2022

Generators of Artchitectural Atmosphere

Elisabetta Canepa

INTERFACES 3

New Prairie Press

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Editors
Elisabetta Canepa
Bob Condia

Authors
Elisabetta Canepa
Bob Condia
Sergei Gepshtein
Kutay Güler
Tiziana Proietti

Copy editors
Kory Beighle
Brittany Coudriet

Graphic designers
Elisabetta Canepa
Brittany Coudriet

Book format
6” x 9” | 152 x 229 mm

ISBN
978-0-9915482-6-2

DOI
10.5281/zenodo.7191265

Electronic edition available online
at www.newprairiepress.org/ebooks/48

2022
New Prairie Press
Kansas State University Libraries
Manhattan, KS, USA

NEW prairie PRESS
open access scholarly publishing

Acknowledgements
This book was born as the legacy of the Generators of Architectural Atmosphere Symposium, an Interfaces event of the Academy of Neuroscience for Architecture (ANFA), sponsored by the EU’s Horizon 2020 MSCA Program — RESONANCES Project, the Perkins Eastman Studio, and the 2020 Regnier Chair. The event was hosted in the College of Architecture, Planning and Design (APDesign), Kansas State University, Manhattan, Kansas, on April 12, 2022. The RESONANCES project (Architectural Atmospheres: The Emotional Impact of Ambiances Measured through Conscious, Bodily, and Neural Responses) received funding from the European Union’s Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement no. 101025132. The content of this book reflects only the authors’ view. The European Research Executive Agency is not responsible for any use that may be made of the information it contains. For further information, please visit the project website: www.resonances-project.com

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INTERFACES 3

Generators of Architectual Atmosphere

Bob Condia

Introduction: The Applied Science of of Generating Atmospheres in Architecture

Let us ask, what is it architects make? Many people build buildings, architects among them. Yet architects know there are essential qualities in our relationship with places they call *atmospheres*. Recent advances in biological science are confirming architect's expert predispositions, while opening new doors of perception about the meaning of constructed spaces. *Generators of Architectural Atmosphere* presents a discourse concerning human awareness of design and buildings, specifically speaking to the significance of the atmosphere of places. *What* exactly do architects make? Architects make atmospheres that vibrate or resonate within us. *How* do architects sensibly make such atmospheres? Replying is a generous inquiry. And, *what* is it that generates the vibrations, the harmonics, and the geometry that sensibly inform behavior? Herewith we present three suggestions.

Elisabetta Canepa investigates how this mess around us, which we understand as a building's construction, transforms via the craft of atmospheric generators. **Kutay Güler** analyzes certain analogies from the experiences of virtual reality with questions of immersion and presence. Then, **Tiziana Proietti** and **Sergei Gepshtein** assert the sensorial influences and visual experiences of proportional space, understood as movement, projection, and conduct, hardened through the scientific method. In this concise summing of descriptions — architecture, phenomenology, and biology — *is there an applied science and craftmanship for architects designing atmospheres?*

Let us see. By way of life, we perpetually find ourselves within atmospheres — even if customarily nonconsciously. It appears how atmospheres behave is something we inescapably need to diagnose. Architects, by way of professional exercise and observation, know that bounded spaces, rooms commonly speaking, are measured by our entire sensory systems, as a whole body, and understood by way of embodied simulation, manifesting via our brain's mirror mechanisms. Hence, *spaces mean something through atmospheres* because of what they afford us as potential actions, and possible life-engagements, always conditioned by our situated ambitions. The consequence of this evanescent exchange or resonant comprehension is *mood*. Here, mood is a simple concept implying our psychological condition adjusting attention through the instant, as we do with music, friendship, and art. From the discovery of mirror mechanisms in the brain comes an embodied simulation theory, which suggests a structural frame for aesthetic understanding in the architect's practice. Here is one of my favorite rooms in the world [**F1**]; an upper-floor gallery at the Castelvecchio (circa 1956 in Verona, Italy). The staging within this galleria frames an explicit *choreography* with precise observation, vision, light, and atmosphere.

The best example of a compositional atmosphere is this place. This room is quite remarkably designed, as no architect plus curator has ever understood *the body as the heart of measuring space* like Carlo Scarpa. For instance, the suspended painting on the right is tilted toward the door where the guard stands. An aesthetic entity composed for central vision, inviting focus and attention. While from the view of our doorway, Scarpa suggests a strangeness with the exposed back of the same painting. Interestingly, when one approaches this position, we encounter the micro or sub-space position (behind the painting) for the smaller picture to the right (on the wall), increasing the intimacy with the smaller picture. Then, when you turn to enter the main gallery, you are greeted by the large work (again in foveated vision) arranged to move your body towards an inspired distance to view the marble sculpture

F1 Bob Condia
Castelvecchio Museum
Verona, 2018

Madonna and Child
with Saint Anne (Sant'Anna Metterza)
by Giovanni Zebellana
Castelvecchio, Reggia wing
exhibition space designed by Carlo Scarpa
1956–1975

at the window wall. And so, the choreography goes as the curator's genius gives away specific experiences of individual works within the wealth of the gallery. Proietti and Gepshtein will later suggest science for similar experiences.

Michael Arbib describes another careful measure of our engagement with space when telling us that atmosphere is our emotions filling up a place. Michael is a neuroscientist interested in architecture and the design of buildings. Over the last ten years, he and I have pursued a vocabulary traversing neuroscience and architecture. His book *When Brains Meet Buildings* (2021) is the preeminent attempt to pinpoint the architect's and neuroscientist's common curiosity in a science of space. It is a pretty good book, if at times difficult to read. It is a neuroscientist thinking about how the brain's biology senses and apprehends the spaces around our bodies. I believe this is the first examination of one's sensorial engagements with buildings from such a defensible and scientific perspective. From Arbib's point of view, atmospheres are the pervading tone and mood realized by affordances manifesting in schemas.

Of all the philosophers borrowed by architects, when it comes to atmosphere there is no one to rival Tonino Griffero. A neophenomenologist, or better an "atmospherologist," his vital definition of atmosphere is what you leave behind when you exit a room. A definition that is simply precise. Atmosphere is also the presence and collaborative co-experience of entering a room. In another example, he tenders the experience of an urban, glass-box-like bank lobby, where, for the workers of the institution, the experience is one of prestige, yet the same lobby that offers esteem to the employees is felt as oppression by a loan-seeking client. Same space, same lighting, and similar affordances, but very different in terms

of how one's sensations are acknowledged or felt. Make no mistake, what we carry with us as mood into an atmosphere has a lot to do with *how* we see it. Architects understand this multiplicity of simultaneous experiences as the poetics of their profession, although, such atmospherology is rarely discussed as anything but light. Canepa's atmospherology begins to suggest the architect's vocabulary by way of her generators of atmosphere.

The Earth's atmosphere, in pressure (at sea level) is 14.7 pounds per square inch on your skin, a force invisible to the human eye and consciously undetectable. That atmosphere, as a liquescent environment, moves well into the background, as it should be. And yet, as professionals discerning buildings, it is prudent for us to comprehend what our exchange with atmospheric presence is and how it informs behavior, voluntarily and otherwise. "In any case," as Tonino Griffero (2018) would say, "in today's debate, atmosphere is not simply meant as a decorative aspect of life, but rather as a feeling or affect that, being not private and internal but [objective] and spatially spread out, 'tinctures' the situation in which the perceiver happens to be and affectionally involves [herself]." So the color of an atmosphere shares instructions for behavior, even as we change it amid our presence. And what we convey into it, our mood, or the focus of our moment, correspondingly engenders something specific to our visit. *Is it* we *who generate atmospheres by being available in them?*

Fortunately, the scientists employed in the neuroscience and architecture debate have acquired Peter Zumthor as the architect they most appreciate. This is a significant intersection because architects appreciate his wisdom too. For instance, Peter Zumthor declares in the introduction to his little book about atmosphere that "I've been keeping [a keen] eye on myself, and I'm going to give you an account now, [...] of what I've found out about the way I go about things and what [comes to] me most when I try to generate a certain atmosphere in one of my buildings. Of course, these answers to the question are highly personal. I have nothing else" (2006, 21). Right. So, the instrument of his understanding of atmosphere, both as a designer and as a person, is his biological senses and memories. We all have the same bodily instruments, only our neurological and sensory tuning differs. An architect as an atmospherologist will be tuned to the generators of human behaviors, meaning the *language of atmospheres*.

Architecture always means something by way of an invitation to action. Architecture always creates atmosphere; sensing what these are is the architect's prerogative and responsibility. This is the position of **Elisabetta Canepa** in our first chapter, "The Atmospheric Equation and the Weight of Architectural Generators." The basic generators of experience from atmospheres can be categorized as biographical, sensorial, and contextual. How we sense this is through a resonance between our body and the spaces we attend to. Her mathematics are quite interesting, by the way. **Kutay Güler** studies atmosphere through virtual reality (VR). His opening volley in "Sensing the Atmospheric Space Through a Virtual Lens: Scrutinizing Opportunities and Limitations" is a noteworthy history of VR architecture and research of the 2015–2016 revolution with the advent of powerful desktop machines. That such precise simulation of experience is available for architectural work infers many investigations for designers. The issues seem to be about presence and immersion; that is: how valid is the virtual? Güler explains his effort to decern, by way of experiments, the discourse on spatial perception,

resolving the relationship between immersion and presence. The key to this may lie in the symptomatic cybersickness people endure when their minds are in one space and their bodies another. This then begs the question for designers about the validity of such disengaged experiences for design decisions. **Sergei Gepshtein** and **Tiziana Proietti** are a team of a neuroscientist plus an architect (respectively) inquiring into the most basic unit of an architect's spatial toolbox in atmosphere: proportion. In "Locating Architectural Atmosphere," they profoundly suggest that geometry (like atmosphere) is an affordance of space and time. Their experiments revealed three layers of visual experience from which humans interact with form through movement and perception. If the Renaissance suggested proportions through one point perspective, contemporary biology confers dynamic spatial engagements of overlap. In short, the three chapters admit that *atmospheric experience is more of a verb than a noun*.

My summation is that when considering the true language of atmosphere, we need three apparatuses to help us: 1. — *Architecture* as design, form, and construction; 2. — *Philosophy* as in a phenomenological description of the spaces in which we find ourselves, and as a way of reading and understanding human nature relative to the world around us; and, 3. — *Neuroscience* by which I mean the biology of the human body in relationship to atmospheres in the life-world. Atmospheres are understood through all our sensory organs as potentials for actions. We are in the world as active agents, and the world is tacit in terms of our neurological systems as a response to what we can do in these spaces. Let us see if we can apply some of this thinking, so briefly introduced, and discover how we generate atmospheres.

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Figure 1: © Bob Condia, 2018.

F1 Incognito
atmospheric equation

[X+X+X+X+X+X]+
[(X+X+X+X+X+X+X+
X+X+X)+(X+X+X+X+
X+X+X+X+X+X+X)]+
[X+X+X+X+X+X+X+
X+X]+[X+X+X+X+
X+X+X+X+X]+[X+
X+X+X+X+X+X] = ?

We are sometimes eager to celebrate
the influence of our surroundings.

The noblest architecture can sometimes
do less for us than a siesta or an aspirin.

(de Botton 2006, 13; 17)

Elisabetta Canepa

The Atmospheric Equation and the Weight of Architectural Generators

Abstract
Atmosphere is the whole of affective meanings identifying a situation or place that allows us to resonate and tune into our surroundings. The complexity of atmosphere is well known [**F1**]. This essay analyzes the — design and aleatory — determinants that prime atmospheric effects to estimate the contribution provided by the physical environment (namely, the architect's domain of intervention). Staging atmospheres is a compositional task in which we orchestrate different architectural generators to let our bodies emotionally resonate with the multisensory entirety of forms, materials, shades, colors, sounds, and scents that constitute a place. Designed atmospheres become generators of identity and meaning.

Keywords
architectural composition
meaning
identity
atmosphere
emotions
body
resonance
attunement
aleatory determinants
design determinants
generators of atmosphere

F2 Paolo Monti
photo series *Gualtieri*, 1977
BEIC 6339054

1 “In terms of its significance for human life, *place* can be defined as any environmental locus that, in time and space, draws together individual or group actions, experiences, intentions, and meanings” (Seamon 2022, 1). A child can turn a lawn into a soccer field by naïvely tying three branches together, which gives their physical domain of movement and interaction experiential value. To further explore the difference between the concepts of *space* and *place*, see Norberg-Schulz 1979, 1988a; von Meiss 2011; Böhme 2013a, 25–26; Mallgrave 2018, 117–120; Robinson 2021, 15–18.
2 As the American historian Lewis Mumford (1895–1990) recalls, “though food-gathering and hunting do not encourage the permanent occupation of a single site, the dead at least claim that privilege. [...] The city of the dead antedates the city

Equation
In school, we learn Euclidean geometry to comprehend fundamental geometric notions like points, lines, and planes in space. Then, we study the Cartesian coordinate system to understand those elements in a numerical language. Euclid’s approach proceeds logically from axioms describing basic properties of geometric objects; the Cartesian approach, introduced almost two thousand years later, employs coordinates to express geometric properties as algebraic equations. These axioms, and the related equations, are carved in our memory. Though many years have passed since high school algebra, we can recite common concepts like any two distinct points determine a unique straight line; or, any three non-collinear points determine a unique plane.

As architects, we outline and internalize this essential axiom: three elements transform *space* into *place*[1] [**F2**]. Three are the elements that gave birth to the beginning of architecture as a *place* where one permanently stays. They are three elements that — initially conceived to take care of deceased loved ones instead of living people — survived until the contemporary era: two upright slabs supporting a horizontal capstone lying upon them[2] [**F3**]. The first physical structures humans fixed to the ground were burial chambers, constructed long before any lasting shelters our ancestors erected to dwell, or simply to defend themselves from nature. This circumstance explains the spiritual origin of architecture,[3] revealing its potential to confer *meaning* to the physical environment — in response to our innate need for deepened and enriched experiences. “Architecture is,” in fact, “ideally located at the intersection of [two] complementary aspects of our lives (i.e., fitness and flourishing),” confirms the philosopher Mark Johnson, “insofar as the ways we organize space and buildings address simultaneously our need for protection from the elements and our need for meaningful experience” (2018, 242).

of the living. In one sense, indeed, the city of the dead is the forerunner, almost the core, of every living city" (1961, 7).

3 Juhani Pallasmaa shared this reflection to comment on Harry F. Mallgrave's exhortation redefining the idea of culture (Mallgrave and Gepshtein 2021) during the ACE meeting held on Friday, August 20, 2021. ACE is the ANFA (Academy of Neuroscience for Architecture) Center for Education.

4 Based on the historical reconstruction elaborated by Harry F. Mallgrave (2018, 120–123), Gottfried Semper (1803–1879) was likely the first architect to employ the word "atmosphere" in a design theory text (2004 [1860–1863], 438–439 n. 85). For further details on the genealogy, evolution, and semantic network of the lexeme "atmosphere," with specific attention to the architectural domain, see Canepa 2022 (chapter II "Roots").

Over the years, architects have tried "to come to terms with the essential question of meaning in architecture" (Pérez-Gómez 1983, 7), which is a "very serious problem" (Johnson 2015, 34). Among several attempts made (Norberg-Schulz 1988b), a rigorous *reductionist strategy* was tested. In the beginning was the German Gottfried Semper,[4] around the mid-nineteenth century. More exactly, Semper was the first to endeavor, in a consistent and methodical way, "to make the process of design analogous to the resolution of an algebraic equation": "the 'variables' represented the manifold aspects of reality that architecture had to take into account; the solution was simply a 'function' of these variables" (Pérez-Gómez 1983, 7).

Unknowns

Regrettably, this logic is grounded in many challenges. First, there are multiple types of architectural meaning (Hershberger 1970), including presentational, referential, affective, evaluational, and prescriptive meanings. An intriguing premise is "architecture gets much of its meaning and significance from the ways it organises our bodily perception and experience" (Johnson 2002, 84). If we focus on personal experiences, the meaningful, qualitative essence of every architectural encounter, whether conscious or not, is felt and assimilated — more than anything — through its atmospheres (Condia 2019). Atmosphere is the *emotional-affective component of lived space*[5] that allows us to resonate and tune into our surroundings. It is the "'something-more' generated by a specific place" (Griffero 2018, 79) transcending its material foundation; it is co-produced by the people who occupy and use that space.

