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RESEARCH ARTICLE

Contemplative neuroaesthetics and architecture: A sensorimotor exploration

Zakaria Djebbara [a,b,*], Juliet King [c,d], Amir Ebadi [e], Yoshio Nakamura [f], Julio Bermudez [g]

[a] Department of Architecture, Design, Media, and Technology, Aalborg University, Aalborg, Denmark
[b] Biopsychology und Neuroergonomy, Technical University Berlin, Berlin, Germany
[c] Art Therapy Department, The George Washington University, Washington DC, United States
[d] Department of Neurology, Indiana University School of Medicine, Indianapolis, United States
[e] Dellustration, Washington DC, United States
[f] Pain Research Center, Division of Pain Medicine, Department of Anesthesiology, University of Utah School of Medicine, Utah, United States
[g] School of Architecture and Planning, The Catholic University of America, Washington DC, United States

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Abstract This paper takes initial steps towards developing a theoretical framework of contemplative neuroaesthetics through sensorimotor dynamics. We first argue that this new area has been largely omitted from the contemporary research agenda in neuroaesthetics and thus remains a domain of untapped potential. We seek to define this domain to foster a clear and focused investigation of the capacity of the arts and architecture to induce phenomenological states of a contemplative kind. By proposing a sensorimotor account of the experience of architecture, we operationalize how being attuned to architecture can lead to contemplative states. In contrasting the externally-induced methods with internally-induced methods for eliciting a contemplative state of mind, we argue that architecture may spontaneously and effortlessly lead to such states as certain built features naturally resonate with our sensorimotor system. We suggest that becoming sensible of the resonance and attunement process between internal and external states is what creates an occasion for an externally-induced contemplative state. Finally, we review neuroscientific studies of architecture, elaborate on the brain regions involved in such aesthetic contemplative responses, provide architectural examples, and point at the contributions that this new area of inquiry may have in fields such as the evidence-based design movement in architecture.

* Corresponding author. Department of Architecture, Design, Media, and Technology, Aalborg University, Aalborg, Denmark.
E-mail address: zadj@create.aau.dk (Z. Djebbara).
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1. Introduction

Following the literature, we define mindfulness as a state of non-judgmental awareness and focused attention on the present moment, while contemplation as a state of intense concentration, introspection, and open or directed consideration (Sumantry and Stewart 2021; Wahbeh et al., 2018). Both involve a heightened level of awareness and an intentional focus on the present moment, fostering a state of deep reflection and non-judgmental engagement. Despite the overwhelming amount of mindfulness and contemplation research conducted in recent years—not to mention the remarkable positive outcomes documented (for review: Tang et al. 2015)—surprisingly, *contemplation* as an aesthetic experience has been largely overlooked by modern neuroaesthetics studies. This paper aims to define a new branch of study for understanding contemplative states by identifying them as cases of aesthetic experience. Although mindfulness and contemplation have distinct philosophical and practical concerns, the brain and body can in both cases engage in contemplative practice to increase well-being by being involved in a heightened level of awareness and presence. That is, the experience of appreciation associated with contemplative practice is itself an aesthetic experience, particularly if it is externally induced. As we are not concerned with the mindful and contemplative states themselves, but rather their shared willingness to engage in a non-judgmental and open way, we thus use the words "contemplative" and "meditative" interchangeably.

From a neuroaesthetics point of view, contemplative states have little to do with deliberately attaining them via internally-induced (IN–I) methods (i.e., self-directed effort at becoming mindful). Instead, the focus is on how contemplative states spontaneously arise through externally-induced (EX-I) means, that is, by the external object or environment affording the individual to move into contemplative states. This is highly valuable for *functional* aesthetic practitioners like architects. From their perspective, EX-I experiences are central to the discourse and performative success of buildings, and this extends well beyond contemplative states. Combining the study of EX-I contemplative states with architecture remains an untapped area of research, which we aim to introduce and elaborate on in this paper. The specific research question we aim to answer is: How can architects, through EX-I, design sensorimotor dynamics that engender contemplative states?

The claim is that architecture enables contemplative states by way of becoming sensible of the attunement process, which we elaborate on in the sections to come. This occurs when a building concentrates a visitor's attention on their body and sensory systems and away from self-referential, random, and/or analytical mentation. Becoming sensible of the process of the resonance and flow of experience itself affords to transcend the attention, making it subject to a process of meta-attention. We unpack this claim by proposing a conceptual sensorimotor framework on the relationship between interaction and contemplative states. Section 2 defines what we mean by contemplative neuroaesthetics and offers insights into how it differs from existing lines of research. We argue that neuroaesthetics studies have largely overlooked contemplative states and focused instead on analytical evaluation and explicit understanding of the meaning of the artefact in question so that they go beyond automatic sensorimotor responses. Architecture is an excellent vehicle to study contemplative aesthetic effects for two reasons: (1) buildings encompass the larger environment (or background) in which most human experiences in contemporary society unfold (Evans and McCoy, 1998; Rapoport, 1990) and therefore (2) any improvement made to their conception and construction may have a considerable positive impact on society at large. To this end, Section 3 introduces a brief sensorimotor account that aims to demonstrate how architecture can invite behaviours that in turn induce aesthetic contemplative experiences, clarifying a relationship among architecture, body, and aesthetic response. We highlight that mere engagement is not sufficient to achieve a complete contemplative state. Nevertheless, when engagement enables an awareness of attunement, it becomes a catalyst for contemplation, which can manifest in different forms and intensities. To provide examples of how that may occur, Section 4 examines how essential components of conventional IN-I methods for attaining contemplative states are similar to those of EX-I methods. To support our arguments, we end by briefly reviewing the existing neuroscientific studies involving contemplative states, attention, and architecture. With such a structure of the paper, the terminology is (inevitably) predominantly neuroscientific and philosophic in clarifying the relationship between aesthetics experience, contemplative practice, and cognitive neuroscience. It is towards the end of the paper, in which we provide examples, that we make use of architectural terminology.

We recognize that the arts and architecture are not alone in intentionally attaining contemplative states of consciousness. All spiritual traditions include some version of contemplative practice as part of their teaching and efforts. Medical, psychological, and neuroscientific research has been able to demonstrate their notable psychological and health benefits through empirical means in recent years (see for instance: Tang et al., 2015). For example, contemplative practices have been found to significantly improve cognitive and affective performances, enhance immunological response, foster brain growth and plasticity, provide a better sense of well-being, reduce stress, depression, loneliness, anxiety, increase motivation, and raise pain thresholds (Keng et al., 2011; Sumantry and Stewart, 2021). These studies are of significant

scientific value to the advancement of contemplative neuroaesthetics, as well as to our understanding of the relations among the brain, mind, and body. In this regard, contemplative neuroaesthetics is also concerned with how design and art may create therapeutic opportunities for advancing population health and well-being.

