Introducing ANFA, The Academy of Neuroscience for Architecture

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Based on his belief that the quality of the built environment has an impact on human brain performance, Jonas Salk’s challenge to the American Institute of Architects (AIA), many years ago, led to the eventual formation of the Academy of Neuroscience for Architecture (ANFA). In September 2012, ANFA held its first international conference at the Salk Institute. It was inspirational to hear the conference keynote dinner speaker, Dr Peter Salk, Jonas’ son, eloquently express his conviction that ANFA exemplifies his father’s commitment to interdisciplinary research.

The Academy of Neuroscience for Architecture was created in 2003 by the San Diego Chapter of the American Institute of Architects with the mission to promote and advance knowledge that links neuroscience research to a growing understanding of human responses to the built environment.

The Academy was formally introduced that June before the National AIA Convention in San Diego, following a keynote address on Architecture and Neuroscience given by Dr. Fred Gage, a senior neuroscience researcher at the Salk Institute and Past President of the Society for Neuroscience (SfN). Dr. Gage was to later become the second ANFA President. At that 2003 Convention, The AIA College of Fellows granted its two-year research grant, the Latrobe Fellowship, to ANFA, with John Paul Eberhard FAIA, founding President of ANFA, as its Latrobe Fellow. His Fellowship laid the basis for his seminal book *Brain Landscape: The Coexistence of Neuroscience and Architecture*. (Oxford University Press, 2008).
The mission of the Academy captured the interest of a group of renowned architects and neuroscientists who came together as the governing Board of Directors. San Diego, the home for this organization, takes advantage of the rich local resources dedicated to scientific research, and to the dedication of the local and national architectural communities.

Early ANFA initiatives included workshops that brought together Architects, Neuroscientists and experts in education, healthcare and so on, to investigate research topics that neuroscientists might pursue to help inform architects of issues relevant to how the human brain responds to the built environment.

New interdisciplinary college courses developed by ANFA Board members have been taught in collaboration with the NewSchool of Architecture and Design and the University of California at San Diego, and there is a new generation of ANFA Research Associates who have been afforded cross-disciplinary work opportunities.

ANFA’s annual lecture series called ANFA Interfaces has paired speakers from either Architecture or Neuroscience with responders from the other discipline, leading to constructive dialog with the lecture audiences.

The first ANFA International Conference was held in September 2012 at the Salk Institute. Conference participants from the design and research communities of twelve different countries gathered to share knowledge at the intersection between Neuroscience and Architecture. The assembly was remarkable for its mix of designers and researchers, including renowned practitioners, investigators and educators; emerging professionals; and graduate students focusing on interdisciplinary studies.

John Paul Eberhard FAIA spoke early in the conference. Referring to E.O Wilson’s theory of Consilience; he offered that ANFA is developing the consilience between the brain sciences and architecture. A combination of keynote presentations, panel discussions, contributed papers, and poster
presentations, given by more than 40 professionals from a broad spectrum of design and research disciplines, supported this theme, and, throughout the conference, generated stimulating discussions among the 150 attendees. Keynote presentations included Dr Tom Albright’s “From the Look of the Room,” a description of the neuroscience of visual perception related specifically to elements of the built environment (Tom is the Director of Salk’s Center for the Neurobiology of Vision, holds the Conrad T. Prebys Chair of Vision Research and is the 2013/2014 ANFA President.) His discussion of how the brain processes visual elements of architecture exemplifies the emergence of neuroscience research that can inform architectural design. Dr Fred (Rusty) Gage’s presentation, entitled “Do Changes in the Environment affect the Brain?” represented another core issue of discussion that continued throughout the conference panels and presentations.

Panels included an interdisciplinary discussion between Rusty Gage, PhD, Larry Squire, PhD (a leader in research on the neurological foundations of memory), Rob Quigley, FAIA (Architect of the new Main Library, San Diego) and Jeff Olson, AIA with Fentress Architects (Architects of the Sanford Consortium for Regenerative Medicine, recently completed adjacent to the Salk Institute). Issues the panel discussed included novelty and familiarity and how the brain responds to architectural elements that represent these contrasting perceptual stimuli.

