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AI, the beauty of places, and the metaverse: beyond "geometrical fundamentalism"

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Abstract

As the tech world moves increasingly toward an AI-generated virtual universe — the so-called "metaverse" — new paradigms define the impacts of this technology on its human users. AI and VR, like the Internet before them, offer both remarkable opportunities and pitfalls. Virtual Reality constitutes a new kind of human environment, and experiencing it relies upon human neurological mechanisms evolved to negotiate — and survive in — our ancestral physical environments. Despite the unrestricted freedom of designing the virtual universe, interacting with it is affected strongly by the body's built-in physiological and psychological constraints. The eventual success of the metaverse will be determined by how successfully its designers manage to accommodate unconscious mechanisms of emotional attachment and wellbeing. Some fundamental misunderstandings coming from antiquated design models have influenced virtual environmental structures. It is likely that those design decisions may be handicapping the metaverse's ultimate appeal and utility.

Keywords AI, Architecture, Artificial intelligence, Beauty, Christopher Alexander, Design, Digital aesthetics, Emotional attachment, Engagement, Healing environments, Metaverse, Objective beauty, Text-to-image system, Virtual Reality

1 Introduction

Digital aesthetics are rapidly assuming a central role in both the commercial sector and cutting-edge technology. Virtual environments are defining new concepts and opportunities in the art world (Mazzone & Elgammal, 2019; Audry & Ippolito, 2019; Revell, 2022; Zylinska, 2020) and in architecture (Eloy et al., 2021). This essay will argue, however, that most of what has been developed up to now has been extremely limited in the key respect of objective beauty.

One definition of the metaverse is that it is a "massively scaled and interoperable network of real-time rendered 3D virtual worlds and environments which can be experienced synchronously and persistently by an effectively unlimited number of users with an individual sense of presence, and with continuity of data, such as identity, history, entitlements, objects, communications, and payments." (Ball, 2021) The metaverse is often confused with VR, but VR is but one component of the metaverse. If the metaverse is ever going to take off on a large scale, it will be as an immersive sensory environment whose visual attraction far surpasses that of most physical settings. Curiosity may trigger a first visit, but it is sensual feedback that will draw users back. Both real and virtual worlds are subject to the same design principles because human beings experience the environment unconsciously in order to use it. So the question is really about beauty. Is it possible to create a virtual world that is more emotionally enticing than the real one of a user's desk and the immediately perceivable surroundings?

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Technologists and investors are understandably excited about the potential capacities of a digital universe. As with any technological advance — particularly those involving the prodigious capacities of AI — there are significant uncertainties ahead (Rosenberg, 2021; Anderson & Rainie, 2022; Gorichanaz, 2022a). Many saw similarly optimistic, even utopian possibilities in the first generation of the Internet, only to later experience an age of clickbait, fake news, and deeply negative impacts on the wellbeing of human users, notably including children (Mehaffy, 2020a). It is too early to predict what consequences might arise as this interconnected set of virtual-reality projects moves forward.

Architect Michael Benedikt outlined some speculative ideas about Cyberspace early on following, unsurprisingly, an architectural approach (Benedikt, 1992). However, the key design and grounding tools for creating a viscerally-attractive Virtual Reality setting for navigation are not generally known to mainstream architects. Having focused upon other, formal concerns for decades, architectural culture is not the best source to provide an emotionally-engaging environment where it is most needed. And developers of virtual worlds have prioritized dominant architectural styles over the totally distinct look of the gaming world. This point is critical.

This paper offers a conjectural explanation of why the virtual world known as the metaverse has so far struggled to realize its potential appeal among users (Manjoo, 2022; Du, 2022). For example, according to Samantha Frew: "Compared to the impressive CGI (computer-generated imagery) we are accustomed to in gaming and cinema ... [the metaverse] appears as a basic world designed by tech moguls who are excited by minimalism. People with little to no imagination regarding the design of physical spaces." (Frew, 2022). This criticism is harsh indeed. But how could a multi-billion dollar project, with access to the latest scientific advances, start off on the wrong track? (Thompson, 2022)

The metaverse's lack of appeal may be due, in part, to a lack of biologically-based beauty in its intrinsic structure (Lavdas & Salingaros, 2022). If this is a contributing factor, then by responding to the innate need for "objective beauty" (a term to be explained later), the metaverse could greatly increase its user allure. Moreover, there is tantalizing evidence that the metaverse could even become a new healing environment. Technical limitations in a virtual world cut down most of the neurological channels of the unconscious engagement possible in a comparable real physical setting. An experience that drastically reduces the biological sensory experience of the real world nevertheless needs to maintain as much engagement as possible. Otherwise, it feels too "alien", too detached.

The outline of this paper is as follows. The association of beauty with special configurations of ordered complexity has been developed by scientists, including the present authors. The concept of "objective beauty" remains problematic and questionable to many readers, yet it is established by a considerable body of research and follows from derivations of its mathematical and neurological characteristics.

Two additional, distinct sources give evidence that visual information from more complex, traditional environments is preferred unconsciously over what architectural culture offers today. First, a clear predisposition comes from AI image generators, which combine preferences of billions of ordinary people; and second, from films and video games. AI text-to-image programs help to confirm survey popularity through films and videogames by establishing the distinct characteristics of objective beauty: we are not claiming that those programs alone are sufficient.

People might think that different-looking architecture is good or not for misguided reasons, which we explain as the phenomenon of "geometrical fundamentalism". Despite established historical and political arguments for the stark plainness of geometrical fundamentalism, it in fact contradicts human psychophysiology. Data from Medicine and Neuroscience reveal that good design based on objective beauty — that is, from evolved biologically-grounded responses — helps to boost human health. Dominant architecture tends to have the opposite informational effect, and evidence suggests that this contrast could be detrimental.

Therefore, it is not such a good idea for the metaverse to be drawing its cues from mainstream architectural culture. The metaverse should instead rely upon beautiful architecture (as defined by precise biological codes underlying objective beauty) and thus promote not only pleasure and engagement, but also human health. We propose the need for a "pattern language of metaverse design" that documents discovered and tested design elements and best practices, following the example of pattern languages in other fields. This approach towards creating a better virtual reality experience would begin with objective beauty.

The rest of this paper outlines our understanding of beauty and how to implement it. Biologically-based beauty is objective. The evidence for this comes from AI beauty ratings, experiments in neuroaesthetics, the mathematics of organic form, etc. We also give details of beauty as a prescription of how to create it. Objective beauty is grounded in geometric structure that combines fractals with informational complexity and multiple nested symmetries. This part of our discussion is necessary to debunk the mistaken notion that it is somehow not possible to create visceral beauty today.

2 How unattractive design might impact the metaverse

The metaverse is becoming a big player in generating new virtual worlds (Dwivedi et al., 2022; Bibri & Allam, 2022). Yet major developers seem to have miscalculated in moving over to virtual universes being created for online socializing and participatory gaming. An infatuation with contemporary minimalist architecture reflects the same subjective aesthetic in a virtual world into which billions of dollars have been invested; but the public is reacting unenthusiastically or even negatively to the perceived aesthetics of the result (Pahwa, 2022). This problem will remain unresolved as long as metaverse designers continue to rely uncritically upon favored architectural images.