2. Defining "contemplative neuroaesthetics"

In defining "contemplative neuroaesthetics" we draw from the two concepts establishing it.

- *Contemplation:* an intentionally induced state of awareness characterized by present-centeredness, focused and sustained attention, relaxation, decreased mind-wandering, and absence of judgment (Boccia et al., 2015; Bond et al., 2009; Cahn and Polich 2006; Lutz et al., 2008a, 2008b; Nash and Newberg, 2013; Tang et al., 2015)
- *Neuroaesthetics*: the scientific study of the neural correlates of the appreciation and aesthetic experience associated with the production, and evaluation of an artwork (Chatterjee, 2011, 2013; Nalbantian, 2008; Shimamura and Palmer, 2012; Zeki 2009).

Cognitive neuroscience looms large in neuroaesthetics (Chatterjee and Vartanian, 2014). It has recently been suggested that neuroaesthetics should be divided into two directions. One involves the cognitive neuroscience of aesthetic experience while the other involves understanding the cognitive neuroscience of art (Pearce et al., 2016). This distinction, based on a narrow interpretation of art, has been questioned. For example, Skov and Nadal (2020a) rightfully argue that the tight link between neuroaesthetics and art research in recent literature has been treated as if these two areas are intrinsically interrelated, thereby overlooking aesthetic appreciation and sensory valuation of non-art artefacts, which was arguably among the initial pursuits of neuroaesthetics (Pearce et al., 2016; Skov et al., 2017; Zeki, 1999). For instance, it is partly the appreciation of worldly factors that guides living organisms' behaviours and decisions throughout everyday life (Brielmann and Pelli, 2018), meaning that it is not only art that can elicit meaningful aesthetic experiences. If aesthetics is considered to be the process of how an organism's interactions with the world may elicit certain psychological and behavioural outcomes, e.g., hedonic, expressive, or contemplative responses, then neuroaesthetics becomes a much wider, useful, and critical field of study—one specifically posed to advance our understanding of the underlying processes behind a variety of behavioural, emotional, and cognitive responses through neuroscience.

In this context, we propose contemplative neuroaesthetics as the study of the relationship between neuroaesthetics as broadly defined and contemplative practices through the neurobiological examination of aesthetic contemplative states occasioned by an artefact or environment (Fig. 1). Both aesthetic experiences and contemplative states can be seen as ways of deeply engaging with the world in a more mindful and present-oriented way, and they both involve a sense of connection and meaning-making through the sensorimotor qualities of an object or environment, such as its form, colour, texture, and composition. These may result in a sense of wonder or awe, as well as a sense of connection to the object or environment (Fingerhut and Prinz, 2018). As such, this new branch has a psychobiological foundation that can elucidate the relation between causes and outcomes surrounding contemplative states.

In terms of the types of aesthetic experiences being studied, research has largely focused on the cognitive decomposition of visual, associative, semantic, and emotional features and responses to artworks (Iigaya, et al., 2020). This focus partially originates from scientific expediency, i.e., the technological and methodological convenience, but it also finds its support (if not a direction) in how we culturally interpret "beauty" and "aesthetics" today, which is different from pre-modern times (i.e., before the 20th century). Neuroaesthetics is largely driven by reductionistic methods that aim to decompose the object that induces the experience of beauty into parts that can be analyzed in isolation. This is typically expressed in experimental designs that separate the features of an artwork, assuming that the sum of the parts is equal to the whole. The trade-off is the loss of the emergent quality of contemplation in beauty, which is generally omitted from neuroaesthetic studies today. However insightful these types of studies may be, the contemplative dimension of aesthetic experiences, what German philosopher Immanuel Kant and other pre-modern philosophers defined as the true and *disinterested*[1] engagement of beauty, has been entirely neglected.

This may be a significant blind spot because numerous pre-modern artworks were directed to produce a contemplative response (Adams, 2007; Davies et al., 2010). While those artists certainly used the sensually beautiful to capture the attention of the spectator, their goal was eventually to lead or evolve the viewer into deeper psychological states (Nehamas, 2007). This is hardly the case with the vast majority of modern and post-modern art, which by and large, demands us to engage it critically, analytically, culturally, psychoanalytically, or ideologically before one can appreciate it. Many artworks of the 20th and 21st centuries unmistakably point at something non-perceptual, beyond the surface, in need of intellectual considerations to be understood and only then enjoyed (Danto et al. 2013; Danto, 2003; Elkins, 2001; Nehamas, 2007). Here, beauty in its perceptual and contemplative sense is not under any dispute. It is this intellectual and detached contemporary interpretation of aesthetic appreciation that has, at least partially, bent contemporary neuroaesthetics research toward predominantly analytical evaluation and conscious understanding of specific meanings associated with the arts.

The type of appreciation underlying the contemplative dimension is much less about intellectual inferences and

[1] A full discussion on disinterestedness is beyond the scope of this paper. However, in short, the concept refers to the idea of being as objective, unbiased and non-judgmental as possible in one's evaluation or appreciation of beauty or other aesthetic qualities. See Skov and Nadal (2020b) for a critique of disinterestedness.

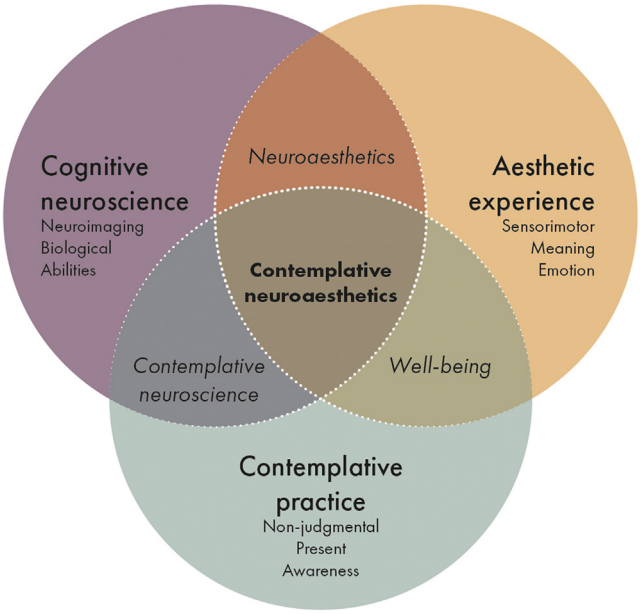

Fig. 1 Contemplative neuroaesthetics is the study of aesthetic experiences associated with contemplative states and practices through a cognitive neuroscientific lens. Source: The Authors.

analytical interpretations of specific features, and more about becoming mindful, non-judgmental, and attentive to the artwork, be it a painting, performance, art installation, or architecture. As opposed to the analytical and intellectual approach, this aesthetic experience is more concerned with the resonance between sensorimotor activity and spatial information relative to an embodied self, which we unpack in the following section. There are remarkable examples of contemporary art and architecture that seek the contemplative, e.g., the works of the light artist James Turrell, the painter Mark Rothko, and the architect Tadao Ando, by integrating and enforcing an embodied experience of presence. This contemplative territory of aesthetic experience is currently not extensively considered by neuroaesthetics today. It is an area that holds great promise with the only condition that it must be approached in ways that respect its present-centred, relaxed, attentive, and non-judgmental nature (Kabat-Zin, 2006).

