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# Towards Responsive Interiors: Practicing Neuroscience-Informed Design Approaches in Interior Design Education

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***Abstract***

*Growing insights from neuroscience—here, understood as an umbrella term for a number of empirical disciplines that study the relation brain, nervous system, genes, and behaviour—and its inquiries into how human behaviour and well-being is affected by interiors can enrich and inform the design of interiors and its properties innovatively. Interior design education can play a key role in linking the insights stemming from research and turn the question of human, experiential responsiveness into an elementary perspective of the design process.*

*In this paper, we explain a pedagogical method developed for one of our graduate studios that addresses this issue and create a framework for a neuroscience-informed focus. Additionally, we illustrate the outcomes of student work created in this studio through two projects, each having a unique focus relating to interiors and the question of human behaviour and well-being, i.e., visual complexity and affordances. With the establishment of this master studio, we aim to provide students with an awareness and insights into how the many fields of study within neuroscience can facilitate, support, confirm, or adjust design knowledge.*

*Keywords: interior design, interior education, neuroscience-informed design, visual complexity, affordance*

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## Introduction

Knowing that we spend about 80% of our time indoors, it is remarkable that we know relatively little about our indoor condition and how interiors influence our minds, physical state, well-being, level of productivity, etc. New developments in the rapidly evolving, modern domain of neuroscience promise a new perspective on how the built environment influences our mental state. Generally, the domain of neuroscience overarches many empirical disciplines such as biology, experimental psychology, cognitive science, chemistry, anatomy, physiology, computer science, and investigates the relationship between the brain and behaviour (Kandel et al., 2012). Tools and concepts deriving from this domain make it possible "to identify the causal biological chains extending from genes to human behavior" (Albright, 2015, p. 199) and to clarify why and how humans respond to outside stimuli.

The increasing evidence-based insights stemming from neuroscience are indispensable for the interior discipline. These insights offer the discipline new, vital approaches that can profoundly improve the comprehension of the complex relationship between man and his immediate spatial environment. They elucidate how our built environment, exteriors and interiors, affects human behaviour and mental well-being. Put simply, they expand the range of design instruments of the interior discipline that considers physical, social, and psychological needs.

This knowledge domain, arising at the intersection of neurosciences and interior design and architecture, offers a set of insights applicable to spatial design in general and interior design in particular. Triggered by the potential that it offers to the discipline of interior design, we installed a master studio that aimed to investigate and enrich the material interior by a better understanding of the spatial effect on the mental well-being of its user. In this master studio, we explored how we can apply this knowledge and how we, through design exercises, can contribute to the development of responsive interior morphologies. We interpret interior morphologies as fragments and elements of space that can enhance responsiveness. This investigating perspective is primarily based on the conviction that the new domain of neuroscience offers unprecedented opportunities to influence the interior.

After a brief introduction to neuroscience and its meaning for spatial design disciplines, we explain the pedagogical objectives and organisation of our master design studio. Subsequently, we examine two projects based on the approach mentioned above, accomplished by graduate students attending the master studio. We discuss and illustrate the added value of a neuroscience-informed design approach for the development of responsive interior morphologies while at the same time exposing the problems and difficulties students faced during the design process.

## Neuroscience and Its Significance for Spatial Design Disciplines

As the neuroscience-informed design approach is young and relatively new for the spatial design disciplines. We will in the following, without pretending to be exhaustive, introduce some of the basic underpinnings of neuroscience.[1] Neuroscience is understood as an umbrella term for several empirical disciplines that study the relation among brain, nervous system, genes, and behaviour (Albright, 2015; Kandel et al., 2012). It is a dynamic and fast-moving scientific domain[2] that delves into how the human brain works: "how circuitry within the brain mediates our action, perception, and memory—all in relation to our interactions with and experiences of both the physical and social worlds in which we are immersed" (Arbib, 2015, p. 76). It provides us knowledge about how information, captured by our senses (sight, hearing, touch, smell, and movement), reaches our brain and is then converted into thoughts, memories, and emotions. Neuroscientists regard our brain as an "information-processing device" and study the synaptic transmissions of stimuli at a molecular and cellular level, providing knowledge about the neural basis of cognition.