Major companies of several countries in the Asia-Pacific region are investing massively on competitive individual metaverse platforms (Sun & Zhang, 2022; ANI, 2022; Goschenko, 2022). It is no coincidence that those governments have, for decades, replaced human-scale traditional urban fabric with clusters of skyscrapers and unattractive urban spaces that, because of their form and size, appear “alien” and oppressive to common people. The metaverse offers a welcome escape from this perceived physical dystopia. Yet the “look-and-feel” of previewed metaverse scenes seems informationally deficient, handicapped by inadequately-engaging design styles.

Metaverse designers do not realize that dated futuristic architecture might be precisely the sort of inhuman experience users are trying to sneak away from. One virtual universe looks like it’s made out of giant LEGO blocks, with intentionally crude modular geometries. Other metaverse developers brought in fashionable international architects as consultants, who then offered their signature curved, industrial, metallic, shiny, and sleek spaces lacking human qualities. This “look” may be fashionable in cutting-edge architecture, but does it really generate a viscerally-attractive virtual environment? We claim not, based on medical and neurological data. Alarmingly, educational institutions are promoting this vision as a metaverse paradigm before testing its commercial success. This is a big gamble.

The metaverse provides a unique opportunity for re-establishing architectural beauty by selecting architectural styles based entirely on visual emotional appeal (Gorichanaz, 2022b). Millions of online users prefer objectively beautiful environments — documented, for example, by travel companies as “the most beautiful places in the world” — to ones that many might consider ugly. Those places share the common geometrical characteristics responsible for objective beauty, which we describe later in this paper, and those are easily implemented in the metaverse. The truly revolutionary next step will occur when users begin to demand that physical places embody the same quality of elevated objective beauty they have already experienced in a virtual world.

Virtual environments wishing to have some semblance of reality that attracts regular participants must draw on positive-valence emotions. Absurdly, in today’s world of almost unlimited technical possibilities, architecture — both material and virtual — tends to be limited by design elements that diminish its degree of objective beauty. An ingrained professional and social inertia inhibits building new physical structures today with a high degree of objective beauty, thus limiting emotional engagement. To realize its full creative potential, metaverse designers need to embrace a biology-based understanding of architectural elements that give rise to healing environments.

Alexandrian design patterns (discussed later in this paper) and traditional architecture already spell out what makes an attractive space, so there is no excuse not to apply this knowledge, or in trying to figure out what we already know. Yet today’s metaverse settings tend to look like high-tech industrial districts. This is understandable, as clients and patrons, from governments to private companies, pay design firms to be cutting-edge and innovative but do not insist on testing adaptation before and after implementation. We now have evidence that new high-tech industrial districts such as Shanghai’s Lingang industrial district and Boston’s Seaport technology hub fail as attractive environments (Zhu & Lu, 2022; Sussman, 2019) What about the open-ended nature of the metaverse? Whereas metaverse users freely alter human features and form in search of “digital beauty”, they regard the virtual environment itself as untouchable (Wharry, 2022). In practice, users are able to choose to alter their own avatar, but leave the background environment and spaces alone. We are not even sure whether any such mechanism exists for users to shape spaces and visual surroundings; hence we assume not. At present, therefore, user-generated creative content will not solve the potential visual problems with the metaverse setting.

3 Affordance, healing environments, kinesthesia, objective beauty, and proprioception

This paper attempts to tackle what for some is the “elephant in the room” of architectural design, i.e. beauty; to define what it is, how is it understood, and how it might influence virtual worlds. Others do not see an “elephant in the room” since they regard beauty as a subject that is objectively non-measurable. The arguments presented here are pushing the debate forward at a time when beauty is being measured, crudely and ignorantly, by AI. Yet, amazingly, those results corroborate other measures of objective beauty based upon mathematics and neuroscience.

Special attention should be paid to the subtle but extremely powerful emotional/neurological forces that define the spatial experience in dance and sport. The same experiences are obviously felt by metaverse users moving their body while wearing a headset. Insufficient attention has been paid to the body-space interaction due to kinesthesia/proprioception, and, while it is difficult to envisage a real solution for this gap, we can at least point it out. Related mechanisms involve affordances, whereby the human neural system perceives unconsciously the bodily "fit" of geometrical components in the immediate environment for human actions, including actual or potential handles available for "grasping" (Salingaros, 2017).

We call for research that generalizes the perception of beauty so as to include other factors such as fundamental influences of cultural conditioning, environmental literacy, regional and peer iconography, age, etc. There are really two distinct topics that the metaverse experience intertwines: (*i*) objective beauty of the surroundings; and (*ii*) the emotional feedback from the geometry of the virtual spatial experience. Elsewhere, we talk at length about the inadequacy of 20th Century physical urban spaces to accommodate people's movements and to elicit positive emotional responses (Salingaros, 2005; Salingaros & Pagliardini, 2016; Franco et al., 2019; Salingaros, 2021).

To truly enhance our understanding of beauty, one needs to investigate topics that are usually considered less architectural, even though they underpin the immediate physical (or virtual) experience. We need to open the conversation to investigating notions of comfort, contradiction between human biology and learned preferences, cultural baggage, environmental triggers of spontaneity, and other related topics. It is essential to delve deeper into the infinite diversity of human cultures and psychologies that propel us to make beautiful things, whether they be cities, buildings, tools, or artifacts.

Designing affordance (i.e. physiological and psychological "fit" to the physical environment) creates viscerally engaging materiality (Mystakidis, 2022; Shin, 2022). Affordance — neglected in favor of abstract visual formalism ever since the 1920s — significantly enhances the user's embedded experience. (But minimalist design identifies both physical and visual "handles" as "clutter" and eliminates them.) As an architectural license is not required to practice in the metaverse, non-architects with an unprejudiced sense of objective beauty can create the successful metaverse. Individuals such as game designers have no problem applying new and traditional design tools in designing beautiful environments that dominant architectural culture dismisses because of style.

This opens up a promising new application: the metaverse as a therapeutic (visually salutogenic) environment (Petrigna & Musumeci, 2022). Wearable sensors that recognize emotions detect the user's state of wellbeing. The healing response from feedback is supposed to regulate participants' emotions towards a positive mood (Fernández-Caballero et al., 2016; Marín-Morales et al., 2018). Until now, changing the "smart" health environment was limited to adjusting piped music and color illumination. It is hardly feasible to change the physical architecture in real time, and this is where a virtual environment opens up enormous opportunities. A better understanding of those mechanisms will help to make salutogenic virtual environments feasible.

The technological basis for this development is already in place, since the new generation of metaverse headsets includes built-in eye-tracking and facial expression sensors. It should be straightforward to use this feedback to change the appearance of the virtual environment in real time. The second half of this paper offers a new "form language" for achieving emotionally-nourishing virtual (as well as real) places.

