

## Through → the Mind's Eye

How neuroscience is recalibrating the built environment.



*This spread* A residence and day centre for adults on the autism spectrum, The Centre Lise et Yvon Lamarre in Montréal by Lemay applies neuroinclusive design by integrating spatial logic with calibrated sensory control. Using its Sensory Fragmentation Framework, developed by Lemay's FLDWRK unit in collaboration with Fondation Yvon Lamarre, the architects developed spatial, material, and sensory interventions that respond to neurodivergent users who experience both hyper- and hyposensitivity. Muted colour palettes and consistent materials prevent visual overload, while gentle textures and balanced daylight fixtures mitigate tactile and glare stimuli. Softened corners and thresholds smooth spatial transitions. The campus unfolds through four architectural fragments including individual houses, transition zones, shared commons, and exterior landscapes, offering graduated engagement.

It is a small irony that as the very idea of science seems under increasing threat, there is a growing movement towards a rigorous application of evidence-based design that relies on sophisticated neural research. Increasingly, the terms neuro-design, neuro-aesthetics and neuro-divergence are finding their way into design firms' self-descriptions.

Briefly defined, neuro-design integrates results from neuroscience into the design process. By understanding how the brain perceives and processes sensory information, designers can create more engaging experiences. For example, the use of colour, shapes and patterns can be optimized to evoke specific emotional responses and improve the quality of user interaction.

Neuro-aesthetics more narrowly explores the neural mechanisms underlying why certain designs or their elements are perceived as

"beautiful" or pleasing as well as how these perceptions influence our subsequent behaviour and emotions.

Finally, neuro-divergence design involves understanding and accommodating diverse cognitive load abilities and sensory sensitivities. While this is frequently applied to individuals with autism or ADHD, the term "neuro-inclusive" suggests a more complex need to accommodate preferences that are not universal to our genetic codes and DNA.

### **Bred in the Bone (or at least our DNA)**

Neuro-design, and particularly aesthetics, often begin with the idea that such things as "beauty" spring from species-wide neural biases in the brain that arrive preloaded through a long genetic and DNA history. Thus, there tends to be a universal beauty preference involving, for example, symmetry, average-



ness, proportional harmony, and biophilic complexity, all honed by evolutionary survival.

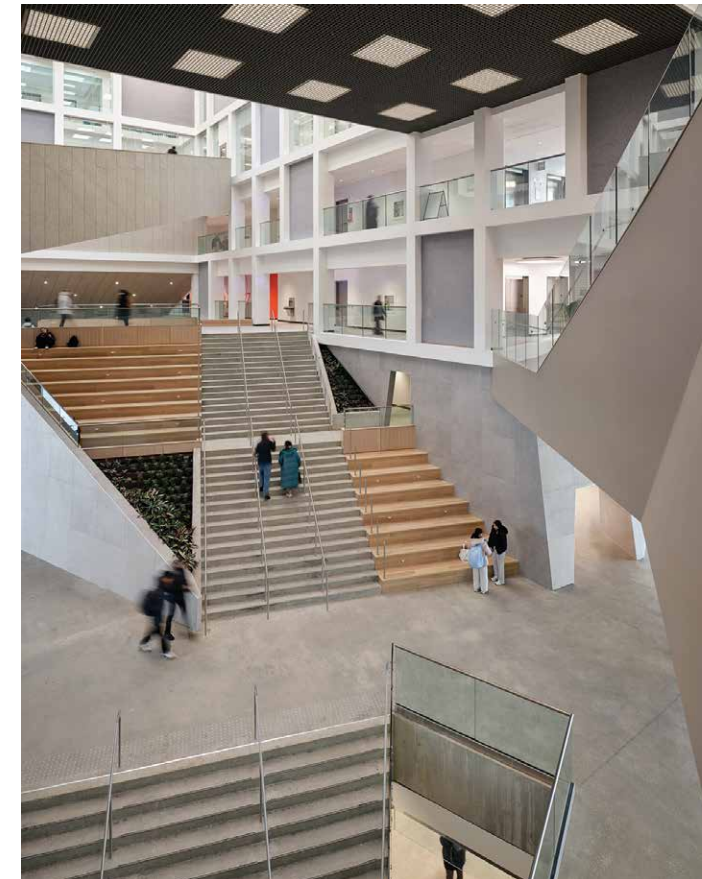
In exploring this intersection of neuroscience and interior design, Toronto-based NeuroDesign Academy has centred on the idea that our aesthetic and restorative responses to design and aesthetics are evolutionarily hard-wired, and that beauty, biophilic cues and responses to spaces resonate across cultures because they are encoded in our neurobiology. The Academy's motto, "Defined by Beauty, Backed by Science," and its guiding maxim, "Form Follows Feeling," both rest on the premise that aesthetic experiences are primarily universal, DNA-driven imperatives, and that tapping into them allows designers to craft spaces that reliably enhance well-being.