Another panel that included Gil Cooke, FAIA (Dean emeritus, NewSchool of Architecture and Design), Eduardo Macagno, PhD (founding Dean of Biology, UCSD), Meredith Banasiak and Margaret Tarampi (both former ANFA research associates), discussed the interdisciplinary courses being offered at NewSchool, UCSD, and the Universities of Colorado and Utah.

Examples of the many other themes covered during the two and a half day conference include visual perception, circadian rhythms,
chronobioengineering & lighting design; designing for individuals with cognitive impairment; environments designed to adapt to individual brain responses; lighting and acoustical properties to improve safety in healthcare environments; and emotional response to elements of architectural space.

Tours during the conference included the Calit2 facility at UCSD with its navigable immersive virtual reality CAVE technology paired with its portable brain scanning technology; a tour of the new Sanford Consortium for Regenerative Medicine and, of course, tours of Louis Kahn and Jonas Salk’s iconic Salk Institute.

The announcement of ANFA’s new grant program for interdisciplinary research created additional interest in forming professional cross discipline collaborations. This new grant opportunity was made possible by a significant gift to ANFA from the estate of Harold Hay. Harold was a researcher and friend of founding board member Gil Cooke, FAIA, of the NewSchool of Architecture and Design. Grantees are selected annually from interdisciplinary research teams who have responded to ANFA’s request for proposals posted on ANFA’s web site. Through this research funding, the Academy commits to further expanding the knowledge about human brain response to the architectural environment. This endeavor parallels the Academy’s ongoing initiative to assemble an ANFA database. Combined with its other new and ongoing activities, these initiatives represent the core of ANFA’s Mission.

Videos of the ANFA Interfaces series as well as the proceedings of the ANFA 2012 Conference, along with other ANFA information and resources can be viewed at the Website www.anfarch.org. A selection of papers from the Conference is provided by this ANFA Special Issue of Intelligent Buildings International.
The Evolution of Neuroscience for Architecture: 
Introducing the Special Issue

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Abstract

We outline a framework for research on neuroscience that will benefit architecture, and topics in neuroscience that will be stimulated by innovations in the design of the built environment. We then use this framework of collaboration and influence to situate the research papers of this Special Issue supported by the Academy of Neuroscience for Architecture (ANFA). The papers expand upon presentations at ANFA’s International Conference, held at the Salk Institute in La Jolla, California in September of 2012.

Neuroscience for Architecture: An Emerging Framework

This section presents views of an emerging framework for neuroscience as a contributor to architecture as seen through the eyes of two ANFA Board Member, architect Betsey Olenick Dougherty and neuroscientist Michael Arbib

Reflections of an Architect

It was my personal privilege to serve the American Institute of Architects as the incoming Chancellor of the College of Fellows for 2004, at the time that the Academy of Neuroscience for Architecture (ANFA) gained recognition. The initial ANFA research was conducted and presented during my tenure as a recipient of the AIA College of Fellows Latrobe Prize, and became a passionate area of interest for me as an architect of educational and
community facilities. It was also my privilege to serve on the AIA National Board at the time that Jonas Salk was our Public Member. His remarks always inspired the governing board, and made tangible the mutually supportive aspects of scientific research and the creative architectural process. My ongoing service to the ANFA Board of Directors as an architect member was a natural evolution from my initial opportunity to know Jonas Salk, my involvement in the awarding of the AIA College of Fellows Latrobe research grant, and my valued relationship with ANFA advocate John Eberhard. In the year that followed, I participated in an ANFA workshop focused upon educational environments. Attendees included architects, neuroscientists, and educators. We discussed supported design strategies that architects have come to know intuitively and discovered opportunities that we had not explored, leading to a creative dialog among clients, designers and scientists regarding the many aspects of environmental design upon learning. Participants deliberated upon key points that result in a supportive environment that enhances the learning process. These points include issues of auditory and visual perception and enhancement, the quality of artificial and natural light on behavior and cognition, and the element of distraction as related to the awareness of the external environment and activities adjacent to the learning space. The particular elements of functional adjacencies, and the influential connection of nature to learning activities goes beyond the indoor and outdoor classroom and to the delivery of the educational curriculum in non-traditional spaces. Conversations related to healthy and sustainable solutions also have a direct influence on the design of successful educational environments. This Workshop brought the purpose of ANFA home for me, and I have been a true believer ever since.