The philosopher Tonino Griffero, presenting his book series *Atmospheric Spaces*, explains the founding idea of the atmospheric phenomenon as

F3 Bob Condia
Poulnabrone dolmen, 2018

5 The locution *emotional-affective* refers to the fact we perceive atmospheres by resonating both through our *feelings* (affective appraisals on the experience as consciously felt) and their bodily correlates, namely our *emotions* (somatic feedback, nonconsciously developed, even if sometimes consciously recognizable). As the neuroscientist Eric R. Kandel explains, "an emotional state has two components, one evident in a characteristic physical sensation and the other as a conscious feeling — we sense our heart pounding *and* we consciously feel afraid" (Kandel et al. 2000, 983: original italics). Emotions and feelings mutually interact and influence each other. *Lived space* is the space of the subject's embodied and affective experience. It is "radically different from physical and geometrical space" since it is "structured on the basis of the meanings

being "a vague ens or power, without visible and discrete boundaries, which we find around us and, resonating in our lived body, even involves us" (see, for example, the introductory note to Schmitz 2019, n.p.). This means deciphering the concept of architectural atmosphere as the emotional charge of any architectonically arranged space that sways the experience of the perceiving agent — eliciting a state of *bodily resonance* and potential *affective attunement*. Being part of the co-production of the atmospheric interplay (bodily resonance), and possibly able to recognize its emotional content (if we consciously resonate), [6] does not imply we have become emotionally aligned with it (affective attunement).

Individuals can feel in tune with a specific atmosphere, but they may remain insensitive or reject it (Griffero 2021). For instance, "saying that we bodily grasp the happiness of the party as an atmosphere is not to suggest that we must feel happy ourselves" (Osler and Szanto 2021, 166); we should consider the possibility "we might even get the atmosphere wrong" (Osler and Szanto, 167). There is a distinction between *perceiving the presence of an atmosphere* (resonance) and *being involved in it* (attunement). [7] From an embodied perspective, we may assume if the bodily resonance is significantly aroused, it influences the subject's affective attunement accordingly (Fuchs and Koch 2014). Attunement is the act of appraising an atmospheric event, particularly relevant to the subject, in which we evaluate its affective content by relating the external world to our self-experience. We assign to the situation a *meaning* grounded in that which our resonance gives to us. Meaning is a matter of perception. It informs our actions and behavioral readiness.

Atmosphere is a complex phenomenon because it is invisible, intangible, without physical limits, spatially unstable, temporally ephemeral, highly

and values projected on [the physical space] by an individual or group, either consciously or unconsciously" (Pallasmaa 2002, 18).
6 The previous footnote illustrates the difference between bodily and cognitive components of the resonance process.
7 Cf. De Matteis et al. 2019, § 40–42, where the authors discuss a "non-coincidence between perception and affective involvement."
8 The German philosopher Peter Sloterdijk calls them "atmo-technologies." This expression indicates all the techniques used for microclimatic control of the air, without which "modern forms of existence in urban or rural contexts would be unimaginable" (2009, 92).
9 The purpose of this essay is to understand the variables at play that compose the atmospheric equation and estimate

subjective, often depicted by way of metaphor, and still not structured in a recognized and shared architectural theory (Canepa 2022, chapter I "A Definition Lacking Definition"). For designers, the thorniest aspect is the fact that atmosphere is composite — it is a cohesive force that orchestrates *numerous variables*. "The judgement of environmental character is," indeed, as Juhani Pallasmaa emphasizes, "a complex multisensory fusion of countless factors which are immediately and synthetically grasped as an overall atmosphere" (2014, 230).

Domain

Atmosphere is not a question of mere *physical-environmental variables*, such as air temperature, relative humidity, or light intensity; these factors can be controlled with great precision thanks to the technologies of indoor climate optimization. [8] *Qualitative variables*, of subjective origin and intricate evaluation, are also involved. The scenario becomes even more convoluted when we consider *design variables* (viz, variables that may be planned, intrinsically related to the modifiable space, and over which the architect has some control) and *aleatory variables* (which cannot be dealt with directly). It is crucial to contemplate and analyze aleatory variables because their impact is as significant as it is difficult to quantify. [9]

The premise behind this complexity is "atmosphere is the prototypical 'between'-phenomenon. [...] [It] is something between the subject and the object" (Böhme 1998, 112). An analogy with light exemplifies this relationship. Light is electromagnetic energy pulsing through empty space — a reverberant interplay between a radiating source and an interacting body, capable of absorbing, grasping, and materializing energy. "No matter how brief or accidental this resonance, it is always a mirac-

F4 Paolo Monti
photo series *Milano*, 1961
BEIC 6361977

Rondanini Pietà
by Michelangelo Buonarroti
Castello Sforzesco, Sala degli Scarlioni
exhibition space designed by BBPR
(Banfi, Belgiojoso, Peressutti, and Rogers)
1954–1956

the weight specifically enacted by features of the physical environment (namely, the architect's domain of intervention). Many insights come from the collective research developed with 5th-year students who attended the ARCH 715A course "Perception of Space: Atmospheres" during the Spring 2022 term, in the Department of Architecture at the College of Architecture, Planning and Design (APDesign), Kansas State University. Professors: Bob Condia and Elisabetta Canepa. Special thanks go to Brittany Coudriet, Natalie Cox, Anne Criddle, Carl Glosenger, Tyler Nguyen, Yovanka Ortega, Edgar Ortuño, Bethany Pingel, DJ Plankinton, Andrew Smith, Carly Temming, and Marvy Whittaker. Abstracts of their research projects are published online (www.resonances-project.com). Preliminary observations about the

ulous sight. [...] As trains of unseen waves resound through, tangle up in, and congeal inside a bodily corpus, light becomes temporarily incarnate" (Plummer 1987, 9) [**F4**].

An atmospheric event cannot exist independent of the individual immersed in their context — or detached from their sensibility, state of mind, and personal life story. A symbiotic balance comes to the surface that rests "at the threshold between biography and world of facts, things, and situations" (Hasse 1994, 58) [10]. With its promiscuous swirl between a subjective pole and an objective one, or rather between the subjective character of experience and stimuli of objective nature, atmospheric dynamics harmonize internal conditions to extrinsic processes, and confront specifically human points of view with material-spatial mechanisms. An atmosphere is never merely a description of the physical properties of the environment; instead, it is situated, comprising only those aspects significant to a *single person*'s emotions, feelings, thoughts, and behaviors in a *certain place* at a *given moment* (Barrett 2006).

Determinants

The first question we should address is: if the physical setting is not the unique variable generating atmosphere in this complex "equation," what are the other affecting sources? There are at least four stimulus sources: the agents, other living beings, objects, and the environment. They are mutually relevant and processed together. Each one produces multiple determinants (both controllable and random, material and incorporeal, objective and subjective) that influence *whether* and *how* we experience atmospheres. The arrangement of this "atmospheric equation" is a speculative expedient, deliberately simplified to facilitate reasoning.

multifactorial structure of the atmospheric process were discussed within the seminar "Elements of Atmosphere," organized by Elisabetta Canepa and Andrea Jelić in collaboration with the interdisciplinary group Research[x]Design in the Department of Architecture of the Katholieke Universiteit Leuven (November 10, 2021).

10 As cited and translated in Griffero 2014a, 121.

11 Cf. Stec 2020, chapter II "Relationship Between Sunlight and Architecture: Determinants."

12 This body-centered label (together with the ones in the following paragraphs) was developed in collaboration with Brittany Coudriet, a student in the course "Perception of Space: Atmospheres." We assume the *body* is the root and threshold of experiencing atmospheres: this experience

Focusing on the symbiosis between the animate body (namely, the sentient individual — equipped with senses and sensibility) and the collection of inanimate objects forming the choreography of architectural elements that populate and characterize their surroundings [**F5**], we identify four categories of determinants: [11]

- physiological determinants
- personal determinants
- sociocultural determinants
- spatial determinants.

Eventually, a fifth category arises, if the intention is empirically mapping and measuring the atmospheric dynamics:

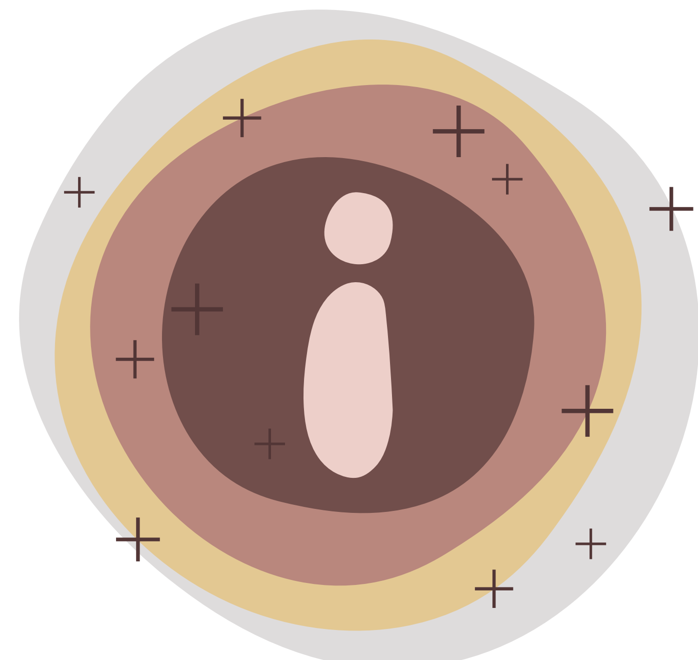
- experimental determinants.

A. Physiological Determinants

The physiological determinants are those related to the structural properties *of* the human body. [12] They exert a significant sway on the body resonance process activated by atmospheric affordances, triggering and conditioning *nonconscious emotions* (both interoceptive and proprioceptive feedback). [13] But that's not all. Since emotions are somatic correlates of *conscious feelings* and mutually interact, physiological determinants affect conscious feelings as well. Here is a list to start the reconnaissance:

age
gender/sex
state of health (both physical and mental) [14]

F5 Categories of atmospheric determinants



subject's effectivity [15]
interoceptive sensitivity [16]
habitual body defenses. [17]

B. Personal Determinants

The human being is a unique creature — synthetic unity of form and matter, genetically determined and simultaneously shaped by lived experiences. Personal determinants are conditioned by pressures *from* the body, which fluctuate between inborn and acquired qualifications, as well as permanent traits and transitory inclinations. *Long-term factors* acting on one's atmospheric perception skills include the following items:

personality
empathic predisposition [18]
emotional intelligence and granularity [19]
creativity and imagination skills
individual body memory [20]
past experiences [21]
level of familiarity with the place [22]
level of familiarity with the sensory inputs
sense of agency [23]
personal preferences for specific architectural qualities. [24]

Several *short-term factors* prime the subjective and emotionally-colored evaluations of the lived atmosphere, impacted by extemporaneous situations (such as what one is feeling, thinking, and doing at any given moment): [25]

is always *unique* and *specific*. As pointed out by the American philosopher Richard Shusterman, the originator of the interdisciplinary field of somaesthetics, "though our bodies unite us as humans, they also divide us (through their physical structure, functional practice, and sociocultural interpretation) into different genders, races, ethnicities, classes, and further into the unique individuals that we are" (2006, 4).

13 *Interoceptive feedback* is produced by the autonomic nervous system and the endocrine system. These systems coordinate somatic and behavioral responses to keep basic physiological processes (including heartbeat, blood pressure, and respiratory rate) operating at optimal levels, reacting instantaneously to changes in the external environment. *Proprioceptive feedback* derives from skeletal muscle, skin, and joints

and is noticeable, in particular, through visual clues (e.g., body posture and orientation, facial mimicry, gestural prompts, and involuntary movements).

14 Certain psychological disorders and neurodivergences provoke disturbance in emotional-affective processing.

15 The term "effectivity" refers to the real action one can take. Depending on their sensory, cognitive, and motor capacities, the agent might perceive, in a different way, suggestions — actual or virtual — afforded by a particular atmosphere. According to the neuroscientist Michael A. Arbib, "each object has an associated set of affordances; but *for each person these depend on their set of effectivities*, and the coupling may change with experience as one masters new skills and adjusts old ones" (2021, 87: original italics). For further explanation on the properties of affordances and effectivities, see Turvey et al. 1981.

16 Namely, the ability to perceive visceral information in the body (such as heartbeat, respiration, gastroesophageal sensations, itching, and pain), in order to detect and interpret physiological changes. Interoception is assumed to have implications for our capacities to recognize and experience emotions (Barrett et al. 2004; Zamariola et al. 2019). The hypothesis is that people who are more interoceptively sensitive (that is, more attuned to their internal body signals and clues) are more accurate in how they perceive and understand their surroundings (Murphy Paul 2021). So far, however, it has not confirmed whether our inside body perspective influences how we perceive the outside environment (Baiano et al. 2021).

17 In parallel to our interoceptive sensitivity (i.e., the ability to focus on internal bodily sensations and detect them: cf. n. 16) and our emotional granularity (i.e., the ability to discriminate and verbally communicate the specificity of one's emotions: cf. n. 19), we must consider our habitual body defenses, which may act nonconsciously. "When an emotion emerges, one often tends to defend against it by bodily counteraction: suppressing one's tears or cries, compressing one's lips, tightening one's muscles, keeping a stiff posture, 'pulling oneself together,' etc." (Fuchs 2013, 624).

18 The hypothesis is that the more people are interpersonally empathic, the higher their arousal when atmosphere emotionally affects them (cf. Canepa et al. 2019). Arousal is the component defining the physiological and/or subjective intensity of a specific emotion. Moreover, certain studies have investigated a possible link between interoceptive processing (cf. n. 16) and affective perspective-taking (i.e., empathy): see review in Baiano et al. 2021, 254–256 (table 1).

19 Namely, the ability to recognize, understand, label, and express one's emotions (Brackett and Simmons 2015) elicited, in this case, by atmospheric interaction. "Individuals differ considerably in their emotion experience" (Barrett et al. 2001, 713): for example, examining the pleasant-unpleasant dimension, some people have highly differentiated emotional experiences, whereas others have quite homogeneous emotional experiences. Lisa F. Barrett coined the expression "emotional granularity" to describe individuals' abilities to discriminate the specificity of their emotions. A subject with high emotional granularity can make fine-grained distinctions between similar emotions (i.e., emotions with similar levels of valence and arousal), describing their experiences with discrete emotional labels. Dr. Barrett (Barrett and Bliss-Moreau 2009) discerns between *arousal focus* (i.e., the amount of information about felt activation, self-rated in verbal reports of emotional experience) and *valence focus* (i.e., the amount of information about felt pleasure), both of which contribute to emotional granularity overall. Arousal focus appears to correlate with interoceptive sensitivity (Barrett et al. 2004), whereas valence focus seems to be linked to efficiency in perceptual processing of affective stimuli in the environment

(Barrett and Niedenthal 2004). Emotional granularity research has evolved in recent years, thanks to Dr. Barrett and colleagues' seminal work. However, investigation on emotional granularity is still in its infancy. It is crucial to establish and test a model analyzing the physiological and psychological processes that underpin it (Smidt and Suvak 2015). The last observation about emotional intelligence applied to atmospheric perception regards the inability to properly recognize the prevailing emotional tone of an atmosphere causing *blunders*, which further affect the overall atmosphere.

20 Body memory re-enacts our individual, specific variations incorporated throughout our entire lives. "What we once had acquired as skills, habits, and experience have become what we can do today" (Fuchs 2012, 11). It, therefore, "influences the circular relations between affective affordances, bodily resonance and emotional response in a given situation" (Fuchs and Koch 2014, 5).

21 There is no such thing as a neutral perception. Perceptual mechanisms take root in hidden knowledge and past experiences. "We continually compare what we see with situations that we have previously met and assimilated. [...] We do not see what we see but what we expect to find. [...] Our memory acts on our perceptions and influences our judgements beyond 'objective' truths" (von Meiss 2011, 27).

22 Places people encounter regularly inspire feelings of belongingness, place attachment, personal identity, and sense of agency. Familiar atmospheres also influence our degree of satisfaction, openness to notice changes, and the place-meaning process.