The acquisition, organisation, and use of information is determined by the constitution and functioning of our brain (Albright, 2015). They can be thoroughly examined today due to the rapid and increasing development of powerful experimental tools, such as electroencephalography (EEG) and functional magnetic resonance imaging (fMRI). These techniques enable scientists to accurately register the flow of data-processing through the brain system, and locate and measure the neuronal activity regarding different sensory, perceptual, cognitive, and/or behavioural conditions. Research shows that our brain is equipped to process certain information better than others. For example, it proves that our brain is exceptionally well-configured to process visual stimuli. According to the American

[1] For an in-depth and exhaustive literature review on the developing and emerging concepts at the intersection of neuroscience and architecture, see Karakas & Yildiz (2020).

[2] Architects and scholars Sarah Robinson and Juhani Pallasmaa claim the following about this evolution: "The knowledge brought to us by cognitive and neurosciences is developing so rapidly, and the implications of this field are so far-reaching, that one is nowadays in a constant state of revision" (Robinson & Pallasmaa, 2015, p. ix)

neuroscientist and psychiatrist Eric Kandel, ″half of the sensory information going to the human brain concerns visual processing″ (Kandel et al., 2012, p. 238), which could explain our visual bias in reading and experiencing our built environment (Holl et al., 2006; Pérez-Gómez, 2008). In one of the following case studies, we examine how visual complexity can be included in an interior design.

An important assumption in neuroscience research finds its origin in evolutionary biology, stating that human beings are a biological species that survived and evolved over successive generations and that our evolution to a significant extent influences the way we interact with the world. During reproduction, generation after generation, our ancestors passed on information on traits and actions which have proven successful in the light of survival and which is deeply stored into our genes. In turn, our survival instinct has determined the way our brains are equipped and function and largely directs our actions unconsciously (Arbib, 2015). In other words, "we survived as a species because of our perceptual system, that is highly influenced in its development by our survival mechanisms" (Pinker, 2003, p. 2).

The domain of neurosciences provides an understanding of how human beings perceive and experience the world. Hence, its importance for disciplines responsible for the man-made built world can hardly be overestimated. A seminal contribution, *The Architect's Brain* by architecture historian and theorist H. F. Mallgrave, announces this new knowledge domain as the "neurological justification for some very timeless architectural ideas" (Mallgrave, 2011, back cover). Scientific initiatives, such as the Academy of Neuroscience for Architecture (ANFA),[3] show the growing interest of the architectural community in the subject. Scholars connected to this platform are trying to close the gap between recent research and its implementation within the design disciplines. Especially phenomena studied within the interdisciplinary field between evolutionary biology, environmental psychology, and cognitive science appear to lend themselves very well to inform spatial design. Such phenomena include, for example, *thigmotaxis* or the tendency to avoid the centre of open spaces, seeking the edges (Kallai et al., 2007; Sussmann & Hollander, 2015); *visual complexity*, human's visual orientation and preference for ordered complexity (patterns) and detailing (Joye, 2007; Taylor, 2006); *visual symmetry,* our preference for symmetrical features, associated with power and robustness (Cárdenas, 2006; Ruggles, 2017); *storytelling*, the human trait of narrative ability or

[3] ANFA, established in 2012, is a scientific platform that organises biennial conferences, lectures, and workshops (https://www.anfarch.org).

the ability to create multiple scenarios in any situation to create a sense of identity and meaning (Aldama, 2015; Young & Saver, 2001); *affordances*, understood as the qualities of an object or an environment that communicate opportunities to act in a certain way (Djebbara et al., 2019; Gibson, 1966; Gibson, 1979; Rietveld & Kiverstein, 2014); and the notion of *biophilia*, concerning human's instinctive need to connect with nature (Kaplan & Kaplan,1989; Kellert et al., 2008). Some of these phenomena will be explained in greater detail in the student projects.

In addition, there is a rising interest of interior design scholars in the influence of interior environments on human behaviour. The majority of these evidence-based explorations focus on healing, retail, education and working environments, and the impact of space on its users (Day et al., 2021; Kim et al., 2014; Olinger, 2012; Petermans et al., 2013; Quan et al., 2017; Shepley & Danko, 2017). It is our intention to contribute to this field by exploring how evidence-based knowledge, stemming from the domain of neuroscience (neuroscience-informed design), can be applied as an additional parameter within the design process, leading to responsive interior morphologies.

