests that our brains are constantly scanning the environment for cues about the social world around us. New research provides further evidence for this theory by showing that we are also drawn to features of our environment that resemble human features, such as faces and bodies. This innate tendency to focus on representations of humans explains the abundance of anthropomorphic ornament and statuary on traditional buildings around the world. Studies on human visual attention have shown that people are consistently drawn to images of faces before any other part of a scene. This suggests that faces are particularly effective at captivating our social brains (Sussman & Hollander, 2021). As we search for more effective ways to design green architecture that speaks to our emotional need for connection, we should consider the importance of incorporating features that resemble human features. This could include using anthropomorphic shapes in the design of buildings, or incorporating images of faces or bodies into architectural elements such as doorways or windows.

4.2. Self-Reflection in the built environment

The hypothesis that humans seek images of their biological selves in the environment is consistent with the work of Christopher Alexander. In his "Nature of Order" series, Alexander theorizes that the objects and buildings to which people feel most drawn are those that provide the most spiritually authentic reflection of their own selves (Alexander, 2002). Alexander arrived at this conclusion intuitively, but subsequent scientific evidence has supported his claims (Sussman & Ward, 2019). Alexander's theory of objects as mirrors of the self-posits that our attachment to objects is not primarily determined by their similarity to human form, but rather by their embodiment of the geometric properties that we perceive to be characteristic of life. He identifies fractal levels of scale, strong centers, multiple local symmetries, and interlocking parts as some of the key features that make objects feel more "alive" to us. To test this hypothesis, Alexander conducted a simple experiment in which he asked participants to choose between two objects, one with a high prevalence of natural geometries and one without, which object they felt best represented their whole selves. The overwhelming majority of participants chose the object with the more natural geometric features. Alexander interpreted these results as evidence that we are innately drawn to objects that reflect our own inner selves. He believed that objects with natural geometries can help us to feel more whole and complete, and even to increase our own vitality (Alexander, 2002). Alexander's hypotheses about degrees of perceived vitality have been substantiated by recent studies. These studies suggest that our visual preferences may be influenced by the act of perception itself, which is shaped by the evolved mechanics of our brains. Richard Taylor, a neuroscientist at the University of Oregon, discovered that viewing fractal patterns reduces stress by 60%, which is a remarkably high impact for a non-pharmaceutical intervention (Taylor, 2006). Taylor (2006) proposed that humans find fractals with a D-value of 1.3–1.5 calming because our retinal search patterns are themselves fractal. Fractals with this D-value are similar to the scale-invariant patterns found in nature, such as trees and coastlines. As a result, our visual system has evolved to process these patterns efficiently. When we view a fractal

image with a D-value of 1.3–1.5, our retinal search patterns resonate with the fractal structure of the image, leading to a reduction in stress levels (Williams, 2017). Sussman & Ward (2019) found that people who viewed a garage wall with fractal art paid more attention, smiled more, and displayed more positive emotions than those who viewed a blank wall. This finding suggests that fractal art may have a beneficial effect on human attention and emotion. As shown in figure 6 people ignore blank facades and fixated significantly more on the image with windows than on the image without windows. This suggests that windows provide visual cues that help our eyes to scan and process a scene. The researchers also created heat maps that aggregated the eye tracking data from multiple participants. These maps showed that participants' eyes were drawn to areas of high contrast, such as the edges of windows and doorways (Sussman & Ward, 2019). Research on the perception of architecture has shown that humans are drawn to buildings with fractal scaling and biomorphic detail, which are similar to the patterns found in nature. This is likely because our brains are prewired to perceive and appreciate these patterns. Green architects can use these principles to design buildings that are both sustainable and aesthetically pleasing. By incorporating fractal scaling and biomorphic detail into their designs, they can create buildings that are more likely to resonate with people on a deep level.

5. Methods

The study explores the concept of eco-emphatic design and its impact on human perception through a comprehensive research methodology that includes a rigorous literature review and analysis of case studies from different areas around the world. The literature review was conducted to identify the key concepts and principles of eco-emphatic design, as well as the potential impacts of eco-emphatic design on human perception. The researchers reviewed a wide range of scholarly and professional publications, including journal articles, books, conference proceedings, and government reports. The case studies were selected to represent a diverse range of eco-emphatic design approaches, including buildings, landscapes, and urban spaces. The researchers used a variety of criteria to select the case studies, such as the project's scale, location, and type of eco-emphatic design features incorporated. The analysis of the case studies focused on how the design features of each project contributed to an eco-emphatic experience. The researchers also considered how the design features impacted the human senses, emotions, and cognitive processes. The research findings were then used to develop a set of recommendations for how to design green buildings, specifically eco-emphatic buildings, today. The researchers used a variety of methods to develop the recommendations, such as synthesizing the findings from the literature review and case study analysis.be noted. For instance, the header margin in this template measures proportionately more than is usual. Those measurements and others are deliberate such that it is not required to modify or revise any of the current specifications.