4 The computable and geometrical basis of objective beauty

4.1 Definition and independent verification of objective beauty

Objective beauty combines fractals with nested symmetries, together with other sources of biologically-meaningful visual information (Lavdas & Salingaros, 2022). Unconscious viewer engagement is clearly not based on intellectualizing subjective criteria. The more intense yet mathematically ordered the stimulus, the higher the degree of objective beauty. This definition is complexity-based: it outlines a beauty scale in which low values correspond either to less visual information or disordered information; while high values correspond to coherent, high-content, organized information (Salingaros, 2014a; Salingaros, 2018).

Experimental results and industry initiatives support methods for evaluating objective beauty using AI. On the one hand, experimental neuroaesthetics is fast establishing the physiological basis of how the body reacts to environmental information. On the other, computational neuroaesthetics is making possible new insights through machine learning. Their overlap has already created breakthroughs in aesthetic commercial applications. The following list contains a synopsis of basic points, whose detailed explanation follows in the main text.

1. Neuroscience supports the existence of objective correlates of the experience of beauty, and helps to distinguish between what we can call objective and subjective beauty.
2. Computational methods of assessing objective architectural beauty correlate well with intuitive methods.
3. The personal beauty industry now employs revolutionary software tools to carry out diagnostics and evaluations.
4. AI-based graphics/painting programs confirm the high and low evaluations on the beauty scale, hence its directionality (which is very important).
5. The digital art world is beginning to use such methods of evaluation to rate fine artworks for the global market.
6. "Ugliness" in the built environment induces facial distortions, perceived as ugly, and physiological sensors combined with AI-based software detect this effect.
7. Biomedical research to date rates the design styles promoted by architectural culture very poorly as healing environments, because of the ugliness-stress connection.

Individuals certainly differ in their beauty judgments (Vessel et al., 2018; Vessel et al., 2019; Corradi et al., 2020). Researchers find agreement among subjects responding to life and natural scenes such as images of faces and landscapes. This result is consistent with the underlying commonality of the unconscious response, which links to emotional and physical wellbeing. We would argue that this response comes into play not only when people are confronted with natural scenes, but also when confronted with artwork and architecture that shares certain geometrical organizational features of natural scenes. Also, divergent education, media influence, peer pressure, and social conformity shape people's tastes on consumer and cultural objects (Asch, 1951; Berns et al., 2005; Salingaros, 2014b; Hesslinger et al., 2017). Artifacts of human culture exist in a feedback loop that enforces — and generates — culturally-specific acquired tastes (Paßmann & Schubert, 2020). This effect is probably responsible for the observed low agreement among participants when responding to artworks and to interior and exterior architecture, where a shared aesthetic taste is not observed.

People's understanding of architectural beauty is influenced by what they see promoted around them, which can overwhelm their own body's signals. The psychological "familiarity principle" or "mere-exposure effect" (Zajonc, 1968; Montoya et al., 2017; Nickerson, 2022) shapes the discipline because consumer culture is tied to images of modernity. The media are engaged in marketing architecture through images that draw attention to design qualities not indicative of engagement. For decades, the most prestigious architecture prizes have been awarded for buildings ranking low in objective beauty, thus validating this stylistic standard through authority. Much of the business of architecture occurs strictly in a world of images with little or no further analysis. Images become buildings, fueling a self-reinforcing loop that transforms architecture into image.

4.2 Artificial intelligence and neuroscience support biologically-based architectural beauty

The neurological approach resurrects historical architecture's instinctive basis that was replaced by abstract, formal ideals at the beginning of the 20th Century. These two foundational bases — AI and neuroscience — are mutually supportive. Recent software can not only help to evaluate visual beauty, but moreover, is now trained to generate it. This is important because it fixes the directionality of the beauty axis, thus validating the biologically-based beauty scale. AI diagnoses design rather than implementing an already-decided formal design vocabulary (which is what dominant architectural culture chooses to focus on).

AI is rapidly evolving, with revolutionary developments motivated, in part, by the realism of the video game industry. The AI text-to-image generators Craiyon and DALL·E 2 are each capable of generating photorealistic original images in response to a verbal description. These programs were trained on online images and their captions (more than 10^8 for Craiyon and 10^9 for DALL·E 2). The prompt "beautiful building" produces traditional-looking buildings high in objective beauty, whereas asking for "ugly building" produces industrial-modernist high-rise buildings low in objective beauty (OpenAI, 2022; Dayma, 2022).

The same results arise when using the photorealistic AI text-to-image generators DreamStudio (DreamStudio, 2022) and Stable Diffusion (Stable Diffusion, n.d.), two direct competitors of DALL·E 2. Asking for "beautiful building" produces neo-classical traditional buildings high in objective beauty, whereas asking for an "ugly building" generates industrial-modernist high-rises low in objective beauty.

Using Midjourney, yet another AI-based image-generating program that creates artistic paintings rather than photorealistic images, the same two prompts as above generate colorful and curved buildings closer to

Art-Nouveau (high objective beauty), versus drab and structurally top-heavy brutalist ones (low objective beauty) (Holz, 2022). The results are unequivocal: Art Nouveau and traditional buildings satisfy the requirements for biologically-based beauty, whereas industrial-modernist/brutalist buildings violate them. Verbal cues signifying positive-valence emotional engagement thus generate a spectrum of traditional architectures.

These software packages correlate with general opinion worldwide about what is beautiful. Consistency between intuitive beauty rankings and AI-based imaging/painting programs is remarkable, because that software was not originally conceived for this purpose. Each of the above AI programs represents a "black box" that is trained from actual user responses to images, and has learned what most people consider beautiful and ugly, so it can generate images corresponding to these reactions. While, in principle, the programs tell us something that we could find from a survey, the scale of their data base makes this application exceed all normal expectations. Duplication is not possible in any survey that we can do, or that has been done before.

4.3 Human physiology implies a directionality of enhancing objective beauty

AI applied to image-processing establishes a direction for increasing objective architectural beauty. Going "up" correlates with increasing informational richness organized by multiple nested symmetries that guarantee perceptual processing fluency. This result brings to light a basic incompatibility between architectural culture and the personal beauty industry.

Although personal beauty standards vary widely in history, a specific direction of enhancing natural beauty in the millennial quest to improve one's appearance would seem to be fixed (Grammer et al., 2003; Little et al., 2011). People are driven by an innate need to display biological attractiveness that signals health, and not its opposite. The huge cosmetics and facial beauty industry is capitalizing on AI-based beauty measures (Spapé et al., 2021; Beauty.AI 2.0, 2022). Applications in that field are growing exponentially, despite cautionary warnings of possible bias and stereotyping. It's only a matter of time before the same type of software is trained to evaluate objective architectural beauty directly.

AI tools are already available for assessing image aesthetics through convolutional neural networks (CNN) (Li & Zhang, 2020; Liu et al., 2020; Takimoto et al., 2021; Goree, 2021; Valenzise et al., 2022; Chambe et al., 2022). Originally developed for selecting technically-superior images from a set of photos, this method has evolved to measure aesthetic appeal. General agreement on likeability or intuitive pleasure response is used to evaluate objective beauty in photos. Current programs develop Google's initial NIMA (Neural Image Assessment) by training it on sets of images (Talebi & Milanfar, 2018). The ones relevant to the present study use prize-winning photographs to train the software: design minimalism scores very low. Assessments so far tend to cluster around a mean value, hence they do not represent the wide range of results that are intuitively obvious from rating architecture on an objective beauty scale.

