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VR models of death and psychedelics: an aesthetic paradigm for design beyond day-to-day phenomenology

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Near-death experiences (NDEs) and psychedelic drug experiences (YDEs) enable access to dimensions of non-ordinary sensation, perception, and insight beyond typical day-to-day phenomenology. Both are associated with a dissolution of conventional spatio-temporal conceptual distinctions, and a corresponding sense of connectedness and unity. Moreover, NDEs and YDEs have shown a remarkable ability to reduce the anxiety that people associate with death. In two recent papers, we showed that multi-person virtual reality experiences (VREs) designed within the 'numadelic' aesthetic (where bodies are represented as light energy rather than material objects) can elicit psychometric results comparable to YDEs. It nevertheless remains an open question *why* numadelic aesthetics achieve the observed results, especially given that the vast majority of VREs represent bodies as typically perceived in the 'real-world'. This article describes the origins of the numadelic aesthetic from subjective accounts of NDE phenomenology, and attempts to unravel mechanistic aspects of the numadelic aesthetic by embedding it within a more general theoretical framework. Specifically, we elaborate a 2-axis schematic grounded in predictive coding models of cognition and matter-energy ideas from physics. One axis tracks 'structural specificity', and the other tracks 'symbolic rigidity'. The majority of VREs, which emphasize photorealistic fidelity to content derived from 'day-to-day' phenomenology, are characterized by high structural specificity and high symbolic rigidity. Such approaches collapse imaginative potential into a limited low-entropy space of 'exogenous' possibility, unlike the high-entropy brain states associated with YDEs. In contrast, aesthetic domains characterized by low structural specificity and low symbolic rigidity are less concerned with fidelity to phenomenological priors, offering an expansive, 'uncollapsed' high-entropy possibility space into which participants can project meaning and corresponding endogenous insights can arise (e.g., as occurs in NDEs and YDEs). Situated within this theoretical framing, the numadelic aesthetic emerges as a practical example of an un-collapsed approach to representation, helping to explain the experimental observations within previous papers. Moreover, the theoretical framing suggests various experimental tests, and lays the groundwork for applying numadelic aesthetics to model NDEs, to help address the anxiety often associated with death.

KEYWORDS

virtual reality, predictive coding, perception, near death experience, neuroscience

1 Introduction

Virtual Reality (VR) enables the construction of immersive environments with the potential to represent a vast range of phenomena, limited by little more than imagination. Nevertheless, the vast majority of VR content–in both popular culture and also within research contexts–is remarkably limited. Broadly speaking, VR tends to follow the dominant aesthetics of the metaverse, which generally aims to maintain fidelity to the sorts of scenarios and appearances which most people encounter during their day-to-day experience. Metaverse aesthetics are largely composed of graphical representations of manmade or natural structures and landscapes inhabited by human-esque or animal-esque beings whose detailed appearances generally 'look like' what one might see in the 'real world'. Within research settings, VR tends to adopt a similar aesthetic. For example, the use of VR as a form of exposure therapy to treat phobias and PTSD aims to recreate scenarios in which people revisit realistic depictions of their fears and traumas (Parsons and Rizzo, 2008). Recent work using VR to induce experiences of 'awe' likewise relies on placing people in digital landscapes that are essentially replicas of what already exists–e.g., mountain vistas, views of open skies, forests, etc. (Chirico et al., 2018) The representational potential of VR might be unlimited; however, both of these VR use-cases rely on aesthetic paradigms designed to achieve 'real-world' fidelity, effectively collapsing this vast potential into the constraints of what already exists. In this respect, most VR content follows a development trajectory similar to that of other computational technologies (e.g., artificial intelligence, supercomputing, internet, etc.), which tends to focus 'on one particular type of future, one very much like the present, only more so.' (Nardi et al., 2018).

The relatively limited scope of VR and metaverse aesthetics poses challenges for those who wish to use VR to explore the outer horizons of conscious experience. For example, mystical type experiences (MTEs), psychedelic experiences (YDEs), and near-death experiences (NDEs) have therapeutic potential precisely because they transcend day-to-day phenomenology. Describing his research using YDEs to elicit MTEs which could help patients deal with death, Walter Pahnke neatly summarized the benefits associated with transcending day-to-day phenomenology: "the mystical experience, by opening the patient to usually untapped ranges of human consciousness, can provide a sense of security that transcends even death . . . [the patient] becomes intensely aware of completely new dimensions of experience which they might never before have imagined possible . . . know[ing] there is more to the potential range of human consciousness than we ordinarily realize. This profound and awe-inspiring insight sometimes is experienced as if a veil had been lifted and can transform attitude and behavior . . . life and death can be looked at from a new perspective . . . to meet the unknown with a new sense of confidence and security. Logical arguments that human experience must be limited to the narrow range of ordinary human consciousness never can have the same force again." (Pahnke, 1969).

In this article, we discuss the potential for multi-person VREs within the recently described 'numadelic' aesthetic (illustrated in Figures 1B–D) to serve as a model for NDEs in order to help alleviate the fear and anxiety associated with death. The term 'near death experience' (NDE) was coined by Raymond Moody in the 1975 book *Life after Life*, to refer to an altered state of consciousness that many people report experiencing on the threshold of death (Moody, 1975). Our inspiration for extending VR to model NDEs emerges from recent work demonstrating the ability of multi-person VREs within the 'numadelic' aesthetic to elicit MTEs which are comparable to the altered state experiences that people report during YDEs (Glowacki et al., 2020; Glowacki et al., 2022). For example, several subjective aspects of NDEs overlap with features of MTEs (Greyson, 2014a), including a deep sense of transcending space and time, in which conventional day-to-day spatio-temporal references are no longer relevant, and also feelings of unity which are often linked to an individual's sense of being connected to processes much larger than themselves. The word 'numadelic' is derived from the Greek words *pneuma*, meaning 'breath', 'spirit' or 'soul', and *delein*, meaning 'to reveal' or 'to manifest', a result of the fact that numerous participants who encountered this aesthetic commented how it reminded them of 'spirit'.

For VR to be used effectively in order to model NDEs, some crucial questions emerge: What sort of aesthetic is most appropriate if we want to develop VR models of MTEs and NDEs? And what sorts of underlying conceptual foundations are best suited to achieve this design? To date, there has been very little work carried out to address theoretical questions of representational aesthetics in VR. As a result, most researchers working with VR default to an approach which favors photorealistic representation with fidelity to day-to-day phenomenology - e.g., as shown in Figure 1E. This lack of theoretical framing has limited efforts to extend VR to simulate NDEs, MTEs, and YDEs, in part because researchers have few theoretical frameworks for overcoming various challenges that arise when one attempts to use VR to design experiences which transcend day-to-day phenomenology. These challenges include the following:

1) MTEs and NDEs are notoriously difficult to articulate using linguistic representations. As Pennachio observed, "*Feelings of insight or great understanding have been associated with the NDE, but such knowledge has often been intuitive and not verbal. It is typical for the subject to report that the insight acquired is not easily expressed in conventional language.*" (Pennachio, 1986) Language is a way of making conceptual distinctions across both space and time, and thus ill-equipped to deal with the sense of unity associated with the dissolution of conventional spatio-temporal distinctions in NDEs and MTEs. The inadequacy of language significantly complicates establishing a design paradigm.
2) The subjective insights which arise during NDEs and YDEs are widely recognized to have a significant 'endogenous' component, with strong dependence on so-called 'set'—i.e., the internal dynamics related to one's own cognition, personality, psychological profile, prior experiences, memories, etc. (de Araujo et al., 2012; Pedro et al., 2020; Winkelman, 2021; Okano et al., 2022) This is one reason why for example, 'psychedelic psychotherapy' nearly always takes place with the participant listening to music with their eyes closed. In contrast, VREs deliver exogenous audiovisual digital content to the sensory system (Aday et al., 2020). There is an open question whether VREs can lead to the sort of strongly endogenous insights that arise during YDEs or NDEs.