Figure 6 .Windows guide eye movements more than blank one. (Sussman & Ward, 2019).

5.1. Eden project, Cornwall, UK

The Eden Project is a prime example of how eco-emphatic design can be used to create sustainable and educational spaces that are both enjoyable and in-formative for visitors. The project has had a significant positive impact on the Cornish economy and environment, and it continues to inspire people from all over the world. The Eden Project is a complex of geodesic biomes that house a diverse array of plant life from around the world. The biomes are designed to mimic the natural environments of the plants, allowing visitors to experience different climates and ecosystems within a single space. The Eden Project is a prime example of eco-emphatic design, as it provides visitors with a di-rect and immersive experience of nature

(Prance, 2002). The Eden Project is located in Cornwall, UK, on the site of a former kaolin quarry. The biomes were de-signed by architect Nicholas Grimshaw and constructed using a variety of sustainable materials, including tim-ber, steel, and ETFE (ethylene tetrafluoroethylene). ETFE is a transparent plastic film that is highly insulated and recyclable. The Eden Project is home to two main biomes (Figure 7): The Humid Tropics Biome and the Mediterranean Biome. The Humid Tropics Biome is the largest of the two biomes and houses a wide range of plants from tropical rainforests around the world. The Mediterranean Biome is smaller and houses plants from Mediterranean climates around the world. In addition to the two main biomes, the Eden Project also has a number of other attractions, including an outdoor gar-den, a children's play area, and a variety of food and beverage outlets. The Eden Project is also home to a number of educational programs and events. The Eden Project is a popular tourist destination and also serves as an important research and education center. It has also been credited with helping to revitalize the Cornish economy (Prance, 2002; Sanchez-Alvarez, 2022). There are some of the key eco-emphatic design features of the Eden Project as illustrated in Table 1.

5.2. New high line bridge: connecting people and nature

A new 600-foot-long elevated pedestrian bridge, the New High Line Bridge, now connects the High Line to Moynihan Train Hall in Midtown Manhattan. The bridge provides a safe and enjoyable way for pedestrians to cross the busy streets surrounding the Lincoln Tunnel entrance, and it is also an ecological oasis, with a woodland landscape and a variety of native plants. The bridge is made of glulaminated Alaskan yellow cedar wood, a sustainable and durable material that sequesters carbon and releases

Figure 7. Overview of the biomes (Source: Prance, 2002).

far less greenhouse emissions than steel (Green, 2023). The bridge is comprised of two segments: a 340-foot-long woodland bridge running east to west, and a 260-foot-long timber bridge going north to south. The wooden bridge is an extension of the landscape of the High Line Spur, and it features 60 trees, 90 shrubs, and 5,200 grasses and perennials. The timber bridge, designed with a truss structure to minimize its impact on the ground, rises above the bustling traffic of the Lincoln Tunnel. The bridge also features a small plaza where pedestrians can take a moment of pause and enjoy the vista (Figure 8). The plaza is located where the two bridges meet, and it offers a respite from the cacophony of midtown (Green, 2023). The New High Line Bridge is a significant addition to the public spaces of New York City. It is a safe, sustainable, and enjoyable way for pedestrians to cross the busy streets surrounding the Lincoln Tunnel entrance, and it is also an ecological oasis. The bridge is a prime example of how sustainable design can be used to create public spaces that are both functional and beautiful.

5.3. Characterful Chimneys: Lessons from Casa Milà and BedZED

Modern HVAC systems require a network of vents, pipes, and chimneys, but these are rarely designed in a visually appealing way. They are usually hidden or minimized, which can make them seem impersonal and utilitarian. However, Antoni Gaudí's chimney designs (Figure 9) from over a century ago offer a promising alternative. His chimneys are functional elements that are also visually arresting and subtly anthropomorphic, which makes them more relatable and empathetic (Semenov, 2020). Gaudí's chimneys are often described as having a "whimsical" or "organic" quality. They are often adorned with colourful tiles, mosaics, and sculptures. Some of his chimneys even resemble human figures or animals. This gives them a sense of personality and character that is lacking in most modern HVAC systems.