As founding director Linda Kafka explains, "our brains were sculpted for millions of years in nature, and we spent almost our entire evolutionary history in nature with only a small part, maybe 6,000 years, in

the built environment. We evolved from living with trees and this is where we live today. What's beautiful in this," she says, referring to an image of a treeless cityscape. "What have we done to ourselves?"

A universal presence of genetic responses means human brains are tuned to recognize and reward quite specific characteristics; and they do so in our non-conscious, Kafka argues, 95 per cent of the time. Across cultures, for example, symmetry in facial features tends to activate brain regions associated with reward and trust, suggesting an evolutionary bias toward recognizing health and genetic fitness. Symmetry also extends beyond faces into interiors where mirror-balanced façades, equal-sided room layouts, and centrally aligned furnishings all register as harmonious and pleasing.

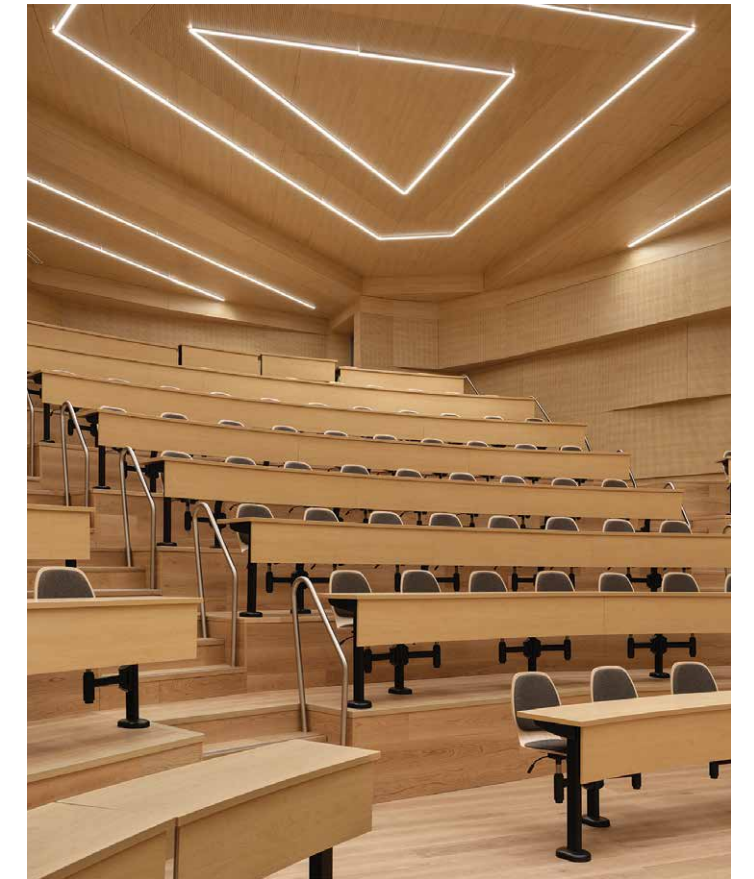
Similarly, *averageness*, or proximity to a population's mean facial template tends to evoke positive responses, likely because they signal genetic diversity and developmental stability. In design, this



*This spread* The Sam Ibrahim Building at the University of Toronto Scarborough plan unfolds as interlocking "printer's tray" compartments arranged in concentric rings around a six-tiered grand stair, clustering 20 classrooms, lounges, and pods. Designed by Danish firm CEBRA and Toronto's ZAS, this ripple-inspired layout reduces navigational stress and cues transitions between active, social and low-stimulus zones. Recessed daylight "harvesting" and tunable LEDs enable automated and occupant-controlled shifts in brightness and colour temperature, aligning circadian rhythms and personal preferences. Pale concrete, warm wood strips and textured insets provide reassuring haptic feedback.