3. Perceiving architecture

3.1. A sensorimotor approach

Since the contemplative experience, as elicited by an aesthetic encounter, necessarily engages the body's sensory systems followed by conscious experience, we see a sensorimotor contingency (SMC) account of perception fit for its operationalization (O'Regan and Noë, 2001a). SMC claims that perception is the outcome of exercising sensorimotor capacities—an embodied skill that is comparable to behavioural skills, e.g., the capacity to ride a bicycle (Degenaar and O'Regan, 2015, 2017; O'Regan and Noë, 2001a, 2001b). Perception is apprehended through action in a dynamic relationship with the environment. Similarly, contemplative experience is also based on particular dynamic interactions and synchrony between an embodied being and its environment.

As perception is an act that requires both sensory and motor neurons, the features of the aesthetic experience can be associated with the neural patterns that underlie such action. These patterns reflect the implicit "know-how" of systematic changes in sensation as a result of movement and the possibility of movement (Ryle, 1945; Noë, 2012). That is, knowing how to engage with the environment is to have motor-related expectations about sensations if one was to act in *this* particular way in *this* particular environment. Here lies a dynamic, rather than a static, kind of implicit knowledge between active states and sensory states (Friston et al., 2017). This is an elementary and fundamental constraint of sensory states as a function of motor variations on which more advanced forms of sensorimotor regularities are built on top. From simple sensorimotor contingencies, we can create, for instance, a *sensorimotor habitat*, which accounts for preferred trajectories in sensorimotor state space, and a *sensorimotor scheme* describes how one becomes attuned[2] to a specific situation following relevant norms.[3]

The relationship between possible action and perception is the essence of the term *affordances* in enacting the whole body (Djebbara et al., 2019a, 2019b; Gibson, 1986; Rietveld and Kiverstein, 2014). Affordances refer to the possibilities for use, intervention, and action that the physical world offers and affordances are determined by the fit among a body's structure, skills, and capacities for movement (Clark, 1999; Goldhagen, 2017). For instance, although large parts of the surrounding space are concealed from our current field of view, e.g., the space currently behind us, we still have an implicit understanding of the space behind us (out of view). This implicit grasping emerges from the affordances and sensorimotor laws providing us with the knowledge of how to act to uncover the expected sensations in the rest of the space. This reflects how the embodied brain relies on its sensorimotor prediction in generating expected behaviours (Djebbara et al., 2022).

As the built environment is experienced, perceived, influenced by culture, and even shaped by evolutionary processes (Robinson, 2011; Ramstead et al., 2016), the experience of the built environment becomes intertwined with various levels of human abstraction, including intricate cultural materials and artefacts (Donald, 2017; Plummer, 2016). Architectural affordances encompass a wide temporal scale in human experience that is beyond the scope of this paper. For instance, cultural affordances can be expressed in transhistorical rituals in churches,

[2] When we refer to *attunement*, we mean the dynamic process enabling aligned perception of invariant structures in the environment—sometimes referred to as *resonance* in ecological psychology (Heft, 2001; Raja and Anderson, 2019; Raja, 2021).

[3] Unpacking how sensorimotor contingencies function as building blocks for more sophisticated behavior is beyond the scope of our paper, but see Buhrmann et al. (2013); Di Paolo et al. (2017), and for the body as the root of language and metaphors, see Lakoff and Johnson (1999, 2008).

masjids, and other temples, or in normative practices that require shared attention and social engagement across a large temporal scale, e.g., hundreds or thousands of years. These affordances provide a sociocultural scaffolding for the human experience (Ramstead et al., 2016; Robinson 2021). In this paper, we limit our framework to the short temporal scale of perceptual capacities (Fig. 2).

3.2. Sensing capacities

While *sensorimotor capacities* refer to the resonance and contingency between bodily movements and sensations, *sensing capacities* refer to the capacities for being attuned to aspects of the environment, which is biologically expressed as a pattern in sensory systems. On the other hand, the perceiver's capacity to make use of the sensing capacities by, for instance, expressing them in a broad range of behaviours and situations, composes the *perceptual capacities* (Degenaar and O'Regan, 2017). It is the making use of sensations that makes it a perceptual capacity.

Sensing capacities implicitly and continuously engage with the environment, providing a palette of background affordances that perceptual capacities may put to use. For instance, a familiar example is walking through the city on the way home, dodging oncoming people, and making all the right turns in the environment, all while mind-wandering and being detached from the environment. The automatic and implicit ongoing attunement to the environment, i.e., background affordances, requires no conscious processing as the attunement depends on sensorimotor contingencies that operate effortlessly (Djebbara et al., 2022; Djebbara, 2023).

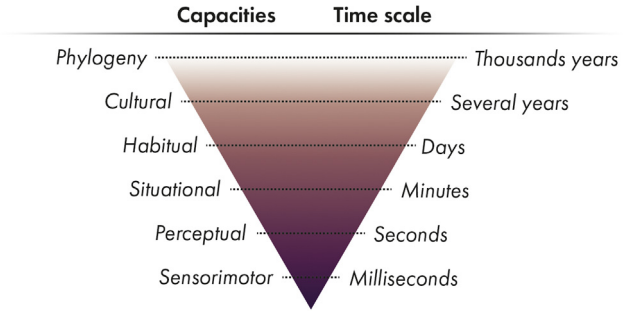

Fig. 2 Human capacities across various temporal scales. Starting from phylogenetic capacities passed on through thousands of years, human beings have become capable of developing cultural rituals that involve habitual and situational constraints on our behaviour and experience. Perceptual and sensorimotor capacities are situated in the territory of the aforementioned scales, so our access to the external environment depends on our sensorimotor capacities. We argue that this level is at the interface between the subject and the object. Thus, as the other capacities function as top-down anticipatory parameters contributing to all capacities, the sensorimotor capacities affect the hierarchy from the bottom-up supporting the experience. The width of the triangle depicts the richness of its influence on anticipatory parameters. Source: The Authors.

