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A Fractal Topology of Transcendent Experience

(Commentary on Marks-Tarlow's "A Fractal Epistemology for Transpersonal Psychology")

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Most problems of real interest combine fractal and topological features in increasingly subtle fashion.
—Benoit Mandelbrot (1983, p. 17)

In this collection Terry Marks-Tarlow gives us the first epistemology of transpersonal psychology aimed towards healing the longstanding rift between what William James termed tender-minded approaches that are rationalistic, idealistic, optimistic, and often spiritual, and tough-minded approaches that are empiricist, sensationalistic, reductionistic, and often skeptical. The present essay is a contribution to this purpose.

To be specific, this present essay explores boundaries at the edge of consciousness during transcendent experiences. Unique characteristics of transcendent experience are compared to those found in other natural boundary conditions. Analogous patterns are identified that suggest far-from-equilibrium conditions are present during such subjective experiences that spontaneously reorder the boundaries of consciousness.

Boundaries are so ubiquitous they are often unnoticed and imperceptible in the natural world. On a physical scale, we need only turn our attention to our own bodies to appreciate that each organ is bounded by form and function despite interacting with other corporeal systems. Each cell and organ is differentiated by its structure and specialization yet needs to function as an integral part of the whole. For example, each neuron in the brain coordinates and communicates a vast amount of information through its synaptic circuitry. Each individual's body is separate from other bodies. And yet, how is it that one of the present first authors was profoundly aware of the moment of her father's death, despite the distance of hundreds of miles, and in an airplane? Is it possible that consciousness is unbounded? The question of unbounded consciousness that unfurls into unity consciousness under certain conditions is behind the present exploration of the experiential boundaries and boundary conditions of experience.

Here we explore how the boundaries of individual experience, or consciousness, is fractal in nature. In doing so, we suggest that it is iterative and exhibits self-similar characteristics regardless of scale. Clearly, consciousness behaves in a nonlinear fashion, as evidenced by the fact that small changes in inputs often create disproportionately large and unpredictable changes in outputs. Given the common feature that dissipative structures can spontaneously reorder themselves at far-from-equilibrium conditions, it is reasonable to suspect that the boundaries of individual consciousness can also reorder under the far-from-equilibrium conditions of transcendent experiences. Thus, the threshold between individual and nondual consciousness is understood as dynamic and responsive, potentially allowing for, or participating in, the sense of unfurling which merges the individual and the transpersonal. Boundaries in general are multifunctional, in that they can be gatekeepers when differentiation and specialization is required, and they can act as porous fractal-like tendrils when driven far-from-equilibrium as in the transcendent experience.

This exploration into experiential boundary conditions is laid out in three sections. The first grounds Jung's transcendent function as the interface between the conscious and unconscious aspects of the psyche (Miller, 2004). The second discusses structural tensegrity and isomorphism as it relates to boundary conditions at the cellular level. For example, citing cell biologist Donald Ingber's (1993, 1997, 2003) findings on the profound impact that cell

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shape distortion has on cellular behaviour is included to support the theoretical argument for alterations in consciousness in the transcendent experience. And finally, we explore boundary conditions found in nature that can be pushed into far-from-equilibrium states with fractal characteristics at gradient interfaces. Conclusions suggest that similar fractal considerations apply in transcendent experiences.

Topology

In the purest mathematical sense, topology is the study of properties that are preserved under transformation, like stretching but not tearing as exemplified by the Mobius strip and the Klein bottle. In this paper, topology is used to describe the texture of the boundaries of individual consciousness in the transcendent experience. This approach facilitates the visualization of ideas. As Gleick (1987; p. 47) writes,

> Linking topology and dynamical systems is the possibility of using a shape to help visualize the whole range of behaviors of a system. For a simple system, the shape might be some kind of curved surface; for a complicated system, a manifold of many dimensions.

Important to the study of transcendent experience is the topological notion of isomorphism. It suggests that a form can be stretched or transformed radically without losing its fundamental *is-ness*. This is a relevant descriptor for the individual who has undergone a transcendent experience. Visual similes include the Möbius strip and the Klein bottle, where the inside and outside of the objects themselves are continuous and therefore reconciled. It is this topological invagination that is helpful in describing the involution and evolution of the self and the universal, individual and collective, secular and infinite in the transcendent experience. As with the Klein bottle, visually we sense that there is an inside and an outside, but topologically there is not; they are one and the same.