It is also possible to measure "ugliness" indirectly through physiological sensors. AI-based programs couple with input from portable body sensors to detect people's unconscious reactions to objective beauty. This information is unconscious, hence unbiased when compared to surveys based on self-reporting (Moore et al., 2011; Menzel et al., 2020). Any signal that alters facial features so that those are perceived as being "uglier" than normal (a relative, not absolute measure) indicates induced stress on the entire body. In this manner, visual ugliness — as information that triggers alarm in the neural system — induces stress, a reaction that permits "ugliness" to be detected through its negative effect on wellbeing.

As if anticipating our proposals, the new generation of metaverse headsets are equipped with eye-tracking and facial expression sensors. This capability makes possible the instant evaluation of virtual environments on the basis of how emotionally-comfortable they are to experience, versus any stress they impose. We expect a wealth of research to be done in classifying the visual "look" of places according to a spectrum of differing degrees of engagement.

4.4 Objective beauty in the world of fine art

In a separate application, Naiada software by Kellify company classifies fine artworks according to their AI-perceived beauty or ugliness (Naiada, 2022; Malfanti, 2022). By simulating human cognitive processes, the program combines a tiny minority opinion, which in the past validated art exclusively, with majority popular preferences. Published details are sketchy; however, regardless of whether the results agree or not with objective beauty, all of this new research shares a common analytical ground combining AI with measured neurological responses. Going beyond neural networks, software is trained to recognize objective beauty from features in an image directly.

Many design professionals hold a strong opinion of what constitutes a beautiful or ugly building. Architects evaluate architectural beauty by how far a design conforms to "approved" versus "unacceptable" design styles, in an absolute, all-or-none appraisal. Standard evaluations go in an opposite direction to the biology-based beauty scale, however; what architects now consider desirable (substituting for "beautiful") actually points towards lower values of objective beauty (Gifford et al., 2002; Greenfield, 2018; Tylecote, 2018; Mehaffy, 2020b; Safarova et al., 2019; Cunningham, 2019; Mack, 2019; The School of Life collective, 2021; Douglas-Home, 2021; Holmquist, 2021; Lind, 2022). The cumulative result is that with very few exceptions, structures built everywhere following World War II fall significantly below a median objective beauty value. The generic International Style is made possible by excessive simplification. This is the reason why the modern world clashes dramatically with previous millennia of human building activity.

The overt antagonism between architectural culture and common preferences is therefore also about the fundamental directionality of the beauty axis. Society has accepted an ideological predilection for low-ranking buildings, and puts its faith in the postulate that "better" means lower on the beauty scale. These results are likely to generate a controversy, since they favor more traditional environments over buildings embodying industrial modernism. A biology-based model of architectural beauty does not favor certain design styles, even though those may be popular in global construction today and be praised by the architectural media. Yet arguments relying upon scientific analysis are not style-based, and have nothing to do with promoting traditional design for reasons of historicism.

4.5 Lessons on biologically-based beauty from the film industry

While dominant architectural culture has doggedly pursued its own aesthetic standards for decades, the film and videogame industries have catered to the public's sensory cravings and basic intuitions in architecture. It is no accident that architectural settings associated with morally "good" elements look overwhelmingly friendly-traditional (high in objective beauty), whereas their opposites are likely to be techno-modernist (very low in objective beauty) (Viladas, 1987; Critton, 2013; Oppenheim & Gollin, 2019; Colette, 2022; Boys-Smith, 2022; Moffat, 2022; Elvenar, 2022).

The brilliant actor and film director Jacques Tati created two comedies, *Mon Oncle* (1958) (https://www.archdaily.com/259325/films-architecture-my-uncle) and *Playtime* (1967) (https://www.archdaily.com/395674/films-and-architecture-play-time), that are scathing condemnations of industrial-modernist architecture (Moon, 2017). Audiences inside the cinemas laughed at these satirical put-downs. Once outside, however, the people never took any corrective action to halt modernist architecture replacing their traditional cities.

There are many films that portray the villain(s) in a sleek modernist redoubt, while the hero is in a beautiful (often new) traditional place. Or the character who is in a sleek modern place is revealed to be a villain later (e.g. a wealthy corporate figure). This is not entirely universal, e.g. "Tony Stark" AKA "Iron Man" lives in modernist surroundings. But it is surely a very high percentage in one direction, revealing something unconscious about audience preferences and perceptions. (And "Tony Stark" has a slightly ironic and comical attitude towards all his surroundings and technologies — as if to say they are somewhat silly toys for silly boys ...).

The Japanese Studio Ghibli has produced popular animated feature films that portray a colorful, detailed, human-scaled world. The depicted urban spaces mix with nature and are viscerally attractive, emphasizing the engagement of the characters to the place occurring through biologically-based beauty. Paralleling Disney, which capitalized on its animated features to create hugely successful theme parks, Studio Ghibli is opening its own theme park in Nagoya (JRailPass, 2022).

4.6 What the profession is doing about this

All of this discussion comes from outside mainstream design. Contemporary architectural discourse skirts around "beauty" and "ugliness" while turning a blind eye to debates occurring outside its restricted sphere of influence. The profession's strategy of uncritically trusting a rigid and subjective design canon evades the core question of emotional wellbeing by emphasizing other, unrelated topics.

Styles of the 20th Century and the first two decades of the 21st predominate in commercial-industrial and state-sponsored construction today. Abstract minimalism has had a long and successful run — about one century — and has consequently become established in a collectively-shared social identity. Nevertheless, it does not correspond to the objective-based aesthetics of most people outside the profession; these common aesthetic attitudes are explained by neuroscience, whereas the subjective aesthetics established in the 1920s are explained mostly in socio-political terms.

The much-vaunted recent applications of AI to design within the profession are limited so far to taking care of technical problems, machine fabrication, and generating innovative (usually strange-looking) shapes. Major architecture firms doing this work are apparently not at all curious about using AI to learn how those structures will be experienced by the users after they are in place. They assume that they already know this; or perhaps the question never arises. Architectural culture holds onto its preferred images, and uses AI-based analytical software only to implement them, not to challenge them.

In every historical case where a new tool has been developed, it can be used either to extend an existing paradigm, or to question the basis of the paradigm itself so as to open up new possibilities. In the case of design, architects have embraced text-to-image programs to generate more of the same type of product as before. For example, AI software is used to mimic the style of current “star” architects, or the styles of an established minimalist design canon (Leach, 2022). We interpret this phenomenon as a limited application of technology.

Remarkably, none of the technology discussed so far is used by the mainstream design profession to evaluate the health responses in users. An insistence on reusing a very limited set of design and tectonic typologies prevents the physiological and psychological evaluation of a building before it is erected; as well as discouraging the same analysis in post-occupancy evaluations.