Table 1. – Eden project design features for Eco-empathy (source: The authors).

Feature	Description
Geodesic biomes	Highly efficient and sustainable form of architecture that is strong and lightweight, and requires less material to construct than traditional buildings.
Sustainable materials	Timber, steel, and ETFE are used in the construction of the biomes. Timber is a renewable resource, and steel and ETFE can be recycled.
Renewable energy	Solar and photovoltaic power are used to meet the energy needs of the Eden Project.
Rainwater harvesting	Rainwater is collected for use in irrigation and other non-potable water needs.
Waste reduction and recycling	A waste reduction and recycling program is in place to help reduce the environmental impact of the Eden Project.
Outdoor spaces for user experience and perception	The Eden Project has a number of outdoor spaces, including an outdoor garden, a children's play area, and a variety of food and beverage outlets. These spaces provide visitors with opportunities to enjoy the natural environment and to socialize with each other.

Exhaust and circulation infrastructure is often hidden from view, but it plays a critical role in our buildings and cities. By designing this infrastructure in a more visible and engaging way, we can draw attention to its importance and encourage people to think about the metabolism of buildings. One way to do this is to use dynamic chimneys. Dynamic chimneys can be designed to change their color, form, or light in response to changes in the building's metabolism. For example, a chimney could change color to indicate the building's energy consumption or air quality. Another way to humanize exhaust and circulation infrastructure is to use biomorphic forms (Semenov, 2020). Biomorphic forms are forms that are inspired by nature. Using biomorphic forms in the design of exhaust and circulation infrastructure can make it more appealing and relatable to people. The BedZED net-zero neighborhood in London (Figure 10) is a good example of how to humanize exhaust and circulation infrastructure (Chance, 2009). In this project, the systems that make these dwellings green are highlighted in innovative ways. The BedZED neighbourhood uses wind-driven ventilation (Chance, 2009). This means that the buildings are designed to use the wind to naturally ventilate them. To highlight this, the architects used bright colors and eye-catching forms to design the vents. The vents are also vaguely biomorphic in shape, which makes them more appealing to people. The BedZED neighborhood is a good example of how dynamic chimneys and biomorphic forms can be used to humanize exhaust and circulation infrastructure. By making this infrastructure more visible and engaging, we can draw attention to its importance and encourage people to think about the metabolism of buildings.

5.4. Bullitt Center as an Eco-Empathetic Design

Bullitt Center is a six-story office building in Seattle, Washington, that is designed to be net-zero energy, net-zero water, and net-zero waste. It is also one of the first buildings in the world to be Living Building Challenge certified, which is a rigorous sustainability standard. The Bullitt Center is an example of eco-empathetic design (Figure 11), which is a design approach that aims to connect people with nature and inspire them to live more sustainably. Eco-empathetic design uses elements are included in the building such as natural light, biophilic design, and natural materials to create spaces that are both beautiful and sustainable. One of the key features of the Bullitt Center is its dynamic chimney (Homchick Crowe, 2019). The chimney is designed to change color and form in response to changes in the building's energy consumption and air quality. This helps to raise awareness of the building's metabolism and encourage people to think about their own energy consumption. Another key feature of the Bullitt Center is its biophilic design. The Bullitt Center uses biophilic design elements such as natural light, plants, and water features to create a more human-centered and sustainable environment. The Bullitt Center incorporates a number of eco-empathetic design features that are explained in Table 2.

Figure 8. New high line bridge and the featured small plaza (Source: Green, 2023).

Figure 9. Gaudí's chimney designs (Source: Google Images).

Figure 10. The BedZED net-zero neighborhood in London (Source: Chance, 2009).

Figure 11. The Bullitt Center (Source: Homchick Crowe, 2019).

Table 2. Eco-empathetic design features, The Bullitt Center (source: The authors).