As a model, the fractal topology of the transcendent experience approximates the dynamic boundaries an individual senses as a reconciliation of *inside* and *outside*, across the boundary that previously served to delineate consciousness into *I* and *not I*, and in the extreme reaching infinite dimensions to become a vanishing interface with an unbounded universe, known by a thousand names yet ineffable.

Transcendent Function

Carl Jung's transcendent function (Miller, 2004) describes boundary conditions between conscious and unconscious aspects of the psyche. If the role of the psyche is to encounter, synthesize, and integrate aspects of the conscious and unconscious self, then the transcendent function is to reconcile this psychic duality and is the process by which the psyche draws the person forward toward the wholeness he or she is meant to be. The transcendent function, according to Jung, is the core of a psychic mechanism through which purposeful guidance takes place (Miller, 2004). The discovery of the true whole self is impossible without discovery of the unconscious and Jung suggests that the transcendent function is the vehicle to reconciliation with the magnificent and mysterious unconscious (Jung, 1961/1989).

Peak, mystical, or transcendent experiences incorporate both physics and neurology according to d'Aquili and Newberg (2000), who probed the epistemology of consciousness along a continuum that at one end is grounded in everyday perceptions and experiences, while at the other represents a state of what is sometimes referred to as *cosmic consciousness* (Bucke, 1905), or *mystical union* (Underhill, 2011). These states exhibit common characteristics documented throughout history, and are referred to in regard to Jung's transcendent function as individual consciousness interfacing and unfurling into collective unconscious (Jung, 1961/1989).

The transformative potential of the transcendent function suggests a dynamic process with porous tensegrity that alters the architecture and function of the boundary itself. This psychic tensegrity is compared to cell biologist Donald Ingber's (1993, 1997, 2003) thesis that structural distortions of cell membranes can profoundly alter cellular behavior. He suggests that distortion of the microtubule cytoskeleton of brain cells may have a pronounced effect on consciousness. In that light, the Penrose-

Hameroff model of conscious processes (Penrose, 1994) at the microtubule level is relevant to this discussion. We suggest that during a transcendent experience, an individual's consciousness is driven to a far-from-equilibrium condition where the boundary at the edge of individual consciousness does not rupture, as formally presumed, but unfurls and spontaneously reorders to increase its fractal dimensionality. A rupture assumes separateness, whereas infinite fractal unfurling with a porous gradient interface suggests expanded or mystical forms of experience. This change from a bounded consciousness, rigid, dualistic and excluding, to one that is richly textured, having a nearly infinite surface area, alters the fundamental role of the boundary from that of dissociating to that of unifying and absorbing the individual self within the universal. The fractal, ubiquitous, non-linear systems of the physical world, suggests a model to understand the topology of the boundaries of our inner being. In this way, the fractal topology of the transcendent experience provides a model in which individual consciousness transcends itself in a state of non-duality and perceives unity.

The Transcendent

Immanuel Kant wrote, "All our knowledge begins with experience . . . but . . . it does not follow that it arises from experience" (Wood, 2001; p. 24). That is, Kant argued we must distinguish between objects as perceived and the experience that perceives them. This distinction is between knowing *about* something as cognition as contrasted to knowing it *directly*, which for Kant was intuitive or *transcendent* knowing, beyond our capacity to know directly (Wood, 2001). Hegel (1807/1997), on the other hand, argued that to know a boundary is to know that which it bounds, and by knowing that which it bounds is also to know that which lies beyond it. This, he wrote, is an inherent state of transcendence. In phenomenology, the *transcendent* is that which lies beyond our own consciousness, thus creating a dualistic boundary. Alternatively, to have a direct experience is to sense becoming *one with* the object. Underhill (1999) refers to the felt sense of *at-one-with* as frequently described in the "conversion" and transcendent experience. "This awakening, from the psychological point of view [and limited sense of reality], appears to be an intense form of phenomenon of 'conversion'" (Underhill, 1999, p. 176).

The Transcendent Experience

Normal waking consciousness is the accepted standard by which altered states of consciousness, including the transcendent experiences, are compared (Baruss & Mossbridge, 2017). Transcendent experiences represent an alteration of consciousness in that they appear to interact superveniently; that is to say, transcendent experiences could not be experienced or known without a kind of elemental or ground level consciousness (Gupta, 2003).