**In Search of Responsive Interior Morphologies: Two Projects**

Our master studio *Morphology of Interiors* operated since 2017 (Michels et al., 2019; Storgaard & Michels, 2019). It was installed with the particular purpose to explore, transmit, and apply neuroscience-informed design insights and its inquiries into how interiors affect human behaviour and well-being in the process of designing interiors. The instructional team consists of two instructors, both having degrees in interior design and architecture as well as having a doctoral degree, one in interior design, the other in architecture. The studio allows 20 graduate students to participate in a one-year program, with full-day meetings once a week. The program is divided into two semesters, each employing two different methodologies, responding to the studio's didactic idea that learning and developing knowledge about the interior goes hand in hand.

The first semester is structured around learning strategies in which knowledge obtained by the reflection on the peers' work, awareness through the process of crafting and designing, and the development of a personal stance about the field of interior elements form the content of the course. Through this method, we aim to develop in-depth insights into and awaken renewed attention for the morphology of interiors through analysis and design exercises (Michels et al., 2019; Storgaard & Michels, 2019).

During the second semester, another method is applied, which is based on the implementation of neuroscience-informed insights and forms the focal point of the master thesis. Students develop their master thesis individually and determine a theme and a site in which the relationship between mental well-being and space can be explicitly examined. Projects in which processes of working, learning, and healing unfold, as well as spaces for rituals and places of experience and sociability, etc. are explored.

Preliminary in-depth exploration and information gathering into these themes are mainly based on the study of scholarly works, articles, and books. Additionally, we invite scholars from various fields related to neuroscience to give lectures that can inspire the design of interiors. These are typically designers who employ evidence-based knowledge in their practice and psychologists. Finally, the students decide on a particular focus from their information gathering. Next to the themes discussed in the following projects, notions like appropriation, acclimatisation, contemplation, mental recovery, collectivity, etc. are in favor.

In the following, we highlight two master's thesis projects (2019–2020) which examined the concepts of *visual complexity* and *affordances*. They are chosen to illustrate the extremity of scope and application, one situated in a building, the other in an urban context. They moreover introduce unconventional interiors, which expand and enrich the field of interior design practice.

These projects demonstrate how the insights gained from past neuroscience research results concerning space can be interpreted, translated, and concretised into a spatial design. The results are subjective interpretations and have not been subject to scientific verification. Therefore, they should also be seen as open-ended design suggestions rather than definitive solutions.

**Project 1: Visual Complexity**

This project concerns a reconversion of a 19th-century sugar factory on an embankment in the Dutch countryside into a 'cultural house' for polyvalent usage. This former factory appears more or less in its original state. Its reconversion did not develop from an interpretation of a specific program but from an appraisal of the crafts characteristic for this industrial building and its intrinsic spatial qualities. Inspired by the many distinct details of the numerous construction elements and by its relatively few but genuine materials, the student developed an approach in which the notion of ornament became centre stage. Subsequently, this focus advanced into an additional implementation of visual complexity.

Research in various domains points to the importance of visual complexity in our built environment and can be seen as the driving force of place experience. Visual complexity, determined by the number of different elements seen and their organisation and symmetry (Forsythe et al., 2011), affects our mental and physical well-being. Nor too much, neither too little visual complexity is good for our mood and cognitive performance, which is why, according to research, the so-called moderate visual complexity is generally preferred above a low or high visual complexity (Berlyne, 1971). Moderate visual complexity influences human behaviour positively and occurs in the organisation of different elements, structures, symmetry, and order. Spaces with too high levels of visual complexity, mostly determined by clutter and disorder, afford human behaviour negatively and can, for instance, cause indecision, lower cognitive capabilities, and bad eating habits (Kotabe et al., 2016; Maxwell, 2007; Vartanian et al. 2017). Spaces with too low level of visual complexity, thus being extremely well-ordered and plain, evoke under-stimulation and can cause reduced workplace performance, inattention, and boredom (Evensen et al., 2015; Salingaros, 2014).