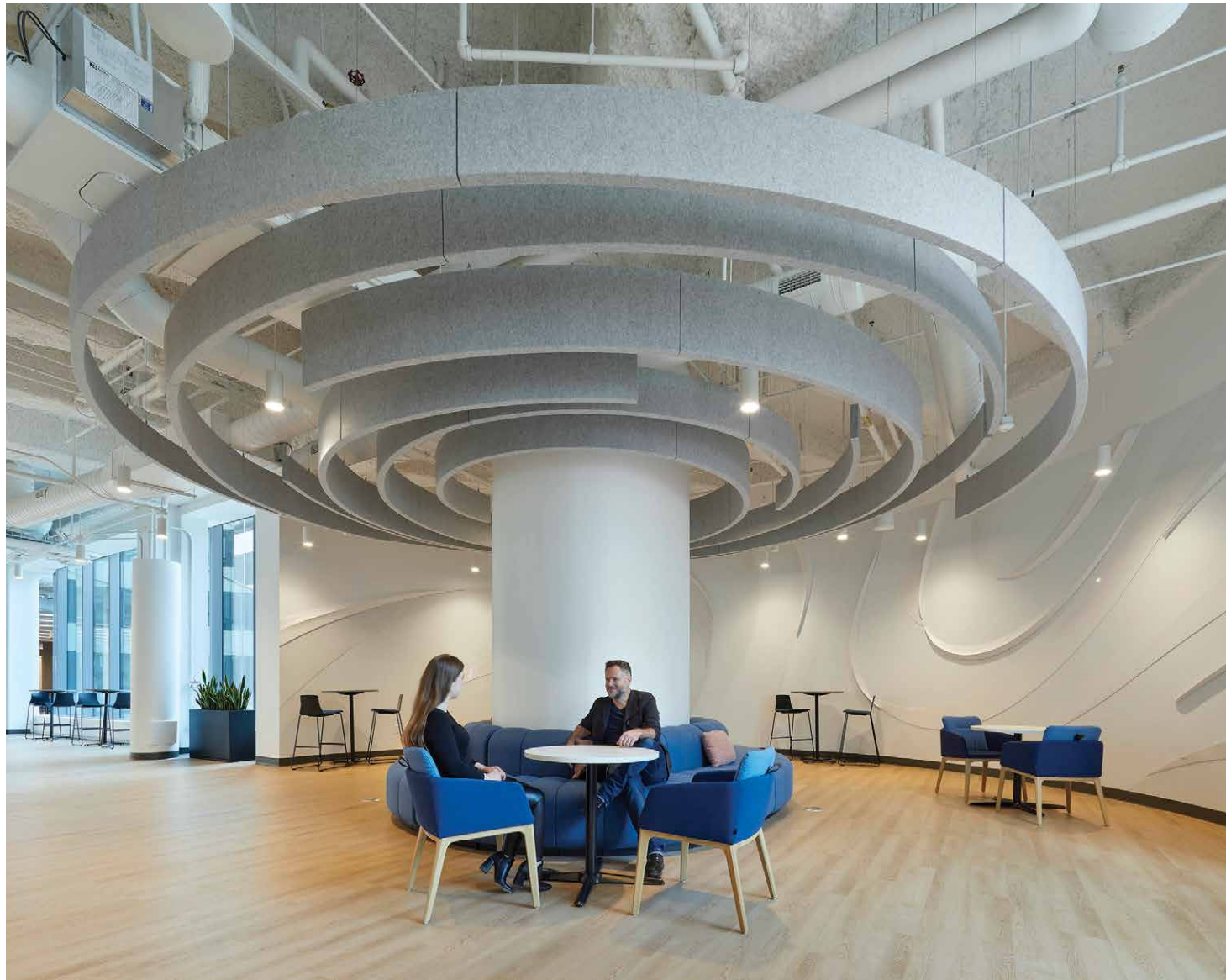
translates into favouring forms and patterns that feel familiar, such as arched windows with gentle curves, softly rounded furniture silhouettes, or repeating tessellations that echo natural proportions. Proportional harmony, particularly the tried-and-true Golden Ratio, further taps hardwired reward pathways. Spaces resembling the Golden Ratio often evoke a sense of balance and harmony, even if we are not conscious of a mathematical underpinning.