23 Sense of agency refers to the "phenomenal experience of initiating and controlling an action" (Braun et al. 2018, 5). Sense of agency, like the subject's effectivity (cf. § "physiological determinants," n. 15), shapes the suggestions afforded by a given spatial element. A lit door, for example, affords opening and entering if we can reach the handle; but the sense of agency may follow, changing one's emotional reactions and behavioral intentions (e.g., we feel embarrassed and unauthorized to violate the privacy of others' rooms).

24 For example, colors and materials.

25 These factors are distinguishable by their high level of variance and instability (above all, mood).

26 The philosopher Tonino Griffero explains a present atmosphere depends on the co-perception of past and expected atmospheres, serving this example: "the atmosphere of a hospital is tense precisely because we anticipate the situation to follow (the visit, the diagnosis, etc.) and we remember earlier ones (further waits, etc.)" (2014b, 37). Seated in the same waiting room, we might perceive an exciting atmosphere if we are there for our first prenatal appointment or an uneasy moment if we must receive a histological examination. One should additionally consider another aspect of hypothetical feelings: "the tendency to perceive the built environment in terms of its contrast or similarity to other environments, and to exaggerate features congruent to the place's atmosphere" (Peri Bader 2015, 260). That is, if the environment is envisioned as a "hospital," people prefigure a sequence of stereotypical atmospheres onto it, even if none are current realities.

27 In experiencing their surroundings, individuals generally undertake two opposite approaches: conscious and selective control to notice small details and enjoy them, aroused by elements of interest, novelty, or variance to the ordinary; or spontaneous, nonconscious indifference. It is fundamental to bear in mind two golden rules: people rarely pay attention to architectural features but rather move through environments in habitual and automatic ways (Vecchiato et al. 2015); and people's attention is drawn to emotionally charged stimuli — involuntarily (Rigoulot et al. 2008).

28 People may react differently to the same atmospheric situation if they are primed with a story about what happened or would happen in that place, as Isabella Bower (Ph.D., Deakin University) suggested to me in a private conversation.

29 We can take into account a broad variety of tasks, such as a practical task or a contemplative task, a high cognitive load task or a stress-free task, an out-of-the-ordinary task or a routine task, a real-time task or a memory task.

30 If we consider, for example, domestic spaces, people have subjective concepts of "home," and differently interpret basic activities such as relaxing, entertaining, or dining.

31 The term "affectability" describes our body's susceptibility to affective affordances. The process of bodily resonance influences our overall emotional perception and evaluation of a given atmosphere. As

current mood
anticipations and expectations [26]
attention span of one's emotions, thoughts, and movements [27]
presence/company of other subjects (not necessarily humans)
suggested narratives [28]
motivations and tasks to be performed [29]
ongoing activity and intended function of the space
subjective conceptualization of ongoing activity or function [30]
current bodily affectability [31]
current permeability and responsivity levels [32]
human-technology interaction. [33]

C. Sociocultural Determinants

The sociocultural scaffolding of experience brings an additional degree of complexity in comprehending how individuals perceive architectural atmospheres. Sociocultural patterns prime our emotional reactions to atmospheres by acting *upon* our bodies:

family background
education level and quality
socioeconomic milieu
individuals' sociocultural history
individuals' sociocultural understanding skills [34]
sociocultural behavioral codes [35]
atmospheric expertise [36]
cultural influences on how we use and experience one's body [37]
semantic knowledge and linguistic habits [38]
intersubjectivity and intercorporeality mechanisms. [39]

Thomas Fuchs and Sabine Koch notice, a *lack of resonance* or an *amplified resonance* (e.g., provided by a steaming cup of coffee in our hands or by a comfortable position) alters "the perception of corresponding affective affordances in the environment" (2014, 4).

32 This aspect is linked to the previous one in explaining emotions are somatic correlates of conscious feelings: they interact and condition each other (cf. also n. 5). According to Thomas Fuchs and Sabine Koch, which hark back to the theories of German-American psychologist Kurt Lewin (1935), our bodies have variable degrees of permeability and responsivity. "The tired body," for example, "is more permeable than the wake body, the drunk body more permeable than the sober body" (2014, 3). See their embodied affectivity model.

33 The digital technological transformation of our society interferes with how we experience reality (and its atmospheres), affecting both interaction and isolation. An example is the way smartphones and wireless headphones alter how we perceive and use our environs, absorbing and diverting attention.

34 We must be aware both familiar and unfamiliar factors can prompt biases in spatial perception and interpretation due to automatic sociocultural associations (Kwon and Kim 2021, § "discussion").

35 Sociocultural behavioral codes might impact, for example, one's sense of agency (cf. § "personal determinants," n. 23).

36 Particular atmospheric situations could privilege individuals who are skilled in appreciating the atmospheric vocation of architecture. The hypothesis suggests a correlation between architectural background/expertise and emotional intelligence (cf. § "personal determinants," n. 19), resulting in a deeper and more meaningful experience. In this vein, the first step should be challenging today's prevailing bodily reductive conceptions in architecture (Imrie 2003; Boys 2018).

37 One example is our culture-specific openness, or restraint, to outward emotional expression (cf. n. 17).

38 The German architecture critic Ulrich Conrads (1923–2013) reveals a curious aspect related to the impact of spoken language on our spatial experiences. He noticed this correlation during his stay in a small Tuscan house: "inside the rooms the loudly spoken word turned into inarticulate reverberation, but over a distance, from one room to another, only the glottal and sibilant sounds of our consonant-dominated language prevailed. We realized that in this house one had to speak in Italian — a vocalic, open, musical and loud language — or simply keep quiet in a way that we found to be almost painful. The house was plainly not built for our language" (Leitner and Conrads 1985, 31).

39 We construct emotions in response to others; in dialogue with others. The presence of other bodies conditions one's movements and intentions, just as one's perceptions of the place. For example, the presence of human figures — or, sometimes, merely human components (cf. § "spatial determinants," n. 42) — might increase a sense of safety. Marketing researchers, who have been adopting an experimental approach to examine atmospheric effects on consumer behavior for years, often monitor crowded situations. For further information about store atmospherics, see the classification of atmospheric factors presented by Berman and Evans (1995) and revised by Turley and Milliman (2000). The latter systematize five categories: 1. — external variables; 2. — general interior variables; 3. — layout and design variables; 4. — point-of-purchase and decoration variables; 5. — human variables.

40 When we study people's emotions, we normally assume the totality of factors influencing their health, wellbeing, and satisfaction (such as thermal comfort, lighting, acoustics, and indoor air) meet the optimal criteria. Nevertheless, in some experiments

focused on emotional responses to multisensory environmental stimuli, researchers noticed "temperature evokes emotions only when it reaches uncomfortable levels" (Schreuder et al. 2016, 14).

41 Particularly furniture and decorative choices.

42 Sensory clues related to human presence (e.g., footprints, photographs, or faces portrayed in artworks and advertisements) can have relevance in affording social interaction and enhancing place identity, considering the premise that "environment perception is largely a social phenomenon" (Schönhammer 2018, 148). Cf. § "sociocultural determinants," n. 39).

43 Intrinsic characteristics of the geographical location reverberate on weather conditions, air components, and sunlight quality, which filter inside through open-

D. Spatial Determinants

The adjective "spatial" alludes to the obvious fact atmospheres do not exist in a vacuum. Multiple aspects of the physical environment atmospherically interact *with* our bodies — "immersed to fusion" in their surroundings (Neutra 1954, 12):

indoor environmental quality (IEQ) performance [40]
culture-specific components [41]
social cues [42]
site-specific constituents [43]
natural (living or imitated) elements [44]
architectural properties and forms
(multi)sensory noise [45]
meteorological special effects [46]
reward-related cues. [47]

Generators of Architectural Atmosphere

Spatial determinants afford emotionally significant invitations. Such affective affordances are so closely interconnected to each other they cannot always be traced back to a specific material source. To affect the emotivity of someone occupying a space, we need an encompassing atmosphere, capable of rendering a space atmospherically perceptible in its complexity. This complexity is an inherent characteristic of architecture: "details tell nothing essential about architecture, simply because the object of all good architecture is to create integrated wholes" (Rasmussen 1962, 33).

Architects have the task (or, simply the desire) to design and stage atmospheres, given architecture "produces atmospheres in everything it

ings such as doors and windows. Those elements, influencing the general atmosphere, are critical to people's moods.
44 This item includes landscape views, natural multisensory stimulation, and nature-based atmospheres produced using biophilic design principles. People show a considerable preference and attraction for settings integrating natural elements. Nevertheless, the German professor of design psychology Rainer Schönhammer points out "for architects and designers, in contrast to non-professionals, 'natural elements' are not a priority" (2018, 152 n. 63).
45 Excessive, unusual, unexpected, and remarkable sensory inputs can destabilize the atmospheric balance, triggering attentional shifts, discomfort, stress, and perceptual biases.
46 Designers sometimes interpret the

creates" (Böhme 1991, 36). The challenge is understanding which design factors contribute more than others to composing an atmospheric sense, conditioning the spatial perception of individuals. Philosopher Gernot Böhme articulates, "the making of atmospheres is restricted to the arrangement of the conditions under which an atmosphere can appear" (2013b, 161) [**F6**]. He calls these designable, determinant conditions *generators*. [48] They "are above all the geometric structures and corporeal constellations" (Böhme 2013c, 93) the architect installs [49] and can be "of an objective kind" (including material details affording motor interactions) or as "non-objective or non-physical," as light and sound (Böhme, 92).

Böhme identifies three main classes of *atmospheric character* (2013a), [50] where by "character" he alludes to the essence of atmospheres, or "the characteristic manner in which they impress" (Böhme 2001, 87). Adopting his taxonomy, we systematize the generators of architectural atmosphere as follows:

> *Gestural generators of atmosphere* (such as dimension, proportions, forms, and geometry), distinguished by their ability to suggest movement and kinesthetic impressions (e.g., sensations of volume, load, and density, which can render a space oppressive, solemn, vast, or poignant).
>
> *Sensorial generators of atmosphere* (such as light conditions, colors, materials, and textures), which produce specific sensory stimuli (among which are visual inputs, sounds, scents, and tactile feedback) that transpire from the architectonic materiality through their sensuous effects and are initially perceived in aggregate. [51]

atmospheric approach as a meteorological mise-en-scène, setting up performances of intangible factors that recall phenomena of the terrestrial atmosphere and their variations (among which are breezes, steams, and rainfall). Cf. Canepa 2022, chapter III "Atlas of Atmospheres."
47 The availability of reward-related cues (namely, stimuli associated with natural and artificial rewards such as addictive substances, sex, or appetizing food) in our environments can alter our perception, prompting both positive and risk-taking behaviors (Chiamulera et al. 2017).
48 The term "generator" helps emphasize the enactive existence of affective affordances in architectural substance (Condia 2020). It is a way to read the fundamental elements of architectural composition (or archetypes, as Norwegian architect Thomas Thiis-Evensen calls them in his 1982 book due to their consistency regardless of time, place, and function) through an emotion-based perspective other disciplines have perfected from the second half of the twentieth century (Griffero 2019). To schematize, we propose the following formula: *architectural element + affective affordance = atmospheric generator*.
49 Using the verb "to install" is not accidental. As the French sociologist Jean-Paul Thibaud says, more than being made, atmospheres are installed. Originating from the premise "to install" means "to locate in a chosen place" (a person or a thing), such a gesture becomes "an action which necessarily involves a place" (2014, 53), from which one can be inspired or conditioned. The preliminary setting not only provides a backdrop for an intended atmospheric performance, but reveals itself to be a significant generator. "Installing an atmosphere therefore always means coming to terms with an existing atmosphere, and finding ways of inflecting and transforming it" (Thibaud, 55).
50 In the beginning (Böhme 2001, chapter VII, 101–116), there were five categories: movement impressions, synaesthetic reverberations, social characters, dispositions of mind, and communicative expressions.
51 For this reason, the term "synesthesia" is frequently used, although it must be carefully treated — distinguished from the neurological condition in which "stimulation of one sensory modality causes unusual experiences in a second, unstimulated modality" (Hubbard and Ramachandran 2005, 509).

F6 Paolo Monti
photo series *Varese*, 1975
BEIC 6364265

F7 Paolo Monti
photo series *Genova*, 1963
BEIC 6361770

Palazzo Rosso, attic
remodeling project by Franco Albini
1952–1962

52 As previously observed (n. 39), atmospheric design has a long history of research in consumer science, especially in sensory marketing. The definition of atmosphere elaborated in sensory terms by Philip Kotler (1973), who is widely credited as the initiator of literature's stream on atmospheric experience in retail spaces, laid the foundation for the following list of atmospheric generators. In this essay, the sensory analysis of atmospheric components is deliberately limited to four Aristotelian senses, even if we know the multisensory essence of atmospheric perception is broader (Pallasmaa 2014).
53 Even if several scholars (e.g., Griffero 2014a) accentuate the primacy of orosensory atmospheres (that is, based on the oral sensory unity provided by smell and taste), we hardly detect the flavor of our environments. We did so in our early childhood,

Contextual generators of atmosphere (such as sense of home, power, or wealth), manifested with symbols and signs of culturally significant content, which contextualize the social condition or historical era through which the architect desires to associate a given environment, embedding well recognizable, conventional canons.

Another possible way to identify and organize the spectrum of architectural generators of atmosphere is by analyzing the elicited sensory modalities. [52] Sight, hearing, scent, and touch are the key sensory channels for perceiving architectural atmospheres. [53] Visual elements [**F7**] of an atmosphere, to which we respond emotionally, play a leading role:

lighting sensation (e.g., brightness, saturation, and contrast)
colors
materiality and texture
form (e.g., structure, shape, geometry, and compositional rhythm)
size (e.g., dimensions, proportions, and scale)
mass and weight
proximity between objects
openings and related indoor/outdoor interplay
furnishings and decorations.

The dominant aural dimensions of an atmosphere are three:

pitch
volume
acoustic reverberation/absorbency.

Atmospheres are enriched due to olfactory cues and their combination.

when our "first impressions of architecture were largely gustatory" (Neutra 1954, 25).
54 Peter Zumthor (2006) compiled the most famous architecturally formulated atmospheric roster, made up of twelve items: "body of architecture," "material compatibility," "sound of a space," "temperature of a space," "surrounding objects," the equilibrium "between composure and seduction," "tension between interior and exterior," "levels of intimacy," "light on things," "architecture as surroundings," "coherence," and "beautiful form."
55 By *architectural generators* we mean the set of physical determinants architects design to stage the intended atmospheric effects, regardless of what future occupants of that space will actually perceive.
56 This digression is purposefully kept to a minimum to avoid going off-topic.

Lastly, are tactile and haptic aspects in generating an atmosphere:

affordances of touch
shapes
materials and textural properties
objects' temperature
indoor environmental quality
ergonomic standards
haptic feedback.

Architects have tested themselves in analyzing atmospheric anatomy. They have drawn up poetic, biographical inventories of their design approach,[54] and outlined more objective strategies, informed by phenomenological and embodied cognition theories (Canepa et al. 2018, 2019) or guided by healing therapeutic criteria (Martin, Nettleton, and Buse 2019). As the architectural historian Alberto Pérez-Gómez stresses, the difficulty is not in compiling a list (all told, an easy operation), but in understanding "our embodied experience where meaning actually appears is always *primarily* synesthetic and enactive" (2016, 31: original italics). In other words, "it is never possible to simply add one characteristic to another as a factor in an equation" (Pérez-Gómez, 31–32).

E. Experimental Determinants

Experimental conditions required by empirical research provide the final affecting factors capable of influencing the atmospheric equation and interacting with the architectural generators.[55] We must evaluate different variables according to the unique experimental paradigm, which is something *outside* the control of the perceiving agent:[56]

laboratory environment
laboratory devices and sensors
sensory stimuli: complexity and multimodality
sensory stimuli: distraction and overload
task performance: difficulty, duration, and familiarity
time of exposure: duration, frequency, and repetition
sense of presence (especially, in virtual reality experiments).

Lesson

We could indefinitely add, improve, or remove items from these lists. Deciphering the mechanisms that generate architectural atmospheres is, after all, analogous to synthesizing the essence of architecture composition. Namely: impossible. We "cannot cover all the combinations that give architecture meaning," tailoring "a recipe for right and wrong" (Thiis-Evensen 1987, 9).

