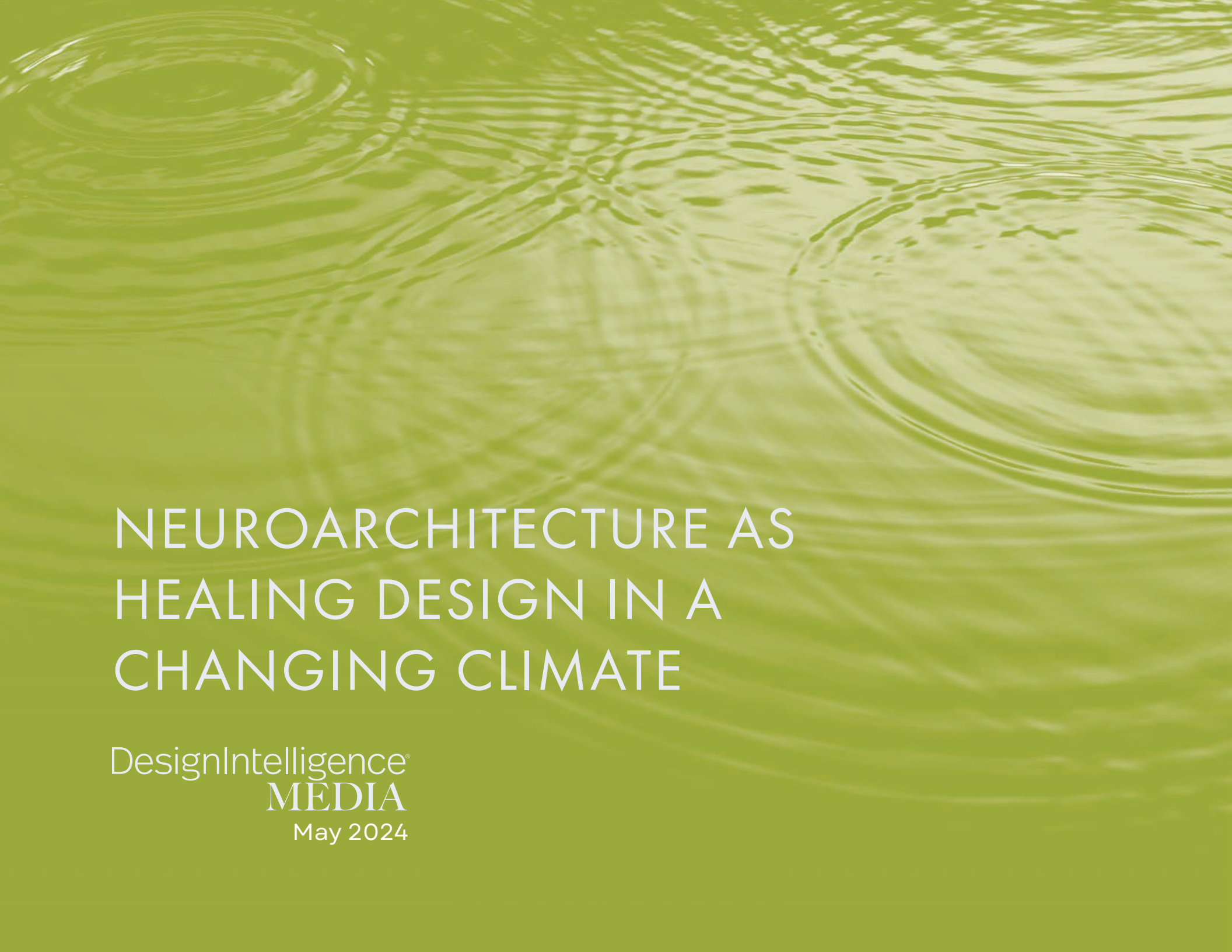

NEUROARCHITECTURE AS HEALING DESIGN IN A CHANGING CLIMATE

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Brains, bodies and the built environment

No two human brains are exactly alike. There are over eight billion people on the planet and every single one of them has a brain uniquely theirs, much like a fingerprint. We know this because of the radical advances in neuroscience that have marked the last few decades. These individualized "brainprints" serve as evidence of the vital, inescapable link between brains and the built environment.