The transcendent experience manifests in many variations, and is known by as many names and meanings. Abraham Maslow's (1964) psychological approach, for instance, refers to *peak* experiences. Whitehead (1969) refers "the universal throughout actuality" (p. 190) and the "inevitable continuity" (p. 191). Hollick (2006) and many others describe transcendent experiences as *unity consciousness*, and C. Grof and S. Grof (1990) refer to *cosmic consciousness* (also see Buck, 1905) as the unity or transcendent experience. They are known as *mystical experiences* by Underhill, (1911), who famously explored them as unfolding spiritual consciousness. Briefly, the commonly described characteristics of the transcendent experience that are relevant and significant to this paper include the following (James, 1911; Underhill, 1911):

- Sudden spontaneous onset;
- An expanded sense of self or loss of sense of self and agency;
- Space-time distortion;
- A sense of *at one with* the Divine or the Void;
- Certitude of the experience itself;
- Profound effect on the individual after the experience; and
- Ineffability in describing the experience.

Transcendent experiences are not a geographically localized, novel or a recent phenomenon; they are historically familiar to Eastern and indigenous cultures around the world.

What is new and interesting is a consilience across formally disparate disciplines such as the "hard" sciences and psychology allowing for fresh and rich dialogue. Examining new sciences of far-from-equilibrium conditions and boundary characteristics in fractal dynamics can render fresh insights into consciousness in the transcendent experience. Both fractal dynamics and far-from-equilibrium conditions address dynamic distortion of system tensegrity and the potential richness of the boundary interface.

Structural Tensegrity

Cell biologist Donald Ingber (1993, p. 613) posits "tensegrity may be used for information processing, mechanochemical transduction and morphogenetic regulation" of the cell. His research into cellular membrane transformation includes tubulin-containing microtubules, such as those in Penrose-Hameroff's model of consciousness (Penrose, 1994). Instead of elastic strands at the joints of the Hoberman sphere, microtubules employ microfilaments to generate cytoskeleton tension in the expanded and contracted state. What is significant to this discussion of consciousness that transforms and reinforms in the transcendent experience is Ingber's (1993, 1997, 2003) remarkable discovery that cellular membrane distortion and transformation profoundly changes the function and behavior of the cell.

The transformation in consciousness that seems to occur in the transcendent experience may actually be linked to microtubule transformation in shape. If normal waking consciousness is an everyday consciousness closer to an equilibrium that interacts with this sensorial space-time reality, then the consciousness in the transcendent experience may be exhibiting unusual behavior far-from-equilibrium. This may be related to conformational membrane change at the cellular level in the brain. We will turn our attention to an extensively researched phenomenon; that of far-from-equilibrium conditions and characteristics.

Far from Equilibrium Behavior

Recently, the branch of physics concerned with condensed matter and material physics (CMMP) has begun to recognize that the language of far-from-equilibrium (FFE) systems is applicable to numerous problems in other fields. Interesting, patterns in far-from-equilibrium systems echo the characteristics experienced in transcendent experiences. Significant characteristics of far-from-equilibrium systems include the following (Jaeger & Lui, n.d.):

- There is spontaneous reordering at the boundary of a FFE system;
- Rich structures and complex behaviors arise from simple parts and few variables;
- They are typically non-linear;
- Systems driven far-from-equilibrium produce unanticipated phenomena;
- FFE systems can be driven to find unique solutions in very rapid fashion.

Equilibrium is a static or unchanged state over time where all competing forces are balanced. Far-from-equilibrium conditions are ubiquitous and are discovered not only in materials, but also in systems and processes.

> Far-from-equilibrium behavior is not confined to special conditions or certain types of materials. Instead, it arises across the entire spectrum of condensed-matter and materials physics in a host of problems of fundamental interest. Far-from-equilibrium phenomena also benefit and plague us in technology and in everyday life. Indeed, some of the most complex outcomes of behavior far-from-equilibrium emerge in situations familiar in everyday experience. (Committee on CMMP, 2010, 2007, p. 91)

Examples of far-from-equilibrium phenomena in nature include earthquakes, turbulence, avalanches, galaxies, swarming fish, the behaviour of birds flocking, and consciousness (CCMP, 2007).