"There are no recipes," echoes the philosopher Tonino Griffero, "in planning atmospheres" (2014b, 35). However, to facilitate understanding, we can follow two opposite scripts which outline a rough formula for staging the atmospheric performance. The first strategy requires designers to limit themselves by subtly suggesting potential atmospheric impressions to inhabitants through a dialogue with their architectural setting. This setting must be intentionally conceived in a "more neutral" manner to stimulate "the hermeneutic and emotional creativity of the user" (Griffero, 37). The second strategy encourages architects to sharply entice their interlocutors by immersing them in a design narrative that affords predetermined emotional responses. It is what Peter Zumthor calls the equilibrium *between composure and seduction* (2006, 41–45).

The atmospheric equation is not an exact algebraic equation — long desired to solve architecture's meaning enigma (Pérez-Gómez 1983). It aspires to be a tool for better comprehending the experiential features of lived space — for gathering the emotional-affective core of spatial experience, weighting its value, and going beyond its physical constitution. Involving the fundamental principles of architectural composition (both in the overall layout and single details, through material elements and intangible qualities), the atmospheric approach provides theoretical lessons, and, hopefully, design essentials for structuring the universe of forms. Atmosphere is a full-fledged compositional dynamic in which *form* — made up of "the most permanent components of architecture" (von Meiss 2011, 11) — resonates with the human *body*, which is "our tool of tools," "the crucial medium through which architecture is experienced and created" (Shusterman 2013, 7; 2012, 227).

Atmospheric design is a compositional task in that defining atmospheric qualities (and, therefore, selecting and arranging their architectural generators) means searching for solutions that are emotionally meaningful for our architectural experience. In addition to the Euclidean and Cartesian grounding, we must learn how individuals emotionally resonate, attune their feelings, and shape their behaviors *within* and *with* their surroundings. Borrowing the words of the Norwegian architect Christian Norberg-Schulz, the atmospheric approach is "a way to 'order' reality," conferring meaning through such order. "Only when space becomes *a system of meaningful places*, does it become alive to us" (1988b, 22; 24: original italics).

This atmospheric equation [**F8**] was developed to map and navigate the jagged landscape of designable and aleatory variables that affect the or-

F8 Atmospheric equation
- x physiological determinants
- x personal determinants
- x sociocultural determinants
- x spatial determinants
- x experimental determinants

[X+X+X+X+X+X]+
[(X+X+X+X+X+X+X+
X+X+X)+(X+X+X+X+
X+X+X+X+X+X+X)]+
[X+X+X+X+X+X+X+
X+X]+[X+X+X+X+
X+X+X+X+X]+[X+
X+X+X+X+X+X] = ?

F9 Paolo Monti
photo series *Italia*, 1960
BEIC 6363710

57 Cf. Bower, Tucker, and Enticott 2019. Their systematic review found only seven research projects that coupled self-assessment procedures with measures of autonomic and/or central nervous system activity to understand how the design of interior settings influences human emotions. This result means, while we intuitively believe our architectural surroundings play a crucial role in generating and perceiving atmospheres, we must still consolidate evidence of the emotion-related (neuro)physiological effects.

chestration of architectural atmospheres and ponder the relative contribution of factors designers can manipulate (all in all, a limited contribution). The next assignment is empirically testing the qualitative nuances of architectural generators [**F9**]. Surprisingly, systematic research and empirical evidence on the emotional impact of architectural atmospheres (or, in a broader sense, the built environment) are still few, and methodologies differ [57] — despite being widely theorized (Franz, von der Heyde, and Bülthoff 2005; Schreuder et al. 2016; Mostafavi 2021). Christian Norberg-Schulz well explains the overarching challenge.

> We experience complex phenomena which are spontaneously given as synthetic wholes. As such they are not accessible to thought because they fall apart during analysis. The objects of science may be compared with a mesh having defined properties. When such a mesh is thrown over reality, only has corresponding properties will be caught, the rest disappears through the holes. What is lost by the fishing net of science, may however be grasped by other kinds of symbolization. (Norberg-Schulz 1988b, 20)

Ultimately, we should recognize that "the atmospheric qualities of place are related to the ways in which space is used by its inhabitants, rather than the intentions of its architects per se" (Martin, Nettleton, and Buse 2020, 85). Here is where the atmospheric equation becomes even more complicated (Seamon 2017) — so much so, we regret forgetting the algebra we studied in high school.

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Acknowledgements

The theoretical premises of this essay were developed within the RESONANCES project — Architectural Atmospheres: The Emotional Impact of Ambiances Measured through Conscious, Bodily, and Neural Responses. This project received funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement no. 101025132. The content of this text reflects only the author's view. The European Research Executive Agency is not responsible for any use that may be made of the information it contains.

Kutay Güler

Sensing the Atmospheric Space Through a Virtual Lens: Scrutinizing Opportunities and Limitations

Abstract
This is an investigation of the idiosyncrasies of perceiving atmospheric space through virtual reality (VR). VR systems have well-known advantages such as convenience, flexibility, and consistency, as well as constraints such as limited immersion, restricted movement, and motion sickness. However, literature on the impact and implications of virtual experience is scattered between many disciplines with minimal research on architecture-related issues. This paper addresses this gap through a systematic review of existing literature. The initial results from a pilot study, designed to explore the opportunities and limitations of perception of atmospheric space through VR, are also shared.

Keywords
architectural space
spatial perception
atmosphere
virtual reality
immersion
presence
cybersickness
scientometric analysis

Introduction

This essay is an investigation of various opportunities and limitations regarding the utilization of virtual reality (VR) and how one perceives architectural atmospheric space through virtual reality. There are two components to the investigation presented here. The first is a detailed systematic survey of the existing literature regarding spatial perception in VR; the second shares the results of a pilot study and sets up a foundation for future research.

VR: What Is It Good for?

It is important to first understand the inception and history of VR because the mechanics of VR determine how we perceive virtual representations of architectural space.

The history of VR extends back almost two hundred years, making it a fairly old technological endeavor. The first VR device is the *Stereoscope*, which we can label as "proto-VR." For these first iterations of VR, the goal is to transport the subject to faraway, foreign, unique environments and this goal is still sustained today. The stereoscope is invented in the 1830s by Charles Wheatstone; this tool simulates a 3D environment by providing two slightly different images to each eye. The device works by virtue of humans having two eyes that are on average 62 millimeter, or 2.44 inches apart (Mahnke 1996). When observing the surrounding environment, this small distance causes the eyes to generate slightly different images between each eye, in turn helping generate a sense of depth, perspective, and space. This phenomenon is called binocular system or stereopsis. The 3D perception of the world, as explained by David Marr in his seminal work *Vision* (1982), is constructed based on a composite of 2D sensory inputs.

One hundred thirty years after the Stereoscope, Morton Heilig (1962) produces the *Sensorama*, a complex multisensory device that provides moving images while also triggering multiple senses with sounds, scents, and haptic feedback through vibrations. It is a bulky device, resulting in a static interaction as subjects simply sit inside. The original experience is a motorcycle ride through New York City, complete with wind generated by fans, chemically induced smells, vibrations on the seat, and noise emitted through stereo speakers. The device fails to generate enough interest and financial gain, so the project is halted.

Around this time, a fundamental definition of VR is formed by Ivan Sutherland (1965), an important trailblazer in VR research. He defines VR as a window through which the subject perceives virtual worlds as if they look, feel, and sound real resulting in realistic reactions. This understanding of VR is referencing the notion of *presence*. Subjects forget they are in the real world and their brain responds with the belief they exist in this other environment. Sutherland produces the first *Head-Mounted Display* (HMD) system. The device is extremely bulky, bolted to the ceiling, and nicknamed "Sword of Damocles" due to a fear of getting injured by system users. However frightening, it does track subjects' head movements, correlating those movements with the subjects' virtual perspective.

Jumping to the 90s, the definition of VR changes slightly: real-time interactivity with 3D models, combined with a display technology that gives the subject immersion in the virtual world and the possibility of direct manipulation (Fuchs and Bishop 1992). Previously there was an emphasis on presence, which is now accompanied by *interactivity* and *immersion*. The right VR tools are beginning to be developed as well.

Movement is key to spatial perception: as individual moves, the details of the environment are revealed, enabling subjects to construct a 3D mental map (Goldstein and Cacciamani 2021). In VR, our brain not only perceives a series of images, but associates information on body movement with images being generated. *Movement* here mainly implies proprioception, or the kinesthetic component, and the change in images is processed in relation to body movement (Tuthill and Azim 2018). In the VR environment, 3D images are constructed by understanding how body movements relate to specific visual features that move as we move. In simple terms, we perceive a series of 2D images to understand 3D space. However, it is not just the perception of a 3D space, but how these elements relate to each other, and create a complex 3D composition. Looking at a series of 2D images and trying to visualize 3D reality is an intensive cognitive calculation. Our brain does this seamlessly. Imagine yourself traveling in a forest at dusk. There are many branches, and everything is dark. You see weird shapes forming, maybe resembling monsters. As you move around, you realize some objects are moving faster than others. Instinctively, you know the closer objects are moving faster than the objects farther away. Suddenly, you realize the monster is actually a branch. Similarly, a head-mounted display (HMD) tracks the movement of your head and helps you understand the virtual world through your movements. If the movement in the real world matches the movement in the virtual one, the system cultivates a sense of immersion.

Besides some commercial curiosities, VR systems in the 90s are prohibitively expensive and require significant expertise to develop and operate. Around this time, Jaron Lanier, a prominent VR visionary, produces a commercial head-mounted display called *EyePhone*. This product is expensive, and the Silicon Graphics workstation needed to run it is even more expensive, rendering the system inaccessible to many. The expense of these systems, combined with the programming expertise required, creates a significant shortage in available software.

Another popular VR system in the 90s is called CAVE, an acronym for *Cave Automatic Virtual Environment*. Still in use today, the system can respond to head movements, walking, and hand gestures (Cruz-Neira, Sandin, and DeFanti 1993). In the CAVE system, images are reflected on the walls of the room, and the perspective changes as we move, creating an immersive system. The user sees their own body and other users' bodies inside the system, generating opportunities for collaboration. However, this system is prohibitively expensive as well, costing hundreds of thousands of dollars today.

In 2012 the *Oculus Rift* Kickstarter project changed the industry. This new device commercializes head-mounted displays. The commercial release of this HMD kit happens in 2016. *HTC Vive* is released around the same time, in late 2015. Many sources define this commercialization of VR as a revolution (Ewalt 2018). Many high-impact papers point to 2015 and 2016 as a turning point. At this time, VR kits become affordable, and the graphic processing power is exponentially increased. Now, users can experience complex virtual worlds without breaking the bank. More money is invested in developing software. Increasing software support and emerging tutorials help the VR systems become truly accessible. Hence, the exponential increase in research (see Kuliga et al. 2015).

Investigating (with) VR

Employing VR during the design process provides a virtual prototype with intuitive interaction capabilities, invoking a feeling of being *there* (Hardiess, Meilinger, and Hanspeter 2015). In architecture, we create a sense of presence using printouts, renders, and video walk-throughs. VR, though different than traditional representational methods, presents a significant potential for design research, in terms of *experience*, *interaction*, and *communication* (Portman, Natapov, and Fisher-Gewirtzman 2015). There are over twenty models of VR kits available in the market. Each with different features, tailored for different purposes. Cable-free and untethered VR sets, as well as accessories for eye tracking, point tracking, and walking treadmills are also available.

There are a variety of VR experiences. The idea of *immersion* is sensory submersion: the more we are cut off from real-world sensory cues and rely on virtual cues, the more immersive the experience becomes. A *computer screen* is considered non-immersive, even though the computer screen provides a virtual environment experience. Another VR system called *Fishtank VR* is semi-immersive. Fishtank VR tracks subjects' movement, adjusting the perspective on a screen based on their head's location. This technology is applied in a variety of video games and creates an engaging experience. Other fully immersive systems include the *CAVE system* and *head-mounted displays* (HMDs). The latter is the one that is most used in contemporary research. Most recently released is the *HoloLens* which offers a fully immersive overlay.

Each device has opportunities and limitations. An HMD system is highly convenient, very interactive, flexible, and consistent. It can be set up anywhere, unlike other systems requiring entire room setups. The HMD system is flexible, as the researcher can adjust the nature of each interaction and environment. It is consistent, as the environment can be replicated from subject to subject. However, there are inherent limitations researchers are struggling to solve. One serious limitation for any VR experience is the intense adaptation process, during which some subjects show signs of *motion/simulator/cyber sickness* (Stanney, Mourant, and Kennedy 1998; Tyrell et al. 2017). When experiencing VR, our body generates many sensations aside from visual stimuli. Sometimes, bodily sensations can clash. Imagine yourself moving in a virtual environment even though your real-life body is not. Your vestibular system tells your brain that you are stationary, creating a cognitive disconnection causing cybersickness, which grows more intense as the VR system becomes more immersive.

VR research is most common in clinical sciences followed by computer sciences, engineering, and allied sciences (Cipresso et al. 2018). There are a limited number of VR studies dealing with the architectural context (Paar 2006; Silvestri et al. 2010; Gill et al. 2013; Song et al. 2018), and the number is growing comparatively slowly. This is largely due to *skill disparity*. The programming and mathematics knowledge involved in creating virtual experiences are completely different from the design knowledge architects possess.

Systematic Review

A large number of VR research has been published since the 90s across many disciplines; only a limited number of these are relevant for this particular study. Therefore, it is crucial to determine the most influential research regarding spatial perception to identify the relevant opportunities and limitations commonly outlined in the literature. In order to achieve this goal, scientometrics and bibliometrics were utilized.

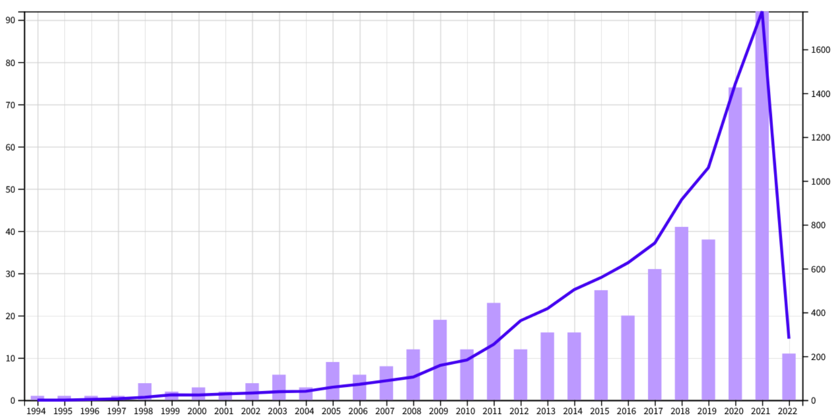
Scientometrics involves a multitude of measurement methods for investigating underlying patterns, relationships, boundaries, and cross sections throughout existing research (Nalimov and Mul'chenko, 1971; Fortunato et al. 2018). In other words, scientometrics looks at which papers cite each other, how many times, and when. This allows researchers to understand trending research topics and themes prevailing at specific times. *Bibliometrics* involves the statistical analysis of metadata belonging to published research to reveal and visualize quantitative features, impact, and relationships (Gingras 2016). These two terms are sometimes used interchangeably.

Google Scholar, an academic search engine commonly utilized by researchers, can find most publications, but there are other databases that look through specific indexes. Most VR research is published through Science Citation Index (SCI) or Social Sciences Citation Index (SSCI) journals. They are most likely to appear on a Web of Science (WoS) database search, which is a similar search engine to Google Scholar developed by Clarivate Analytics. Consequently, I utilized WoS to identify relevant publications.

An initial search using the keywords "virtual reality," "spatial," and "perception" resulted in 494 publications from January 1994 until March 2022. The first descriptive analysis of search results focused on the following: 1. — distribution of publications and citations over the years; 2. — publication output based on discipline, journal, and country; 3. — publication output distribution based on publication type; 4. — most prominent authors published on the subject. Isolating the timeline, we see around 2015 and 2016 VR research specific to spatial perception begins to blow up, growing exponentially until 2021 [**F1**].