British architect Thomas Heatherwick, designer of the much-praised neuro-design driven Maggie's Centre Leeds, recently commissioned a study from Colin Ellard, a cognitive neuroscientist and director of the Urban Realities Laboratory at the University of Waterloo, to do a "boring building" study of Toronto. He found our eyes can't anchor to modern blank buildings because there are no details and that the visual complexity of historic buildings notably influenced mood and stress levels. Sensory-rich environments promote mental wellbeing (Adolf Loos, given the



long-lasting impact of his 1913 essay "Ornament and Crime," may have a lot to answer for!). According to Kafka, another study found subjects in buildings with views of primarily linear objects (buildings) complained about headaches and exhaustion by 3 o'clock. "The researchers found that constantly staring at vertical lines takes a toll on cognitive load."

Survival instincts play a not-insignificant role in defining comfortable environments. Our ancestors, goes the argument, traversed open savannas where threats could emerge from any direction. As a result, human brains evolved to seek out environments offering both *prospect* (clear views) and *refuge* (protected enclosures). Findings of survival-driven "prospect-refuge theory," therefore, might argue that spatial comfort through back-to-wall seating relaxes the amygdala (a fear processing part of the brain) and clears sightlines that satisfy threat detection. Overhead canopies balance enclosure with openness in vaulted ceilings or suspended baffles.



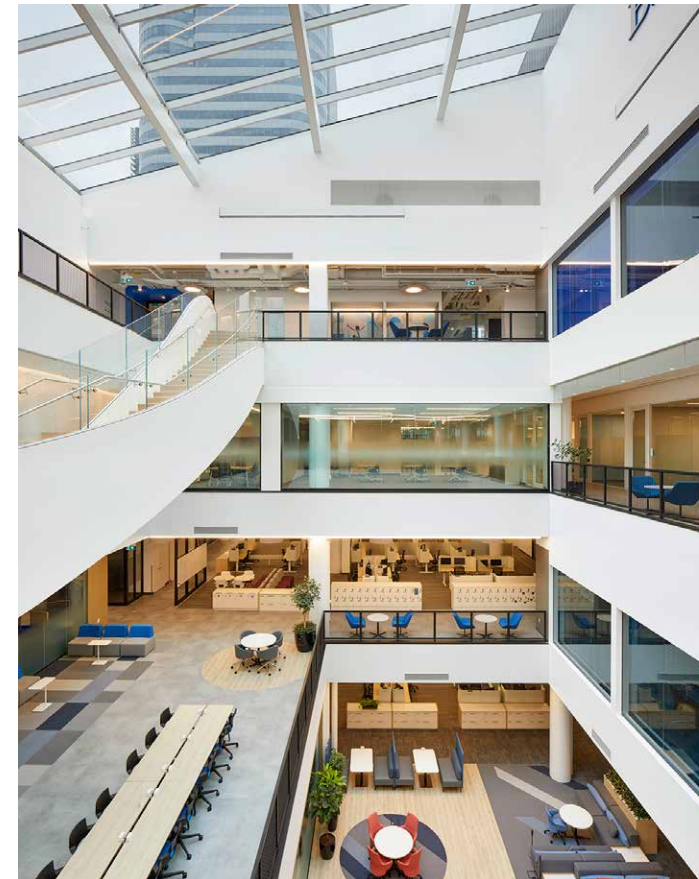
In addition, biophilic safety cues such as water features and abundant greenery signal resource abundance and low threat, reducing cortisol and enhancing focus. Textural interplay mimics skin tone signals of health and vitality. Matte-and-gloss contrasts, pastel underlays, and subtle highlights evoke warmth, approachability, and human scale.