Systems and structures are driven to far-from-equilibrium behavior when energy is pumped into them. Subjecting *materials* to far-from-equilibrium conditions results in properties that are otherwise unattainable; subjecting *systems* to far-from-equilibrium conditions results in emergent properties that do not reside in the constituent components (Committee on CMMP, 2010). In some cases, once the energy source is removed a system will relax and return to its previous state, while in other cases the material undergoes an irreversible phase transition.

As an example, a school of fish being attacked by a pod of whales is a system driven far-from-equilibrium. The individual fish gather together to protect themselves through collective safety in numbers. The energy injected during an attack triggers a spontaneous reordering of behavior in the school of fish, which begins to exhibit the complex hydrodynamics of swarming. Beyond collective behavior or cooperation, the far-from-equilibrium condition actually reorders the dynamics of the school to a level of coherence that borders on that of a single organism. Once the attack is over and the energy removed, the system relaxes; fish disengage from coordinated behaviour, and return to individualistic behavior.

In other cases, the phase transition caused by driving a system far-from-equilibrium is permanent. Such is the case with the rapid heating and cooling which is instrumental in the creation many modern materials, including plastics, alloys, polymers, the crystalline structure of silicone chips, and the annealed edge of blades. (CMMP 2010, 2007).

During far-from-equilibrium states, nonlinear systems can be driven rapidly into creating rich, unique, and spontaneously reordered structures and dynamics. It appears that this is an analogous corollary to what occurs at the edge of individual consciousness at the far-from-equilibrium condition of a transcendent experience. This model suggests that the boundary of individual consciousness does not so much dissolve or become nothing, but perhaps its fractal dimensionality increases towards the infinite.

Fractals and Consciousness

Fractal is a term coined in 1975 by French mathematician Benoit Mandelbrot (1989) to depict the geometry arising from nonlinear dynamics. In nature, fractals are ubiquitous and can be seen in structures such as mountains, clouds, and coastlines, as well in the dynamics of flowing rivers, avalanches, and weather systems as Figure 1 illustrates.

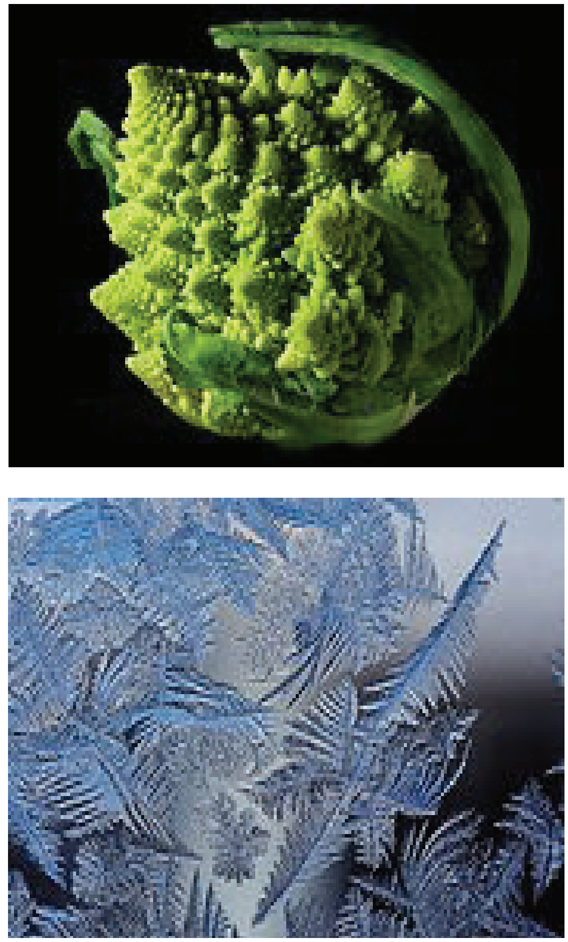

Figure 1. Naturally Occurring Fractals.
These naturally occurring fractals demonstrate fractal development in frost crystals on the left and Romanesco broccoli on the right. Reproduced in accordance with the Gnu Free Documentation License (Wikipedia contributors 2012). Retrieved July 2012 from http://en.wikipedia.org/wiki/Fractal

Fractal *dynamics* are useful for understanding patterns of human interactions from a sociological point of view, through an economic lens to describe market behavior, and even to model inorganic structures such as traffic jams. Indeed, Kant himself wrote:

> We see the first members of a progressive relationship of worlds and systems; and the first part of this infinite progression enables us already to recognize what must be conjectured of the whole. There is no end but an abyss… without bound. (Hastie, Trans., 1900; p. 65).