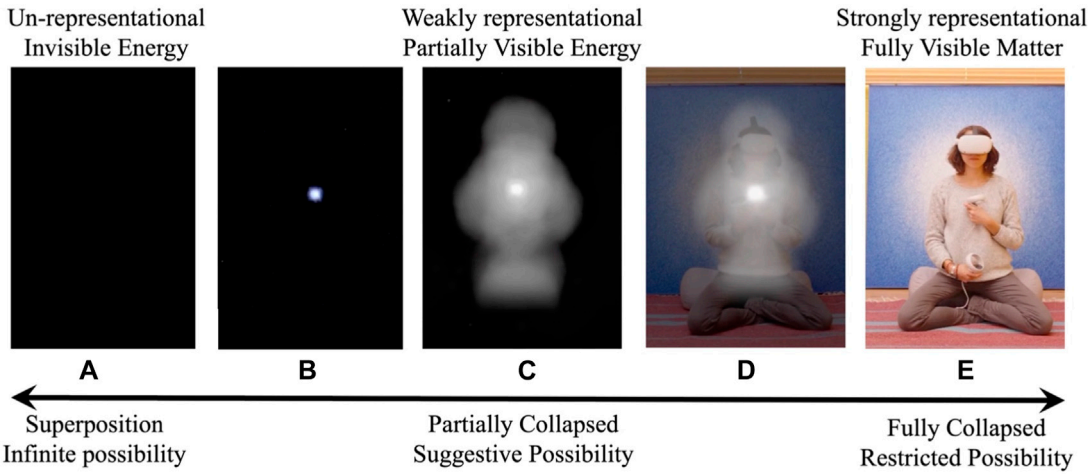


FIGURE 1
A continuum for understanding the so-called 'numadelic' aesthetic. Panel **(A)** illustrates a completely 'un-representational' approach, similar to an eyes-closed meditation practice, while panel **(E)** illustrates a 'strongly representational' approach similar to day-to-day perception. The 'numadelic' aesthetic spans panels **(B)**, **(C)**, and **(D)**, which are 'weakly representational' and incrementally connect non-representational approaches to strongly representational approaches.

3) There is no easily accessible design reference for NDE or MTE phenomenology. An MTE is often special, memorable, and profound precisely *because* it is distinct from day-to-day phenomenology. In the language of hierarchical predictive coding, the 'non-ordinariness' of YDEs is associated with relaxing the precision weighting of high level priors or beliefs, sensitizing them to 'bottom-up' information which is otherwise filtered (Carhart-Harris and Friston, 2019). However, this adds complexity to the design task: without a reliable "day-to-day" design reference, how do designers evaluate whether a VR model has 'fidelity' to MTE, YDE, or NDE phenomenology?

Death in particular has a kind of fundamental significance owing to its universal inevitability, perhaps more fundamental *per se* than YDEs or any other class of experience. Death is often framed according to 'terror management theory' (TMT), whose fundamental premise is that high anxiety (i.e., 'terror') results from the conflict between humans' evolutionary self-preservation instinct and awareness of their inevitable mortality (Becker, 1997; Solomon et al., 2015). TMT frames human behavior as a way of managing this fundamental anxiety–e.g., through constructing cultural beliefs, systems, and communities that act to counter biological reality with more significant and enduring forms of meaning and value. Seen through the lens of TMT, the experience of 'nearly dying' should *amplify* death anxiety, in the same way that other forms of trauma amplify the associated fear. However, NDEs offer a fascinating exception to TMT: they appear to dramatically *diminish* the anxiety associated with death (Tassell-Matamua and Lindsay, 2016; Bianco et al., 2019). Moreover, the reduction in death anxiety is not merely associated with having been close to death: people in life-threatening situations who do not encounter the typical features of an NDE [e.g., as measured by Greyson's NDE scale (Greyson, 1983)] do not appear to show the same reduction in death anxiety (Sabom, 1982; Ring, 1984; Flynn, 1985; Greyson, 2014a). Greyson suggested that the extent of death anxiety reduction is correlated with the NDE intensity (Greyson, 1992). Moreover, a number of studies suggest that the anxiety reduction following an NDE occurs very quickly (Sabom, 1982; Van Lommel et al., 2001; Schwaninger et al., 2002). Precisely why an NDE reduces death anxiety remains an open research question. Tassell-Matamua and Lindsay proposed that four features of NDEs are responsible for alleviating the fear of death: (a) *out-of-body-experience and the corresponding sense of disembodiment*, which suggests that one's own consciousness can persist beyond the physical body; (b) *the seeing, hearing, and sensing of other spirit beings*, which suggest that other forms of consciousness persist beyond the physical body; and (c) *perception of a bright light often associated with a luminous spiritual being*, which hints at participation in an expansive divine energy which does not end with death. Finally, each of these items is associated with (d) *overwhelmingly positive emotions*, suggesting that death need not be feared (Tassell-Matamua and Lindsay, 2016).

The ability of NDEs to transform attitudes toward a reality so fundamental as death has inspired researchers to investigate experiences which might serve as models for NDEs in order to address the anxiety associated with death. Within the research literature, YDEs have been explored as a model for NDEs going back to the work of Pahnke, who proposed that the mystical states of consciousness which arise during LSD therapy helped patients facing life-threatening illness to address their 'fear of the unknown' and the associated 'depression, anxiety, loneliness, and suffering' (Pahnke, 1969). Pennachio subsequently analyzed a number of NDE accounts and showed that their associated phenomenology was similar to Pahnke's MTE typology (Pennachio, 1986). More recent studies investigating the effects of psilocybin on anxiety and depression in individuals with a life-threatening cancer diagnosis found that a single dose significantly reduced anxiety and depression symptoms in these patients, with the effects lasting up to 6 months. (Griffiths et al., 2016; Ross et al., 2016). Timmerman et al. used the Greyson NDE scale (Greyson,

1983) to compare responses from individuals administered DMT with responses from those who had 'actual' NDEs, and found that most scores were statistically indistinguishable (Timmermann et al., 2018). A recent large-scale analysis (N = 3192) comparing the phenomenology of YDEs (specifically, psilocybin, LSD, and ayahuasca) to other non-ordinary experiences which included NDEs highlighted similarities in positive changes regarding attitudes about death, increases in personal wellbeing, an enhanced sense of life purpose and meaning, and in many cases a deep sense of insight (Sweeney et al., 2022).

This article suggests that a weakly representational approach to aesthetics offers a promising strategy for NDE and YDE design research within immersive digital environments like VR. In what follows, I weave together predictive coding models of cognition, accounts of NDE phenomenology, and matter-energy concepts in physics, to elaborate a theoretical framework for weakly representational aesthetic paradigms. Many of these ideas build on previous work by Glowacki and co-workers to develop immersive digital environments that go beyond the strongly representational aesthetic in Figure 1E, enabling people to see their real-time reflections as abstracted energy fields (Glowacki et al., 2013; Glowacki et al., 2014; Mitchell et al., 2016). Specifically, this article presents a two-axis aesthetic design space for thinking about representation in immersive environments like VR. One axis tracks 'structural specificity', and the other tracks 'symbolic rigidity'. The vast majority of VR content is strongly representational (e.g., Figure 1E), entrenched in a kind of familiar classical aesthetic characterized by high structural specificity and high symbolic rigidity. In this domain, imaginative possibility is collapsed into a relatively limited low-entropy space of 'exogenous' possibility, unlike the high-entropy states associated with YDEs and NDEs. In contrast, 'weakly representational' domains of this aesthetic design space are less concerned with fidelity to phenomenological priors or real-world design references, offering a more expansive, 'un-collapsed' high-entropy possibility space for imaginative meaning making to take place and corresponding endogenous insights to arise. Such approaches can soften top-down models and create the conditions for MTEs, analogous to what occurs during YDEs and NDEs.