Neuroarchitecture

The term neuroarchitecture encompasses the research and emerging design practices that explore this link. In other words, neuroarchitecture is an "emerging field that combines neuroscience, environmental psychology, and architecture to focus on human brain dynamics resulting from action in and interaction with the built environment."[1] Increasingly advanced technologies ranging from functional magnetic resonance imaging (fMRIs) and mobile brain/body imaging to virtual reality technologies have allowed scientists to study people's neural responses to all our environments, designed and natural. The language and boundaries around this research, however, remain nebulous – a permeable space that encapsulates many words and ideas evolving in real time. A close, relevant relative of neuroarchitecture is neuroaesthetics, an area of research popularized by scientist Anjan Chatterjee that examines the neural mechanisms

underlying our responses to the arts. He is one of many scholars now trying to understand how and why we find creative pursuits – visual arts, music and dance, theater performances – meaningful, beautiful and, at times, deeply cathartic to consume and create.

Neuroplasticity

Fundamental to our current understanding of the relationship between environments and brains is scientist Marian Diamond's work on neuroplasticity. She studied the brains of rats after placing some in "impoverished environments" devoid of anything but essential food, water and daylight and others in "enriched environments" that contained toys, textures and opportunities for play and exploration.[2] Diamond found that the rats in the enriched environments had larger cerebral cortexes than their counterparts in impoverished environments, whose brains had shrunk. Not only did Diamond illustrate that "impoverished spaces have a slow, corrosive effect on health and well-being,"[3] but she also proved that our physical environments have the capacity to reshape our brains. Many factors rewire and change the structure of our brains. Stress, trauma, sleep, meditation, food, language, substances – all can alter your brain. The phenomenon of synapses firing and wiring in endless changing patterns across billions of neurons is called neuroplasticity, and it plays an important role in neuroarchitecture.[4]

Neuroscience

Neuroscience in the context of the built environment can be broadly characterized by a few key themes:

- A rejection of dichotomies and binaries in favor of relational ecosystems.
- Architecture as foundational in memory and identity.
- The value of empirical evidence combined with collective embodied knowledge and awareness.

Because of these defining features, neuroarchitecture holds the potential to radically improve human health and drive equity-focused solutions throughout the built environment in the face of a rapidly changing climate.

First, the notion of dichotomies. Neuroscience and psychology are disciplines that have historically been defined by binaries. These include perception versus action, organism versus environment, mind versus body and subject versus object.[5] Descartes' notion of dualism, in which the body and mind are separate entities and the body is merely a passive object feeding information to the brain, dominated neuroscientific thinking until very recently. Then, we started to understand embodied cognition, which refers to the idea that the body each of us inhabits shapes our thoughts and experiences in the world.

Cognition

Design scholar and architecture critic Sarah Williams Goldhagen explores cognition as the product of a deeply collaborative, continuous exchange between the body, mind and whatever environment one occupies. In Goldhagen's view, science has greatly underestimated the role of the body in human cognition:

> The body is not merely some passive receptacle for sensations from the environment, which the mind then interprets in a somewhat orderly fashion. Instead, our minds and bodies – actively, constantly, and at many levels – engage in active and interactive, conscious and non-conscious processing of our internal and external environments.[6]

As much as 90% of human cognitions are subconscious, meaning they happen without us realizing it or applying language to them. These cognitions include sensory impressions, of which we have countless throughout a single day. They include traditional sensory information like touch, taste, sight, sound and smell, but also other senses we are just beginning to understand, like proprioception and interoception.

Cross-Modality

In Goldhagen's mind-body-environment paradigm, these sensory impressions and subconscious cognitions shape each other as well as our actions and conscious cognitions. Their cross-modality serves as the foundation of human experience. Walking in the rain, for example, may change your perception of temperature or wind, making you feel colder. It also might color your mood, making you more short-tempered or shaping an interaction you have with someone you pass by. And

vice versa: If you're walking in the rain and have a negative interaction with someone, it may impact your perception of the rain, wind or temperature. Different sensory information would create an entirely different experience. Even these same sensory factors for one person might produce an entirely different experience for another depending on previous personal experiences, identity and context. This is the complexity and nuance of the human condition.