This is important to note because, in the context of process philosophy (Nicholson and Dupré, 2018), the origin of our behaviour and perception can be roughly segmented into hierarchical phases delineated by their temporal scale that all contribute to the process (Fig. 2). At the highest level, we experience the world according to our phylogenetically given structures that operate at an evolutionary time scale of millennia (Cisek, 2019). Our socio-cultural capacities, formed by our socio-cultural upbringing, values, and norms, are also deeply involved in our behaviour and perception (Damasio, 2019; Mace and Holden, 2005), which affect, and are affected by, habitual patterns and reading of situations (Barsalou, 2008; Gallagher, 2017). Our perceptual capacity borders our sensorimotor capacity and is the result of the integration of all the capacities. That is, our experience happens all at once, spontaneously collapsing all these operating layers into an integrated present moment (for a temporal analysis of human experience in sensorimotor dynamics, see Bogotá and Djebbara, 2023).

3.3. Sensible of attunement

We claim that architecture can lead to contemplative states by enabling individuals to become *sensible of the attunement process*. When we are in tune with architecture, we engage our body with the external built environment, effortlessly reaching a non-judgmental flow and resonance that leave very little room for analytical thought (Csikszentmihalyi, 1990; Vara Sánchez, 2022, 2023). Attunement is precisely this dynamic coherency and harmony with the environment. The boundaries between self and world become blurred, which can result in the withdrawal from our habitual, cultural, and other capacities that depend on conscious deliberate processing. Our body becomes both inhabited by the space and inhabit the space. This leads to directing attention towards the active sensing of the body vis-à-vis the surrounding environment or the object of interest. When such a shift in attention becomes intense and absorbing, it brings forth a contemplative state. The body and perception take up all the space of our attention—this is how the body becomes inhabited by and inhabits space. We become sensible of attunement in an embodied way, quite similar to Shusterman's somaesthetics (Shusterman, 2008).

How can the process of getting attuned to the environment set a stage for contemplation? Although aesthetic environmental features may attract attention, they do not guarantee the emergence of a contemplative state as it requires more than superficial attention. We propose that an EX-I contemplative state involves becoming sensible of the ongoing sensorimotor responses so that attention dynamically fluctuates between inward and outward states. Fluctuations of this kind are initiated by external factors but are resonating, and thus actively engaged, with internal states (Charalambous and Djebbara, 2023; Vara Sánchez, 2023). Becoming sensible of attunement is essentially to actively resonate with environmental features in such a way that a contemplative experience materializes effortlessly and fluently across numerous sensory systems. Certain aesthetic environmental features may elicit contemplative states through sensorimotor responses to

arts and artefacts, e.g., some paintings, photographs, artefacts, or spaces in a museum, or a specific (part of a) song, theatre play, or movie. Despite other ongoing mental activities that may be occurring at the time (e.g., mind-wandering), these aesthetic features would promote salient sensorimotor dependencies that invite us into an absorbing attentive state (on "inviting affordances", see Rietveld and Kiverstein, 2014; Withagen et al., 2012; Withagen et al., 2017).

Given the foundational nature of sensorimotor capacities, there is no need in ordinary life to be explicitly aware of the sensorimotor, emotional, or cognitive operations underlying them (Noë, 2012). For this reason, embracing the attunement process implies turning those operations from *implicit* to *explicit*, from *unconscious* to *conscious* (Djebbara et al., 2022). It is conceptually to become aware of the dynamic alignment between self-tuning and environmental features (Gibson, 1966). Given the central role of attention in attunement, it is imperative to recognize at least two levels of attention.

- The first level of attention is to become aware of the percept. This level, which is central to SMC, corresponds to exercising sensorimotor dependencies so that our experience is supported by an interactive capacity, which we know as *perception*.
- The second level refers to becoming aware of the process of the flow of experience in a meta-cognitive fashion (Jankowski and Holas, 2014). This level, in light of SMC, corresponds to becoming sensible of the ongoing dynamic attunement that the sensorimotor dependencies afford.

For contemplative neuroaesthetics to develop fully as a field of scientific inquiry, it must address both levels of attention as both are necessary.[4] Indeed, the first level will not suffice for reaching a contemplative state as it corresponds to the mere act of simply *perceiving*. This is typically referred to as attenuation or selective attention through overt or covert capacities that involve a gating process in the early stages of the sensorimotor system (Djebbara et al., 2022; Foxe and Snyder, 2011; Llinás et al., 2005; Steriade et al., 1990; Sherman and Guillery, 2011). The second level refers to the capability to move beyond perception by addressing the underlying processes that enable human experiences (Teasdale, 1999a, 1999b). Because contemplative states can emerge from being attentive to the process through a metacognitive approach (Kabat-Zinn, 2003), accessing the second level afforded by architecture can lead to spontaneous contemplative states experienced effortlessly (Fig. 3).

To be clear, a crucial challenge for contemplative neuroaesthetics is to illuminate how attention to the ongoing adaption across our sensorimotor system correlates with an aesthetic experience. It is important to note that strictly speaking, we are not suggesting a two-step framework, but instead a continuous flow between the steps depicted in Fig. 3. There are both different kinds and different degrees of contemplative states, which we believe architectural features may support inducing. Another challenge is to demonstrate that external factors, e.g., architectural qualities, can furnish effortless transitions from the first to the second level of attention. One way to address this challenge is to consider whether the procedures and methods of conventional IN-I that are known to elicit contemplative states are compatible with an EX-I approach. We explore this option in the next section.

4. Are IN-I techniques compatible with an EX-I approach?

Achieving contemplative states using internally-focused techniques, such as counting breaths, repeating mantras, practicing open monitoring, or engaging with koans, requires systematic regulation of internal mental processes (e.g., attention), necessitating a significant amount of discipline and intentional exertion. In contrast, the EX-I approach utilizes perceptual and objective elements, e.g., paintings, sculptures, and built environments, to draw and uphold attention. Since the individuals find themselves attuned to such aesthetic conditions, there is little cognitive or affective effort demanded. These two methods correspond to the two directionalities of the human mind (Burgess et al., 2007; Corbetta and Shulman, 2002; Nobre et al., 2004), that is, either towards stimulus-independent (mental and intra-personal events) or stimulus-oriented (perceptual and extra-personal targets). Both directionalities are associated with the operation of two global brain networks involved with processing intrinsic, self-referential stimuli, as well as extrinsic task-related stimuli (Golland et al., 2007).