Eco-Empathetic Design Feature	Human Perception and Experience Benefits
Living roof and green walls	Improved air quality, reduced stormwater runoff, insulation, reduced noise pollution, increased biodiversity
Natural light and ventilation	Reduced need for artificial lighting and HVAC systems, improved mood and productivity, connection to the natural world
Biomorphic design elements	More inviting and appealing environment, reduced stress levels, increased sense of well-being
Sustainable materials and construction methods	Reduced environmental impact, healthier and more comfortable environment, connection to the natural world

6. Results

The Results section presents a comparative analysis of the previously discussed cases to extract the main guidelines for eco-empathic design. The comparative analysis is illustrated in Table 3.

Table3. Comparative analysis between research cases (source: The authors).

	Feature of eco-empathetic design	Impact on human behavior and well-being
Case 1 (Eden project)	- Direct and immersive experience of nature, Sustainable materials and construction educational programs and events, - Sustainable materials and construction - Educational programs and events - Revitalized Cornish economy	- Increased awareness of and appreciation for nature, increased sense of connection to nature, which will contribute in reducing stress and anxiety levels, improving mood - Increased awareness of the importance of sustainability, reduced environmental impact, increased sense of community pride - Increased knowledge about nature and sustainability, increased engagement with environmental issues, increased sense of empowerment to take action on climate change - Increased employment opportunities, increased tourism revenue, increased sense of community pride
Case 2 (New high line bridge)	- Woodland landscape and native plants - Sustainable and durable materials - Safe and enjoyable pedestrian bridge - Respite from the cacophony of midtown	- Increased connection to nature, reduced stress and anxiety levels, improved mood - Increased awareness of the importance of sustainability, reduced environmental impact - Increased physical activity, reduced reliance on cars, improved quality of life - Reduced stress and anxiety levels, improved mood and well-being

Table3 (Continued). Comparative analysis between research cases (source: The authors).

- Case 3 - (5.3. Characterful Chimneys)	- Visually appealing and subtly anthropomorphic chimney designs - Dynamic chimneys that change color, form, or light in response to changes in the building's metabolism - Biomorphic forms in the design of exhaust and circulation infrastructure	- Increased connection to buildings and infrastructure, reduced feelings of alienation and disconnection, increased awareness of the m tabolism of buildings - Increased awareness of energy consumption and air quality, increased engagement with e vironmental issues - Increased appeal and relatability of infrastru ture, reduced feelings of alienation and disc nection, increased connection to nature
- Case 4 (Bullitt Center	- Dynamic chimney that changes colour and form in response to changes in the building's energy consumption and air quality, Biophilic design elements such as natural light, plants, and water features. Sustainable materials and construction	- Increased awareness of the building's metab lism and people's own energy consumption, duced environmental impact, Increased connection to nature, reduced stress and anxiet levels, improved mood, improved air quality Increased awareness of the importance of su tainability, reduced environmental impact, i creased sense of community pride

The study findings analyse the previously discussed case studies to extract the main guidelines and keys for eco-empathic design in our neighbourhoods and urban spaces, bringing the human back to the core of urban design. This means designing urban spaces that are both environmentally sustainable and empathetic to the needs of people. Eco-empathic design considers the natural world and the human-built environment as one interconnected system. It seeks to create spaces that are both beautiful and functional, and that promote a sense of well-being for all who use them. Eco-empathetic is a relatively new approach, but it is gaining traction as cities around the world grapple with the challenges of climate change and urbanization.

There are a number of key eco-empathetic design guidelines that can be used to create sustainable and livable spaces. These include:

1. Database of eco-friendly materials and construction practices: The application would include a database of sustainable materials and construction practices, with information on their environmental impact, cost, and availability. This would help users make more sus-

Figure 12. Eco-friendly material (Source: Google Images).

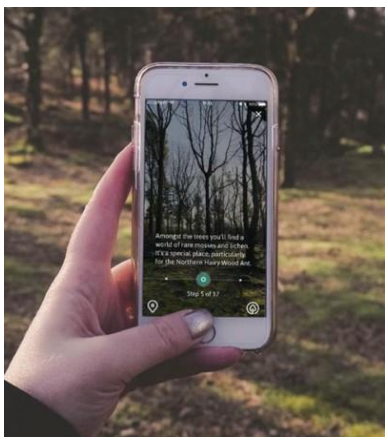

Figure 13. a map of green spaces in the user's area using mobile phones (Source: Google Images).

tainable choices when designing, building, or renovating their own homes or businesses (Figure 12).