In the last 40 years, the discovery of fractals has facilitated accurate descriptions of irregular shapes and processes that had previously only been approximated through linear depictions. Fractal geometry has replaced the former linear Euclidian standard as the mathematical tool used to depict nonlinear systems. "It is based on a form of symmetry that had previously been underutilized, namely self-similarity, or some more general form of invariance under contraction or dilation" (Mandelbrot, 1989, p.3).

The possibilities of fractal computation emerged with the dawn of the digital age. With computers, Mandelbrot and others were able to find solutions to nonlinear equations, a laborious process that was beyond manual computation given the sheer number and the complexity of calculations required. In the early days of fractal geometry Mandelbrot programmed the *Julia set* equation into his computer, left it to work for the weekend, and was astonished at the graphics that were produced (Mandelbrot, 1989). The shapes that emerged continuously depicted self-similarity at different orders of magnitude. It was the scale of the observation—the number of iterative calculations where output was fed back as input—that provided a large enough perspective for the emergence of the fractal.

Laszlo (1972, p. 65) wrote of the iterative nature of nonlinear systems that give rise to fractals that "From within and without [they] call forth innovations, and the innovative system produces new kinds of inputs on all systems with which it communicates… thus a change in one triggers changes in others."

Fractals are important examples of scaling, or tiling, that mathematically demonstrate invariance and self-similarity under displacement. They describe the border between order and disorder (Mandelbrot, 1983). The fractal border both differentiates and unites the two. This border between order and disorder is akin to Jung's transcendent function that seeks to unite the conscious with the unconscious (Jung, 1961/ 1989).

The most common feature of transcendent experiences is the loss of a sense of self that occurs when the individual experiences the dissolution of the boundary separating his or her consciousness from universal consciousness, melting discrete into collective. The boundary at the edge of individual consciousness is that which is transcended in the transcendent experience. As such the nature of that boundary is central to this inquiry.

It is in boundary conditions—between states of order and disorder, at the edges of phase transitions, and at the threshold of physical transformations, that fractal dynamics are indispensable as a tool for understanding. As Scaruffi (2012) writes,

> Kauffman showed that the best strategy for reaching the peaks occurs at the phase transition between order and disorder, or, again, at the edge of chaos. The same model applies to other biological phenomena and even nonbiological phenomena, and may therefore represent a universal law of nature.

Key to the present inquiry is the question of whether the boundary of individual consciousness, like most physical boundaries and boundary conditions, is indeed fractal in nature. As we have shown, consciousness is self-similar, iterative and exhibits self-same characteristics regardless of the scale of inquiry. It is also nonlinear in that small changes in input can create disproportionately large and unpredictable changes in outputs. The evolution of experience from moment to moment, as well as over large spans of time, is iterative, in which each new experience feeds back into the hopper of the ongoing flow, generating new iterations, that are the very kinds of process that produce fractal dynamics mathematically, in physical systems, and apparently in experiential reality as well.

Fractal Characteristics of Gradient Interfaces in Nature

There are numerous examples of fractal gradient boarders in nature. One only needs to sit at the ocean's edge to appreciate the dynamic interplay of the waves at the shoreline. If the shore is rocky, the nutrient-rich intertidal zone is a fractal at many scales. From an airplane, meandering rivers and streams dot the landscape while fractal mountain peaks seem to touch the floating fractal-like clouds. Fractals are as abundant in our natural surroundings as they are in our bodies.

Gell-Mann (1992) posits that nature is conformable to itself and is self-similar. Following this, it is no stretch of the imagination to think that if individual consciousness itself is fractal in nature, then boundaries at the edge of individual consciousness exhibit fractal characteristics as well.

Two specific fractals, Sierpinski's triangle and the Koch snowflake, are briefly examined here to illustrate how their characteristics are analogous to the boundary characteristics of individual consciousness in a transcendent experience.