Visual complex conditions are highly dependent on vision. Research reveals that one sense takes the upper hand in the interaction between man and his environment. Half of the sensory information going to the brain is visual, which means that vision plays a primary role in the experience of the spatial environment (Albright, 2015; Gibson, 1979; Kandel, 2012; Sussman & Hollander, 2015). Humans have evolved to register and favour certain forms over others. Our visual preferences are informed by what nature wants us to see. In the end, this property led to the survival of our species in the past. The way our brain processes visual information and how our visual system works largely directs our likes and dislikes (Albright, 2015; Brown & Owen, 1970; Starr, 2015; Sussman & Hollander, 2015).

Across studies, it appears that human beings appreciate complex visual stimuli. The human sight easily discerns inherent order and regular structures, consisting of repeating lines in colinear, curvilinear, parallel, and radial patterns (Polat & Sagi, 1994; Li & Gilbert, 2002). Possibly, these ordered patterns, which are ubiquitous in nature—think of the veins of a leaf or the barbs of a feather—have a calming effect because they are effortlessly processed by the organisational properties of our visual system. These patterns, however, have to come with a level of complexity (Albright, 2015).

In nature, such complex patterns, also called fractal geometry, occur everywhere. Visual complexity in nature can be described as a recurrence of similar visual information across different levels of scale or as patterns that repetitively occur in smaller and smaller scales. These patterns consist of more or less of the same amount of elements at all scales. Such fractal geometry generates moderate visual complexity in natural environments, which can explain why nature is experienced as a relaxing, nurturing environment (Van Den Berg et al., 2007; Van Geert & Wagemans, 2020).

Intuitively, architects have been aware of visual complexity and its influence on architectural perception. Through elaborations of concepts such as order and disorder, regularity and irregularity, rhythm, symmetry, and scale and proportion, the (interior) architectural culture has always dealt with the principles inherent to visual complexity (Arnheim, 1977; Rasmussen, 1959; von Meiss, 2011. Perceptual psychologist Arnheim (1977) argued, for instance, that

> (O)rder is possible at every level of complexity: in statues as simple as those on Easter Island or as intricate as those by Bernini, in a farmhouse and in a Borromini church. But if there is no order, there is no way of telling what the work is trying to say. (p. 162)

### ***Design proposal: Visual complexity and reinterpretation of ornamentation***

The development of this master thesis revolved around the ambition to reevaluate the intrinsic characteristics of a typical 19th-century industrial building—and to explore the concept of visual complexity as a concept that can positively influence user's behaviour and sense of well-being (Berlyne, 1971). An in-depth morphologic inquiry, an analysis and a listing of the various construction elements, features, and materials, revealed a rich range of refined detailing. The appearance of such rich detailing, in the current condition largely invisible due to dust and dirt, was for the 19th-century construction practices customary. Compared to contemporary construction practices, the student realised, such a level of detailing is extraordinary. For this reason, the student chose to focus on this particular aspect, relating it to the notion of ornament. The cultivation and fostering of ornament became, in this thesis, key as a way to produce visual complexity.

Figure 1
Former sugar factory, characterised by strong structural construction features and few, genuine materials (Photograph by Lotte van Alphen)

In current interior and architecture culture, the question of ornamentation is subject to great attention. As a reaction to modern interior design where the implementation of ornamentation for decades has been avoided (influenced by, amongst others, priorities of functionalism and minimalism), a renewed interest among interior designers and scholars brings the notion of the ornament back on the agenda (Grafe et al., 2004; Necipoğlu & Payne, 2016; Payne, 2012). This interest might be nurtured by the increasing awareness of human beings' psychological need for complexity, the student argued—a complexity that could be expressed through the implementation of ornaments. This need has been touched upon by H. F. Mallgrave (2011), who points to the aspect of *ambiguity*, being a psychological need:

> Ambiguity, in its neurological definition, is thus the obverse of constancy; it is a neurological play as it were that … engages and challenges the brain to allow multiple meanings. … It evokes something less familiar, something that forces the brain to pause, to engage multiple areas, and reflect upon the new phenomenon it encounters. … (T)he brain enjoys the teasing of an enigma. (p. 149)

Pursuing a reformulation of ornament that transcends any confusion or resemblance with decoration and mere embellishment, and searching for architectural ambiguity, the student developed an approach in which a reinterpretation of ornament and the concept of visual complexity went hand in hand.