As the Architect member of a two-person editorial review team for this issue, partnering with Michael Arbib of the USC Brain Project, I entered a world
outside my usual comfort zone. Although I have authored many articles and business-related publications, I found myself having to re-read first drafts of the articles twice just to comprehend the jargon and capture the intent of the scientific research. Architects are known to flaunt jargon of their own, such as soffits, plinths, naves and crickets, but taking a plunge into the world of scientific nomenclature has been a new experience for me. As editors, we have developed an acute awareness of the challenges of merging two worlds of thought into one and hope that our efforts in helping each author better express their ideas for “the other half” will make their ideas accessible to a wider readership. We are at the threshold of a rich confluence of concept and theory, of art and science. As professionals working in distinctly separate, but equally creative fields, both architects and neuroscientists are enriched by the potential influence of one on the other. The powerful result can be a series of tangible strategies in the design of the built environment that can positively stimulate brain function. The potential is staggering.

It has been a privilege for me to have focused on the design of educational facilities throughout my career. There is an intrinsic reward in knowing that, in some small way, lives can be changed through the thoughtful design of educational environments. In my daily practice, I find myself recalling the many topics that we at ANFA have discussed. This informed perspective has carried over into my design sensibilities, and I share this perspective and this growing body of knowledge with my clientele and with other design professionals. The application of these ideas into our design solutions provides immediate feedback, and serves to verify the significance of these deliberations and the direct influence of neuroscience upon architectural design.
Reflections of a Neuroscientist

Although I have long had a keen interest in the architecture of the built environment, my professional expertise long lay elsewhere – in the development of computational models of brain mechanisms serving action and perception in animals and humans and their evolutionary relation to language in humans. However, in recent years I have sought to understand how the findings of neuroscience concerning the brains of animals, including humans, may impact the future design of intelligent buildings. In promoting such understanding, ANFA (www.anfarch.org) has emphasized the Neuroscience of Architectural Experience which studies architecture in terms of the impact of the built environment on the human brain: What is it about a designed space that affects the human brain and how might understanding the response of the brain lead us to improvements in architecture in the future? This theme was given expression by John Eberhard (2008) in his book Brain Landscape: The Coexistence of Neuroscience and Architecture (Eberhard 2008) and is the dominant theme of this issue. In his book, Eberhard’s thesis was that we use neuroscience to establish a framework for decision making in the design process of architecture, focusing on such factors of people’s reactions as: How could we reduce stress? How could we improve cognition, whether in an educational environment or in a home for people with Alzheimer’s Disease? How could we increase productivity, whether in a factory or a research environment. And, if designing a church, how could we increase the sense of awe and inspiration that could be offered? Complementing this, I have begun to pursue what I call Neuromorphic Architecture, an approach to incorporating brain functions into buildings. What happens if our knowledge of the structure and function of brains informs our design of perception, control and communication systems for buildings, so that these systems are based on brain operating principles
rather than ad hoc computational designs? My first paper on this theme appeared in the pages of this journal (Arbib 2012).

The Story So FAR

The Special Issue in Perspective

Intelligent Buildings International has published varied studies of how to endow buildings with a measure of intelligence. They can adjust to changing circumstances; turning lights down or up automatically depending upon the time of day, controlling temperature, perhaps even adjusting the acoustics depending on how crowded a room may be. In the future, we can expect a transition from such simple types of “intelligence” – let’s make it warmer if it’s colder outside; let’s turn up the lights if it’s getting dark – to the design of buildings in which, in some sense, the room engages in some communication with the users to better serve them. A large motivation for smart architecture has come recently from thinking about how to go beyond LEED (Leadership in Energy and Environmental Design) standards for “green” – e.g., energy efficient – buildings. The focus of this issue is less on how to make buildings smart than on how to learn more about people to better address their needs in building design. Neuroscience has the potential to contribute much to this process but it is still early days yet, and cognitive science and evidence-based design are as much in evidence as neuroscience in the papers that follow.