Roger Ulrich's 1984 study found hospital patients recovering from surgery who viewed nature scenes instead of a brick wall had faster recovery, lower stress, and higher "pleasure" ratings and this kicked off the now well-established evidence-based medical facility design movement. In their 1999 paper, Vilayanur Ramachandran and William Hirstein outlined a set of eight guiding principles—ranging from peak-shift effects to grouping—that they argue underlie why specific visual patterns tend to be appealing across different societies. Both before and after this influential work, multiple other studies have supported and nuanced the theory of genetically embed preferences.

### But Are Genes Universally Structured?

Complicating these "universal" bottom-up drivers, however, lie genetic polymorphisms: discontinuous genetic variations existing in the same population that can modulate an individual's reward sensitivity outside the norm. Variants in dopamine-related genes tune how an individual may respond quite differently from the norm regarding design aesthetics. While symmetry and proportion may spark similar initial reactions, colour perception diverges even among genetically similar individuals. Variations in retinal opsin genes affect how finely we distinguish hues, making some people more sensitive to subtle shifts in blues or reds. Serotonin transporter variants, for example, shape mood stability and stress resilience in response to lighting schemes and colour palettes. Opsin gene variations govern hue discrimination, making one person's vibrant teal subdued to another.

Individuals with dopamine-sensitive alleles may prioritize rich, high-contrast patterns that strongly engage reward centres while



*This spread* Designed by Zeidler Architecture, a central "ripple" motif radiates from BMO Academy's central stairwell, guiding movement and reducing navigational stress while introducing biometric shapes. Curved corridors and concentric zones are intended to create a calming, intuitive journey that mirrors natural water patterns. Acoustics and lighting which include glass partitions balanced with soft goods ensure speech clarity in active zones while maintaining low reverberation in quiet areas. Recessed cove lighting and flexible LEDs create gentle transitions of brightness and colour temperature but allow users to adjust visual stimuli. Light blues, soft greys, pale concrete, and warm wood finishes minimize glare and visual clutter while smooth glass, polished metal, and subtle wood grain offer tactile variety without overwhelming the senses.

Zeidler

those with serotonin-stabilizing variants might gravitate toward calming palettes and soft gradients. Such diversity, from a designer's perspective, ensures a "one-size-fits-all" colour scheme will never satisfy everyone, underscoring why neutral backdrops plus accent lights or adjustable LEDs are often used to optimize broad appeal. Ironically, says Kafka, grey has been the go-to for homes, yet neuroscience has shown it increases stress and may be why there is a resurgence in earth tones, natural dyes and more warm hues.

Emerging neuro-diverse design, therefore, recognizes that cognitive and sensory variations reflect a spectrum of common polymorphisms. Frequently referenced in design projects is autism that is largely polygenic, meaning it arises from the combined effect of thousands of common variants, each nudging neurodevelopment in small ways. All this underscores that while genetics shape neurocognitive profiles, no single DNA blueprint can universally prescribe



optimal design solutions. The challenge for the designer is compounded when spaces are designed neither for the "universal" influences nor solely for such individual profiles.

Joanne Fernandes, project lead for Holland Design's award-winning Wonderment Child Centre in Calgary, emphasizes crafting flexible spaces that adapt to each child's unique needs, ensuring every material, light source, and acoustic treatment is tailored to individual sensory profiles. For the BMO Academy in Toronto, Ian Franceschi, creative director of interior design at Zeidler Architecture, reports "we were able to enhance the planning strategies and address sensory regulation, focus, and cognitive variability. This produced a wider range of environments: from quiet zones and low stimulation areas, both acoustic and visually, to larger flexible gathering and event spaces." Instead of "additional" areas, they integrated inclusive responses "into a broader design rationale and used it as a lens through which decisions were made."