F1 Number of research papers published each year (1994–2022)

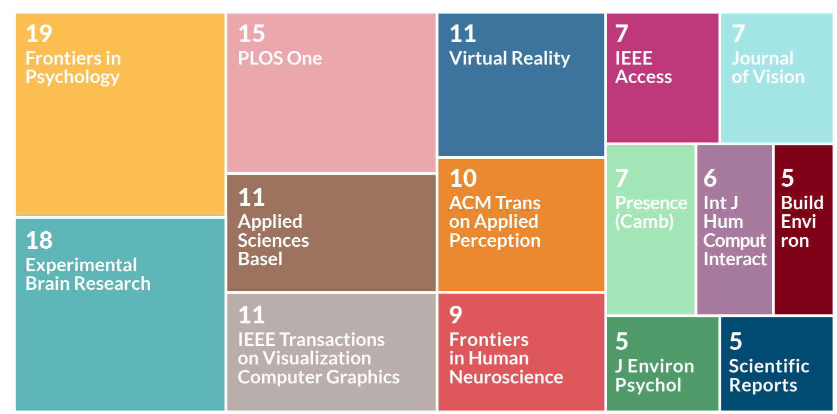
Key
- publications
- citations



Contributing the most to the literature are the fields of neuroscience, construction, building technology, and civil engineering [**F2a**]. In Web of Science, we can analyze research results through several filters such as the editorial source. Journals like *Frontiers in Psychology* have the highest number of published papers on spatial perception in VR [**F2b**]. To further filter, 460 publications are research articles and 30 are review articles [**F2c**]. Systematic review papers analyze available research and interpret their findings, providing the readers with a critical summary of whatever is going on in that particular research subject. In conclusion, the most influential authors appear to be Heinrich H. Bülthoff, Juno Kim, Robert Bodenheimer, and Isabelle Viaud-Delmon [**F2d**].

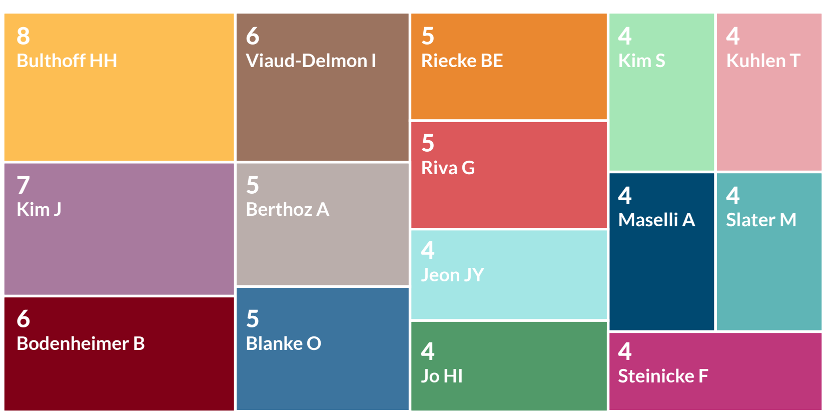
F2a Search result treemaps based on academic disciplines

F2b Search result treemaps based on journals



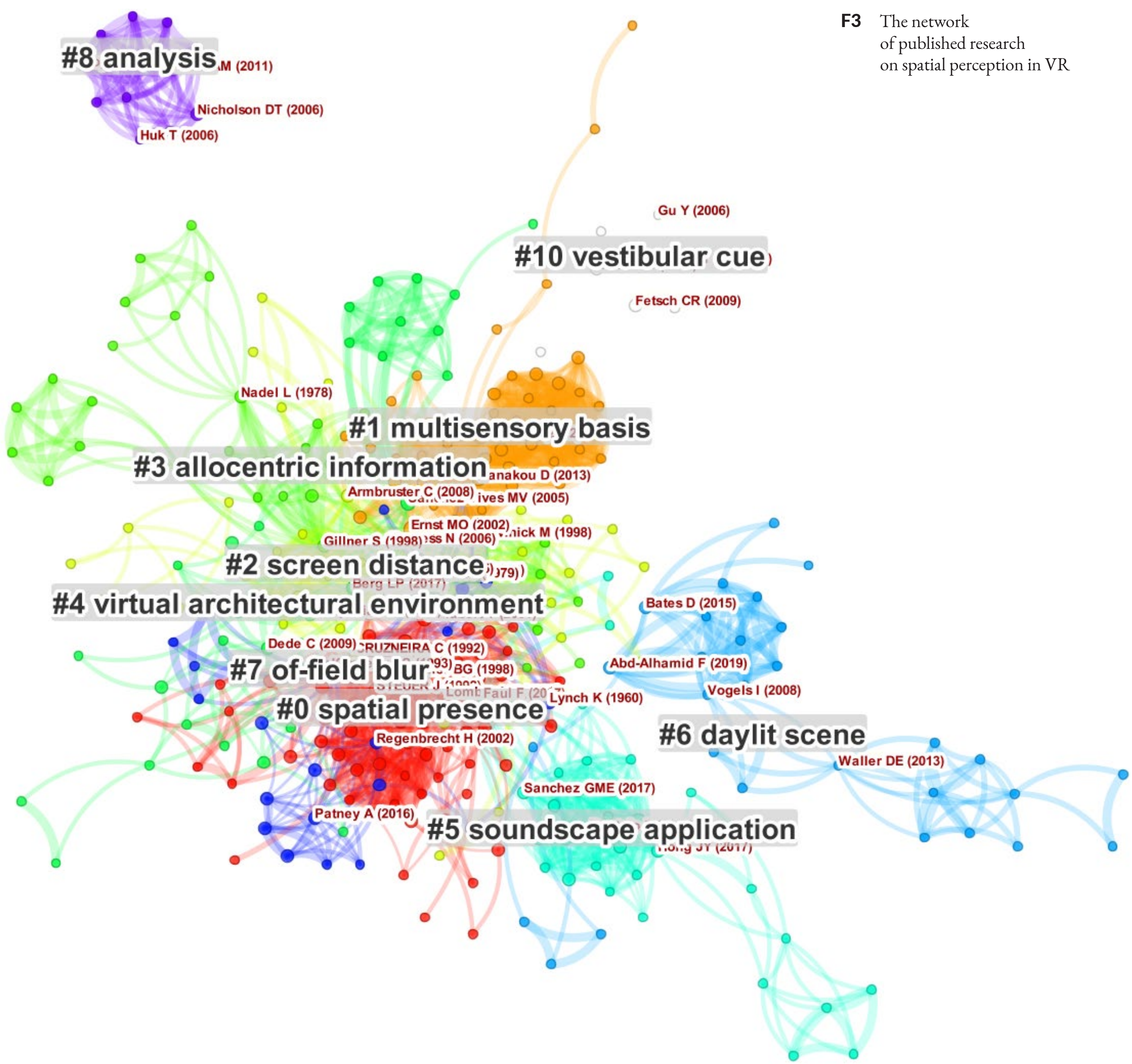
F2c Search result treemaps based on publication types

F2d Search result treemaps based on prominent authors



I utilized CiteSpace to segment and analyze the metadata and reveal trends and relationships (Chen, Ibekwe-SanJuan, and Hou 2010; Chen 2016). This software tool outlines a network of published research and displays connections among articles. Document co-citation analysis (DCA) method was utilized to map citation networks and identify impactful research, publications, and clusters (Chen 2016). I searched for papers on spatial perception in VR research between 1994 and 2022. Then, I refined the search to 2015 through 2022, based on the claim that starting from 2015 commercial HMDs became widely available (HTC 2016) and mobile electroencephalography (EEG) data became commonly utilized (Gramann et al. 2014; Kontson et al. 2015). Among 313 publications, 21,255 distinct references were identified to generate a network of 269 nodes and 2567 links [**F3**]. Even though this is a complicated *network*, the analysis has good modularity (Q = 0.6531) and high silhouette (S = 0.9055) scores, indicating an acceptable level of reliability and homogeneity (Chen, Ibekwe-SanJuan, and Hou 2010; Shahapure and Nicholas 2020).

The next step of analysis involved identifying clusters and burstness values. *Clusters* are outstanding entities that form homogeneous characteristics identified through prominent key phrases, recurring themes, and interrelationships (Chen and Song 2017). After identifying the clusters, we can calculate the burstness value for each paper. *Burstness* is an abrupt increase in the frequency of citations for a specific publication over a specific time interval (Chen and Song 2017). This indicates exactly when and how influential a publication has been during a particular period. Top references with the strongest bursts can be seen in table [**T1**]. The assumption is highly influential research provides a reliable insight into core issues of VR usage and analyzing burstness uncovered prominent themes.



F3 The network of published research on spatial perception in VR

T1 The top publications with strongest bursts

Key
- period of average citation generation
- period of high citation generation
- period of burst

References	Year	Strength	Begin	End
Weech S, 2019, FRONT PSYCHOL, V10, P0, DOI 10.3389/fpsyg.2019.00158	2019	**2.57**	2021	2022
Ruotolo F, 2013, ENVIRON IMPACT ASSES, V41, P10, DOI 10.1016/j.eiar.2013.01.007	2013	**2.32**	2019	2019
Cummings JJ, 2016, MEDIA PSYCHOL, V19, P272, DOI 10.1080/15213269.2015.1015740	2016	**2.24**	2020	2022
Lessiter J, 2001, PRESENCE-TELEOP VIRT, V10, P282, DOI 10.1162/105474601300343612	2001	**2.24**	2020	2022
Ernst MO, 2002, NATURE, V415, P429, DOI 10.1038/415429a	2002	**2.16**	2017	2020
Paes D, 2017, AUTOMAT CONSTR, V84, P292, DOI 10.1016/j.autcon.2017.09.016	2017	**2.14**	2021	2022
Kuliga SF, 2015, COMPUT ENVIRON URBAN, V54, P363, DOI 10.1016/j.compenvurbsys.2015.09.006	2015	**2.14**	2021	2022
Wirth W, 2007, MEDIA PSYCHOL, V9, P493, DOI 10.1080/15213260701283079	2007	**2.14**	2021	2022
Flavian C, 2019, J BUS RES, V100, P547, DOI 10.1016/j.jbusres.2018.10.050	2019	**2.14**	2021	2022
Nadel L, 1978, HIPPOCAMPUS COGNITIV, V0, P0	1978	**2.1**	2016	2017
Sanchez GME, 2017, LANDSCAPE URBAN PLAN, V167, P98, DOI 10.1016/j.landurbplan.2017.05.018	2017	**1.98**	2019	2019
Slater M, 1997, PRESENCE-TELEOP VIRT, V6, P603, DOI 10.1162/pres.1997.6.6.603	1997	**1.95**	2020	2022
Nicholson DT, 2006, MED EDUC, V40, P1081, DOI 10.1111/j.1365-2929.2006.02611.x	2006	**1.86**	2016	2016
Kearns MJ, 2002, PERCEPTION, V31, P349, DOI 10.1068/p3311	2002	**1.8**	2017	2017
Aletta F, 2016, LANDSCAPE URBAN PLAN, V149, P65, DOI 10.1016/j.landurbplan.2016.02.001	2016	**1.74**	2019	2019
Hong JY, 2014, LANDSCAPE URBAN PLAN, V125, P28, DOI 10.1016/j.landurbplan.2014.02.001	2014	**1.74**	2019	2019
Hong JY, 2015, LANDSCAPE URBAN PLAN, V141, P78, DOI 10.1016/j.landurbplan.2015.05.004	2015	**1.74**	2019	2019
Viollon S, 2002, APPL ACOUST, V63, P493, DOI 10.1016/S0003-682X(01)00053-6	2002	**1.74**	2019	2019
Luigi M, 2015, ENRGY PROCED, V78, P471, DOI 10.1016/j.egypro.2015.11.703	2015	**1.74**	2019	2019
Maffei L, 2016, SUSTAIN CITIES SOC, V27, P338, DOI 10.1016/j.scs.2016.06.022	2016	**1.74**	2019	2019

Table [**T1**] shows burstness strength of publications, when these papers are active with red and thicker blue lines. For example, Weech, Kenny, and Barnett-Cowan (2019) generate a strong burst in 2021 and 2022, meaning they are frequently cited in that period and generate a huge interest. The list primarily shows highly cited papers, but there are some with numerous citations who do not appear on the list, such as J.J. Gibson's (2014 [1979]) seminal book on ecological perception. This research fails to generate a burst within the given time frame. In the case of Gibson's book, among 490 papers, generating 40 citations does not mean much, so we must find the ones creating and influencing the discourse.

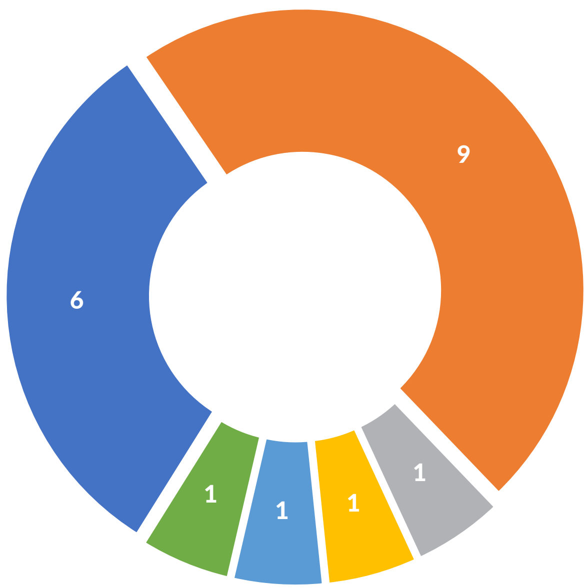
Although VR research on multisensory implementations seems like the most numerous [**F4**], in fact, all the bursts happen over a single year in 2019 [**T1**]. After 2020, interest dies off. Most of these papers have low citation numbers (66 to 127). In this multisensory group, the paper from Ernst and Banks (2002), published in *Nature*, is the odd one out. Their paper is about the integration of visual and haptic information is cited 4650 times, deservedly so. The most impactful subject matter appears to be the issue of *immersion vs presence*. There are 6 highly cited works on the subject, most creating bursts for three years, between 2020 to 2022, meaning they have been highly relevant in the last three years. An indication of when researchers started looking carefully at immersion vs presence.

Prominent Research Themes

In order to identify the prominent research themes pertaining to spatial perception in VR since 2015, I looked at the previously listed twenty

F4 The distribution of publications with high burstness based on topic

Key
- multisensory implementations
- VR for empirical research
- VR user experience
- VR for education
- cognitive mapping
- immersion and presence



papers with the highest burst values [T1]. When examined, the most influential papers focus on the issue of presence and immersion. Simply, *presence* is a sense of being *there* (ISPR — International Society for Presence Research 2001), and *immersion* is a state of sensory submersion (Biocca and Delaney 1995). Though different, both concepts are related. Immersion relates to the objective and quantifiable capabilities of a medium (Slater and Wilbur 1997). For example, if our medium is a screen, immersion will depend on the capabilities of the screen, such as resolution and field of view. These are features we can quantify and measure. On the other hand, presence is a state of consciousness, associated with how invested/engaged the subject is (Lessiter et al. 2001; Wirth et al. 2007), and how they evaluate the naturalness/believability of the virtual environment (Lessiter et al. 2001). Presence is what the individual subjectively thinks about the experience. One can even feel a sense of presence while reading a book. The reader might feel transported into another environment; start imagining what is happening in that environment. This means, sense of presence is not limited to the media, as it only requires a failure to acknowledge the role of mediating technology (Wirth et al. 2007). Too much immersion would spoil one's sense of presence. Therefore, the relationship between immersion and sense of presence must be balanced.

The second prominent theme is *cybersickness* and it is closely related to immersion and presence. Plainly, immersion causes cybersickness whereas sense of presence suppresses it (Weech, Kenny, and Barnett-Cowan 2019). When the individuals feel presence, their attention is being directed away from factors that would create a sensory conflict, eliminating cybersickness. On the other hand, immersion requires a suppression of real-world cues causing a perceptual disconnect and confusion. Cybersickness is enhanced if the individual is immersed and bodily disconnect is exaggerated. In conclusion, more immersion, more cybersickness; more presence, less cybersickness. One needs to experience immersion to feel presence, but too much immersion and one loses the sense of presence.