The papers in this issue begin to capture the potential applications of scientific research to find architectural solutions, and address topics of behavior, healthcare and environments for children. Research is measured through functional magnetic resonance imaging, through simulation, and through observation. Topics vary in complexity, some relying upon technical analysis, and others upon more fundamental means of perception and measurement. Much of this research is ongoing, so what is represented
here is truly work in progress – we are still at an exploratory stage where promise is greater than achievement, and the forging of a vocabulary that neuroscientists and architects can share is still a daunting task. But an important start has been made. This transitional phase can be seen by assessing the various methods employed and the various types of stimuli used in the five papers that follow:

Joel Martinez-Soto, Leopoldo Gonzalez-Santos, Erick Pasaye and Fernando Barrios: Exploration of neural correlates of restorative environment exposure through functional magnetic resonance

Vedran Dzebic, Justin Perdue and Colin Ellard: The influence of Visual Perception on Responses Toward a Real-World Environment and Application Toward Design

Eugenia Victoria Ellis, Elizabeth Gonzalez, and Donald McEachron: Chronobioengineering Indoor Lighting to Enhance Facilities for Aging and Alzheimer’s Disorder

Robyn Bajema, Upali Nanda, Debajyoti Pati and Hessam Ghamari, Lessons from Neuroscience: Form Follows Function, Emotions Follow Form

Karen Dobkins and Gail Heyman: Using Neuroscience and Behavioral Data to Tailor Visual Environments for Infants and Children

The first three report actual experiments, though only Martinez-Soto et al use brain measures (fMRI, functional magnetic resonance imaging), while Dzebic et al and Edelstein et al analyze subjects’ response to architecturally relevant stimuli. The last three papers anchor their reports by literature reviews, but with varying specificity as to the extent to which the reviews ground hypotheses subject to current or potential future testing. The emphasis is primarily on visual stimuli, though Edelstein et al focus on auditory “soundscapes.” Ellis et al look not at visual perception but rather at how lighting patterns affect circadian rhythm. The remaining four studies use visual images as stimuli, with the single exception of Dzebic et al, who
monitor subjects’ judgment of three-dimensional spaces, both in the laboratory and in an actual building. Overall, we see hypotheses being generated on the basis of behavioral studies and neuroscientific data from both animal and human studies, though only one paper (Martinez-Soto et al) reports new neuroscience data. Nonetheless, the five papers between them address a wide variety of topics, creating a rich tapestry of interrelated subjects, findings and directions. The application of these findings points the way to broad-reaching implications for the influence of the built environment upon brain development in the formative years of childhood, in adult experience, and in aging populations.

With this general framework in place, we turn to a brief overview of the contributions of each chapter:

**Joel Martinez-Soto, Leopoldo Gonzalez-Santos, Erick Pasaye and Fernando Barrios: Exploration of neural correlates of restorative environment exposure through functional magnetic resonance**

Environmental Psychological Restoration is the result of the recovery of stress or attentional fatigue through restorative environmental exposure. Neural correlates of restorative environment exposure are assessed with functional magnetic resonance imaging (fMRI) to evaluate the influence of restorative environments upon mood and well-being, while behavioral evidence of psychological restoration was provided by having participants view photographs with low or high restorative potential as assessed by baseline measurements of self-reported stress before and after viewing these two categories of environment. Activation of the middle frontal gyrus, middle and inferior temporal gyrus, insula, inferior parietal lobe and cuneus was dominant during the view of highly restorative environments, whereas activation of the superior frontal gyrus, precuneus, parahippocampal gyrus and posterior cingulate was dominant during viewing of environments of low restorative value. The list of brain regions may at first seem overwhelming,
so the authors briefly review results from cognitive neuroscience that will help us interpret the role of these key regions. The authors see their results as consistent with Kaplan’s attention restoration theory and suggest that building-integrated vegetation could provide cognitive resources necessary for adequate human functioning. It is interesting to note the restorative powers of the natural environment over the built environment, raising the question of the ability to mimic nature in building solutions, and to integrate natural environments into urban planning solutions to support the positive aspects of psychological restoration.