Ecological Psychology

In another radical rejection of binaries, psychologist J.J. Gibson pioneered an area of study called "ecological psychology," which reimagined the organism versus object dichotomy as a relational system.[7] In his view, every built environment was full of affordances, or opportunities for action. As people move through the world, they scan for affordances in a constant perception-action loop that shapes their cognitions. Our perceptions of affordances matter as much as the actions we choose to take, and our ability to perceive affordances depends on active exploration of our environment. In this conception, affordances depend equally on the organism and the environment, and they exist as two codependent facets of a singular system.[8]

If we understand the connections between brains, bodies and buildings through the lens of relational systems, embodied cognition and neuroplasticity, the role architecture holds in memory and identity begins to materialize. It comes down to something quite simple: Because we are embodied beings moving through time and space, all our memories have spatial and temporal contexts, and these memories accumulate to form our identities.

Making Meaning

Through his extensive work and scholarship, Finnish architect Juhani Pallasmaa has solidified himself as a formative voice in neuro-informed architecture. Pallasmaa underscores architecture as a central, collective method of meaning-making:

> Buildings mediate the world and our consciousness through internalizing the world and externalizing the mind. Structuring and articulating lived existential space and situations of life, architecture constitutes our most important system of externalized order, hierarchy, and memory.[9]

“It comes down to something quite simple: Because we are embodied beings moving through time and space, all our memories have spatial and temporal contexts, and these memories accumulate to form our identities.”

In the most palpable sense, our identities and self-narratives become embedded in the places we inhabit, just as those places become formative parts of our biology. Brains and buildings transform one another.

Brain Functions

All this neuroarchitectural research originates in the uncovering of highly specific functions of the brain's anatomy that fuel better design. For example, the olfactory bulb feeds directly into the limbic system, where long-term memories and emotions are stored in the brain; this is why smell can trigger memories and emotions so instantaneously, bringing someone back to a place and a moment from decades ago. This makes olfactory cues in the built environment incredibly powerful. Human spatial mapping abilities are located in the hippocampus, where new memories are formed, intertwining wayfinding abilities with memory and identity, which yields fruitful solutions in the realm of user-specific design approaches like aging in place.

In his essay "Losing Myself: Designing for People with Dementia," architect and professor at the Barlett School of Architecture, University College London, Niall McLaughlin reflects on his neuroscientific research throughout the process of designing a respite center for those with Alzheimer's disease. He writes about how his team "thought about the experience of dementia as a continuous present tense. You are unable to remember where you have been and therefore cannot project where you might go. We wondered what it might be like to experience the world as an ongoing unfolding, held between empty expanses on each side. The sense of the past moving into the future must dissolve. The intuition of sequence, of one event or place following another, would collapse."[10] Only through advances in neuroscientific inquiry can practitioners engage in a more empathetic design process that accounts for a loss of identity and sense of self as much as it solves for physical needs like navigation and wayfinding.

If we place this case study into Gibson's affordance framework, relational systems are also made abundantly clear. Stairs, for example, only function as transportation when the being in the building has both the physical capacity to climb them and the mental ability to orient themselves in time and space. McLaughlin's project had no stairs because his building occupants were universally living in various states of cognitive and physical decline. Stairs would offer no viable opportunities for action in this occupant-building ecosystem.