To practically illustrate the weakly representational aesthetic, we refer throughout to results obtained using the aforementioned 'numadelic aesthetic', which is intermediate between the non-representational aesthetic in Figure 1A, and the strongly representational aesthetic in Figure 1E. The numadelic aesthetic is 'suggestive' of energetic essence on the one hand and tangible material essence on the other. It invites people to imagine themselves as beings that are inherently energetic and luminous, with diffuse spatial boundaries rather than fixed material entities with hard boundaries. The numadelic aesthetic blurs conventional self-other boundaries, enabling participants distributed across the world to cohabit shared virtual spaces and collectively experience the emergence, fluctuation, and dissipation of their bodies as energetic processes. The ideas in this paper suggest a mechanistic hypothesis which may explain the effectiveness of non-representational paradigms like the numadelic aesthetic. Along the way, the paper discusses ways in which these hypotheses might be experimentally tested moving forward.

2 Conceptual foundations

2.1 Hierarchical predictive coding and entropy

Hierarchical predictive coding (predictive coding for short) is perhaps the most prevalent neurobiological and computational model for describing cognition and related psychological phenomena in health and disease (Carhart-Harris and Friston, 2019). The fundamental idea is that the brain uses its hierarchical architecture to make best-guess 'top-down' statistical models of the causes that explain incoming 'bottom-up' sensory data. These statistical models, based on Bayesian principles of empirically informed belief updating, attempt to minimize prediction error for incoming sensory data at every level of the cognitive hierarchy, and in so doing furnish the best possible explanation for sensory input at multiple levels of hierarchal abstraction. In its simplest formulation, predictive coding entails a cognitive tension between the precision weighting of 'top-down' predictive models, and 'bottom-up' sensory data. 'Top-down' predictive models provide a kind of general abstract explanatory power; however, their predictive power relies to some extent on how strongly they average over the variegated details of constantly fluctuating 'bottom-up' sensory perception. In the regime where 'top-down' models dominate, perception is inflexible, overly constrained by expectation based on previous experience (or 'priors' in Bayesian language), and unable to easily accommodate new or unanticipated sensory phenomena. In the regime where 'bottom-up' sensory input dominates, perception varies according to constantly fluctuating sensory input, and struggles to organize perceptual variation into models which have a more general abstract explanatory and predictive power. A number of recent neurophysiological studies within the YD research literature aim to evaluate the extent to which YDs impact the precision weighting of 'top-down' models vs. 'bottom-up' information. Many of these studies have highlighted brain entropy as a marker which is inversely related to 'top-down' model precision (Schartner et al., 2017). For example, researchers like Friston and Carhart-Harris have suggested that the YDE is associated with 'high entropy' brain states compared to normal 'low-entropy' waking states. Using predictive coding as a theoretical framework for analyzing YD phenomenology, they suggest that YDEs increase brain entropy by shifting the balance of 'top-down' models vs. 'bottom-up' perceptual mechanisms: specifically, YDEs create a reduction in the top-down precision-weighting of low-entropy prior beliefs, opening them up to revision from an influx of 'bottom-up' high-entropy perceptual inputs (Carhart-Harris and Friston, 2019).

Entropy corresponds to the number of configurations a system can sample in a particular state. For example, there is an enormous number of ways to arrange the atomic building blocks that make up an organism. However, relatively few of these arrangements correspond to the state of 'being alive'—i.e., can sustain the configurational complexity that physiological function requires (Horowitz et al., 2017). And so being alive represents a relatively 'low entropy' state compared to the higher entropy state of not being alive. Extending this idea by analogy to cognition, the perceptual information flowing through an organism can be organized, processed, synthesized, and interpreted in an enormous number

of ways. Predictive coding suggests that day-to-day cognition is limited to sampling relatively few of these possibilities–namely, the set of 'top-down' models which furnish the most accurate predictions in order to sustain the complexity that living systems require. And so the day-to-day cognition of living organisms represents a relatively restricted low-entropy state compared to a much higher entropy space of possibility. YDEs open up this space of entropic possibility, relaxing the relatively restricted cognitive models that characterize day-to-day consciousness.

It remains an open and interesting question the extent to which cognitive models like predictive coding apply during the circumstances associated with NDEs. Certainly, there seems to be an emerging consensus that top-down models break down somewhat during YDEs, giving rise to higher entropy brain states compared to typical waking states. If YDEs model NDEs as some have suggested (Timmermann et al., 2018), then we would anticipate a similar breakdown of top-down hierarchical models during NDEs. Compatible with this idea, the literature indicates significant variability articulated by those who have had NDEs - e.g., a recent article identified no less than 43 different phenomenological features associated with NDEs (Parnia et al., 2022), while another article found little consistency in the temporal progression of phenomenology reported by those who have had NDEs (Martial et al., 2017). This wide variability suggests that NDEs represent a phenomenological regime in which Bayesian priors have little predictive utility–an expansive possibility space with the potential to furnish a number of different interpretations owing to the breakdown of priors. As discussed above, entropy essentially corresponds to the number of potential configurations which a system can sample in a particular state. The rich variety of phenomenologies associated with NDEs suggests a relatively high entropy brain state in which several different configurations can be sampled, distinct from low entropy waking states in which the system samples relatively few configurations.

2.2 NDE phenomenology, luminosity, and entropy

To date, there has been little discussion of how concepts like entropy relate to the design of VREs. The typical avatars adopted by the vast majority of metaverse VR content makers and researchers mostly reinforce our cognitive priors: they focus on humanoid forms which have an associated set of "human-esque" features that reaffirm aspects of physical identity: gender, skin color, eye color, hair style, clothing style, etc. Avatars within this aesthetic have an associated 'real-world' design reference in the sense that it is possible to ascertain the extent to which they look like 'real-world' analogues. Working within this aesthetic, Slater, Blanke, and co-workers have, for example, shown how VR can be used to create bottom-up perceptual mechanisms which override top-down knowledge in phenomena like body ownership (Slater et al., 2010; Slater and Sanchez-Vives, 2016) and bodily self-consciousness (Lenggenhager et al., 2007). They have argued that VR's ability to create 'bottom-up' sensory illusions which override 'top-down' cognitive constructs arises from the so-called 'place illusion' ('I feel I am in the place I see through the VR display'), and the so-called 'plausibility illusion' ('I feel the events happening within this virtual environment are actually happening, and I have an associated sense of agency') (Slater and Sanchez-Vives, 2016). Previous publications by Slater and co-workers (Bourdin et al., 2017; Barberia et al., 2018) describing the application of immersive VR environments to simulate dying have similarly utilized strongly representational paradigms–i.e., participants with humanoid-type avatars undergo some of the hallmarks that characterize a near-death experience, including, for example, out of body experiences, life reviews, travelling through tunnels, etc. The numadelic aesthetic represents a significant departure from the way in which VR avatars tend to be rendered. Avatars do not have a comparable real-world design-reference: they are characterized by little more than an intrinsic luminosity with a shape that might be human (Spiegel, 2023). Recent results (discussed below) suggest that the plausibility illusion and place illusion can be satisfied using weakly representational aesthetic approaches like the numadelic aesthetic (Glowacki et al., 2020; Glowacki et al., 2022).