Accurate tracking of user movement and input, use of stereoscopic visuals, and a wider field of view are much more impactful than the quality/realism of the visual and auditory content (Cummings and Bailenson 2016). One's ability to interact with the virtual environment and manipulate various aspects enhances a sense of presence (Lessiter et al., 2001). In addition, intuitiveness of control and interaction contribute to a higher sense of presence (Weech, Kenny, and Barnett-Cowan 2019). Cummings and Bailenson (2016) indicate visual and audio quality contributes less to sense of presence. However, a simplistic model could be suitable to study behavior in isolation from other factors, but not sufficient for understanding emotional response or aesthetic appraisal (Kuliga et al. 2015). Immersion is still important, as the nervous system attempts to combine various sensory information, one dominating the other when the information is stronger and reliable (see Maximum Likelihood Integrator: Ernst and Banks 2002; Ronsse, Miall, and Swinnen 2009). The perceiver needs high quality sensory information to create a reliable sense of the virtual environment they are experiencing.

Slater and Wilbur (1997, 605) identify five variables affecting immersion: inclusive, extensive, surrounding, vivid, and matching movements of the observer with the virtual environment. *Inclusive* is the extent of shutting out physical reality; *extensive* is the range of variety in provided multisensory information; *surrounding* is the extent to which sensory information encircles the observer, such as field of view (FOV); *vivid* is

1 Within the context of this research, *augmented reality* and *mixed reality* refer to the method of viewing the environment through a device that superimposes the image of digital visual elements on top of the image of the real world, creating a hybrid image of the digital and physical visual content.

2 Within the context of this study, the term "atmosphere" refers to the overall cognitive and psychological impact of holistically experiencing the various qualities of the architectural space that can be categorized as environmental stimuli, such as form, lighting, volumetry, materiality, color, biophilic content, acoustics, or even the individuals who occupy the space alongside the subject.

the extent of the resolution, fidelity, and "variety of energy" simulated; *matching* is the extent to which virtual movement matches proprioceptive feedback (i.e., turning our head in HMD systems).

Multiple studies highlight the immersive capabilities of VR (in some cases opposed to augmented and mixed reality) [1], its potential to facilitate the identification of spatial cues, and the ability to sustain a greater sense of engagement (Ruotolo et al. 2013; Kuliga et al. 2015; Paes, Arantes, and Irizarry 2017; Flavián, Ibáñez-Sánchez, and Orús 2019). These features lead to a greater sense of engagement, making HMDs reliable research tools. However, there are also issues. Almost all studies report low sample size (Weech, Kenny, and Barnett-Cowan 2019), which is a significant issue in terms of achieving statistical power and the ability to generalize results. Another common discrepancy is gender difference. Multiple studies reveal gender differences regarding spatial cognition, completing tasks, and suffering from cybersickness (Paes, Arantes, and Irizarry 2017; Weech, Kenny, and Barnett-Cowan 2019); however, conclusions are highly mixed and partial effects are unclear (Kearns et al. 2002; Weech, Kenny, and Barnett-Cowan 2019). No researcher knows the partial effects, or what exactly causes this disparity. When planning research, it is best to pull equally from males and females.

Pilot Experiment

Throughout the design development phase, architectural space is experienced in different modes (still images, walkthroughs, stationary VR, and mobile VR). Understanding the subjects' response to architectural space when communicated with different media is important. The pilot study set out to answer the following questions: 1. — what is the immersion vs presence balance for various viewing modes? 2. — where is the point of diminishing returns? 3. — is there a significant difference between subjects' experience using stationary vs in-motion VR? 4. — is there a different emotional response between viewing an image vs experiencing the image in VR? The study also presented a chance to understand the opportunities and limitations outlined early on that applied to different media: 5. — does the subjects feel sicker while moving around in VR vs stationary VR? 6. — does a walkthrough feel familiar to the subject? 7. — are still images less engaging? 8. — does the subject feel more in control using a keyboard and mouse or an HMD device?

I developed two custom environments in Unreal Engine 4.27. Unreal Engine was chosen for its high graphical fidelity and flexibility to create custom experiences. I designed two separate virtual environments for the study [**F5a**; **F5b**]. The first setting was called the *natural environment*. It is not actually natural, but there is a nice view, an introduction of color, and the light is richer. The aim was to differentiate the overall atmosphere [2] as much as possible, to exaggerate emotional response. The second environment was called the *sterile environment*. The view outside is more urban, and there is no greenery inside the room. It lacks natural qualities, so it is dubbed the sterile environment. Lighting, color, materiality, views, and plant-life were all differentiated, inspired by Peter Zumthor's (2006) twelve *generators of atmosphere* and by Fritze and Güler's research (2021).

Twenty students participated in the pilot study (convenience sample, n_f=13, n_m=7). The experiment was administered to groups of three or four students at a time. An Alienware 17 R5 laptop with a GTX 1080ti graphics card was utilized as the experiment computer. The laptop's

F5a The natural virtual environment

F5b The sterile virtual environment

F6a Photos of students participating in the pilot test: still image set and walkthrough set

F6b Photos of students participating in the pilot test: stationary VR set

F6c Photos of students participating in the pilot test: mobile VR set

own display at 3840 x 2160 (4K) resolution was utilized during the still image and walkthrough phases. An HTC Vive HMD kit was utilized during the stationary and mobile VR phases. There were four interaction sets: 1. — Still Image Set; 2. — Walkthrough Set; 3. — Stationary VR Set; 4. — Mobile VR Set. For each set, the participants experienced both the "natural" and "sterile" environments for 1 minute each (4 x 2 = 8 passes in total) [**F6a**; **F6b**; **F6c**]. Phases were randomized with a Random Number Generator (RNG) to minimize direct comparison (e.g., 2, 8, 1, 3, 5, 4, 6, 7) deterring bias. After each pass, participants filled out a short survey. Intended to be quick, the survey contained two short sections. The first section was a Self-Assessment Manikin (SAM) questionnaire asking about *pleasantness*, *calmness*, and *control*. The second section included five 9-item Likert scales asking about *discomfort*, *boredom*, *restriction*, *familiarity*, and *naturality* [**Appendix A**]. Being an exploratory pilot study, multiple different criteria were tested for effectiveness in revealing various tendencies and connections.

Though the research is ongoing and the sample size is too small to draw scientific conclusions, we can identify patterns [**T2**]. Most of the responses relates to spatial qualities. Even though it is the same exact system, participants felt more restricted or less excited based on the environment. The spaces' design affected the excitement response. There is a higher separation for the walkthrough experience followed by stationary VR, though average excitement is higher for mobile VR. In terms of overall pleasantness, VR experiences are diverging from screen-based experiences. In mobile VR experience participants felt most in control, whereas screen-based walkthrough and stationary VR response were very similar. Participants are semi-comfortable with all systems; however, mobile VR positively diverges from the other systems. It should

Appendix A The data collection form

Parameters
- valence
- arousal
- dominance
- discomfort
- boredom
- restriction
- familiarity
- naturality

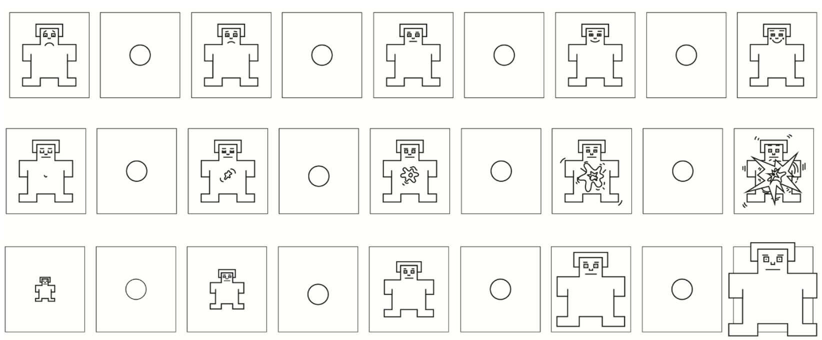
Sensing the Atmospheric Space Through a Virtual Lens: Scrutinizing Opportunities and Limitations

– Pilot Study Response Sheet –

Respondent Pseudonym [ ] | Display Medium [1] [2] [3] [4] | Environment [A] [B]

Self-Assessment Manikin – Choose either an icon or the circle (1 to 9) in between that best represents your emotional state after interacting with the given environment.

Unpleasant – Pleasant / Calm – Excited / Controlled – In Control



Please choose one of the 9 options that best represents your state of feeling after interacting with the given environment.

Level of <u>Discomfort</u>

Highest *Neutral* *Lowest*

1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7☐ 8☐ 9☐

Level of <u>Boredom</u>

Highest *Neutral* *Lowest*

1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7☐ 8☐ 9☐

Level of <u>Restriction</u>

Highest *Neutral* *Lowest*

1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7☐ 8☐ 9☐

Level of <u>Familiarity</u>

Highest *Neutral* *Lowest*

1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7☐ 8☐ 9☐

Level of <u>Naturality</u>

Highest *Neutral* *Lowest*

1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7☐ 8☐ 9☐

T2 A look at the initial raw data

Key
- 3.0 ≤ mean value ≤ 3.5
- 3.5 < mean value ≤ 4.0
- 4.0 < mean value ≤ 4.5
- 4.5 < mean value ≤ 5.0
- 5.0 < mean value ≤ 5.5
- 5.5 < mean value ≤ 6.0
- 6.0 < mean value ≤ 6.5
- 6.5 < mean value < 7.0

		S A M							
		Unple-Ple	Calm-Exc	Cont-In C	Discomfort	Boredom	Restriction	Familiarity	Naturality
Still Img.	1-A	5.95	4	5.05	6.05	5.2	4.55	4.8	4.75
	1-B	5.2	3.25	4.95	5.6	3.45	3.55	4.45	3.3
Walkthr.	2-A	6.15	5.05	5.7	6	6	5.7	4.6	4.3
	2-B	4.8	3.95	5.45	4.7	4.5	5.85	4.6	3
Stat. VR	3-A	7	5.25	5.5	6.35	6.7	5.6	4.45	5.15
	3-B	5.7	4.2	5.45	5.35	4.7	4.65	4.8	3.9
Mob. VR	4-A	6.75	5.8	6.5	6.7	7	6	4.3	4.1
	4-B	5.75	4.95	6.2	5.75	5.95	5.15	3.9	3.5

be noted, when participants took off the VR set, their heads were red, and they were swaying slightly. A higher immersion level does not seem to cause higher discomfort. One would expect as much, considering it is so immersive that it might induce cybersickness. However, the subjects express comfort. Each pass of the experiment takes only one minute. If the experiment were five minutes, perhaps the result would have been different.

Still images seem induced boredom, pointing to a lower sense of presence. On the other hand, the more immersive mobile VR system comes across as the least boring. Participants found the experience of still images to be the most restricting, though responses to the other media is inconsistent. Familiarity and naturality do not seem to be interpreted in a consistent manner and do not yield a meaningful outcome. Some people think of things as natural and others think of the same thing as unnatural, so there is too much discrepancy. The data does not form a logical pattern, so I intend to omit these elements from a future study. Participants liked talking about their experiences, and what they provided verbally was illuminating. Short focus group interviews following the experiment might yield interesting data, making the findings more grounded.

Conclusions

The most prominent themes in the last three years of spatial perception research in VR are *immersion* and *presence*. The existing research suggests a relationship, however, there is no specific research investigating spatial perception, or a relationship between the two notions. The issue of *cybersickness* is exceedingly significant and research suggests a relationship tied to both immersion and presence. Large-scale studies with high statistical power are needed to bolster the discourse. The pilot study's data point to a possible strong impact of environmental qualities on how various media is experienced. They are not dissociated from the medium, nor how subjects are experiencing these environments. Moreover, it would be interesting to study how environmental features affect the experience. Within the context of atmospheric space, the relationship between immersion, presence, and cybersickness might differ from existing research and needs further investigation.

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Tiziana Proietti
Sergei Gepshtein

Locating Architectural Atmosphere

Abstract
Architectural atmospheres are often described in spatial terms, but the nature of their spatial organization remains elusive. Here we consider how spatial characteristics of architectural atmosphere can be investigated from a new perspective emerging in the interface between architectural design and empirical science. We observe that qualities of architectural atmospheres must vary across location, and their perception is necessarily divided to spatial regions because different sensory information is available in different regions of the environment. We consider how boundaries of these regions and their sensory content can be identified using principles of geometrical optics, physiological optics, perceptual organization, and orienting behavior.

Keywords
empirical science
atmosphere
architectural proportion
regions of experience
boundaries
vision
locomotion
geometrical optics
physiological optics
visual contrast sensitivity
perceptual organization
orienting behavior
attention

Introduction

The concept of architectural atmosphere plays an important role in architectural theory and practice, yet it remains shrouded in ambiguity (Canepa 2022; Wigley 1998). In spite of sustained attention, investigators of the meaning and properties of architectural atmosphere are still seeking to attain the definitional and operational clarity needed for productive investigation. Attempts to improve understanding of architectural atmosphere have been undertaken from a variety of perspectives, including architectural phenomenology (Pallasmaa 2014; Sharifian et al. 2020), criticism (Malnar and Vodvarka 2004; Poon 2018; Choi 2020), and poetic reflection (Holl 2000; Zumthor 2006). Yet another perspective has recently emerged at the interface of the disciplines of empirical science and architectural design (Eberhard 2009; Mallgrave 2010, 2021; Robinson and Pallasmaa 2015; Gepshtein and Snider 2019; Albright, Gepshtein, and Macagno 2020). Here we ask how this emerging line of inquiry can help elucidating spatial properties of architectural atmosphere.

Prior efforts to define and investigate architectural atmosphere have invariantly engaged concepts of space. As an influential illustration, consider how editors of the book series titled *Atmospheric Spaces* by Mimesis International introduced their subject matter by explaining that architectural atmosphere was, first, a "sensorial and affective quality widespread in space" and, second, it was "a vague ens or power, without visible and discrete boundaries, which we find around us and, resonating in our lived body, even involves us" (e.g., Griffero and Moretti 2018, 3). We must agree that numerous qualities of architectural atmosphere are each distributed throughout the built environment. But their distributions differ from one another, as expected in an inhomogeneous field. By nature of sensory perception, sensory effects of parts of the environment are confined to spatial regions that contain different sensory information, whose boundaries can be fuzzy or sharp. The person who moves through the environment may experience these changes accordingly, as smooth or abrupt.

Scientific studies typically begin by means of analysis. The analytical approach requires identification of components that are immediately tractable and suitable for subsequent synthesis. Accordingly, in empirical studies of architectural atmosphere one can readily identify certain components of perceptual, cognitive, and affective nature. Similarly, one may elect to focus on the spatial structure of experience or its temporal dynamics, and concentrate on how these are modulated by the person's attention, memory, and intent. Here we focus on spatial and sensory properties of architectural atmosphere. But even as we begin this focused study, we note that this investigation engages numerous other components of architectural atmosphere, as we point out in the section of this essay "Orienting Behaviors and the Content of Experience." Recognizing this complexity prompts one to imagine a broader integral study of architectural atmosphere, even at this early stage.

Experience of Architectural Proportion

Just as architectural atmosphere is thought to characterize every instance of the built environment and has its effects distributed in space, *architectural proportion* is a ubiquitous characteristic of objects populating the environment, and its effects are thought to be distributed in space. Among these effects, architectural proportion is believed to affect one's emotive response to the environment (Dosen and Ostwald 2017; Shemesh et al. 2021), facilitate comprehension of structural properties of the environment, and inform behavior (Proietti and Gepshtein 2022).

Numerous attempts have been made to define proportion and its role in design and experience of architecture. But this work has concentrated on two exceedingly narrow conditions. First, architectural proportion has been mainly conceived as a two-dimensional property of architectural objects. For example, consider how regulating lines are typically imposed upon plans and elevations of buildings in two-dimensional architectural drawings. Second, the perceiver of architectural proportion has been typically imagined as a stationary observer, positioned to maximize appreciation of object proportions. The latter assumption traces back to Renaissance architects fascinated with *perspectiva artificialis*, presuming that the human eye coincides with the ideal eye implied by the drawing (Kubovy 1986; Edgerton 2009).