As previously indicated, attention plays a crucial role in IN-I contemplative states. Dahl et al. (2015) classified contemplative practices into three categories, and among them, the attentional family is widely employed across various methods of mind training. By focusing on IN-I modulation of attention, we suggest on a similar note that the EX-I approach is equally viable in inducing an occasion for contemplative states. Attentional mechanisms afford to narrow the scope of consciousness and thereby cultivate the concentration on a single internal or external focus that produces complete immersion (Brefczynski-Lewis et al., 2007; Lutz et al., 2008a,b). In the context of contemplative neuroaesthetics, we are interested in moving beyond mere attention into becoming sensible of the attunement process, which essentially increases the sense of presence that is central to contemplative states (Csikszentmihalyi, 1990; Maslow, 2013). Getting attuned to the environment is to internally resonate with the external changes. Uncovering the details of this particular experience remains another challenge for comteplative neuroaesthetics. However, the resonance occurs at multiple levels, introducing non-linear coupling among the brain, body, and environment (Ryan and Gallagher, 2020), which may be one way how architectural features, i.e., through repetition and rhythm in architectural features (Charalambous and Djebbara, 2023), can

[4] Notably, mainstream sensorimotor theories do not address the process of becoming sensible of attunement and thus remain inadequate for making sense of contemplative states. We provide a conceptual framework explaining the second level of attention using SMC.

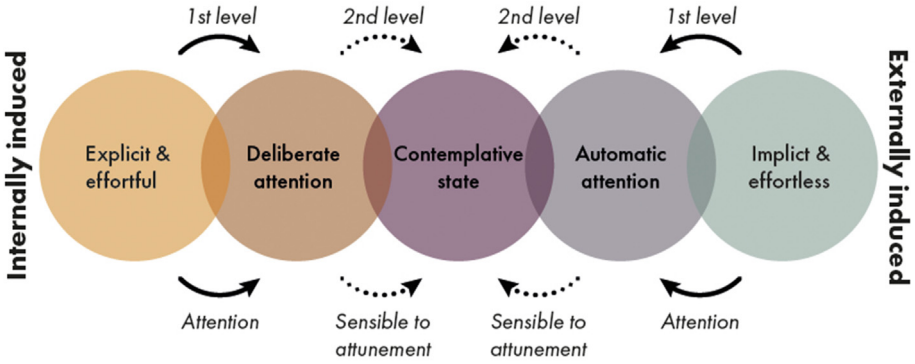

Fig. 3 General steps for both an EX-I (right to centre) and an IN-I (left to centre) process to reach contemplative states. Starting from the 1st level of EX-I, the ongoing implicit sensorimotor grasp of the environment sets the point of departure. Attention is precipitated by environmental features and causes a sensorimotor response to external objects and/or space. That is, attention makes us aware of external objects by getting attuned to the sensorimotor laws of change. On the 2nd level, whereas arriving at IN-I contemplative states requires a deliberate act of intention, an EX-I mindful experience demands devoting full attention to (or letting it be absorbed into) the sensorimotor flow of aesthetically pleasing spaces and other artefacts. In becoming increasingly sensible of the ongoing attunement (interaction between self and situation), one can transcend the self-centred experience and become attentive to the attunement itself, i.e., conscious of the emerging dynamic pattern between sensory and motor actions vis-à-vis the environment. The main difference between EX-I and IN-I is the presence or the absence of the deliberate effort in controlling attention toward the attunement, making one sensible of attunement rather than the external object.

attract and sustain attention to induce a contemplative state.

For instance, directing attention to the pace[5] and experience of breathing is a fundamental IN-I method (Kabat-Zin, 2006, 2013). This technique allows to diminish self-referential processing and enhance sensory processing—both alterations are core components of contemplative states (Tang et al., 2015). It requires directing attention to the embodied experience of breathing, that is, the process of being filled with air and deflating, only to start the sequence again if distracted by analytical discoursive thoughts. While the last breath is gone and the next breath has not yet arrived, focusing on the present breath invites the meditator to go into a sharper awareness of the present. One could argue that directing our attention to the rhythmic and consistent process of breathing, which inherently demands continuous presence, is akin to the pervasive nature of surrounding architecture. In doing so, it naturally anchors us in the present moment and eventually brings full attention to the process of attunement. The act of breathing, which affirms our existence and sustains life, can be likened to the constant sensory exposure we experience from the world, affirming our embodiment as beings in the world. Similar to our constant and involuntary act of breathing, we are perpetually exposed to the external world. Therefore, deliberately directing our attention to this ongoing exposure can be seen as a comparable skill and potentially can serve as an alternative approach to induce contemplative states. Mastering this alternative approach, which is a natural part of our lives, may prove to be less challenging than attaining IN-I practices like focused attention meditation with breathing, which may be rather unnatural for many people.

The environment needs to allure the perceiver by way of salient aesthetic features, which certain architects and artists excel at exploiting, and thereby direct attention towards the bodily rhythms. To be engulfed by the environment is in stark contrast with ordinary mental states (e.g., mind-wandering) that encompass stimulus-independent thoughts that usually result in decoupled internal states with the sensed environment. Mind-wandering is centred on the narrative-self and causes detachment from our context or environment and reduces attention to the present moment (Smallwood et al. 2007), whereas getting attuned is more about resonating with our surroundings free of any analytical or other self-centred mental narratives.

4.1. Exemplary cases

What exactly does it mean to be sensible of the attunement process? Consider the following brief analysis by Henry Plummer on the agility of the floor in the Rundetårn (The Round Tower; Fig. 4) in Copenhagen, Denmark:

> *As the floor begins to tilt, all of our kinesthetic faculties are brought into play to remain balanced while counteracting gravitational forces with powers applied through our angled feet and swinging torso and limbs. This kind of creative navigation is a central experience of the ramps in Renaissance villas, or equestrian coils such as the Rundetårn in Copenhagen, whose inclines take off from the earth in a low trajectory, to then bend or curve around on themselves and keep altering the course mid-flight, complicating kinesthesia with*

[5] The pace of sensorimotor information as the mobile user explores an environment is also relevant in this case. For instance, installations by James Turrell exploit the slow and continuous change in sensorimotor information when experiencing his artworks, which typically involve the phenomenon of light in intentionally designed isolated and minimalist environmental conditions. The absence of distracting sensory information allows visitors to maintain experiential focus without unexpected changes that allure attentive behavior to go elsewhere.

Fig. 4 An image of the tilted floor of Rundetårn, Copenhagen. Source: Djebbara (2023).

> *centrifugal forces. The entire body comes alive as it strains to generate lift and propulsion, drawing arms and legs into action with a miraculous blend of energy and equilibrium, coordination and endurance. The climber is made intensely aware of the relation between his centre of gravity and the lifting and pushing pressure of legs, as well as the need to carefully keep shifting weight to balance and rebalance the body in motion.* (Plummer, 2016)

Engaging the whole sensorimotor system induces a heightened awareness of how the body is challenged and recalibrated in time and space, resulting in complete resonance with the built environment. The rhythmic movement aligns with the rhythmic visual perception, which in turn aligns with the lift and propulsion, the equilibrium and coordination of the limbs. The entire body is what induces the contemplative state. Attention is entirely directed towards the sensorimotor dependencies, guiding the gaze and gait. Architecture can truly be a verb that can put human interactions in motion (Robinson, 2021).