Koch Snowflake

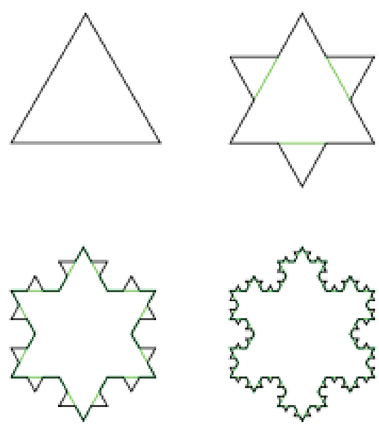

Figure 2. The Koch snowflake demonstrates the construction of a Koch snowflake through repeated iterations. (Reproduced in accordance with the Gnu Free Documentation. Retrieved January 6 2018 from http://mathworld.wolfram.com/KochSnowflake.html)

As illustrated in figure 2, the construction of a Koch snowflake is an accessible example of fractals as a mathematical process. Constructing a Koch snowflake begins with a triangle with sides of length 1. At the middle of each side, add a new triangle one-third the size, and continue doing this. As this process continues the actual enclosed area remains less than the area of a circle drawn around the original triangle. Thus an infinitely long line surrounds a finite area.

The unique characteristic of the snowflake is that, as the boundary gets more and more detailed, increasing in its fractal "dimensionality," a paradoxical situation is generated in which the finite area inside the snowflake is enclosed by an infinite boundary. As the boundary is increasingly refined from a few simple triangles to an infinitely crystalline surface, the *ratios* between, and therefore the *relationship* between, the container, the contained, and the excluded space, changes. Much the same can be said of the boundaries of individual consciousness during a transcendent experience.

Where a simple boundary once sufficed merely to identify the Koch snowflake and conserve its identity, differentiating the inside from the outside of the shape, an infinite boundary provides infinite potential for interaction between the contents of the snowflake and its boundary. The fractal nature of the boundary can embody a shift from merely conserving information, to providing potentially infinite opportunities for interaction with both the contained and the excluded.

In this way, the characteristics of the Koch snowflake can be said to be analogous to the boundaries of individual consciousness during a transcendent experience. As individuals enter into a transcendent experience, they sense the boundaries of self and sense reality dissolving, and they experience an immersion in an expanded nonlocal experience (Loy, 1997). While empirically we know that individuals do not dissolve during transcendent experiences, even as their sense of self does, the paradox can be addressed by suggesting a Koch-like fractal boundary to individual consciousness.

Physical systems are driven into far-from-equilibrium behavior when energy is pumped into them. We believe that conditions that may drive human consciousness into far-from-equilibrium behavior and transcendent experiences may include stillness of the mind as in meditation, the feeling of ecstasy as in love, the sense of awe and connection at the beauty of nature, or perhaps intense physical or psychic distress (Taylor, 2017).

Fractal Dimensionality and Enfoldment

If, as is suggested in this paper, the boundary at the edge of individual consciousness is fractal in nature, then it follows that reports of transcendent experiences would share descriptions of consciousness that resemble fractal dynamics. Fractal dimensionality appears to be just such a corollary dynamic.

All fractals have a fractal dimensionality; that is, their degree of complex enfoldedness. Crumpled paper, the folding of proteins in replication, and vortices that arise as back eddies in laminar flow are visually accessible examples of fractal dimensionality. As fractal dimensions increase, so too does complexity. The Mandelbrot set, with its high fractal dimensionality, is one of the most complex mathematical objects known. Science writer James Gleick writes, "An eternity would not be enough time to see it all, its disks studded with prickly thorns, its spirals and filaments curling outward and around, bearing bulbous molecules that hang, infinitely variegated, like grapes on God's personal vine" (Gleick, 1987; p. 221).

Boundaries of natural systems are universally nonlinear, are often in flux, and they often exhibit fractal characteristics. This is also true of the boundaries of consciousness. What fractal dynamic accounts for the sense of dissolution of self and immersion in nondual experience prevalent in many transcendent experiences? Descriptive accounts over a wide range of such experiences suggests that consciousness changes during a transcendent experiences as an individual's consciousness unfurls or increases its fractal dimensionality at the boundary separating individual consciousness from nondual consciousness. This unfurling is experienced as spontaneous, due perhaps to the far-from-equilibrium state of transcendent experience.

We suggest that consistent with far-from-equilibrium phenomena in general, the boundary of an individual's consciousness can undergo a rapid reordering where the border between the individual and the universal increases with fractal dimensionality. This increase in the boundary's fractal dimensionality increases the richness of its chenille-like texture. The experience of encountering the Absolute, the mystical, nondual, or samadhi reported in transcendent experiences could be understood through the almost infinite uptake of information made possible via the higher fractal dimensional ratio at the interface of individual to universal: the secular to divine.