These two idealizations prevent one from appreciating the full range of experience of architectural proportion because they disregard the complexity of the dynamic interaction between the flesh-and-blood person and the built environment. Proietti and Gepshtein (2021, 2022) proposed a new empirical approach to investigate architectural proportion. In their framework dubbed "new proportional thinking," experience of architectural proportion is couched in terms removed from the narrow issue of aesthetics of proportion. [1] Instead, numerous other properties of experience of architectural proportion are brought to the fore, emphasizing the following conditions of natural architectural experience.

> *Mobility*
> Perception of proportion should be studied from a mobile point of view, which is how architecture is typically experienced, in contrast to the artifice of static observers presumed by adherents of perspectival representation in architecture.

1 This approach is reminiscent to the study of quantitative relationship among dimensions of objects, described by the architectural historian Matthew Cohen as *proportion-as-ratio*, and contrasted with the aesthetic notion of *proportion-as-beauty* (Cohen and Delbeke 2018).

2 Psychophysics is a scientific discipline concerned with the relationship between physical patterns (called "stimuli") that activate the observer's sensory systems, on the one hand, and the sensations elicited by the stimuli, on the other hand (Fechner 1966 [1860]; Green and Swets 1966; Link 1992; Kubovy, Epstein, and Gepshtein 2013).
3 The theme is developed further in a forthcoming article: Proietti and Gepshtein, "Architectural Proportion beyond Beauty," in which the authors observe that architectural proportion may have many effects on the person outside of the realm of aesthetics. The authors concentrate on realistic conditions of perception, in which architectural proportion is experienced by the moving person; they ask how this experience can be elucidated using concepts and methods of modern sciences of human perception and behavior.

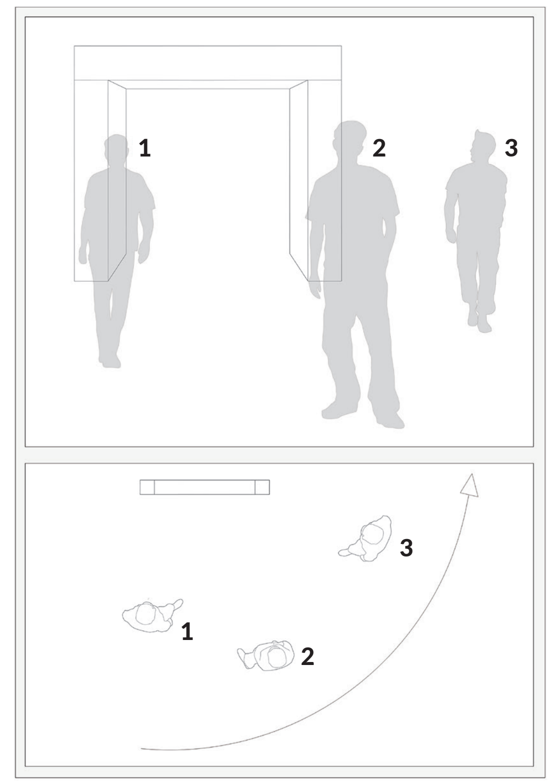
Three-dimensionality
Conceptions of proportion useful for architectural design should be defined for three-dimensional objects, rather than two-dimensional projections of objects.

Perceptibility
Mathematically distinct proportions are notable in design only after one has ascertained the proportions in question are perceptually discriminable from one another.

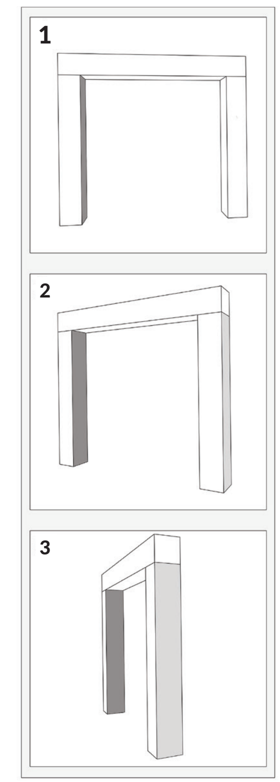
Elaborating the consequences of these three conditions for perception of the built environment leads to a significant departure from prior conceptions of architectural proportion. Together these conditions help one to appreciate how specific spatial attributes of objects interact within the perception of architectural proportion. For example, consider an observer standing in front of a portal [**F1a**]. The three illustrated locations entail different perception of parts of the portal: its pillars and the beam. As we show [**F1b**], the perceptibility of facet proportions of these tectonic elements diminishes when viewed at sharp angles (Proietti and Gepshtein 2022). Generally, the variable perceptibility of tectonic elements is inevitable under the realistic conditions of architectural experience. This reasoning makes it clear that *effects of proportion must be confined to spatial regions where features of interest are perceptible to different extent*. Proietti and Gepshtein (2021, 2022) developed a research program to identify these regions using methods of sensory psychophysics[2] (also see Proietti 2021).[3]

F1 Effects of observer location and orientation on perception of object proportions

From every location, the person can experience only a part of the environment. A full grasp of the environment, including its proportional structure, can be attained only by considering multiple successive locations of the person. In particular, the ability to perceive proportions of tectonic elements diminishes when they are observed under sharp angles (Proietti and Gepshtein 2022).



F1a



F1b

Perceptual Access

The just described limits of the perception of architectural proportion by a moving person belong to a larger family of factors that may be collectively identified as "perceptual access." These factors determine where the person can obtain information needed to form specific experiences. Still, having access to information does not guarantee the person will attain the concomitant experience. For this reason, the notion of perceptual access concerns *possibilities of experience* rather than actual experience (Gepshtein 2022).

The scientific literature dedicated to perceptual access consists of several departments. It concerns different sensory systems and several levels of analysis within each system. Here we offer an illustration of how these varied factors cooperate between levels of analysis within the visual system. In spite of our focus on visual perception, one cannot fully separate visual factors from other sensory and motoric factors. We find it useful to divide the analysis of visual access into three layers, each governed by a different explanatory mechanism: one concerned with the outer boundaries of experience, the second with the potential content of experience, and the third with actual experience.

A. Geometrical Optics and the Container of Experience

Concepts of geometrical optics are familiar to architects under the rubric of "isovist" or "polygon of visibility." *Isovist* is a formal description of potentially visible parts of an environment: the surfaces that can be connected to the eye by uninterrupted straight lines simulating rays of light (Benedikt 1979; Harris and Jenkin 2011). Numerous applications of isovist in design is a testimony to the power of analysis based on geometrical optics alone. Still, isovist analysis does not reveal what a person will perceive — or even what the person can perceive. For this reason, isovist is more aptly described as a tool for the analysis of *invisibility*.

In other words, isovist reveals with certainty the parts of the environment that cannot be perceived: these are the parts that remain outside of isovist and are excluded from further analysis. Whether one can see the parts inside of isovist depends on the factors described in the next two sections. Still, isovist boundaries between the invisible parts of the environment, on the one hand, and the potentially perceptible parts, on the other hand, constitute a useful starting point for the effective analysis of visibility.

B. Potential Content of Experience

Among the reasons for not seeing the objects contained in isovist, *attention* comes to mind first. And yet, there are several other forces that determine perceptibility which are more pervasive than attention. These forces are readily affiliated with two large rubrics of perceptual literature: "physiological optics" and "perceptual organization."

Physiological optics

The term "physiological optics" is traditionally associated with the eminent German physicist, physiologist, and physician Hermann von Helmholtz, whose numerous early contributions to understanding visual perception were collected in *Handbuch der Physiologischen Optik* (1867). Today, the scope of ideas originating in Helmholtz's work has broadened significantly (Rock 1983; Frisby and Stone 2010; Kubovy, 4 Unconscious inference is a host of automatic processes of perceptual decision making (Knill and Richards 1996; Maloney, Trommershäuser, and Landy 2007; Pouget et al. 2013).

Epstein, and Gepshtein 2013), divided into the study of physiological factors that limit perception and the study of processes affiliated with Helmholtz's influential idea of "unconscious inference."[4]

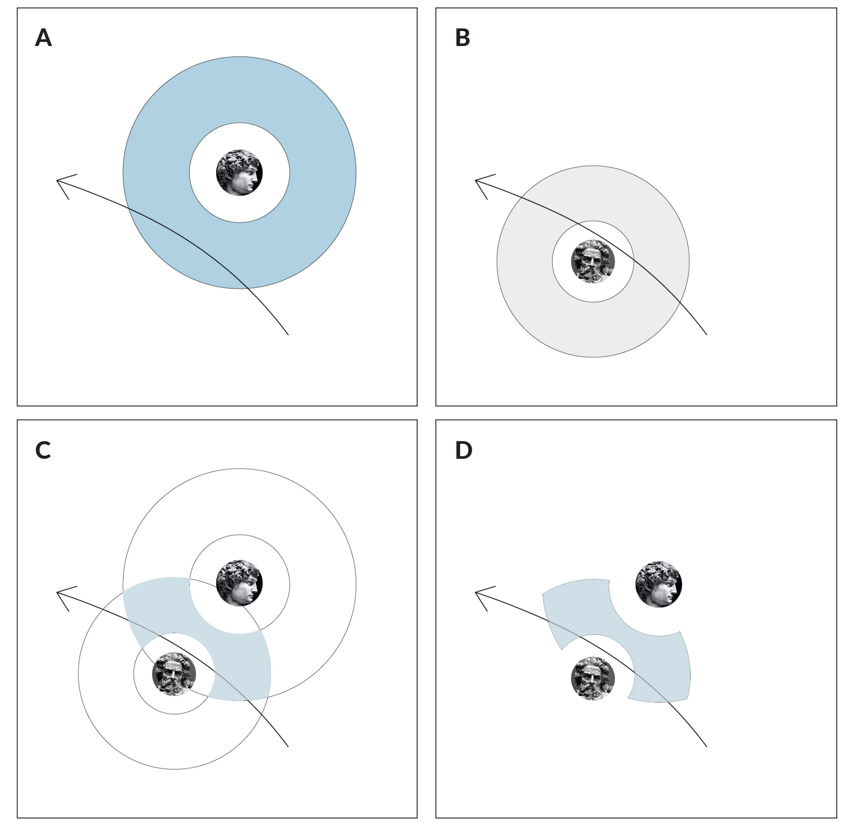
The physiological factors that limit perception determine which features of the visual scene can be perceived, including the features that appear within the field of view (and thus are included in the isovist). One of the most pervasive factors that determine perceptibility of features is studied in the extensive literature on *visual contrast sensitivity* (Cornsweet 1970; Kelly 1979; Gepshtein 2010; Gepshtein, Lesmes, and Albright 2013; Watson and Ahumada 2016; Gepshtein and Albright 2017; Pawar et al. 2019; Gepshtein et al. 2022). An important result emerging from this line of investigation is that perceptibility of a visual feature depends on its luminance contrast and distance from the eye. This notion can be illustrated using the *Ring Model of Visibility* [**F2**], whose genesis and empirical grounds were recently elaborated in Gepshtein 2022.

Perceptual organization

Traditionally separated from physiological optics are a host of "constructive" processes termed "perceptual organization" (Hoffman 2000; Kubovy, Epstein, and Gepshtein 2013). Just as certain parts of a scene can fail to be perceived due to limitations imposed by physiological optics, certain parts can fail to be perceived because the visual system does not organize them into (or "constructs") perceptual wholes or objects. This line of inquiry was initiated by Gestalt psychology (Koffka 1935; Kubovy and Pomerantz 1981), and continued into modern experimental psychology, cognitive science, and neuroscience (Kubovy and Gepshtein 2003; Gepshtein, Elder, and Maloney 2008; Wagemans et al.

F2 Regions of visibility

A plan view of two visual features and their regions of visibility (shaded rings), shown separately in panels A and B. The ring shapes of the regions of visibility are derived from a model of human contrast sensitivity (Gepshtein 2022). The curved arrow represents the path of a mobile perceiver. In panel C the regions of visibility are shown together to reveal their overlap (shaded in C, plotted separately in D), which is the region of joint visibility. In every case, the moving person will potentially experience the features of interest only when the person's path overlaps with the shaded regions.



2012a, 2012b). Research of perceptual organization has traditionally pursued two themes: perceptual grouping and layering of experience into figure and ground. Studies of *visual perceptual grouping* asked which parts of the visual scene are organized into visual objects. And studies of *visual figure and ground* asked which parts form figures that "own" their contours and appear to stand in front of the ground that "fills in" behind figures. Both perceptual grouping and figure-ground organization are important for our inquiry because they determine the "phenomenal identity" of objects that may contribute to the experience of architectural atmosphere.

In contrast to the effects described in the previous section, concerned with the question of where features of interest can be detected or discovered by the mobile observer, further studies of perceptual organization are needed to learn where objects acquire their phenomenal identity, so their meaning (and not only their presence) affect perception.

C. Orienting Behaviors and the Content of Experience

Objects that are potentially perceptible from the standpoints of physiological optics and perceptual organization may become actually perceived for reasons that can be usefully described under the unifying umbrella of "orienting behaviors." Generally, these behaviors form a hierarchy ranging from (1) movement of focal attention in the field of view, independent of eye movement, to (2) movement of the eyes in eye sockets, or orbits, fixed in the head, to (3) movement of the head relative to the body trunk, to (4) movement of the trunk on the feet, and eventually to (5) locomotion of the person's body, including translational and rotational movements.

Much is known about these orienting behaviors from scientific investigations, yet this knowledge is only beginning to penetrate architectural literature and practice (e.g., Gepshtein and Snider 2019; Albright, Gepshtein, and Macagno 2020). It is important to note, however, that key concepts of *orienting* are intuitively clear to design practitioners. [5] The factors described in the previous sections are less intuitive because they are not accessible to introspection or phenomenological reflection. Accordingly, we expect the bulk of future work on spatial properties of architectural atmosphere to depend on ideas of physiological optics and perceptual organization being integrated into architectural research.

This very brief account of visual orienting makes it clear that analyses of visual aspects of perception amount to much more than an isolated sensory process of "pure" vision (Churchland, Ramachandran, and Sejnowski 1994). Motoric systems, the vestibular system and proprioception, and parts of the autonomous nervous system (such as the system controlling pupil size), all take part in visual perception, often designated as *visual behavior*.

Analysis of Visibility

We began elucidating the spatial structure of architectural atmosphere. The notion of *spatial structure* can be interpreted several ways, for example as a spatial modulation of a given atmosphere or as several atmospheres located near one another in the same environment. In either case, a person moving through said environment will cross the boundaries separating regions characterized by different experiences, even if the change is immediately unnoticeable.

5 It is immediately evident an object cannot be seen if one's body is oriented away from the object, or if the environment is organized such that the person's attention is diverted to other objects.

We reviewed several concepts developed in scientific studies of perception that may help understand how such regions arise and how they affect one's experience and behavior. How can these ideas help designer perform analysis of architectural atmospheres? Let us consider an example of this challenge.

Figure [**F3**] portrays a rectangular room formed by solid walls and interior colonnades on every side. Suppose a painting is displayed on one of the walls. Multiple locations inside the room afford a view of the painting, even though each view presents *different possibilities of perception*. We use several analytical devices to illustrate perceptual access of the person at three locations in the room.

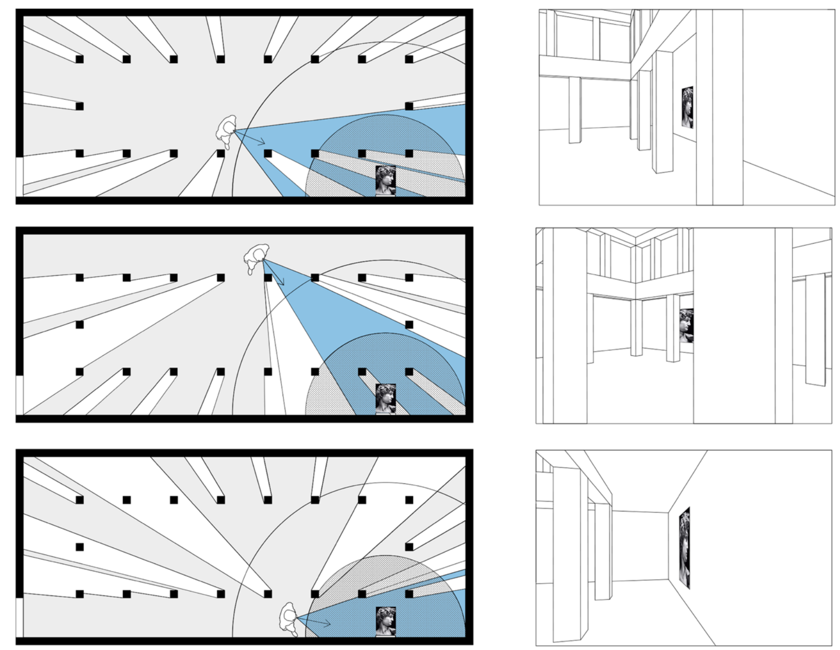
First, the grayed areas represent the *isovist*, indicating which parts of the room are excluded from the momentary analysis.