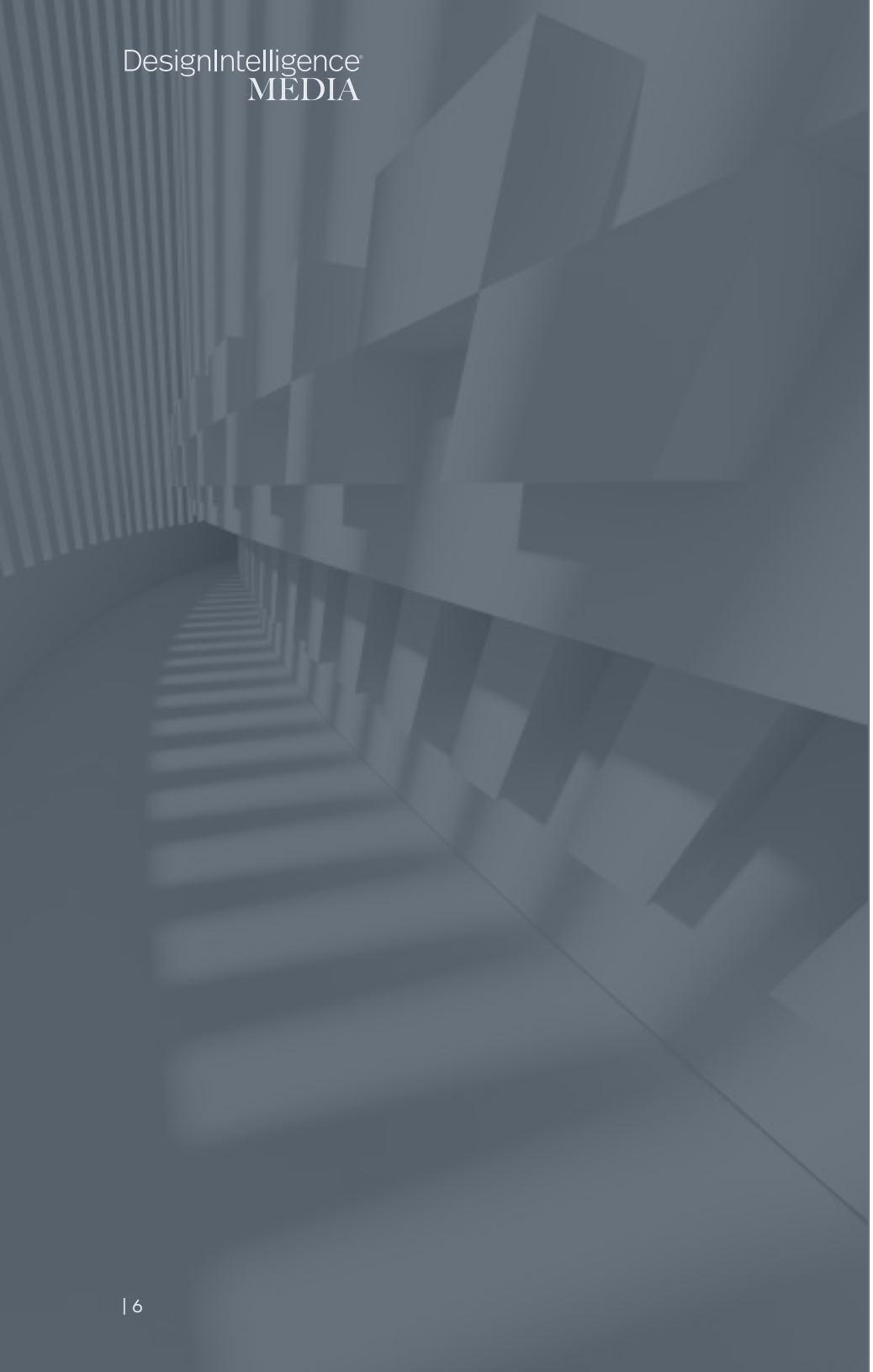
Climate Change & Neuroarchitecture Interplay

Neuroarchitectural research stresses the relationship of reciprocity between our brains and the environment. And our environments – designed or not – are changing rapidly in the face of the climate crisis. Our brains are already undergoing massive transformations as a result.

A recent article in Natural Climate Change by Kimberly Doell et al. stresses that higher temperatures "increase human and non-human mortality, decrease cognitive performance and ability to learn, decrease self-control, and have been associated with increases in crime rate and civil conflict."[11] Furthermore, research has shown that heat makes the blood–brain barrier more permeable, allowing dangerous toxins to leach into the brain.[12] While poor air quality has long been associated with respiratory concerns, it also correlates with negative impacts on the brain. As is most often the case, those living in poverty are more severely impacted by the consequences of climate change. In the realm of brain health, significant structural and functional neural changes are a result of a lack of cognitive stimulation, exposure to toxins, poor nutrition and heightened childhood stress among lower socioeconomic demographics.[13]

Environmental Justice

As climate change renders some climates uninhabitable and natural disasters like forest fires become frequent, people are forced inside, increasing the burden of well-being on the buildings to which they have access. For these reasons, environmental justice sits squarely in the center of the dialogue about brains and the built environment. As we suffocate and overheat the planet, natural resources like clean air, clean water and safe, enriching environments become increasingly commodified and harder to access. Only those who can afford thoughtfully designed places in areas with robust public infrastructures reap the benefits of breathable air, drinkable water and nourishing places to live and work. This echoes poverty expert and scholar Matthew Desmond's exploration of the vicious cycle of private opulence and public squalor in his book "Poverty, by America." He illustrates a self-reinforcing cycle of disinvestment in public infrastructure in which those with private wealth become less dependent on public infrastructure and services, and therefore less interested in supporting them. The more vast the privatized resources become, the greater the disinvestment in public spaces and services.