5 How the misuse of language prejudices experimenters

Readers who admire contemporary and minimalist architecture will probably react to the above preferences, derived from film and AI-based programs, with a predictable objection: that those represent the popular preferences of an ignorant public. But this then raises the question of whom the architecture of buildings and virtual reality settings is actually for. And, while the debate about the visual style of physical buildings can range without resolution, the metaverse is supposed to attract paying users, and not to make an ideological statement. It is, therefore, imperative to re-establish the aesthetic value of common shared experience.

There exists a split between ordinary people endowed with common biological responses, and individuals who have been psychologically conditioned into a simulated universe where neuro-responses are muted (Weinberger et al., 2021; Weinberger et al., 2022). These two categories of humans react very differently to buildings (both real and virtual). An unfortunate choice of language perpetuates an old confusion. Instead of identifying the conditioning process that causes clustering in judging beauty, some authors divide the world into “novices” and “experts”. But these labels prejudice the situation because they belittle people with evolved, unsullied neuro-responses as being “novices”, while endowing an undeserved authority on “experts” who diverge from the intrinsic, shareable basis of beauty.

Categorizing the participants in any experimental survey into “novices” and “experts” can be quite misleading. In common language, “experts” are people who possess technical knowledge and an understanding of the subject matter as, for instance, when comparing musicians and non-musicians in experiments studying reactions to tonal or harmonic violations. But regarding contemporary architecture, that label refers to people who have been taught to actively *ignore* engagement and what the human perceptive system registers as violations of visual organization. We are dealing with two groups having opposite preferences, and not comparing an educated versus an ignorant group.

The “novices”, along with all humans (and animals), start to process complex environmental information as babies, and that interaction in turn contributes to the shaping of the synaptic profile and, effectively, the wiring of their brains (Mehaffy & Salingaros, 2012; Lavdas & Salingaros, 2021; Aresta & Salingaros, 2021; Bourgeois et al., 1994; Shonkoff & Phillips, 2000; Sakai, 2020). It is therefore wrong to use this term, because it hints at someone who has come to a topic only now without any previous background. That impression is deceiving, since from birth, people use their neurophysiology to engage with and negotiate the built environment, while they instinctively avoid immersing themselves in a setting that evokes anxiety.

6 Geometrical fundamentalism

6.1 Biological complexity is the basis for life

A deep network structure is a key to living processes, including human intelligence, and by extension, human environments. Much of what it means to be alive, and much of what humans create, is based on organized complexity, with its overlapping, pattern-like relationships. Life itself is an emergent property of highly complicated and organized structure. Its main function is to construct and maintain — and also reproduce — this remarkable “discovered” complexity. Death occurs when an organism can no longer preserve its organized complexity. If it is unable to pass on the encoded information on how to recreate itself, then the pattern is lost forever.

Human creations can be interpreted as natural extensions of the geometry of life, which is why traditional architecture, art, design, music, ornament, etc. depend upon and embody organized complexity. Respecting this link amounts to a re-focusing of the design professions on the essential needs for humans, and the planet, so that they can maintain a healthy life. There are specific geometrical and informational attributes required in the environment, which reflect human evolution and survival. They cannot be obscured or “undone”; and when societies try to do that, it leads to long-term problems.

6.2 Oversimplification removes essential life qualities

The architectural character of many recent VR designs seems to be no accident, but rather, a deliberate choice of the designers. In part this is because they are influenced by the current design fashions prevalent in the physical world. In part, too, they are limited by the same oversimplified mechanical forms that are rooted in a primitive stage of industrial development — what we have previously described as "geometrical fundamentalism" (Salingaros & Mehaffy, 2014). Industrial design has moved through several historic phases of increasing complexity, but styles remain in a relatively crude phase — particularly when compared to complex biological structures.

The architect Christopher Alexander made a key contribution to this growing understanding with his first book, *Notes on the Synthesis of Form (*Alexander,1964*)*, and a later successor, *A Pattern Language: Towns, Buildings, Construction (*Alexander et al., 1977*)*. His "patterns" were design elements that could be operated upon in context, while remaining "interrelated into an organic whole". For Alexander, designers had over-emphasized the neat, top-down (tree-like) hierarchies of many mental constructs, erasing the critical web-like connections that formed overlapping, reinforcing relationships. These in turn formed clusters of "strong forces", surrounded by connections he called "weak forces". Clusters of relationships, called "patterns", could be managed more successfully within a language-like web of larger relationships — a "pattern language".

6.3 The "deep net" structure of Alexander's patterns, artificial intelligence, and organized complexity

Alexander pointed to an essential web-like structure within human environments, which was not captured in earlier scientific and technological models. A related recognition of network structures is occurring across the biological sciences. These insights have been confirmed and greatly expanded in the intervening years, in fields like ecology, genetics, and even brain science. It is now recognized that, just as the genome of DNA and the "proteome" of proteins are not simple linear or statistically average collections of elements, but have an essential interrelated network structure, the so-called "connectome" of the brain has an essential deep network structure.

These "deep network" insights are finding particular relevance in the field of artificial intelligence. There is an intriguing coorollary with the structure of the most robust neural networks at the heart of many AI systems. The process of machine learning mimics what happens in human brains to some degree, as the neural networks are allowed to evolve and "learn", in order to more accurately manage the structure of their subject of interest. For example, an elementary AI program "learns" to distinguish a dog from a cat, not by absorbing principles or rules, but by generating and evolving neural networks in response to numerous examples, and "learning" through feedback. The system develops its own overlapping pattern-like structure, and its own form of organized complexity.

The neural sensing system tries to predict sensory inputs from the environment in a way that optimizes informational meaning, thus assuring the organism's survival. Such a fit between the external environment and a small set of internal patterns cannot waste energy in processing random or structurally-surprising forms. It is this "free-energy" minimization that favors the organization of complexity (Friston, 2010; Parr & Friston, 2018), and which apparently gives rise to animal — and eventually, human — intelligence (Kagan et al., 2022).

6.4 Architectural myopia

Today's interconnected world working through information and communications technologies is precisely what Alexander predicted, decades before the fact. Nevertheless, we will argue that the dominant (and flawed) conceptual model of the living world goes back much further, to a non-network hierarchy, and that has never changed despite all the intervening technical advances.

Alexander observed that contemporary design was lagging far behind in coming to terms with the insights of organized complexity. If the life sciences have made such brilliant progress, why do architects and city planners (among other designers) continue to lag behind? We have previously pointed to several interrelated causes, including the continued dominance of the outmoded pre-biological models, the continuation of economic incentives that tend to reduce design to marketing and commodification (e.g. an image of the future as a marketable fantasy, not one grounded in human realities), and, most relevant here, forms of cognitive bias that result from overspecialized training and cognitive distance. We refer to this phenomenon as "architectural myopia": the inability to actually see what users experience, and thus the failure to serve the users' actual needs (Mehaffy & Salingaros, 2011).