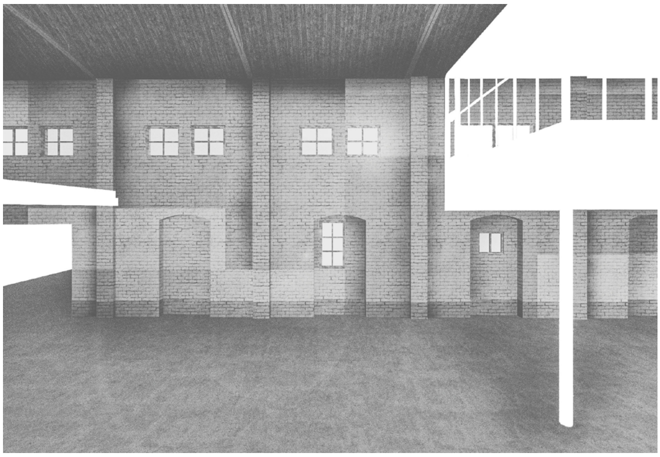

Figure 2
Subtle interventions reinforcing the existing, inherent notion of ornament (Image by Lotte van Alphen)

In this process, the student examined various morphological components of the building. Here, we will concentrate on three of them: the roof truss of cast iron, the cast and wrought iron beam and column structure, and the masonry walls.

At first, the formal and ornamental qualities of the iron structural elements, such as the roof truss and the beam and column structure, were considered closely. In order to call attention to the inherent complex but ordered structural elements, the student used colour. The intervention was based on the assertion that colours guide and capture attention, particularly in complex visual images, and that objects which deserve the most attention should be red (Andersen & Maier, 2019). In addition, floors were complimented by adding the colour green.

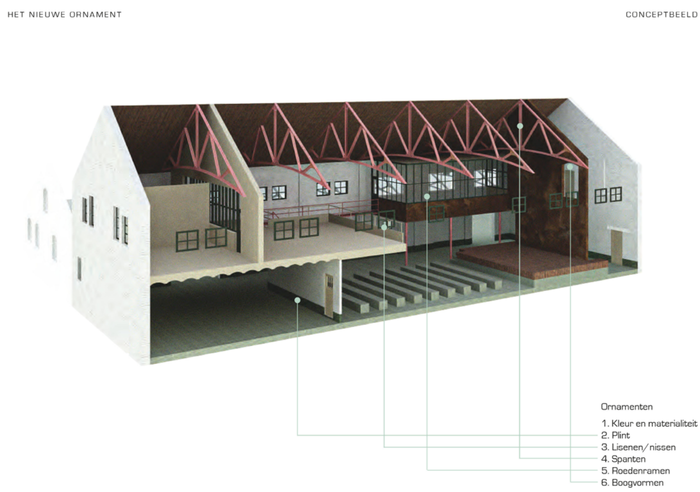


Figure 3
Preliminary design proposal. Structural elements pronounced by colour (Image by Lotte van Alphen)

### *Critical review*

In the course of crits, it became apparent that this intervention seemed to ignore the intrinsic potentials of the building as a whole, disregarding a range of other aspects. Albeit principles affording visual complexity (i.e., order, regularity, and symmetry) were emphasised through colour articulation, any consideration of the multiple, inherent detailing of the individual elements, their interplay, and the many irregularities found in minor alterations—such as doors that have become windows—was left aside. A profound study of the building became key to achieving less superficial and literal design outcomes. This conclusion gave rise to a more precise design question: In what way can the multifarious, intrinsic parts, details and materials of the building—in concert with the notions of ornament and visual complexity—induce the creation of responsive morphologies?

Figure 4
Exhibition space. Final design proposal, imposing an elaborated level of visual complexity (Image by Lotte van Alphen)

In this new approach, the notion of ornament became paramount. In a rereading of the morphological study, which was made at the beginning of the design process, new and unnoticed properties surfaced.