Assuming that NDEs relax statistical priors in a similar way as has been proposed to occur during YDEs, then NDE phenomenology can be understood to be reporting on what arises during high-entropy brain states. For this reason, I wish to highlight the similarities between the numadelic aesthetic and the phenomenology described in a number of NDE observations. For example, several NDE accounts describe bodies appearing as light energy rather than physical objects with well-defined appearances and boundaries. Those most likely to perceive such light are often those whom medical records indicate were particularly close to death: *'Experience with the light, regardless of the form it may take, is without exception perceived in a positive way . . . [frequently] regarded as the most powerful element of the NDE.'* (Tassell-Matamua and Lindsay, 2016) In the book *Consciousness Beyond Life*, van Lommel describes patient accounts recalling how *". . .[All these people] were all made out of light, and I could see them, and it was incredible, really beautiful, and I was overwhelmed by that experience because I could not really imagine what light was like . . . "* (Van Lommel, 2010) Similarly, Greyson outlines NDEs where people describe perceiving themselves as beings of light (Greyson, 2014b). Ring and Cooper include first-hand accounts of individuals seeing how "*everybody was made of light. And I was made of light.*" In one particular account, a patient named Vicki recalls how she separated from her body, and subsequently perceived her body as light: "*while in her out-of-body state, she [found] herself in a non-physical body . . . that was, as she put it, 'like it was made of light.'*" (Ring and Cooper, 2008) Nahm discusses a variety of luminous phenomena associated with bodies on the verge of death, often described as having radiant qualities that appear as fogs, clouds, mists, or halos (Nahm, 2011). Tassell-Matamua and Lindsay identified experience of a non-blinding white light as a core NDE feature, which can appear in any number of ways–a being of light, a luminous being, or a spiritual being (Tassell-Matamua and Lindsay, 2016). This 'aesthetics of luminosity' is also aligned with some Buddhist traditions, which, for example, identify the 'bardo of luminosity' as the transition state which immediately follows physical death (Fremantle and Trungpa, 2019).

Translating third-person linguistic accounts of luminous bodies experienced during NDEs into digital VR representations is complicated. Part of the difficulty lies in the fact that language offers a low-dimensional capture of multisensory experience. To form an aesthetic representation which can reconstruct a multisensory experience, language needs to be decompressed.

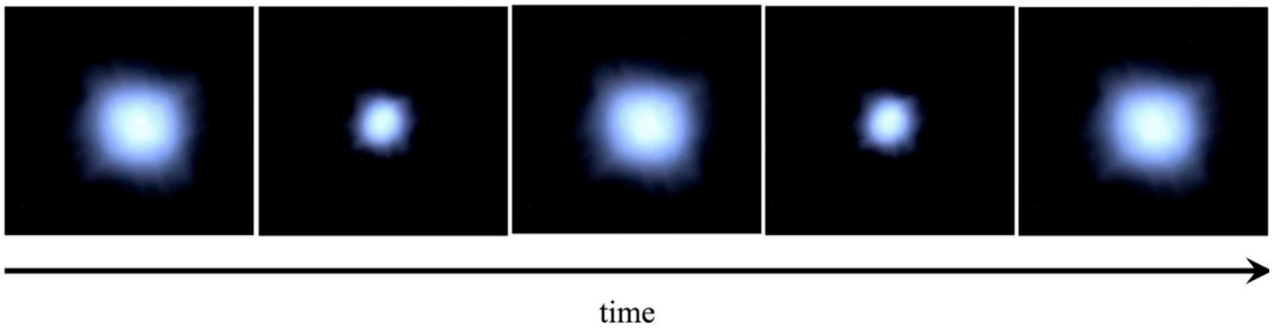


FIGURE 2
Time sequence of the pulsing light which I perceived during my NDE. Reproduced from Glowacki, David, "Ripple", Vimeo video, 1 min 20 seconds, July 31 2023, https://vimeo.com/850251580. Licensed under CC-BY 4.0.

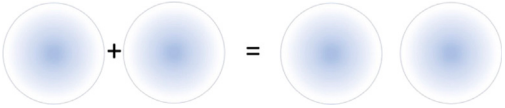
Information is lost during this compression and decompression process because language does not perfectly conserve multisensory data. For this reason, I wish to highlight that the numadelic representation of bodies illustrated in Figures 1B,C, Figure 2 and https://tinyurl.com/yrz7w2b2 derives directly from first-person NDE phenomenology–specifically that which I experienced after falling approximately 30 m and suffering severe multiple trauma (both arms shattered, fractured acetabulum, fractured vertebrae, fractured ribs, severe lacerations, and a thoracic contusion which caused internal bleeding into my lungs). In the hours after impact as I laid on the ground alone waiting for help to arrive, breathing became increasingly difficult, until I was gasping for air at each breath. Everything was dark, and I had the sensation of my awareness separating laterally and then slowly orbiting my physical body. During these orbits I perceived my physical body as a luminosity whose dynamics were synchronized with my breath, as shown in Figure 2 and https://tinyurl.com/yrz7w2b2. With each inhale, the light intensity increased, and with each exhale it decreased. Overall, the intensity envelope of the pulsing light was decreasing, and I had the feeling that it would soon become invisible. Similar to the NDE accounts described by (Tassell-Matamua and Lindsay, 2016), awareness seemed not to be *disappearing*, but rather *transforming*–becoming less tightly bound and more distributed, and mixing with everything else. Like a concentrated, ordered, and tightly packed solid melting and transforming into a more disordered, diffuse, and expansive liquid. A field of awareness that was less localized in one particular physical body, and instead distributed into many things simultaneously. No fear was associated with this process; rather, there was a sense of peace, curiosity and wonder, along with relief to move beyond the confinement and continuous energetic input associated with the structure of a physical body, to a state of rest in another dimension. The fact that the numadelic representation of bodies derives directly from my own first-person experience suggests that it may be less affected by data loss owing the fact that it has not required a language compression/decompression process.

2.3 Physics metaphors for elaborating an aesthetic paradigm

If the death transition represents a domain where conventional cognitive priors derived from day-to-day experience break down, what is the most appropriate design of NDE models using immersive VR? One strategy for simulating this phenomenological variety would be to construct VR instantiations of every phenomenological possibility imaginable–i.e., an enormous number of representations, each of which is 'low-entropy' in the sense that its representational specificity cannot easily accommodate multiple interpretations. A simpler strategy is to use flexible representational approaches at a more fundamental level of abstraction, which can accommodate a broad range of phenomenological significance–i.e., a single abstract representation which is 'high-entropy' in the sense that it can accommodate multiple interpretations as to what it might represent. Modern physics offers a particularly helpful conceptual schema for developing such an aesthetic approach, owing to the fact that it provides descriptions of material objects using more unified levels of abstraction. Below we outline some physics concepts which offer particularly helpful analogies for elaborating a flexible, 'high-entropy' aesthetic approach to imagine beyond the relatively rigid 'classical' metaphors we use to think about material objects, bodies, and identities.