Importantly, we are not referring to how the experience comes about as this would include any kind of experience. Instead, we are referring to the attention directed toward the process of experience itself, which is a skill that architects master greatly in the context of sensing space. Consider for instance how Juhani Pallasmaa, the Finnish architectural phenomenologist, focuses on how his body is captured by, and reflecting, the structure of space:

> *When experiencing a structure, we unconsciously mimic its configuration with bones and muscles; the pleasurably animated flow of a piece of music is subconsciously transformed into bodily sensations, the composition of an abstract painting is experienced as tensions to the muscular system. The structures of a building are unconsciously imitated and comprehended through the skeletal system unknowingly, as we perform the task of the column or the vault with our body.* (Holl et al., 2006)

As we surrender to the allure of the environment's beckoning possibilities, our movements take on a meandering quality, guided by the serendipitous encounters that unfold along our path. In this unhurried exploration, we immerse ourselves in the richness of our surroundings, embracing the unscripted and spontaneous nature of our journey. Each affordance discovered and experienced becomes a gateway to new experiences, inviting us to engage with the world in a fluid and intuitive manner. Through this process, we become active participants in a dance of discovery, harmonizing with the rhythm and flow of our environment. Peter Zumthor, the renowned Swiss architect, put it elegantly:

> *Architecture is a spatial art, as people always say. But architecture is also a temporal art. My experience of it is not limited to a single second. […] That means thinking about the way people move in a building […] Let me give you an example, in connection with some thermal baths we built. It was incredibly important for us to induce a sense of freedom of movement, a milieu for strolling, a mood that had less to do with directing people than seducing them. Hospital corridors are all about directing, for example, but there is also the gentler art of seduction, of getting people to let go, to saunter, and that lies within the power of an architect. [The thermal baths] were spaces you would enter and begin to feel you could stay there […] but then something would be drawing me round the corner—it was the way the light falls, over here, over there: and so I saunter on—and I must say I find that a great source of pleasure. The feeling that I am not being directed but can stroll at will—just drifting along, you know?* (Zumthor, 2006)

Zumthor's description delves into the joy of sauntering, offering a reflection that goes beyond architectural design. This passage offers no architectural details of the baths. Instead, it offers a reflection of his focus on bodily awareness and the interconnectedness of spatial affordances. This distinction is crucial as it emphasizes the interaction with space, transcending the narrow perception of architecture solely based on visual sensations prevalent in modern times. Rasmussen, the Danish architect and theorist, aptly articulates that experiencing architecture involves active engagement rather than mere observation. A notable instance that exemplifies this perspective is found in the Santa Maria Maggiore church.

> *The many tourists that are transported to the church barely realize the place's peculiar character. They merely note that they have visited one of many famous places as mentioned by the tour guide and then hastily move on to the next one, but they do not experience the place the same way that I witnessed some boys did a few years back. I suppose they were enrolled at the local convent school. They had their recess by eleven o'clock where they played a kind of football on the large, wide landing of the stairs, however, they also made use of the wall, similar to Squash, only this wall was curvilinear—and they did with liveliness and virtuosity. […] I do not claim that the Italian learned more about architecture than the tourists, however, without their knowledge, they experienced some of the foundational architectural elements: the horizontal planes and the vertical walls above the slope. And they learned to play on these elements. While sitting in the shadow, following their game, I sensed the whole three-*

dimensionality of the space more intensely than ever. (Tanslated from Rasmussen (2012))

Rasmussen suggests that while the tourists may not have gained a deeper understanding of architecture, the boys, through their spontaneous interaction with the architectural elements, experienced a fundamental aspect of the space. As the author observes their game from a shaded spot, an intensified sense of the space's three-dimensionality engulfs them. This passage highlights how attunement to the affordances offered by the architectural environment, as exemplified by the boys' playfulness, can lead to a more profound and sensorially rich experience of space.

The results of a large survey on "extraordinary architectural experiences" offer further evidence of the capacity of architecture to produce remarkable contemplative states in response to its physical (aesthetic) manifestation. Bermudez (2009, 2015) and Ro and Bermudez (2015) report nearly 2900 poll respondents defining their powerful encounter with architecture as being introspective/silent (87% of them) and characterized by non-talking (62%), higher level of awareness than normal (89%), spontaneity (82%), strong body reactions (53%) including weeping (21%), and their emotional and sensual/perceptual/physical nature. A majority in the top 10 buildings cited to produce such memorable experiences were structures dedicated to sacred functions (i.e., temples, churches, masjids). Bermudez offers several testimonial examples from which we extracted the following three, one of them confirming Zumthor's statement (Figs. 5—7):

The Salk Institute, La Jolla, California, 1971

We arrived at the Salk and just walked out into the courtyard without going into the reception office first. Within the first 5 minutes of being in the courtyard and seeing the horizon, I remember having a tremendous rush of joy. I remember coming to a (sudden) realization that I was now involved with something that was connected to something powerful and bigger than I ever imagined possible. I remember a physical feeling in my chest: like my "heart in my throat", which I do not remember feeling before (but have felt since). I also recall wanting to jerk into motion – I wanted to run; swing my arms; do anything other than just stand in place. It was like I suddenly knew something that I didn't know before. I also recall thinking about the fact I could not make a direct correspondence between what I was feeling and the architecture, per se. It's that strangeness that in retrospect points me to the feeling that … I was in touch with something really awesome and bigger than the structure itself. Joy and optimism.

Therme Vals Bath, Switzerland, 2007.

I felt this building more deeply than I have ever felt any piece of architecture. As soon as I entered the baths, I felt that I had been reduced to nothing but senses and emotions. I touched the expertly crafted stone to my fingers and toes. I dipped my body into each individual pool, marveling at the sensations each change in temperature caused. I breathed in the sweltering black heat of the sauna. I smelled the mineral water and swished its metallic coolness in my mouth. I watched the green mountains from the outdoor pool. I was overcome. Such overwhelming simplicity in design and material was closer to divinity than I had felt in any other man-made design. As I surrounded myself with the purity of living rock, water, mountain, and light, I couldn't help but crying for the beauty and deep spirituality of it all. I felt the spirit of the place. I cried and cried at the realization of the deeper meaning of it all. Zumthor had captured the immaterial and the immortal. I had no idea that someone could do this in architecture.