Second, within the isovist, the conic blue regions indicate the likely *directions of observation* (and subsets of the isovist) that are likely to affect experience.

Third, two circles (shown in left panels) represent the differential visibility of features of the painting as a function of the viewing distance. These are simplified renderings of the *rings of visibility* previously introduced [**F2**]. The small circle represents the region in which the person can perceive fine details of the painting. The large circle represents the region in which the fine details are indiscernible, but the painting's general shape, proportion, and figurative content can be readily perceived. Outside the second circle, the viewer may notice the object but fail to appreciate it as a painting.

F3 Analysis of visibility

A rectangular room formed by solid walls and colonnades on every side of the room is shown in plan and perspectival drawings. A single painting is displayed on one of the walls. A person looks at the painting from three points represented in separate panels. Four spatial regions are shown for each location. The grayed areas represent the isovist. The conic blue areas within isovist represent visibility associated with the likely direction of viewing. The small, shaded circle is the region of visibility (simplified as compared to F2) within which the person can perceive fine details of the painting. The large circle is the region within which the person cannot discern the fine details of the painting but can appreciate its general shape, proportion, and figurative content. Outside of the larger circle, the person may notice the painting but fail to appreciate its identity.



Fourth, in addition to the above factors, the bottom panel illustrates how the painting's *angle of observation* becomes too sharp for the person to appreciate properties of the painting, including its proportional structure (cf. [**F1**]).

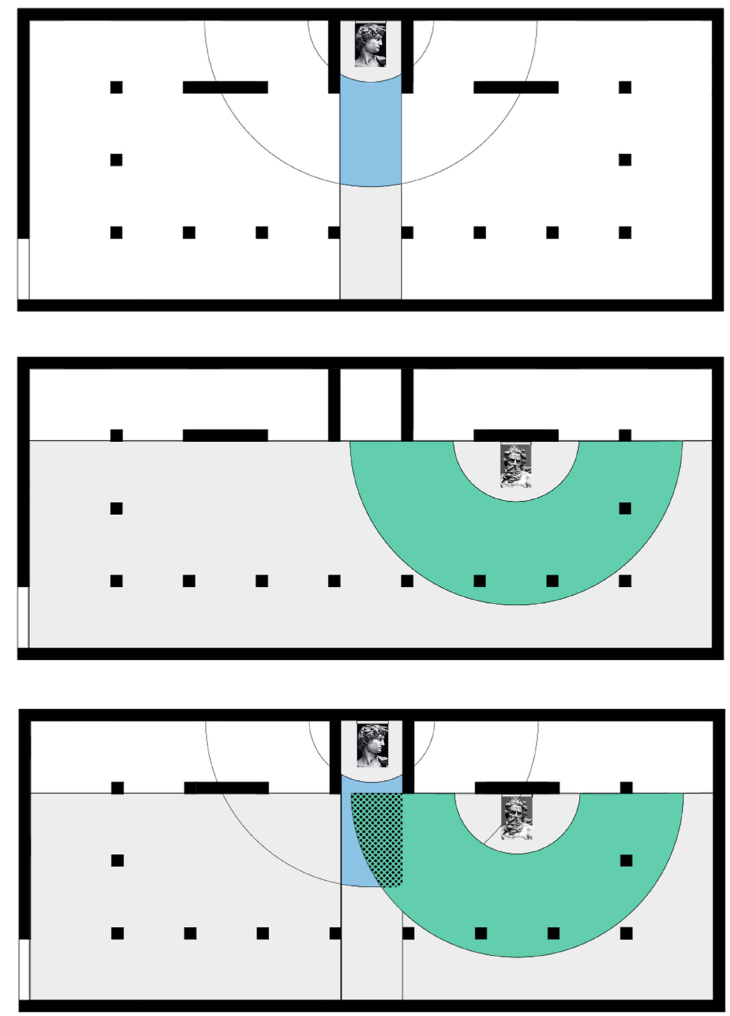
Developing these analytical devices and making them accessible to designers will aid in understanding the sequential experience of a person moving in the built environment, and adjust design to attain the desired *narrative* and *atmospheric effects*.

Adding another feature to our analysis considerably increases the complexity of the spatial structure. Figure [**F4**] portrays a different room with two features of interest: two paintings placed on the same side of the room. One painting is hung inside a niche and the other one on a free wall in the middle of the room. Consider how one of the devices introduced above leads to further division of the spatial structure of experience. The rings of visibility associated with the paintings overlap, creating a new region (marked by the dotted texture in the bottom panel) in which the person's experience is potentially affected by both paintings.

Since complexity of this analysis increases with the number of spatial features considered, designers concerned with human experience need new methods to help discover regions of distinct experience. These methods are likely to take the format of *interactive design platforms* allowing the designer to select features of interest and the layer of analysis. Such tools will prove indispensable in the analysis of dynamic experiences of moving persons because the intricate shapes of the regions of experience vary continuously as they are construed from different locations along the person's path of movement.

F4 Intersection of regions of experience

Two paintings are displayed in a room structured by partition walls and colonnades on every side. One of the paintings is displayed inside a niche, while the other is on a partition wall. The rings centered on each painting represent the regions of visibility introduced previously [see F2]. The textured region, obtained by the intersection of rings of visibility, affords concurrent perceptual access to both paintings.



Conclusions
We have studied how concepts and methods of the empirical science of perception can help elucidating the spatial structure of architectural atmosphere. Using perception of architectural proportion as an example, we considered how changes in conditions of observation limit the person's ability to experience specific features of the environment. Such limitations of experience determine where the person can potentially experience ("perceptually access") the features of interest. By pursuing this line of reasoning, we argued that sensory experiences are confined to spatial regions, dubbed *regions of experience*. Experience of architectural atmospheres is necessarily modulated by this spatial structure of sensory perception.

Because of the complexity of this structure, designers and scientists will do well by working together to develop new tools of representation of dynamic human experience, beyond representing the material environment alone. The new manner of understanding architectural atmospheres that may arise from this method of investigation will offer to the architect new capabilities of conceptual and practical nature. Conceptually, experience of architectural atmosphere will be construed as a dynamic process that unfolds in the mobile perceiver who crosses the boundaries separating regions of experience. Practically, by developing awareness of the spatial structure of architectural atmosphere, the architect will acquire new tools for shaping experience by selectively addressing properties of these regions.

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Symposium

Generators of Architectural Atmosphere

April 12, 2022
Recent advances in science confirm many of the architect's expert intuitions opening new doors to the perception of space and the meaning of architectural and urban design. The symposium *Generators of Architectural Atmosphere* presented to an audience of students, educators, architects, and scientists a conversation about human perception of design and building, specifically speaking to the significance of atmosphere, virtual reality, and proportion. It was an Interfaces event of the Academy of Neuroscience for Architecture (ANFA), sponsored by the EU's Horizon 2020 MSCA Program — RESONANCES project, the Perkins Eastman Studio, and the K-State 2020 Regnier Chair. The event was hosted in the Regnier Hall of the Department of Architecture, Planning and Design (APDesign) at Kansas State University (K-State), Manhattan, KS.

Speakers
Bob Condia, FAIA (APDesign — K-State, Member of the ANFA Advisory Council) | Elisabetta Canepa (EU Marie Curie Postdoc Fellow — UniGe, ANFA Member) | Kutay Güler (APDesign, IAID — K-State) | Tiziana Proietti (College of Architecture — OU, ANFA Member).

Lectures
Recorded videos of each lecture are available on the RESONANCES project website (www.resonances-project.com/harvest) and its YouTube channel (UCk32skDiT4Bz1AHnltT51Yg).

Support
Special thanks go to the P\Lab2003 team for the technical-organizational support, the videographer Matthew Knox, and the video editing crew, composed of Brittany Coudriet and Jacob Shreve.

“It is in the very nature of science that it succeeds by focusing on parts of the whole. The challenge is to determine which the ‘right’ parts are, and how lessons gained from the study of separated parts may provide a firm basis for study of the larger system formed when the parts are combined.”

Arbib 2013

“[Architecture] produces atmospheres in everything it creates. It does, of course, solve objective problems and build objects, buildings of all descriptions. But architecture is aesthetic work inasmuch as rooms and space are always created with a specific quality of mood and hence as atmospheres.”

Böhme 1991

“I’ve been keeping an eye on myself, and I’m going to give you an account now, [...] of what I’ve found out about the way I go about things and what concerns me most when I try to generate a certain atmosphere in one of my buildings. Of course, these answers to the question are highly personal. I have nothing else.”

Zumthor 2006

Generators of Architectural Atmosphere

An Interfaces event of the Academy of Neuroscience for Architecture, sponsored by the EU H2020 MSCA program —— Resonances project, the Perkins Eastman Studio, and the 2020 Regnier Chair

Bob Condia

Tiziana Proietti

Kutay Güler

P\Lab2003

Elisabetta Canepa

12 April 2022
8:30 —— 12:30

Regnier Hall, APDesign
Kansas State University

The Resonances project has received funding from the European Union’s Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement no. 101025132 —— www.resonances-project.com

Authors

Elisabetta Canepa (M.Sc.Eng., Ph.D.) is an architect and researcher from Genoa, Italy. She is currently an EU Marie Curie Fellow running the RESONANCES project (2021–2024) in collaboration with the University of Genoa, Kansas State University, and Aalborg University. Her research focuses on the hybrid connection between architecture and cognitive neuroscience, analyzing topics such as atmospheric dynamics, the emotional nature of the architectural experience, embodiment theory, the empathic phenomenon between humans and space, and experimentation in virtual reality. Dr. Canepa is a member of the Academy of Neuroscience for Architecture (ANFA), based in San Diego, California. She is a faculty member in the Neuroscience Applied to Architectural Design (NAAD) Master's Program at the Iuav University of Venice and serves as an Adjunct Professor in the Department of Architecture at Kansas State University. She wrote *Architecture is Atmosphere: Notes on Empathy, Emotions, Body, Brain, and Space* (2022), published by Mimesis International within the *Atmospheric Spaces* book series, directed by Tonino Griffero.

Bob Condia (FAIA) is a Professor in the Department of Architecture at the College of Architecture, Planning and Design (APDesign) of Kansas State University. He is the design partner at Condia+Ornelas Architects, Manhattan, Kansas. The 2017–2020 Regnier Chair of Architecture at Kansas State University, Prof. Condia teaches design as art with consideration to the biology of perception, the real, the ancient megaliths of man, and the sensible poetics of an architectural experience. He has been a studio critic for more than thirty years in architecture and interior design. Prof. Condia's place in the neuroscience for architecture debate is as an architect and studio critic, seeking the consequences of applied science for architects. Bob Condia is a member of the Advisory Council to the Academy of Neuroscience for Architecture (ANFA), based in San Diego, California. Regarding architectural affordances, atmosphere, and mood, he edited two books: *Meaning in Architecture: Affordances, Atmosphere and Mood* (New Prairie Press, 2019) and *Affordances and the Potential for Architecture* (New Prairie Press, 2020).

Kutay Güler (Art.D., NCIDQ, IDEC) is a multi-award-winning interior architect and Associate Professor in the Department of Interior Architecture and Industrial Design (IAID) at the College of Architecture, Planning and Design (APDesign) of Kansas State University. His research focuses on the intersection of environmental design dynamics and digital tools. Aside from numerous papers in high-impact factor journals such as *Computers and Education* and *Journal of Simulation*, he authored two books: *Simulating Visitor Behavior* (Cambridge Scholars Publishing, 2016) and *Interior Materiality* (New Prairie Press, 2021). He also edited a volume titled *Contemporary Issues in Housing Design* (Cambridge Scholars Publishing, 2018). In addition to his academic work, Dr. Güler completed over sixty commercial and residential interiors and many other design and visualization projects for international clientele.

Sergei Gepshtein (M.Sc., Ph.D.) is a scientist working in the areas of perceptual psychology, systems neuroscience, and computational neuroscience. His research interests include perception of visual depth and movement, perceptual organization, planning of multistep actions, and dynamics of cortical neural networks. Dr. Gepshtein is a member of the Center for the Neurobiology of Vision at the Salk Institute for Biological Studies in La Jolla (California), where he investigates perception and active behavior from the mechanistic perspective of neuroscience and from a perspective that respects phenomenal experience as an independent area of research. Dr. Gepshtein directs research of Adaptive Sensory Technologies at the Salk Institute with the goal to translate results of basic science for applications ranging from immersive visual technologies and adaptive sighting devices to urban design and forensic science. He directs the Center for Spatial Perception and Concrete Experience at the University of Southern California in Los Angeles: a platform for investigating spatial experience as a natural narrative process. Dr. Gepshtein is a member of the Board of Directors of the Academy of Neuroscience for Architecture (ANFA), based in San Diego, California.

Tiziana Proietti (M.Arch., Ph.D.) is an architect and Assistant Professor at the Christopher C. Gibbs College of Architecture, University of Oklahoma. Here, she directs the Sense|Base Lab, which bridges architecture and neuroscience, emphasizing the perception of architectural proportion. Dr. Proietti earned her doctorate from the Department of Architecture at Sapienza University of Rome (Italy) in collaboration with the Delft University of Technology (Netherlands). Her Ph.D. dissertation focused on the theory of proportion in architecture. Together with the scientist Dr. Sergei Gepshtein (from the Salk Institute for Biological Studies in La Jolla, California), she is developing an interdisciplinary program of research to intertwine neuroscientific knowledge and architectural design, by testing long-standing hypotheses about the human responses to architectural proportion. Dr. Proietti is a member of the Academy of Neuroscience for Architecture (ANFA), based in San Diego, California.

Index

Generators of Architectural Atmosphere

2022
New Prairie Press
Kansas State University Libraries
Manhattan, KS, USA

Generators of Architectural Atmosphere embraces Alberto Pérez-Gómez's lesson of atmosphere as a power to attune human life and explores the horizons offered by an experimental approach, challenging the inherent resistance of the atmospheric phenomenon to be objectified, quantified, and measured.

—— The editors

Atmosphere. Appellation for the moods and ambience created by architecture, adjusted for lived events in its discrete spaces and attuned to its site: amplifying and harmonizing priory meanings abiding in place. Most arduous to objectify and impossible to quantify. From Ancient Greek *atmós*, "vapour, steam," either poisonous or advantageous for the body and mind, taken in by respiration. Originally in the Sanskrit *âtman*, "inner self," a breathing, non-dualistic soul: first principle or true self of a liberated individual before identifying with phenomena. *Atmós*: moving water, foggy air, once deemed capable of bearing fleeting emotional images, like the imagination of the inner self, abiding both inside and out. Amenable finally to denote our spherical, airy, and affective abode, site of emotions and words coupled to the human breath, where we speak and are with others. Latin renders breath as *spiritus*, also the life-force and inner self. Atmospheres may thus accomplish architecture's spiritual function as we breathe and live, accommodating wise a priori habits with semantic amplification, offering poetic and ethical change, assisting our affective and intellectual self-knowing. An architectural atmosphere is a power to attune human life, one inherently out of tune for acknowledging itself as mortal, and in humble affinity with the beneficial actions of affectionate and amorous divinities.

—— Alberto Pérez-Gómez
An Alliterative Lexicon of Architectural Memories
A notion in progress

Interfaces 3 features three excellent essays on atmosphere as a phenomenological component of architectural experiences. Each complements the others to assemble both a compelling definition of the subject of atmosphere in buildings and an expansion of scientific knowledge about how perception and cognition work together to stimulate the emotions and feelings. If none of these papers settles the issue of whether atmospheric qualities can be measured, each brings us closer to understanding how we might do so in the future.

—— Mark Alan Hewitt, FAIA