First, all material objects can be described as energy. The closer one looks at the microscopic world, the less solid it appears, and the more its energetic nature becomes apparent. David Bohm said 'all of matter is frozen light', and Karl Popper wrote: *"Matter turns out to be highly packed energy, transformable into other types of energy; and therefore something in the nature of a process . . . the results of modern physics suggest that we should give up the idea of a substance or essence . . . there is no self-identical entity persisting during all changes in time . . . "* (Popper and Eccles, 2012) Schrodinger's famous 'wave equation' establishes that particles with some mass m can be rigorously described as time-dependent 'wave functions'—i.e., what appears to be a finite point mass can be viewed as a dynamical wavelike process with a blurry energetic probability distribution that evolves in time. Everything which appears to be material, solid, separate, localized, and bounded has an essence which is energetic and delocalized. When individual quantum systems are in close proximity, they can combine to yield entirely new global states which are delocalized over their individual constituents, dissolving individual identity. This is distinct from classical objects, which retain their individual identities during a mixing process. An 'aesthetic lens' which recognizes the fundamental energetic essence of material objects

TABLE 1 Some aesthetic qualities of 'Energy' vs. 'Matter', which help to articulate aspects of Figure 1 and Figure 2.

	Energy	Matter
Visibility	Mostly Invisible	Mostly visible
Metaphor	A wave-like probability distribution	Newtonian billiard balls
Limits	Unbounded	Bounded
Locality	Delocalized and Diffuse	Localized and Confined
Radiance	Luminous	Reflective
Potential	Expansive: an un-collapsed superposition	Limited: a collapsed instantiation
Mixing	Boundaries dissolve in new delocalized states 	Objects always retain their individual identity 

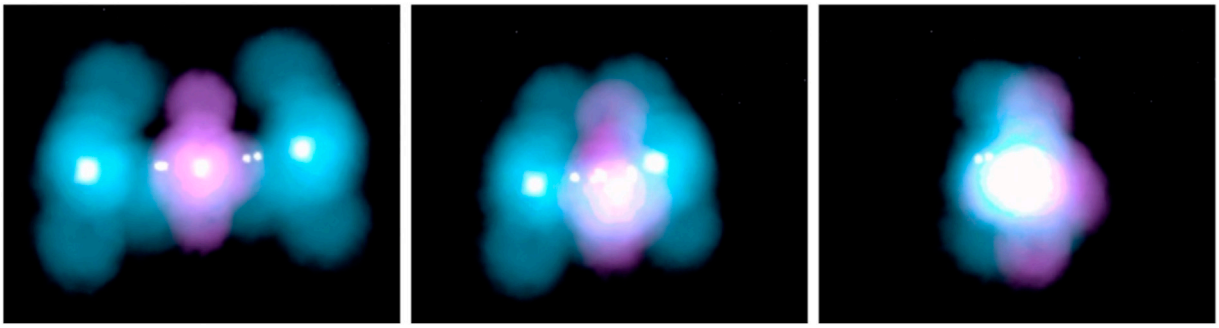


FIGURE 3
Illustration of the coalescence process where three bodies merge to become one. Reproduced from Glowacki, David, "dissolving into energy & merging with others", Vimeo video, June 1 2022, 1 min 13 seconds, https://vimeo.com/715931693, licensed under CC-BY 4.0.

offers a kind of unified aesthetic perspective in which any given material body has the same essential nature regardless of how it appears. Table 1 provides a succinct application of this lens to characterize some salient aesthetic qualities of energy vs. matter.

Figure 3 and tinyurl.com/y757p4rf illustrate the process of 'energetic coalescence' (Glowacki et al., 2022), a practical implementation of the non-classical mixing behavior of quantum systems shown in Table 1. This rendering strategy was previously used by Glowacki, Martinez, and co-workers to visualize time-dependent quantum mechanical electronic energy transport in photosynthetic light harvesting supramolecular complexes (Sisto et al., 2017). Specifically, Fig 5 and supplementary video http://tinyurl.com/2wf784r6 of (Sisto et al., 2017) have a very similar aesthetic to the numadelic representations shown in Figure 3. The aesthetic question which arises in representing quantum mechanical electron transport (How do we visualize the delocalized mixing dynamics of an electron?) is essentially the same question which arises for numadelic bodies (How do we represent the delocalized mixing dynamics of distributed bodies?). Similar to the continuous visual representation that one observes when adjacent excitonic eigenstates have comparable probability amplitudes, numadelic energy bodies located in different physical spaces but the same virtual space can become continuous with one another when they are in close spatial proximity, and can undergo a kind of merging whereby each individual eventually overlaps with the other energy bodies in the space, so as to include all of the others within their self-representation. The merging that occurs in this process has a kind of smooth dynamical quality which might be compared to what happens when drops of liquid combine. At the aesthetic extrema shown in Figure 1A, energy is not sufficiently visible to represent the coalescence process, whilst at the material extrema shown in Figure 1E, the boundedness of material bodies makes it aesthetically awkward to accomplish a coalescence process, like trying to combine Newtonian billiard balls.

Coalescence within the numadelic aesthetic creates a scenario in which conventional 'top-down' ways of thinking about self (*I have a solid body which is spatially distinct from others*) are transformed (*My luminous body can fluidly merge with other luminous bodies*). For many participants, it facilitated a particularly strong sense of connectedness: *"we could get closer than [in real-life] which felt more intimate, and connecting—nearly as much so as with a partner, child or pet—even though we were in different places."* For others it produced somatic sensations: "*I can just literally walk into people and it is quite sensuous*", and also "*I could feel subtle changes in my hands as if something was passing by, something physical.*" Others commented how, during moments of coalescence "*I got quite emotional . . . I got this surge of*