**Vedran Dzebic, Justin Perdue and Colin Ellard: The influence of Visual Perception on Responses Toward a Real-World Environment and Application Toward Design**

The key notion of the paper is the *isovist*, the two-dimensional polygon of the ground plane generated by the space visible from a particular viewpoint in a built environment. Each isovist is unique to its own particular viewpoint, and as an individual moves through their environment the isovist will change to reflect their new viewpoint within the environment. The authors provide two experiments to examine the extent to which isovist analysis can capture experience of real-world environments. Experiment 1 uses isovist analysis to describe experience within a controlled, real-world, laboratory environment, whereas experiment 2 uses a student centre to examine the robustness of isovist analysis in capturing experience of a complex, real-world environment. Experiment 2 suggests that isovist analysis can capture experiences such as spaciousness, but failed to capture other responses. Regression analysis suggests that many variables contribute to experience, including previous experience with the building and the presence of other individuals. This suggests that experience of real-world, complex environments cannot be captured by the visual properties alone.
**Eugenia Victoria Ellis, Elizabeth Gonzalez, and Donald McEachron:**

**Chronobioengineering Indoor Lighting to Enhance Facilities for Aging and Alzheimer’s Disorder**

Chronobiology examines temporally periodic phenomena in living organisms. Chronobioengineering, then, is an emerging field that translates these concepts into practical applications such as the impact of light cycles on circadian rhythms. The authors review data on circadian rhythms and the impact of disruptions of these rhythms on human health and well-being, with special attention to the elderly. This is the basis for hypotheses, yet to be tested, on the positive impact of new forms of LED lighting on, for example, aging populations with dementia. A daylight-mimicking “luminaire” will be installed at St. Francis Country House as a clinical trial of ways to improve sleep and global functioning of individuals with dementia.

**Robyn Bajema, Upali Nanda, Debajyoti Pati and Hessam Ghamari:**

**Lessons from Neuroscience: Form Follows Function, Emotions Follow Form**

The authors offer a perspective on restorative environments complementary to that of Martinez-Soto et al. They view “the visual image” as a bridge between architectural environments and fMRI experiments, reviewing literature on neural responses to pleasant versus unpleasant stimuli, with special attention to the amygdala and related brain regions. Many studies show that visual images of scenes from nature can reduce the negative emotions of fear, pain and anxiety, aiding restoration to a positive state. But which specific visual properties contribute to this effect? The authors study visual “contours” within the theoretical paradigm of neuro-architecture to generate specific hypotheses for architecture and neuroscience. However, their argument for a rapid emotional response to form elicited by the specific property of contours seems somewhat reductive, given the role of contours in diverse visual tasks, whether or not they carry an affective load.
Nonetheless, they claim that work in progress will “provide a potent and
objective route to engineering emotions through form, and a way to harness
neuroscience theories, tools and methods to deliver predictable functional
outcomes in the built environment.”

Karen Dobkins and Gail Heyman: Using Neuroscience and Behavioral
Data to Tailor Visual Environments for Infants and Children

The final paper has some common concerns with the one which precedes it,
but with a special emphasis on visual environments which support child
development. The authors review literature from visual neuroscience plus
studies assessing how different types of visual environment affect well-being
and mood. On this basis, they outline future research aimed at creating
tailored visual environments which help promote basic visual development in
infants, and which promote certain psychological states (moods) that best
complement an individual child’s particular temperament. The authors
discuss infants (ages 0 – 3 years), where the main design goal is to create
visual interiors that are easily discernible and preferred by infants and then
move to older children (ages 3 – 17 years), discussing the concept of
temperament, how it can be measured, and how it can be steered by the
environment in beneficial ways. The general concern, then, is with the study
of how personal living spaces might improve well-being, mental health
and mood, with a particular focus on the effects of the visual
environment (although, the auditory and tactile environment are
important as well – see Edelstein et al for a discussion of the auditory
dimension).

The authors all agree that environmental factors influence brain activity and
have the power to influence well-being in, and experience of, the built
environment. This opens the door to diverse applications linking
neuroscience research – as well as cognitive science and other evidence-
based studies – to the design of the built environment, and the careful
integration of the built environment and the natural environment. Architectural design strategies that have been identified as significant factors include natural and artificial light; acoustics; aesthetics; wayfinding and landmarking; space making; proportion and dimension; focal length and angles of incidence; color and pattern; visual arousal and stimuli; distraction and confusion; and restorative environments. If such commonly conceived strategies can be appropriately applied to design solutions, then human behavior, including education and healing, can be directed and reinforced through environmental design. The architect and neuroscientist can work together to assess how to tailor environments to help achieve desired outcomes. This prospect is both promising and challenging, and it is the task of the Academy of Neuroscience for Architecture catalyze the collaborative deliberations that will have a profound impact upon the future of architectural design.

References