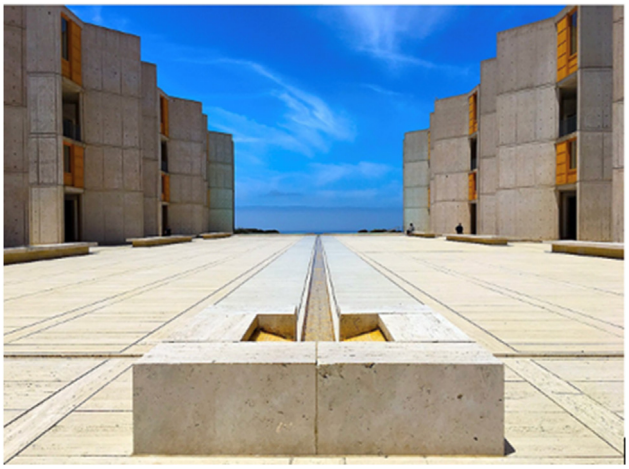

Fig. 5 The salk institute by Louis Kahn, La Jolla, California, USA, Copenhagen. Source: Codera, 2023.

The Chartres Cathedral, France, 1981

I remember walking into the nave which seemed to be in twilight. The strength of the dome and archways recalled to me the people who created it. I felt as though their hands were my own and, through history, I could sense the focus with which they had put the stone together. I also felt the faith, or strength of belief, that thousands of people had brought to this structure before me. In total, it was deeply moving and something which still brings tears to my eyes.

By presenting startling sensorimotor opportunities that afford making us sensible of the attunement process, certain architectural works are capable of bypassing mind-wandering and self-referential thinking activities. Bypassing of ordinary mental processes is what is required to enter into a contemplative state (Gethin, 2011; McCracken et al., 2014). The architectural conditions that propitiate contemplative states are to be found in many types of designed buildings and not properties of a specific type of architecture. Recognized architects are known precisely because they can utilize the sensory and motor capacities of human beings to produce such conditions, e.g., Peter Zumthor, Louis Kahn, Carlo Scarpa, and Steven Holl to name a few.

In contrast to the relative ease in accessing EX-I contemplative states (when the right conditions are in order), IN-I methods involve intentional effort (Fernandez-Duque et al., 2000) and require prior practice and directions typically done through some form of systematic

Fig. 6 Therme vals by Peter Zumthor, Switzerland. Source: Mariano Mantel, Flickr.

learning (Kabat-Zin, 2006). At an early stage, the deliberate effort is demanding and may seem unnatural. Maintaining meditation practice will lead to an intermediate stage where the effort is directed at reducing mind-wandering. At an advanced stage, after years of practising, the contemplative state may begin to be attained effortlessly (Tang et al., 2012, 2015). The constant exposure to human-made environments and artfacts suggests that when the appropriate architectural circumstances are in place, directing attention to sensorimotor processes offers a more familiar or natural (and therefore easier) way to initiate contemplative states than quieting the mind on demand by the IN-I mind training. It remains to be seen if there are some meaningful differences in the nature and the quality of contemplative experiences elicited by EX-I vs. IN-I methods developed for contemplation, and as such, contemplative neuroaesthetics seems to be poised to investigate this type of empirically tractable questions in the near future.

What pattern of activity might we expect in the brain during such experiences? According to SMC and the existing literature on mind-wandering and mindfulness, we anticipate an increased activity of the sensorimotor cortex, with a significant decrease in cortical areas involved in self-referential processes, e.g., prefrontal regions. Unfortunately, there is currently only one empirical study of EX-I contemplative states to date that limits our ability to evaluate our theoretical proposition. Yet, such investigation along with another on architectural affordances appealing to the sensorimotor contingency provides preliminary support for the theoretical approach presented in this paper, as we will see in our brief review next. By the same token, this absence of studies designed to examine architecturally-induced contemplative states indicates that contemplative neuroaesthetics finds itself in unexplored territory of human behaviour and experience.

Fig. 7 Interior of the chartres cathedral, France. Source: King, 2023.

5. Empirical insights

To move beyond theoretical considerations, this section provides a brief examination of the neural patterns associated with EX-I contemplative states compared to IN-I methods. Although there is currently only one study explicitly addressing the induction of contemplative states through architecture, we also discuss another neuroscientific investigation concerning architectural affordances to underscore the significance of affordances in shaping neuronal responses. This serves as a crucial foundation for the proposed theoretical framework. The key takeaway is that heightened engagement of regions linked to sensory and motor experiences is associated with an intensified bodily awareness. Additionally, reduced activity in frontal areas, which are responsible for mind-wandering, appears to contribute to an enhanced sense of being present in the current moment.

In an exploratory study, Bermudez et al. (2017) compared the responses of 12 architects to viewing visual images of ordinary and contemplative buildings. The study consisted of both neuroimaging data using an fMRI and a subjective self-report during scanning, including a phenomenologically oriented exit interview. Stimuli, which were visually presented to the architects as they were laying in the scanner, consisted of two blocks; ordinary (control) and contemplation-inducing (experimental) buildings. Subjects were instructed to imagine themselves to be in those places. Based on experiential data from self-reports, the study found significant reductions in anxiety and mind-wandering for the condition of viewing contemplation-inducing architectural pictures. Additionally, subjects reported an experience whose depth, character (defined as beautiful, timeless, and emotional), outcomes (defined as peace, pleasure, and insight), levels, and directionality of attention may be safely characterized as both aesthetic and contemplative. The fMRI data consistently revealed the down-regulation of the frontal lobe along with the up-regulation of sensorimotor regions of the brain during viewing visual images of contemplative buildings. Specifically, the study found activation of sensorimotor regions that are involved in processing information from the external world, such as premotor, visual areas (occipital gyrus), precentral and superior frontal lobes, and inferior parietal lobe. The study further found activation in the anterior cingulate cortex and insula that are related to emotional and interoceptive capacities, respectively. The insula has been associated with reflecting visceral processes, critical to interoception, which supports the embodiment of aesthetic experiences (Brown et al., 2011; Uddin et al., 2017; Wang et al., 2019). Most remarkable was the down-regulation of the prefrontal cortex and orbitofrontal cortex, indicating a disruption of

the default network and related mind-wandering cerebral activities. It should be noted here that since this was an fMRI study, participants were situated in the scanner, which prevented them from moving in space. This is a major limitation of the study. A more naturalistic study combined with mobile EEG technology, investigating how people respond to ordinary and contemplative buildings (allowing them to move in space in the real world), is needed to investigate and evaluate these preliminary findings further.