As the boundary of one's consciousness increases, its fractal dimensionality and its fractal tendrils of perception reach towards infinity, and the boundary undergoes a phase transition from a demarcation of inner and outer experience (Sheets-Johnstone, 2016), to a zone of rich interaction between self and not self. The resultant exchange of information described in transcendent experiences is not experienced in normal waking consciousness.

Conclusion

During the process of researching this paper, the importance of the boundary at the edge of individual consciousness began to assume increasing significance. In the literature, this boundary is consistently described as a passive entity that, in the transcendent experience, was ruptured as individual consciousness went rushing out into the infinite, or alternatively mystical experience came rushing in (Dalal, 2001; McDermott, 2001).

Upon closer examination, however, it appears that the function of the boundary in transcendent experiences may not be only that of a failed gatekeeper. Given the nearly universal fact that the boundaries of dissipative structures can spontaneously reorder at far-from-equilibrium conditions, it is not unreasonable to conclude that the boundary of discrete consciousness can also reorder under the far-from-equilibrium condition of transcendent experience.

> Far-from-equilibrium behavior is ubiquitous... [it] underlies a wide range of phenomena outside the traditional boundaries of condensed matter physics, including earthquakes, hurricanes, galaxy formation, and consciousness. As a result, breakthroughs in the area have the potential for far-reaching impact across many scientific disciplines. . . . Far-from-equilibrium behavior is not a simple extension of equilibrium or near-equilibrium physics. Instead, it corresponds to qualitatively different types of behavior and response, typically associated with crossing some threshold into a new regime. (Jaeger & Liu, n.d.. p. 2)

In this way, the threshold between individual and cosmic consciousness could be considered dynamic and responsive, potentially allowing for, or participating in, the sense of rupture that merges the individual and the cosmic. As condensed matter and materials physics (CMMP) research suggests, "Importantly, far-from-equilibrium processes can achieve structural and dynamical richness even with the simplest of ingredients, such as the intricate dendritic growth realized in snowflakes" (Committee on CMMP 2010, 2007, p. 95).

This is not to ascribe agency to the boundary, but rather to suggest that, as with many other nonconscious systems, the boundary at the edge of individual consciousness appears to exhibit nonlinear dynamics and is capable of complex adaptive behavior.

The literature shows that with rare exceptions such as shamanic induction, Buddhist meditation, and ingestion of psychotropic drugs, the transcendent experience cannot be reached through willful intention. Although the experience can arise spontaneously, there are also numerous cases of transcendent experiences accompanying critical or even traumatic incidents (Fox, 2016; Taylor, 2017). Indeed, it appears that expanding the gradient interface between individual and transcendent experiences may not rely on, but might in some cases be facilitated by catalysts that "push" the system beyond its normal limits.

> One way to keep a system from its natural state of rest and to push it into the far-from-equilibrium regime involves continual and sufficiently strong forcing. Driven systems such as these . . . give rise to rich and unanticipated phenomena. (Committee on CMMP 2010, 2007, p. 95)

Anecdotally, subjects who describe their own returns from transcendent experiences report that their consciousness has been forever expanded, and their previous sense of discreteness has changed to an irreversible openness and sense of interconnectivity. This would suggest that in addition to the learning brought about by any experience, the transcendent experience may also result in a structural change in the boundary of the self. The authors believe that the fractal dimensionality of the boundary of individual consciousness may maintain a residual degree of openness after the transcendent experience. This is a common occurrence found in other far-from-equilibrium conditions that do not relax back into equilibrium even after all driving forces have been removed. (Committee on CMMP 2010, 2007, p. 95).

As the previously enfolded fractal tendrils of consciousness unfurl in the transcendent experience, the rich, chenille-like texture of awareness is increased, allowing the emergence of a nearly infinite interaction between the individual and nondual or mystical expansion. Fractal topology can assist the understanding of the transcendent experience of seamlessness and the dissolution of the sense of self.

Boundaries are multifunctional in that they can be gatekeepers when differentiation and specialization is required, and they can act as porous fractal-like tendrils when driven far-from-equilibrium, as occurs during transcendent experiences.

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