More broadly, both contemporary and 20th century architectural geometries are in fact very poorly adapted to the complexity of human physiology and psychology (Salingaros, 2014c; Lavdas & Schirpke, 2020; Lavdas et al., 2021; Salingaros & Sussman, 2020; Mehaffy & Salingaros, 2019a; Mehaffy & Salingaros, 2019b; Mehaffy & Salingaros, 2020; Brielmann et al., 2022; Mehaffy & Salingaros, 2015; Mehaffy et al., 2020). As part of a growing movement, researchers use scientific analysis to expose the limitations of the architectural tradition of the past hundred years, and propose a return to more human-centered design techniques, both new and traditional (Buras, 2020; Alexander, 1979; Ruggles, 2018; Sussman & Hollander, 2021; Galle, 2020).

A new adaptive design paradigm becomes apparent, which is based on scientific experimental data (Zeki, 2019; Chatterjee & Vartanian, 2014; Coburn et al., 2017; Armstrong & Detweiler-Bedell, 2008; Pelowski et al., 2017; Gallese & Freedberg, 2007; Kirk et al., 2009; Kawabata & Zeki, 2004; Brielmann & Pelli, 2019). Evidence reveals a four-way relationship among: (1) the web-like structure of organized complexity in buildings and cities; (2) the design pattern structure employed by Alexander and his associates, and later applied to design patterns in software; (3) the pattern structure of wikis and Wikipedia, and the logic behind Agile Methodology and other developments in software and project management; and (4) the structure of neural networks and machine learning.

Our point is that the architecture of the virtual universe does not have to abide by limitations — the dictates of fashion, the imperatives of a technocracy, and the economic and institutional power structures — that control and influence physical architecture. A new world, and one that can be controlled and shaped totally without investing in building materials or engineering, can define its own logic. So far, the digital universe has inherited contradictions from the architecture of physical buildings. Those stylistic priorities are unnecessary baggage.

7 Toward a "Form Language" of new geometries

7.1 Rediscovering the biological basis for design

Bonna Jones and Yen Wong already suggested that virtual environments be made more viscerally attractive through human biology, designed by following Christopher Alexander's results (Jones & Wong, 2008). They wished to endow online virtual library spaces with the same beauty and human feeling found in the most emotionally attractive of evolved traditional places. But more recently, the Lingang Digital Technology Library, claiming to be the world's first metaverse library, simply mimics the high-tech industrial architecture of Lingang Science and Technology City. This misses an opportunity.

Below is a summary of the qualities that human-adaptive architecture requires to promote wellbeing through the physiological and psychological reactions of the viewer. These qualities combine descriptions from theoretical constructs suggested by Christopher Alexander (the Fifteen Properties), Donald Ruggles, Ann Sussman, researchers on Biophilic Design, several generations of traditional practitioners, and a complexity model developed by one of the present co-authors (NAS).

1. Fractal scaling, in which structure is present at every magnification, possibly with scaling symmetry (where a magnified portion looks similar to the original).
2. Sufficient detail and coherent detailed structure to define the smaller scales sharply (through contrast).
3. Geometrical coherence defined by continuity and multiple nested sub-symmetries (whereas an overall bilateral symmetry is unimportant).
4. Definition of the vertical axis through symmetries that privilege the gravitational sense and also allude to bilateral face-like symmetries.
5. Curvature, especially in the smaller scales (whereas arbitrary, unbalanced curvature strictly on the largest scale can be disorienting).
6. The presence of rich colors intensified and made coherent through color contrast and color harmony.
7. Organized complexity containing a large amount of visual information that is made coherent — hence easy to process — via multiple nested symmetries.
8. Representations of living organisms, and the actual presence of plants, animals, and other people.

It is useful to itemize the elements found in Industrial-Modernist, Post-Modernist, and Deconstructivist buildings that this list *excludes*. Anxiety-inducing architectural styles include standard design and tectonic characteristics such as: plate-glass curtain-walls; minimalist grey, metal, or white surfaces; brutalist raw concrete walls; exaggerated horizontal windows; misaligned or randomly-distributed windows on a façade; tilted columns, edges, pilasters, tectonic elements, and windows; a lack of frames and borders; elimination of organized detail; willful avoidance or distortion of any symmetries in patterns, etc. Those design typologies are visually hostile because the neural system does not expect them (Silber, 2007; Millais, 2019; Curl, 2018; Curl & Calder, 2019; Salingaros, 2014d).

While the above list may appear to be deliberately anti-modernist, including some arguments of other schools of thought in favor of minimalism or modernism is problematic. We are unaware of scientifically-validated arguments (among a very large volume of writings promoting the exceptionalism of a narrow set of styles) that justify those dominant styles by the effect they have on the user, as opposed to advantages for the construction industry. A genuinely salutogenic aspect of the modernist style was the development of the glass curtain wall, which let in more light than the typical building at the time around World War I. The antiseptic and antibiotic properties of sunlight are beneficial. Yet the widely accepted notion of smooth, shiny surfaces having antiseptic properties is not supported by the data (MPHonline, 2023; Miranda & Schaffner, 2016; Aviat et al., 2016).

We mention the history of workspace environments, settings that provide closely related precedents to working in the metaverse. A sequence of invented — but untested — design ideas have continuously re-shaped office distribution and interiors ever since World War II (Salingaros, 1995). Dominant architectural culture considers that workers have to inhabit the latest "concept" imposed top-down. Corporate and government clients buy into this "innovative" thinking without insisting on prior user evaluation. The result has been one sub-optimal working environment transformed into yet another. Style-based industrial-modernist images override ideas of adaptation and beauty.

7.2 A pattern language for designing the metaverse

Surprisingly, metaverse designers have not yet utilized the time-tested technique of cataloging and developing useful design patterns, by now a standard method in computer science. Drawing inspiration from the work of Christopher Alexander, developers document design patterns and practices that work, and also note those "anti-patterns" that may at first seem attractive, but which later turn out to mess things up (Salingaros, 2000). Pattern catalogs for behavior, organization, software, etc. have saved an enormous amount of effort in the tech industry. Cataloguing anti-patterns helps other developers from falling into the same trap and repeating mistakes that could easily be avoided.

It would make sense to develop a patterns catalog for designing the metaverse, just as has been done for video games (Barney, 2018; Barney, 2021a; Barney, 2021b), and for user interfaces and web design applications (Vora, 2009; Design Patterns, 2023; Juliver, 2022). Successful, tested elements of metaverse design should be catalogued into an open archive for use by other developers. By following the design pattern format, no design component or element is automatically assumed to function well before testing, especially as many of those are ported from different fields/platforms. A useful pattern collection will emerge, hopefully in open source, as more and more working design patterns are added to the list. Also, the designers get a better idea of how to optimally combine those patterns to obtain a more coherent, functional result. Such relationships are never obvious.

Christopher Barney, author of *Pattern Language for Game Design*, devotes a chapter of his book to Alexander's "Fifteen Fundamental Properties" (which we describe in the next section). There is an intimate connection between design patterns (Alexander's earlier work) and the geometrical concepts presented in Alexander's later work, *The Nature of Order*. The discussion and recognition of the purposes and functional requirements or performance criteria, which surely impact morphology, lie in the domain of the proposed pattern language for designing the metaverse. We make no attempt to derive any of that specific material in this paper, since it extends beyond matters of beauty.