The results of this study speaks to the Transient Hypofrontality Hypothesis in the literature of neural correlates of altered conscious states (Dietrich, 2004, 2006; Dietrich and Al-Shawaf, 2018). While recent theories of the neural correlates of consciousness emphasize frontal cortical function for higher attributes, the hypofrontality hypothesis suggests that during certain cognitive states or activities, there is a temporary decrease in frontal brain activity. This reduced activity in the prefrontal cortex can lead to a diminished sense of self-awareness and less reflective thinking, allowing individuals to fully focus on the task at hand and experience a heightened state of engagement. This hypothesis is supported by studies involving brain lesions, imaging, and electrophysiology showing that the prefrontal cortex is not necessary for basic awareness, unlike other brain areas such as brainstem nuclei and intralaminar nuclei (Baars, 1995). One interpretation suggests that during hypofrontality, there is a suppression or a reduced activity in the frontal regions, including those involved in self-referential thinking and mind wandering, allowing for a state of heightened focus and absorption in the present moment through increased activity in sensorimotor cortices. To evaluate whether the environment can have an impact on our sensorimotor network, we next review the study by Djebbara and colleagues (Djebbara et al., 2019a, 2019b, 2021). Their study offers insights into how sensorimotor brain dynamics is directly coupled with architectural affordances. Their experiment applied a Mobile Brain/Body Imaging technique (Gramann et al., 2011, 2014) involving the integration of Virtual Reality with an electroencephalogram (EEG) to study how the affordances of architectural transitions affect brain dynamics. The moving participants were instructed to pass through a door from one virtual space into another. The doors varied between three conditions, easily passable, barely passable, and impassable. Their study showed firstly that upon perceiving the door, the early perceptual processes over the sensorimotor region systematically reflected the affordances of the door, suggesting that the bodily and interactive capacities are inherently entangled with our perception and experience of architecture; affordances manifest in parallel with sensory information (Djebbara et al., 2019; Djebbara et al., 2021). Secondly, their study showed that while the participants actively approached the different doors, another systematic change in the alpha frequency domain over the temporo-occipital region reflected the affordances of the door. The alpha desynchronization over the temporo-occipital region has previously been theorized to reflect the gating function of sensory information in thalamocortical systems modulated by attentional capacities (Foxe and Snyder, 2011; Llinás et al., 1998, 2005; Van Diepen et al., 2019). Furthermore, their study was able to identify the involvement of the para-hippocampal area, premotor, and posterior cingulate cortex, which are areas also recognized by Bermudez and colleagues' study.

These two studies demonstrate (1) the possibility of applying neuroscientific research methods to investigate contemplative states using architecture (2) the plausibility of using architectural affordances to investigate the sensorimotor dynamics. These two reviewed studies are far from sufficient in presenting a convincing argument for architectural features as inducing contemplative states. However, we are encouraged by the reported results so far and, more importantly, the potential of this emerging research field. As discussed in Section 1, the health benefits of contemplative practices have been and continue to be amply demonstrated (see Kabat-Zinn, 2003; Keng et al., 2011). In this regard and for future explorations, contemplation in therapeutic settings also offers a valuable translational path to connect systems of the central and autonomic nervous systems with the observable behaviours of an individual. Studies that integrate elements of architecture and neuroaesthetics provide a framework within which to further understand the role of the environment as a therapeutic tool and healing agent[6] (King and Parada, 2021). Conducting neuroaesthetic studies aimed at facilitating access to contemplative states helps to translate data from the lab to clinical health populations while taking into consideration necessary social and contextual factors that influence the mind and behaviour. These translational data may contribute to the development of culturally competent, innovative, and scientifically grounded treatment approaches geared to enhance the quality of life of both the general public and those in need, e.g., art psychotherapy, hospice, hospitals, psychiatric clinics, museums, office areas, libraries, public spaces, and so on.

6. Conclusion

We set out to define the novel emerging field of contemplative neuroaesthetics in the context of architectural works by distinguishing our approach from the existing literature in neuroaesthetics. At large, we suggest that EX-I contemplative states should increase our dynamic embodied awareness by becoming attentive and sensible of the experience underway. In laying a broader framework to cultivate the new domain of study, we first elaborated on the theoretical framework for contemplative neuroaesthetics. We then turned to a conceptual application by comparing and translating the main components of conventional IN-I methods to an EX-I approach, focusing specifically on architectural experiences, as existing literature on sensorimotor account makes this effort viable. We suggested that becoming sensible of the attunement process is what creates an occasion for entering into a contemplative state.

[6] For example, concretizing concepts of mirror neurons and embodied simulation are informative in the clinical treatment of trauma and provide a guide for the therapeutic intervention (Buk, 2009).

We emphasize that our sensorimotor exploration of the aesthetic experience of architecture aligns with a growing number of theoretical, phenomenological, or neuroscientific studies in architecture, such as the works of Pallasmaa (2009, 2012), Mallgrave (2013, 2018), Robinson and Pallasmaa (2015), Pérez-Gómez (2016), Goldhagen (2017), Gallese (2015, 2020), Shusterman (2008), and Robinson (2021) indicate.

Investigations on peak experiences (Maslow, 1976, 2013) or flow states (Csikszentmihalyi, 1990) in psychology point at responses similar to aesthetic contemplation: attentive absorption directed to the external world, leading to highly emotional and pleasurable experiential results with neural correlates such as hypofrontality along with high activation of motor and sensory centers and the inferior parietal lobe (Csikszentmihalyi, 1990; Dietrich, 2004, 2006; Goldberg et al., 2006). We speculate whether various psychological constructs, such as the experience of wonder, appreciation (Fingerhut and Prinz, 2018), awe (Bonner and Friedman, 2011; Guan et al., 2018; Joye and Dewitte, 2016; Van Elk et al., 2019), and contemplative states (Bermudez et al., 2017) may be similarly supported by an underlying shared neurobiological system that are operative in a wide ranging of cases involving alterations in the construction of consciousness.

While our theoretical exploration of Contemplative Neuroaesthetics is in its beginning, the impacts of such thinking and practice in fields such as architecture could be meaningful. For example, many de-facto claims by architects and users that some building types (e.g., churches, libraries, museums) may occasion contemplative responses would be both taken seriously and testable using scientific methods. Additionally, if certain buildings can be empirically shown to induce, or even approximate, contemplative states in people, then clients and communities could use them to positively affect human health and well-being, thus ushering in a scientifically-grounded therapeutic and positive-psychologic practice of architecture. In this regard, designers would be able to analyze the architectural features, conditions, and qualities producing such beneficial responses in order to reproduce them in future built environments. Finally, developing Contemplative Neuroaesthetics would significantly contribute to architecture's evidence-based design, a growing movement that uses the scientific method to better understand, design, construct, and evaluate the built environment's impact on human beings and nature.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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