When we look at the relationships between brains, bodies and our environments, the research once again points us back to nature. Susan Magsamen, the founder and director of the International Arts + Mind Lab, Center for Applied Neuroaesthetics at Johns Hopkins University, and Ivy Ross, the vice president of design for hardware products at Google, in "Your Brain on Art: How the Arts Transform Us" call nature "the ultimate enriched environment."[14] According to them – and the many researchers working in biophilic design, evolutionary biology and psychology – "nature is the most aesthetic of places, because it is our original home."[15] As much as neuroarchitecture sparks debates about neuroanatomy and better building design, it also begs the question: How might buildings once again democratize our original home, regenerate her natural resources and ensure equal distribution for all? Architects and designers undoubtedly have a role in developing answers.

For Practitioners

As our neuroscientific understanding of the human brain becomes more sophisticated, so too can neuroscientifically informed design strategies. The coming decades will see a rise of concrete and unified design frameworks to be applied to the design of the built environment. In the meantime, neuroarchitecture calls for an evidence-based approach to designing buildings, which has been made most accessible by the Center for Health Design.

Neuroarchitecture also invites closer, more meaningful collaborations between architects and neuroscientists. It asks architects to peel away, even if for a brief time, the pressures of performance, bottom lines and stakeholders so that they can consider how a building will interact with its occupants and how it will set the stage for their lives. What might it mean to approach a building as a "living ecology of affordances"[16] that will invariably become a critical part of a life-affirming and identity-affirming feedback loop for every occupant in a unique way?

Neuroarchitecture ultimately helps people live in bodies, minds and places that feel fundamentally safe; it helps people make sense of their inner and outer worlds. Perhaps most importantly, neuroarchitecture illuminates where the significant inequities of the built environment hide as our planet rapidly warms. Innovative solutions emerge at the place where empirical evidence meets imagination and embodied awareness.

[1] Tulay Karakas and Dilek Yildiz, "Exploring the influence of the built environment on human experience through a neuroscience approach: A systematic review," Frontiers of Architectural Research (October 2019), https://doi.org/10.1016/j.foar.2019.10.005.

[2] Susan Magsamen and Ivy Ross, Your Brain on Art: How the Arts Transform Us (New York: Penguin Random House, 2023), 14.

[3] Magsamen and Ross, Your Brain on Art, 14.

[4] Magsamen and Ross, Your Brain on Art, 14.

[5] S. Wang et al., "The Embodiment of Architectural Experience: A Methodological Perspective on Neuro-Architecture," Frontiers in Human Neuroscience 16 (May 2022), doi: 10.3389/fnhum.2022.833528.

[6] Sarah Williams Goldhagen, Welcome to Your World: How the Built Environment Shapes Our Lives (New York: HarperCollins Publishers, 2017), 47.

[7] Wang et al., "The Embodiment of Architectural Experience."

[8] Wang et al., "The Embodiment of Architectural Experience."

[9] Juhani Pallasmaa, "Body, Mind, and Imagination: The Mental Essence of Architecture," in Mind in Architecture: Neuroscience, Embodiment, and the Future of Design, ed. Sarah Robinson and Juhani Pallasmaa (London: MIT Press, 2017), 53.

[10] Niall McLaughlin, "Losing Myself: Designing for People With Dementia," in Neuroarchitecture: Designing with the Mind in Mind, ed. Ian Ritchie (Oxford: Wiley, 2020), 53.

[11] Kimberly C. Doell et al., "Leveraging Neuroscience For Climate Change Research," Nature Climate Change 13 (2023): 1288–1297.

[12] Doell et al., "Leveraging Neuroscience For Climate Change Research."

[13] Doell et al., "Leveraging Neuroscience For Climate Change Research."

[14] Magsamen and Ross, Your Brain on Art, 15.

[15] Magsamen and Ross, Your Brain on Art.

[16] Sarah Williams Goldhagen, Welcome To Your World: How the Built Environment Shapes Our Lives (New York: HarperCollins Publishers, 2017), 208.

DeeDee Birch is a regular contributor to DesignIntelligence on science-based topics.