8 Approaching environmental aesthetics through biology

8.1 The incompleteness of "modern" aesthetics

What, then, are the missing aesthetic characteristics, and how can we re-integrate them into the structures of the metaverse? Once again, the work of Christopher Alexander offers an instructive contribution. In his four-volume masterwork *The Nature of Order: The Art of Building and the Nature of the Universe,* he identifies "Fifteen Properties" that are common to the geometries of living systems, including human creations and human environments (Alexander, 2001; Alexander, 2002; Salingaros, 2015; Salingaros, 2013).

Importantly, these properties arise spontaneously as a result of common symmetry-generating and self-organizing processes. One of the most familiar is the property of fractal structure, or "levels of scale". Other properties can be considered as classes of symmetry, including tiling symmetries ("alternating repetition"), coherence working through radial symmetry ("strong centers"), and the nested "local symmetries".

These properties are not extraneously applied to the structures in question (as added aesthetics), but arise from the network interactions of their spatial elements. The process of generating coherent structure has its counterpart in the product of environmental form. Self-organization creates coherence. The Fifteen Properties are identified in the deep network structure of living systems — and indeed, one can see many of these properties arising from living processes, including embryogenesis (Newman & Bhat, 2009) (Fig. 1).

It is notable that contemporary design partly or wholly lacks these properties. In part, this omission can be explained by the influence of simplification through elementary processes of industrial manufacturing, including stamping, rolling, slicing, and the like. The limiting aesthetic that resulted then gave rise to a kind of thematic branding of modernity, as characterized by precisely the stark "look" of these limited geometries. This was the regime of "geometrical fundamentalism" described earlier.

Other contributing factors for this violation of the Fifteen Properties can be explained by the over-reliance of economies of scale and standardization (stamping identical parts, creating copies at large scales); and the comparative minimization of economies of place and differentiation, as is seen more commonly in natural phenomena (e.g. local signaling, mutual adaptive evolution, self-organization in place). Scale and standardization are not absent from biological processes (e.g. standard DNA molecules, large-scale seeding, etc.) but they are strictly balanced with differentiation and local adaptation.

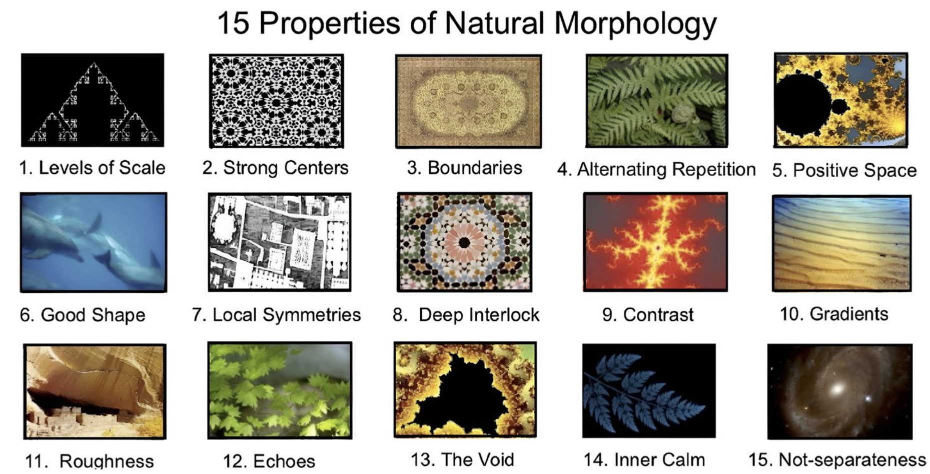

Fig. 1 Alexander's "Fifteen Fundamental Properties" that characterize organized complexity. Image by Michael Mehaffy

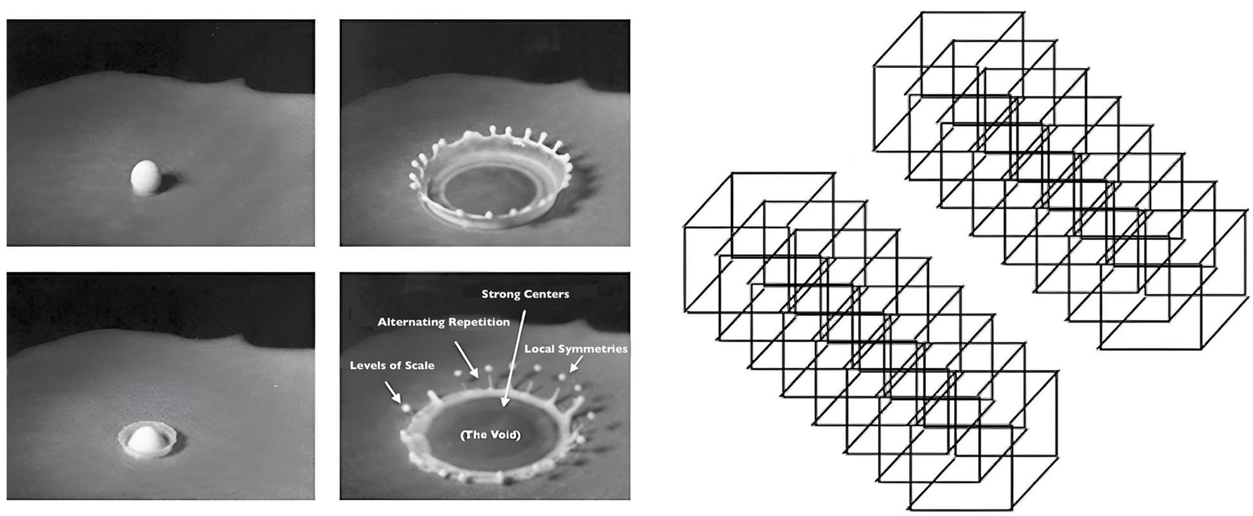

Fig. 2 On the left, a symmetry-breaking event (Harold Edgerton's famous photograph of a milk drop shattering against a sheet of milk) produces characteristic geometric properties, including levels of scale, alternating repetition, strong centers, local symmetries, etc. But the relatively crude "modern" industrial processes of manipulating fundamental geometric shapes (lines, planes, cubes, on the right) and then stamping, replicating, enlarging the scale, do not produce these characteristic properties. Image credits: Left, revision by Michael Mehaffy of image courtesy the Edgerton Digital Collection; right, drawing by Michael Mehaffy

Human technologies have not yet adopted this crucial countercheck.

With the advent of computer technologies, and particularly the pattern technology of Alexander, with its lineage of deep networks and organized complexity (wiki and Wikipedia, many AI systems, *et al.*), this goal of fully using insights from how nature organizes complexity is now within reach (Salingaros, 2014a; Salingaros, 2018; Cunningham & Mehaffy, 2013). In order to proceed with confidence, we must clarify one misconception about aesthetics and the nature of beauty (Fig. 2).

8.2 What is beauty, anyway?

It seems essential for us to anchor "beauty" in a framework of shareable experiences instead of esoteric notions of architectural aesthetics that may not be shared beyond academia and a narrow section of the profession (Lavdas & Salingaros, 2022). Encouragement comes from the new discipline of neuroaesthetics, in which the perception of beauty can be correlated with the way that objects and physical settings trigger reactions in the human brain.