The impressive, pitched roof trusses of cast iron are omnipresent in the building. A more detailed examination of its different parts reveals a complex but ordered set of wrought-iron beams, slim tie bars, and elegant joints. Other refined construction elements are observed in spaces where the ceiling/floor construction is assembled by a jack-arch floor, resting on wrought iron beams and cast-iron columns. Characteristic for these elements are the multiple bolts that join all parts. Seen from a distance, these bolts create another pattern of fine-meshed dots in their own right. Through very subtle colour applications and additions of supportive spatial elements—such as skylights and additional but hardly noticeable structures and textiles—the intrinsic characteristics of these elements were brought to the fore. Due to the added elements, the functionality of the building was enhanced. Next to these pronounced pieces of architectural engineering, which features must be distinct, the student engaged with the more anonymous masonry walls. Here, she discerned patterns less distinguishable to the eye through indistinct colour additions in well-defined sections and niches, a strengthening of vertical and horizontal lines, and an accentuation of ambiguous additions and remains from former minor transformations. Conclusively, this master thesis suggests a new approach to the notion of the ornament where ornament is center stage in the urge to both appraise the historical architectural elements and achieve a moderate visual complexity.

**Project 2: Affordances**

The second project initially departed from the aim to create a new, improved public interior for the outdoor areas of a social housing complex dating from the 1970s. This project is located in the city centre of Antwerp, a former working-class neighbourhood, that is currently undergoing a gentrification process. Characterised by various sizes of apartment buildings clustered around small park-alike zones in combination with concrete, dull passageways, this site holds great potential in terms of greenery and amenable open-air places yet suffers from anonymity and alienation due to its poor materialisation and virtually non-designed pedestrian infrastructure. This specific urban condition gave rise to the idea of redesigning the site, paying special attention to the multiple uncanny walkways, squares, and non-places. Departing from a design approach, wherein the concept of affordances is chief, those undefined, randomly furnished settings became subject for the design of morphologies in the realm of public interiors.

Figure 5
Housing complex Sint-Andries square (left) and passageway (right). Anonymity and alienation are chief (Photographs by Rienske De Baere)

The concept of affordances was initiated by psychologist James J. Gibson in 1979 (Gibson, 1979). This case study develops from Gibson's definition of affordances of which the basic principle is understood as the qualities of an object or an environment that communicate opportunities to act in a certain way (e.g., a canopy signals a dry shelter on a rainy day; a sun-lit spot on a cold winter indicates an opportunity to warm up). According to Gibson (1979), different layouts or objects afford different behaviours and opportunities for different users, animals, and humans. Put simply, a branch may offer repose for a bird, but not for a dog, and what affords jumping for a child may not do so for an adult. The concept of affordances, as computational neuroscientist Arbib (2015) explains, is used to identify the opportunities for action that our brain registers without necessarily being consciously aware of the object that affords those actions. In recent neuroscientific research, how people perceive their surroundings and how the possibilities of action shape perception has added to an in-depth understanding of the concept of affordances (Djebbara et al., 2019; Gepshtein & Snider, 2019).

This concept has become a valuable tool for creative professions to understand the logic behind a design better and to direct it purposefully. In architecture and design, the architecture and philosophy studio Rietveld Architecture-Art-Affordances, RAAAF, established by philosopher Erik Rietveld, elaborated the concept of affordances by broadening its theoretical scope. Instead of only understanding affordances as the generator of possibilities evoked by the environment such as sensorimotor actions like reaching, grasping, walking, sitting, lying, etc., RAAAF suggests that human life is bound to different practices to be found in different cultures and social environments. Thus, each aspect of a material environment is inherently socially determined, and the other way around, each social aspect of life is also materialised. RAAAF research assistant J. Martens coined this aspect:

> A chair, for example, only makes sense as something to sit on in the context of the … practice of sitting at a particular height consistent with tables on which we can put things. Had our bodies or traditions been radically different, then this same 'chair' aspect of the environment would assume a completely different meaning. (Storgaard & Michels, 2019, p. 71)

Accordingly, the social and the material aspects of our environment are inextricably intertwined, RAAAF maintains.[4]

[4] In its design practice, the studio aims to use this insight by creating designs that can afford new physical or social possibilities. Such design approach the studio realised in the installation *The End of Sitting*, an experiment that suggests an alternative to the traditional working environment dominated by chairs and tables. *The End of Sitting* is a large sculptural landscape of surfaces and niches that affords atypical working positions. The conventional act of sitting is here virtually impossible—but still, the

### *Design proposal: Urban living room, affording domesticity and activity*

This project focuses on the malfunctioning outdoor areas of a social housing complex in Antwerp. It aims to remediate the existing exterior context, a network of dull and static pedestrian walkways and a desolate square into an environment where use, activity, and involvement can unfold.