2. Directory of accessible and inclusive spaces: The application would include a directory of accessible and inclusive spaces in the user's area, such as parks, plazas, and community centers. It would also include a feature that allows users to rate and review the accessibility and inclusiveness of different spaces. This would help users find places where they can feel comfortable and welcome, regardless of their age, ability, or background.

3. Map of green spaces that can be used through electronic devices: The application would include a map of green spaces in the user's area, such as parks, gardens, and trails. It would also include information about the different plants and animals found in different green spaces. This would help users find places to connect with nature and enjoy the outdoors (Figure 13).

4. Directory of social events and activities: The app would include a directory of social events and activities happening in the user's area. It would also include a feature that allows users to create and share their own social events and activities. This would help users connect with others who are interested in sustainability and eco-empathetic design.

5. Educational resources: The app would also include educational resources about eco-empathetic design and sustainability. This could include articles, videos, and interactive quizzes. These resources would help users learn more about the importance of eco-empathetic design and how they can make more sustainable choices in their own lives.

The four case studies discussed in the literature part demonstrate eco-empathetic design features in different ways. The Eden Project is a complex of geodesic biomes that house a diverse array of plant life from around the world. Visitors can experience different climates and ecosystems within a single space. The Eden Project also has outdoor spaces, such as a garden, play area, and food and beverage outlets. this case focused on how people can perceive different experiences to connect with nature. The New High Line Bridge is made of sustainable materials and adorned with a woodland landscape, making it a safe and enjoyable way for pedestrians to cross busy streets and access a new ecological oasis. The new high line bridge promotes social interaction besides the perceived values of connecting with natural elements. Casa Milà and BedZED are two examples of how to make exhaust and circulation infrastructure more visually appealing and engaging for people. This can help to make these spaces more welcoming and inclusive, and it can also raise awareness of the sustainable features of the buildings. The Bullitt Center is designed for net-zero energy, water, and waste. It incorporates eco-empathetic design features such as a dynamic chimney and biophilic design to create a sustainable and healthy work environment that gives users an immersive experience that mimics natural settings. These four case studies provide design features that can be used to create eco-empathic sustainable and livable spaces.

7. Conclusion

Eco-empathic design is a novel approach to architecture and urban planning that seeks to create sustainable and human-centered built environments. It is grounded in the understanding that the built environment can have a significant impact on human health and well-being. This research explores the potential of eco-empathic design to improve human health, well-being, and productivity. The paper argues that incorporating natural elements into the built environment, such as plants, natural light, and views of nature, can create calming, relaxing, and productive environments. It is clear from the previously explained cases that green architecture that integrates the human senses is achievable with current design methods. Buildings that involve their occupants in their ecological system can have a greater positive impact on the environment than those that rely on system efficiency alone. However, the success of this emotional approach to green architecture is often subject and based on intuition and believes, rather than clear rules or tangible measures. Meanwhile, buildings that meet LEED standards for energy and water efficiency

may still be emotionally fruitless and visually indiscernible from conventional architecture. The green architecture profession urgently needs to develop a framework for measuring, forecasting, and designing for emotional responsiveness to buildings and structure systems. This will tackle a critical gap in the current green architecture agenda. If urban designers could predict how much people would attach to and appreciate key features of green spaces and buildings before construction starts, they could form designs that increase the benefits of these features. For example, green architects could use this knowledge to design buildings that encourage people to use stairs instead of elevators, recycle their waste, or reduce their water consumption. A framework for testing and ranking designs based on neurological base could become just as significant as an energy use intensity rating. There are a number of challenges that need to be addressed in future research on eco-empathic design. One challenge is to develop more effective methods for measuring the human benefits of eco-empathic design. Another challenge is to develop more affordable and accessible eco-empathic design solutions. Finally, there is a need to develop more effective strategies for implementing eco-empathic design principles in different cultural and environmental contexts. Future research can meet these challenges by developing more effective methods for measuring the human physiological and psychological markers of health and well-being. For example, future research could develop and validate new wearable devices or smartphone apps that can track people's stress levels, heart rate, and other physiological markers in real time as they interact with different types of built environments. This data could then be used to assess the impact of different eco-empathic design features on human health and well-being. Future research could study how to design eco-empathic environments that are culturally sensitive and appropriate for different regions of the world, and could also study how to design eco-empathic environments that are resilient to climate change and other environmental challenges. This research is interdisciplinary, drawing on insights from fields such as psychology, neuroscience, and environmental science. It is global in scope, considering the needs of people from different cultures and living in different environments.

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