There is now abundant evidence against the proposition that beauty is entirely subjective and "socially constructed". While it is true that some aspects of beauty are socially defined and individually differentiated, the experience we call "beauty" is a universal human phenomenon rooted in our common shared biological structures and evolutionary histories. We might refer to objective beauty as this basic shared experience, whereas the subjective component of beauty is shaped by other factors, and is what we might experience separately from others, or other groups that were not exposed to those same factors.

A brief definition of "objective beauty" relies upon what triggers any emotionally-nourishing unconscious response to visual (and other) stimuli. This approach prioritizes the impact that "beauty" has on user experience and health, and it also pushes beauty as a measurable construct towards a layman's experience of the environment. Most importantly, the interactive process that provides the experience of beauty is revealed to be just as important as inherent characteristics of the object.

Interestingly, the experience of beauty across different modalities has been correlated with the strength of activity in a specific brain region, the medial orbitofrontal cortex (mOFC) (Ishizu & Zeki, 2011). Increased activation in the same area has also been correlated with non-sensory experience of beauty, such as coming from mathematics (Zeki et al., 2014), and the experience of sorrow (Ishizu & Zeki, 2017). And, while individual brain responses to certain stimuli can be considered as subjective by definition, this new research reveals objective invariants. Such responses correlate with the experience of beauty, while the correlation of this experience with certain structural features of the stimuli fits well with a direct objective causal sequence between stimulus structure, brain reaction, and subjective experience.

Extensive studies on evolutionary aesthetics identify the mechanism for the perception of beauty as conferring an evolutionary advantage (Turner, 1996; Swami & Furnham, 2006; Prum, 2017; Seghers, 2015; Confer et al., 2010; Leder et al., 2016; Deutsch & Sainani, 2015). In order to profit from such a beneficial effect, one expects the mechanism of perception to have high visual fluency; i.e. the specific visual information must be processed very easily by the neural system. The basis for estimating architectural beauty as an objective value (that is to say, as a value relevant to all by nature) is to realize, following cumulating evidence, that the human body is an exquisitely-tuned instrument for perceiving specific geometries that are experienced as beauty.

All experience of beauty, regardless of the source, seems to have some specific converging neural correlates. Informational input is to a large degree visual, and even more so in the case of architecture, which is why this and related discussions necessarily focus on visual stimulation even though all of our senses are at play (Hirst et al., 2018). The informational experience of the environment is dynamic and multimodal, whereas when we talk about the beauty of a building, we are mostly talking about visual beauty anyway, unless we are inhabiting it.

Multiple nested symmetries organize visual complexity, displaying it in a more "fluent" manner. This constraint adds to randomly-distributed forms that happen to be fractal (such as, for example, Jackson Pollock's paintings). Stochastic fractals (as opposed to exact fractals, which are mathematical constructs) are an important part of the geometry of Nature, and thus part of what mediates the positive effects of exposure to natural environments. Evolutionary preference for specific natural forms — offering meaningful information from particular geometrical characteristics and color qualities — appears to be built into the human body. The perception of fractal forms utilizes different brain networks and appears to require a more fluid, less intensive processing, as suggested in functional brain imaging studies (Fischmeister et al., 2017; Martins et al., 2014).

Among promising investigations into quantifying beauty, another related approach measures the three factors: coherence, fascination, and hominess (Coburn et al., 2020; Gregorians et al., 2022). Originally introduced in a study of how architectural interiors affect neurological responses, this idea is now being applied to evaluate exteriors, and, more importantly, to study the dynamic effects of moving through a scene. Data is gathered either with portable sensors, or with virtual reality simulations using videos. These studies are directly relevant to coherence explained by mathematical complexity.

Visual coherence is only roughly equivalent to beauty. In the real world, buildings that most people would call ugly are quite often visually coherent through an overall symmetry; but they lack fractality and multiple, nested sub-symmetries. At the other extreme, fractals — especially exact fractals (Bies et al., 2016) — can be used to design ugly buildings whose awkward proportions and asymmetrical geometries are viscerally unappealing (Langdon, 2015). There are many more factors that contribute to objective architectural beauty (Olszewska, 2020a; Olszewska, 2020b).

We can, at this point, answer a question raised by admirers of contemporary architecture in buildings: "Why is there no recognition of recent architecture with high levels of organized complexity, as high as those found in Nature, and arguably much higher than classical facades?" As developed in our other publications, and supported by the research of other authors, the type of complexity responsible for human engagement and well-being is very special. It is not enough to design and build a complex-looking façade. The difference between natural-looking buildings (engaging) versus merely complex (but not engaging) is due to basic mathematical distinctions in their respective geometries. Non-engaging buildings fail to satisfy several of the 8 qualities of human-adaptive architecture listed earlier, as well as necessary design patterns. This mechanism has nothing to do with style, and is certainly not limited to classical façades.

9 Roku City gets it right

A screen saver for a streaming television platform managed to overcome the design misfires of the metaverse, and is now talked about as a huge VR success (Winkie & New York Times, 2022). Roku is a continuously scrolling painting of a street front consisting of traditional building façades ranging in style from Art-Deco to Neoclassical. An extensive natural park and open water separates the foreground buildings from a dense built-up city seen in the far distance. The user's immediate experience is with the façades, which are drawn in a way that embodies elements of design coherence such as Alexander's 15 properties (intuitively so, as graphic artists do not implement those by name).

The irony here is that Roku City contains some far from realistic characteristics; for example, it is bathed in a dim blue-purple light. Yet the façades' coherent and detailed human-scale design attracts people to want to inhabit it, and this is a recurring comment from internet readers (Craighead, 2021). Another surprise is that the over-dense modernist city in the background is actually unappealing, but it is situated at a far enough distance so that it doesn't alarm a viewer concentrating on the foreground experience. Kyle Jones, the artist who created Roku City, placed alien invaders, an erupting volcano, giant robots, and other monsters among the skyscrapers in the background city, yet those seem more funny than menacing.

10 Conclusions

This paper suggested reasons for why the visual experience of the metaverse, as it is presently conceived, has thus far not met expectations in attracting users. We hypothesized one possible cause (among other unknowns). There is a basic contradiction in the emotional appeal of architectural industrial-modernist images, versus an entirely different type of environmental geometry based on objective beauty. Research findings reveal unexplored impacts of the "beauty of place" on users that designers should pay more attention to. Evidence-based knowledge of attractive environments is critical in the field of metaverse development, and provides insights into how to solve those challenges. AI text-to-image generators confirm that a majority of people use their intuition to judge architectural beauty. Drawing upon massive internet data, these results correspond to the neurological mechanisms that guaranteed human survival during evolution. Avoiding subjective aesthetic definitions influenced by habit, ideology, or the media, new technology resolves ages-old questions. By virtue of their enormous data base, AI text-to-image generators represent the *vox populi* missing for a century from architectural discourse. Scientific research has discovered innate preferences for salutogenic (health-inducing) environments, which embody human informational needs. At the same time, a critical break was revealed with dominant architectural culture.

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