The project departs from properties such as domesticity and the notion of intimate, human scale. The student designed a master plan for the entire infrastructure of the housing complex area and went into detail with numerous parts. In this examination, we focus on two architectural configurations: the passageway between the apartment building and a large concrete bunker—an uncanny leftover from the cold war period—, and the square located at the edge of the site.

The passageway between the apartment building and the bunker is relatively long and broad. Massive, greyish walls flanked it without any significance. As the passageway is not furnished by any sort of urban interior, it evokes no reason to pause or sit down. The student wanted to transform this transition area into a space that would encourage people to slow down, stop, and stay for a while. In a first design proposal, the student designed a longitudinal bench along the bunker wall. This bench consisted of a two-step alike sitting element, which regularly was divided by integrated planters. The niches on the opposite side in the plinth of the apartment building were accentuated by colour in the proposal. Further, the student designed a new tile pattern for the walkway itself.

Figure 6
Preliminary design proposals of the passageway and the square (Images by Rienske De Baere)

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landscape affords working (RAAAF, n.d.).

The second design intervention in this project concerns a square located at the edge of the site, surrounded by both apartment buildings and the traditional urban tissue of early 20th-century townhouses. Again, the idea behind the design proposal was to create a place worth staying in and attract people from both inside and outside the housing complex. Because of the distance to the adjacent buildings, and thus to the defining edges of the square, the student chose to install several demarcated small 'rooms' that mediate between the different scales and afford informal encounters and multiple uses such as small-talks, pick-nicking, homework, etc.

The design outcomes generated at the beginning of the design process did not achieve the objective of making the areas more alive, active, and attractive satisfactory. At this point, the design question was reformulated: How can architectural interventions transcend the use of traditional urban furnishings and settings and stimulate interaction and engagement between inhabitants of the neighbourhood? In the subsequent design phase, the student started to employ the concept of affordances as conceptualised by Gibson (1979) by creating opportunities for action without being overly explicit (Arbib, 2015).

The student strived to extract the atmosphere characterising a domestic setting, projecting it in different ways in the design of the passageway and the square. In this process of construing the activities taking place, for instance, in a living room, such as sitting, lying, reading, playing, gaming, gathering, crafting, etc., the typical living room furnishing was reconsidered. In the new design proposal, the interior elements such as the couch, rocking chair—implemented in the niches opposite the bench—, reading lamp, dining table, carpet, and spatial morphologic enclosures such as the door, floor, wall, ceiling, and window, were reinterpreted and transformed into elements and constellations that intuitively afford actions that also take place in the private interior. These interventions were complemented with warm colours, tactile materials, and plants. By creating such a 'domestic' environment in an urban context, the student wanted to stimulate users to act as in their own home, counting on a recreative, relaxed, and amical behaviour.

This project illustrates an attempt to implement the concept of affordances, designing intuitive user interfaces. For instance, the passageway, now arranged with intimate color sections, variegated surfaces for sitting, hanging, lying, and equipped with lamps, is perceived as an inviting place to stay, accommodating various actions. The 'rooms' at the square are now abstract almost sculptural configurations that strongly refer to the spatial dimension of an interior space built up by elements that facilitate domestic actions.

Figure 7
Urban interior interventions that afford multiple use and various spheres (Images by Rienske De Baere)

**Lessons Learned: Translating Neuroscience Knowledge into Design**

The two projects discussed above contribute to a broader understanding of the design potentials which are to be found in neuroscience-related knowledge. By approaching an interior design question with the lenses of 'visual complexity' and 'affordances,' it is possible to investigate stimuli that address the notion of human well-being. As in the project that deals with the theme 'visual complexity,' the application of ornamentation become meaningful—and comes to terms with the often-critical attitude towards its use, having no function as such or being purely cosmetic. In the project concerning the theme 'affordances,' the concept of designing elements that go beyond traditional urban furniture evoke new patterns of behaviour and use. In both projects, the designers contribute to an enrichment of the design practice.