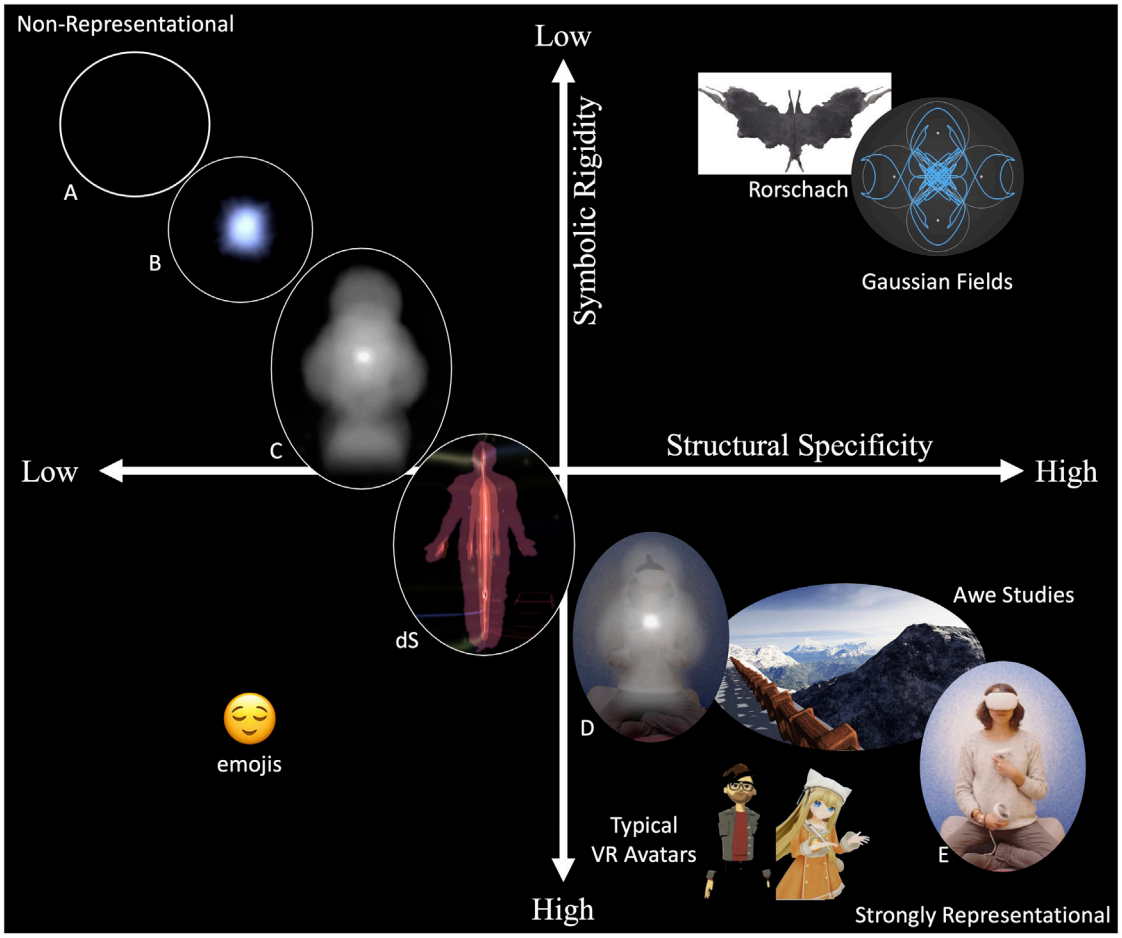


FIGURE 4
A two-axis schematic illustrating the transition from a nonrepresentational 'energetic' paradigm to a strongly representational 'material' paradigm. The different axes and images are discussed in the text. Panels **(A–E)** are identical to the corresponding panels in Figure 1. The (Rorschach) panel is discussed within the text, and reproduced from (Taylor et al., 2017) under Creative Commons CC0 public domain dedication. The panel depicting (Typical VR Avatars) is discussed within the text, and reproduced from (Lin and Latoschik, 2022) under Creative Commons Attribution License (CC BY). The panel depicting (Awe Studies) is discussed within the text, and reproduced from (Chirico et al., 2018) under Creative Commons Attribution License (CC BY). The (Gaussian Fields) and (emojis) panels are discussed within the text.

emotion where I do not know if I wanted to gasp or cry or what it was, but I was kind of shocked in awe." (Glowacki et al., 2020).

The final physics concept which is key to the discussion that follows concerns the distinction between 'collapsed' instances vs. 'un-collapsed' potential. Wave functions can exist in so-called 'superpositions', which describe all possible ways that a system can appear in time and space. However, it is impossible to observe the wave function in its superposition state: as we know from our day-to-day experience, things tend to appear in one way, at one place at a time. Thus there is a tension: if the wave function contains expansive possibility, why do we observe only one possibility at a time? One answer to this apparent conundrum says that the act of making an observation causes the wavefunction to 'collapse'—i.e., to instantiate into a single spatiotemporal appearance amongst all the ways in which it *could have* appeared. The connection between collapsed and un-collapsed states offers an aesthetic perspective whereby any given system which we observe represents a specific (i.e., low-entropy) instance that has arisen within a more expansive (i.e., high-entropy) field of possibility and potential.

3 A paradigm for aesthetic representation

Combining the aforementioned ideas from predictive coding with the physics metaphors enables us to formulate a 2-axis aesthetic design space for thinking about representation, illustrated in Figure 4. Inspired by ideas from predictive coding, the vertical axis tracks 'symbolic rigidity', which captures how strongly a given representation has fidelity to 'real-world' design references and therefore how strongly it overlaps with pre-existing cognitive priors. Symbolic rigidity helps distinguish between low entropy regimes in which a symbol's representational potential is rigid because it signifies something very specific *versus* high entropy regimes in which a symbol's representational potential is more flexible. It is associated with how much space is available for a participant to 'imagine into' what a representation signifies. Inspired by the matter-energy ideas outlined above, the horizontal axis tracks 'structural specificity', which captures how precisely a given representation is delineated–i.e., the complexity of the 'instruction set' required for an artist or a machine to create a

particular representation. A blurry source of luminescence like that shown in Figures 4B, C has low structural specificity, whereas a precisely delineated image of a person like that shown in Figure 4E has a high structural specificity. Elaboration of Figure 4 aesthetic design space is best understood through the examples, which I discuss in turn for each of the quadrants in Figure 4. These examples are illustrative rather than exhaustive, and it will be interesting to map other representational aesthetic approaches onto this schema as this work evolves.

3.1 Strongly representational aesthetics: high structural specificity, high symbolic rigidity

This is the quadrant of 'strongly representational' aesthetics, and characterizes most VR content, which is designed to 'look like' what has been encountered before, and therefore has strong overlap with phenomenological priors. Referring again to our wave function analogy, this quadrant is the domain in which the wave function is fully collapsed into a specific tangible spatio-temporal instance, making it hard to imagine any other way in which things could have instantiated. For example, Figure 4E shows a material body seen using the so-called 'pass-through' mode available on the latest generation of VR headsets. With well-defined lines and colors, this representation has high structural specificity: the level of complexity and contrast is comparable to our day-to-day experience, enabling us to quickly recognize a seated white woman with dark hair wearing a VR headset. The symbolic rigidity of Figure 4E is high: the body is completely determined, and there is little which needs to be 'imagined into' to fill in the details of the representation. As such, this representational regime is fully collapsed and therefore offers limited imaginative possibility. The other images depicted in this quadrant are similarly characterized by High Structural Specificity & High Symbolic Rigidity. For example, Figure 4 shows the typical VR avatars available in various metaverse applications. Figure 4 also shows images that have been used in studies which aim to induce awe using 360 video shown through VR headsets using digital reconstructions of natural scenes (Chirico et al., 2018). Figure 4D represents a weaker degree of structural specificity, with many of Figure 4E details of the woman's figure transforming into luminosity, expanding the space of imaginative possibility. Strongly representational aesthetics (e.g., Figure 4E) are 'low-entropy' in the sense that they limit the space of possibility for the participant to 'imagine into' what a representation signifies.

3.2 Weakly representational aesthetics: low structural specificity, low symbolic rigidity

This is the quadrant of weakly representational aesthetic approaches, which are not attempting fidelity to previous experience, and therefore have weak overlap with phenomenological priors. The extrema of low *structural specificity* is essentially an aesthetic for 'energy' as it most commonly arises in the Universe–i.e., formless and invisible, and therefore depicted in Figure 4A as black, without any guide to visual attention, similar to closing one's eyes. The *symbolic rigidity* of Figure 4A is low: by analogy to the wave function, this is the domain of an un-collapsed superposition prior to collapsing into a more tangible spatio-temporal instance. Being un-collapsed into any kind of form, we can imagine a vast possibility of latent forms which might emerge. Figures 4B, C represent increasing degrees of structural specificity as the formless potential represented by Figure 4A begins to gradually collapse into a spatio-temporal instance. As structural specificity subtly takes shape, there is a slight increase in symbolic rigidity and the space of imaginative possibility begins to gradually narrow: the representations–without being definitive or obvious–gently suggest certain interpretations. Weakly representational approaches are 'high-entropy' (compared to strongly representational 'low-entropy' approaches) in the sense that they offer the participant a broader space of imaginative possibility. Participants immersed in a weakly representational VR environment are less likely to spend cognitive energy evaluating the extent to which it has fidelity to 'real-world' appearances. A recent study by Mediano et al. supports these ideas: they showed that the brain entropy of LSD users watching videos of nature scenes was lower compared to LSD users with their eyes closed (Pedro et al., 2020). In a similar vein, Rastelli et al. (Rastelli et al., 2022) showed that cognitive flexibility increased when participants watched hallucinatory fantastical immersive video (Suzuki et al., 2017) *versus* conventional video of the same scenes.