*This spread* Wonderment Child Centre in Calgary by Holland Design blends foundational neuro-design strategies with principles tailored for neurodiverse learners to foster both stimulating yet soothing environments. The design incorporates zoned experiences while interactive features offer creative sensory profiles. Sliding door abacuses and wall-mounted pegboards let children adjust auditory and visual stimulation at will, empowering those who seek extra input or need moments of withdrawal. Clearly marked routes, consistent material cues and organic-shaped pathways reinforce predictability and reduce anxiety for all young learners who respond best to routine and spatial clarity.

### Embedded Genes or Learned Responses?

While the argument for understanding embedded universal responses to guide neuro-design and aesthetics is compelling, there are also counter studies that have challenged these findings. Lived experience such as education, culture, education and even the interaction with distinct physical environments, it is argued, may hone or even counter embedded preferences. For example, a study of responses to European and Chinese landscape art found Western viewers had neuro-positive responses to the former but negative to the latter while Chinese viewers reacted positively to the later but neutrally to the former.

Several studies found the preference for the Golden Ratio in designs yielded mixed results or failed to show across-culture “universality.” Also, while the link between “averageness” in faces or objects connected to perceptions of safety and health is well-documented in Western samples, cross-cultural work has shown significant variation. Similarly, some studies testing the preference for clear sight-lines coupled with shelter found personal familiarity with landscape type or task demands could reverse these preferences. Many critics



continue to complain that too much of the research reflects sample bias skewed towards Joseph Henrich’s (and others) 2010 acronym WEIRD (Western, Educated, Industrialized, Rich, Democratic).

Cultural-neuroscience research shows that even basic perceptual and emotional circuits are tuned by local norms, language, education and accumulated experience. For instance, the positive neuro-responses to the Golden Ratio using Italian students can be neutral or even aversive in other populations. Cross-cultural architectural surveys confirm that ornament, colour symbolism, spatial hierarchies and organic motifs carry locally specific meanings.

What feels “restorative” in a Finnish sanatorium may not translate directly to a Japanese ryokan or an Omani majlis, because decoration, materiality and shape are freighted with cultural narratives. Minimalist tatami rooms in Japan draw serenity from learned ritual just as Baroque opulence appeals through centuries of contextual conditioning. Kafka recognizes this key nuance. “Our reaction is subject to many things. It is subject to culture, to race, religion, age. Part of what we as human beings find attractive and beautiful may differ. Some



may find a minimalist space beautiful while others will find a more maximalist space more beautiful.” Even Anjan Chatterjee, considered by many as the godfather of neuro-aesthetics, argued in 2013 that evolutionary pressures endow humans with foundational aesthetic inclinations, but these are continually reshaped by such variables as cultural symbols, educational contexts, and personal narratives.

The implications for neuro-design practice are that we begin with universal tendencies such as daylight, biophilic cues, organic forms and moderate complexity, but must always validate with the actual user. Expect and embrace variation from education, social norms and personal history that may cue different neural pathways. Neuro-design tools like EEG, eye-tracking or post-occupancy surveys should be applied in the field, in each cultural context, rather than assumed. In short, core biases toward nature, gentle curves or symmetry likely do spring from our DNA and deep evolutionary heritage, but they are far from impervious to the sculpting force of culture, learning and environment. In terms of culture, Fernandes laments that although Wonderment uses carefully designed play areas to encourage positive interaction between

children from different cultures, she believes understanding cross-cultural neuro differences needs more investigation.

A truly human-centered neuro-design practice recognizes both our shared brain “hardware” and our richly diverse and “evolving” brain-software. For designers, these findings suggest a blueprint involving first engaging universal triggers (although cross cultural universality needs more work); second, factoring in implications of neurodiversity; and third, mediating results with individual, environmental and cultural cues. In all three areas, the sophisticated brain monitoring tools of neuroscience will have a roll to play. Only this will produce truly neuro-inclusive design. It is happening, says Kafka (some larger firms, such as Lemay and Denmark’s CEBRA boast their own internal neuro-design research units, with projects featured here), but unfortunately “not fast enough. We have yet to have one neuroscience laboratory in any Canadian design department to train the next generation of designers.” ■