The knowledge that currently evolves from the domain of neuroscience unmistakably contributes to the spatial design disciplines in general and the interior design discipline in particular. In an attempt to raise the attention for this fact and be aware that interior design education can play a key role in nurturing this knowledge—turning the question of human, experiential responsiveness into an elementary perspective of the design process—we installed a master studio which centre stages this domain. In short, this was put into practice through the choice of design objectives that entail themes occurring within the domain of neuroscience and through a focused inquiry into scholarly work exploring these themes. Having applied this teaching program for more than five years, we have started to draw lessons at both an educational and disciplinary level.

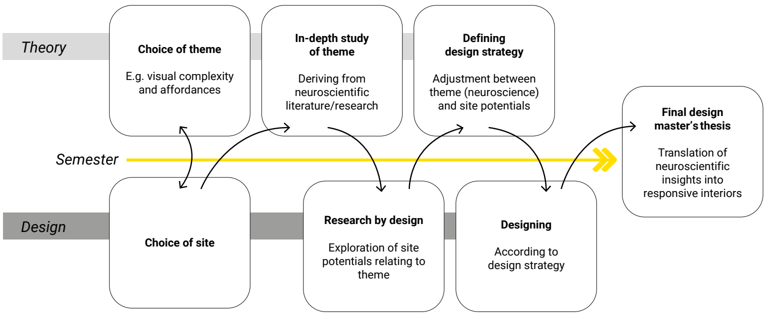


Figure 8
Diagram illustrating the design process, explaining the reciprocal information exchange between theory and design, between neuroscientific insights and interior design strategies (Image by authors)

At the level of education, we observe various assets. By applying a design approach (method) in which students are incited to design, paying particular attention to the properties of basic morphological elements and with a focus on neuroscience-informed design—often psychological—effects of spaces, we see that students learn the following: first, to take into account a new design parameter, namely the spatial effect on human behaviour; second, as an argument in design decisions to implement knowledge and insights from other disciplines that go beyond the individual frame of reference and intuition; third, to develop a new design language that responds to informed findings; and finally, to critically question concepts and ideas concerning interior elements.

Regarding the interior design discipline in general, we note that: first, by addressing neuroscience-informed knowledge into the design process—through the study of already conducted research in the domain of neuroscience—the creation of distinct, responsive interior features is stimulated; second, the possibility that interior design outcomes respond to human being's well-being increases significantly when taking into account evidence-based informed insights during the design process; third, through student's studio work produced during several years, we can collect a fair amount of design material which eventually, through reflection and comparison, can lead to deeper insights. The ultimate objective is to build up a collection of responsive interior morphologies that can be deployed by students, educators, and practitioners and eventually contribute to the specialised knowledge building of the interior discipline as a whole.

We notice, however, that interpreting and translating the neuroscience-informed findings into adequate interior solutions is not always successful. Too often, there is a gap between the scientific findings and the interior design outcome. Ill-conceived and literal interpretations of these findings often propel weak design results, as exemplified in the projects. An apparent 'correct' design, one that is ticking all the boxes and fulfilling all the objective requirements, can still fail in terms of esthetics or tacit qualities. Being aware of this pitfall, we want to point to the importance of an all-encompassing design approach, which includes neuroscience-informed insights together with multiple contextual conditions. This problem needs attention in future classes. One way of approaching the problem could be undertakings of critical examinations of existing interiors, distinguishing what makes a good or a bad design. Assessing and discussing design proposals, not only with peers and instructors but also with user target groups, could be another way of addressing this issue. Ideally, students should also examine how their designs might influence behaviour, emotion, and experience. On a scientific level, such endeavour implies very specialised expertise and professional use of technical measuring equipment. This is impossible to realise within the short time scope of the master's thesis (one semester, 15 weeks of instruction). The design proposals could nevertheless be utilised as case study material by, for instance, psychologists who investigate psychological mechanisms accounting for the cognitive and emotional effects of interacting with space.

Despite its imperfections, the pedagogical objectives and organisation of the master design studio *Morphology of Interiors* introduces a method that can enrich how we can design relevant interiors. Through its design approach, we advocate, responsive interior design results can occur, and as Mallgrave eloquently argues: "we can always become better designers by adding to the complexity of our synaptic maps, and thereby create a better or more interesting environment in which the human species can thrive" (Mallgrave, 2011, p. 2).

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