3.3 High structural specificity, low symbolic rigidity

There is a general correlation between structural specificity and symbolic rigidity. As structural specificity increases, the corresponding symbolic rigidity tends to increase–i.e., the space of imaginative potential shrinks as the wave function begins to collapse, and there is less flexibility to 'imagine into' what a representation signifies. As a result of this correlation, there are more examples along the diagonal of Figure 4 than the off-diagonals. In some cases the superposition collapses into structures with high specificity, but which are open to imaginative interpretation. Rorschach images offer an example of such a representation: they have relatively high structural specificity, but can be imagined to represent several different things and therefore have low symbolic rigidity. Within this quadrant, we include an image generated by the 'Gaussian Fields' software project (github.com/IRL2/gaussian-Fields), which uses real-time atomic physics algorithms to generate images that perpetually evolve into unpredictable symmetries and patterns. Like Rorschach plots, the images that arise are reminiscent of a wide variety of phenomena–e.g., flowers, butterflies, angels, crystals, humans, cell division, energy transfer, etc.

3.4 Low structural specificity, high symbolic rigidity

This quadrant similarly has fewer examples owing to the correlation between Structural Specificity and Symbolic Rigidity. It includes representations with low structural specificity and high symbolic rigidity. Emojis, for example, fit into this category, given that they are designed to represent a specific emotional state often using simple representations. Figure 4 dS illustrates another

example, taken from the so-called 'danceroom Spectrosopy' (dS) project by Glowacki and co-workers (Glowacki et al., 2013; Glowacki et al., 2014; Mitchell et al., 2016), which described a technological framework combining computer vision and real-time graphics enabling people to see their real-time reflection as an energy field which could be used to sculpt the dynamics of a real-time atomic physics simulation. The Figure 4 dS image is immediately recognizable as the silhouette of a person, and therefore has a higher symbolic rigidity in comparison to Figure 4C, owing to the fact that imaginative possibility is slightly collapsed, but with less structural complexity than Figure 4D.

4 Experimental tests

4.1 Can 'bottom-up' endogenous insight arise from 'top-down' exogenous content?

It is often assumed that high entropy subjective experiences like those associated with NDEs or YDEs involve a significant endogenous component–i.e., the experience arises from the 'bottom-up', strongly dependent on the considerable variability of an individual's 'set' (their accumulated cognitive composition at any given time). In contrast, the subjective experiences that arise with VR are thought to be largely exogenous and low entropy because they are shaped from the 'top-down' using perceptual content presented to the subject from outside within pre-established aesthetic parameters that sample a relatively small set of perceptual domains. The ideas advanced in this paper suggest that such a perspective is overly simplistic: VR is 'exogenous' when it adopts a fully collapsed, low entropy aesthetic characterized by high structural specification and high symbolic rigidity. In such a regime, it is more difficult to imagine all the un-collapsed possibilities of what *could* arise. In contrast, VR content within 'un-collapsed' representational domains characterized by low structural specificity and low symbolic rigidity can create the conditions for endogenous experiences. Un-collapsed aesthetic domains without strong associated priors furnish a broad space into which a participant can project meaning. Participant engagement in this imaginative meaning-making process entails the possibility for meaning to arise from the 'bottom up'—i.e., from the latent content within one's cognition. In such cases, subjective experience has the potential to be significantly more endogenous, similar to the fashion in which meaning arises for participants during eyes-closed meditation practice.

Aesthetic approaches within the collapsed low-entropy, strongly representational limit of Figure 1 and Figure 4—characterized by strong overlap with cognitive priors, high structural specification, and high symbolic rigidity–have little in common with the un-collapsed high entropy regime of ill-defined priors likely to be encountered during NDEs. While it may seem intuitive and reasonable to adapt standard metaverse aesthetics to represent the phenomenologies associated with NDEs (e.g., giving participants 'out-of-body' experiences or 'life reviews' using avatars and environments derived from standard representational approaches), the ideas put forth herein offer a perspective where such approaches–reasonable as they may seem–may be inadequate because they represent a kind of top-down 'collapse' of expansive structural potential into a relatively rigid and strongly specified low-entropy representational environment. The weakly representational structural blurriness of the numadelic aesthetic (which spans Figures 4B–D) offers an interesting alternative for 'bottom-up' meaning making to arise.

'Un-collapsed' forms of representation with low structural specificity and low symbolic rigidity such as those used within the numadelic aesthetic invite participants to imaginatively construct meaning within an expansive possibility space. For example, recent numadelic study participants recounted being '*struck with how quickly the abstract lights grew to hold tangible meaning . . . as other people*' but without any of the '*judgements that come from how people look, sound and that sort of thing.*' (Glowacki et al., 2022). From the perspective of predictive coding, previous published results showing that VREs within the numadelic aesthetic score similarly to YDEs on a number of psychometrics seem to be associated with a decreased precision weighting of 'top-down' models (*I have a well-defined physical body with impenetrable boundaries*) vs. 'bottom-up' information (*The essence of my body is diffuse energetic luminosity*), enabling participants to reimagine the conventional ways they think about themselves and others, and weakening their attachment to egoic identity (Glowacki et al., 2020; Glowacki et al., 2022). In future work, it would be interesting to directly compare how participants project meaning onto weakly representational aesthetics vs. strongly representational aesthetics. The ideas outlined herein suggest there should be greater variability for endogenous meaning making associated with weakly representational aesthetic approaches, and relatively less variability for exogenous meaning making associated with strongly representational approaches.

4.2 Does representational entropy correspond to brain entropy?

Recent neurophysiological studies to evaluate the extent to which YDEs impact the precision weighting of 'top-down' models vs. 'bottom-up' information have highlighted brain entropy and the ratio of forward/backward travelling cortical waves as two measures which are inversely related to 'top-down' model precision. When analyzed using Lempel-Ziv compressibility, brain states measured under the influence of psychedelics (LSD, psilocybin, ketamine) show increased signal diversity compared to states of wakeful rest (Schartner et al., 2017). The interpretation of these results is that high entropy, high-diversity brain states are subject to less information compression of the sort usually performed by high-level top-down internal models, 'priors', or 'beliefs', and are therefore associated with less compressible neurophysiological signals (Carhart-Harris and Friston, 2019). Forward (FW) and Backward (BW) traveling cortical waves provide a complementary physiological marker of the precision weighting of high level priors and beliefs vs. bottom-up information flow: more prominent BW waves suggest a higher weighting of 'top-down' models and priors in cognitive processing, while more prominent FW waves suggest a higher weighting of 'bottom-up' information flow (Friston, 2019; Alamia et al., 2020). In experiments comparing brain signals of participants administered the psychedelic drug DMT vs. placebo, Alamia *et al.* showed that DMT significantly decreased the typical top-down alpha-band

BW wave rhythms associated with closed-eyes rest, and simultaneously increased bottom-up FW waves. These results have been interpreted to provide evidence that YDEs attenuate the dominance of top-down cognitive models and liberate the flow of bottom-up information.

Discussing the potential of immersive technology in consciousness research, Metzinger previously suggested how a 'volume control for realness' (which we henceforth refer to as a 'reality dial') defined along a continuous reality/virtuality axis could enable the experimental psychologist, neuroscientist, or philosopher to set the phenomenological 'level of realness' for a given experience (Metzinger, 2018). Metzinger suggested a wide range of experiences could be situated along this axis: VR, drug-induced states of consciousness, religious experiences, dreamlike states, out-of-body experiences, optical illusions, etc. The 'reality dial' proposals are largely theoretical, with little in the way of aesthetic suggestions that would enable practical implementation. The aesthetic design space illustrated in Figure 1 and Figure 4 offer some practical approaches for systematically modulating aesthetic phenomenology along a 'reality dial'. For example, each of the states shown in Figure 1 represents a distinct class of 'bottom-up' phenomenology, spanning a continuum which includes non-representational aesthetics at one extrema (i.e., low settings on the reality dial, not-so-obviously-close-to-real) and strongly representational aesthetics at the other (i.e., high settings on the reality dial, more-obviously-close-to-real). With corresponding neurophysiological signals measured using integrated XR/EEG headsets across different reality dial settings, it would be possible to make quantitative comparative statements about the extent to which various points along the numadelic aesthetic continuum impact the precision-weighting of priors, and thus alter the balance of top-down *versus* bottom-up information passing. Specifically, it would be possible to measure: (a) spontaneous Lempel-Ziv (LZ) complexity of EEG signals (Schartner et al., 2017), which tracks the compressibility of spontaneous brain activity and has been found to predict conscious level across conscious states, including under psychedelics at various intensities; and (b) forward (FW) and backward (BW) cortical traveling waves (Alamia and VanRullen, 2019; Friston, 2019; Alamia et al., 2020), which provide a simple model for understanding the weighting of 'top-down' vs. 'bottom-up' information flow in cognitive processing. Together, these measures would enable quantitative comparison of the relative precision weighting of top-down models vs. bottom up information at various settings of the reality dial, and a quantitative comparison to the results obtained during YDEs, discussed above. The ability to link phenomenology at specific 'reality dial' settings' to neurophysiology and psychometric data may offer first steps toward rational design principles for exploring un-collapsed phenomenologies using immersive technologies.

5 Conclusion

Despite limitations which have been discussed in detail in previous papers (Glowacki et al., 2020; Glowacki et al., 2022), numadelic approaches have shown potential to elicit subjective experiences which are comparable to YDEs. In this paper, we set out to understand whether multi-person VREs within the recently described 'numadelic' aesthetic might serve as model for NDEs, and thus help to alleviate the fear and anxiety often associated with death. For VR to be used effectively in such a context, a crucial question concerns the aesthetic that should be deployed. This paper argues that the majority of VR content may not be well suited to such purposes, because it adopts a 'strongly representational' aesthetic characterized by high structural specificity and high symbolic rigidity. This tends toward a kind of collapsed, low-entropy, photorealistic approach which aims to achieve fidelity to familiar visual phenomenology, with well-defined 'real-world' design references. Transformative non-ordinary experiences like NDEs are potent in part because they are so dramatically different from 'real-world' phenomenology, and do not have strong overlap with priors derived from day-to-day experience. As such, developing models for experiences like NDEs requires *new* aesthetic paradigms. Herein, we combine matter-energy ideas from physics with concepts from predictive coding to elaborate a design paradigm for thinking about representation in VR, in which a range of different aesthetic approaches can be situated. Analogies from physics enable us to distinguish strongly representational approaches (where objects are bounded and finite) from weakly representational approaches (which describe unbounded energetic properties). Whereas classical systems are fully collapsed into a specific spatio-temporal instance, quantum systems can exist as un-collapsed superpositions with the potential to instantiate in any number of ways within an expansive space of possibility. Analogies from predictive coding enable us to distinguish between low entropy regimes in which a symbol's representational potential is rigid and signifies something very specific *versus* high entropy regimes in which a symbol's representational potential is more flexible.

In contrast to strongly representational classical approaches, the 'numadelic' aesthetic does not have a well-defined 'real-world' design reference. It enables participants distributed across the world to cohabit a shared virtual space and collectively experience the emergence, fluctuation, and dissipation of their bodies as unfolding energetic processes with soft spatial boundaries, rather than fixed material entities with hard boundaries. Whereas the 'strongly representational' aesthetic is collapsed into a particular spatio-temporal instance and therefore limited in its imaginative potential, the weakly representational numadelic aesthetic has a low degree of structural specificity and is only partially collapsed. It has relatively low symbolic rigidity, offering a more expansive space of imaginative possibility, and inviting endongenous meaning-making to arise from the content latent within one's cognition. Through the lens of predictive coding, 'strongly representational' aesthetic approaches reaffirm and strengthen high-level internal cognitive models (i.e., 'priors' or 'beliefs'). In contrast, numadelic aesthetic approaches are associated with a reduction in the top-down precision-weighting of priors, decreasing their compressive influence and opening them up to revision from an influx of 'bottom-up' perceptual inputs, similar to the mechanisms associated with YDEs. The numerous comparisons between YDEs and NDEs hint at the fact that the NDE is the ultimate 'bottom-up' reweighting, given its status as an experience from which one's egoic identity does not return.

The ideas presented herein challenge the application of conventional classical VR representational aesthetics in cases where VR is used to develop models of non-ordinary, high-entropy experiences like YDEs and NDEs, both of which have demonstrated their potential in addressing the anxiety often associated with death. In a similar way that physics has evolved from localized classical material descriptions toward delocalized quantum energetic descriptions, this paper makes the case for exploring weakly representational strategies with low structural specificity and low symbolic rigidity. Such aesthetic approaches may be good models of non-ordinary experiences where phenomenological priors are ill-defined owing to weak overlap with day-to-day experience. Given the recent interest in using immersive technologies to develop non-ordinary and transformative experiences (Gaggioli, 2016; Chirico et al., 2022; Smith and Warner, 2022; Stepanova et al., 2022; Hartogsohn, 2023; Kaup et al., 2023; Liedgren et al., 2023; Miller et al., 2023), aesthetic research of the sort outlined in this article is essential, especially if VR is to be used in order to develop immersive experiences which can model NDEs in order to dissolve the fear often associated with death. Moving forward, this work raises a set of fascinating research questions. How do other representational approaches–e.g., those which distinguish visual realism vs. abstraction, or those which are designed to be 'open to interpretation' as described in Umberto Eco's *Open Work* (Eco, 1989)—map onto the Figure 4 framework? How do experiences designed using different aesthetic approaches map onto psychometrics like the Greyson NDE scale (Greyson, 1983)? To what extent can the Figure 4 design space be quantitatively characterized? Can mathematical approaches for analyzing entropy, information content, and structural specificity (Larkin, 2016; Khalili and Bouchachia, 2021; Suzuki et al., 2023) be applied in order to better classify the aesthetic domains spanned by Figure 4, and how might different aesthetic classifications impact participants? Despite the fact that energy bodies within the numadelic aesthetic are characterized by low structural specification and low symbolic rigidity, they satisfy various conditions required for the experience of 'self', which some researchers call 'minimal phenomenal selfhood' (MPS) (Blanke and Metzinger, 2009). Can experiences like energetic coalescence–which entail a form of spatiotemporal identification with an energy body, but challenge one's conception of their boundedness with respect to others–be used to better understand MPS? And finally, can we measure the extent to which numadelic group-based VR programs support mental wellbeing in patients facing life-threatening illness–e.g., those with stage IV cancer diagnoses? Comparing pre-numadelic scores to post-numadelic scores on scales that evaluate anxiety and depression in the face of a life-threatening illness would provide quantitative insight into the extent to which the approaches outlined herein support mental wellbeing for patients facing the transition that ultimately awaits us all.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the patients/participants or patients/participants legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

DG: Conceptualization, Writing–original draft, Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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