CHAPTER FIVE

FRACTAL EPISTEMOLOGY AND THE BIOLOGY OF EMOTION[1]

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Introduction

In the history of Western science, the academic discipline of psychology is relatively new. Unlike harder sciences (i.e., physics and chemistry), psychology is among the squishier of the "soft" sciences. Its general objects of interest are mental processes as they relate to human behavior, subjective experience, and functional well-being—objects that comprise the human "mind" (whatever that may be).

While central to a scientifically informed understanding of human nature, empirical inquiry into such "objects" is faced with unique methodological challenges and inherent limitations. Indeed, the field of psychology's nascent claims as a grown-up science depend upon testing (and replicating) observations against normative population statistics, and grounding theories in evolutionary biology in general (and genetics in particular). This is a rather tenuous top-down tether, given the profound variability, contextual contingency, developmental plasticity, agentic participatory efficacy, and subjective relativity of any given individual-phenotypic-personality or mind.

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The situation is still more precarious within the subfield of transpersonal psychology (TP)—a discipline still struggling to define its own territory (Caplan, Hartelius, & Rardin, 2003). TP emerged (relatively recently) to address unique states of conscious experience and the outer, more porous, boundaries of human identity, not otherwise included in existing disciplines. This new terrain intersects with the domain of spirituality, encompassing the varieties of religious experience captured by Williams James (1902), as well as themes from Eastern religions (Roller, 2018). Although our spiritual proclivities seem to be human universals (de Jager Meezenbroek et al., 2012; Elkins, Hedstrom, Hughes, Leaf, & Saunders, 1988), we remain bound by the proposal that science and religion should remain strictly separate and "non-overlapping magesteria" (Gould, 1999).

Fortunately, this new territory also intersects with the now burgeoning *complexity sciences* (Waldrop, 1993), which loosely include: the lawful, mathematically precise—mechanics of pattern formation in nature (Kelso, 1997); the nonlinear dynamics and control processes (Walleczek, 2006) of complex adaptive systems (which includes all living creatures); and the paradigm of *self-organization* in the evolution of biological systems (Camazine et al., 2003). These are all new and interrelated ways of understanding the *bottom-up physical processes* undergirding being and becoming, that have already enhanced the field of psychology (Guastello, 2001). And, as luck would have it, they offer newly distinct conceptual foundations for understanding the ontology of our most personal, mystical, meaningful, and transpersonal experiences.

So, it is with equal enthusiasm that I echo Terry Marks-Tarlow's proposal that fractal geometry is pregnant with potential as a new interpretative paradigm for TP. I hope to underscore and further expand upon that theoretical utility in the context of the common *emotional biology* of living systems—historically missing science that can inform not only the discipline of psychology but the social sciences in general.

The new biology of emotion

This new approach relies upon a broadened definition of the "emotional system," rolling it back to its ancient evolutionary roots in core affect and stimulus-response behavior. This new definition encompasses the complete suite of biophysical processes that give rise to the *perception of hedonic qualia*. "Perception" by this definition, does not require neural structures or complex consciousness, just the rudimentary ligand-receptor capacities on cellular membranes that instantiate sensory-motor control in single-celled organisms. These are perhaps the earliest mechanisms for sensory perception, and those that evolution has carefully conserved and continuously built upon.

"Hedonic qualia" are herein defined as binary in nature, including subjective *feelings of pleasure and pain* (AKA "affect") and their coupled *approach and avoidance behaviors.* They are double-barreled, both feelings and behavioral reactions—the original sensory-motor stimulus-response coupling that undergirds Pavlovian learning (via reward and punishment). While these bare bone sensory capacities were functionally sufficient in early life forms, the later emergent neural structures have added the necessary-informational complexity to manifest the subjective experiences of interest to the psychological sciences (specifically via the *basic* (primary, "natural kinds," e.g., Ekman, 1992) and *complex* categories of emotional feelings (secondary, "unnatural," e.g., Lutz, 1988) which carry more *universal* and *personalized* information, respectively (Peil, 2012). But their binary nature also encodes a deep evolutionary logic without which we can neither fully understand the scope and function of the system nor decipher the full range of the informational meaning offered within the spectrum of human feeling.

But, by this new definition, every living creature experiences some form of emotional sentience. Indeed, the perception of emotional qualia undergirds the ubiquitous pattern of *hedonic behavior* (action toward that which is beneficial and away from that which is harmful), observable across the entire animal kingdom (Medicus, 1987). It also assumes an underlying capacity for consciousness in living systems, some rudimentary "proto-self-awareness" and accompanying "feeling of what is happening" as set forth by Antonio Damasio (1999). To which I add: The feeling of something happening *to me;* in honor of the distinctly "self-relevant" (LeDoux, 1989) nature of affective—hedonic, emotional—stimulus.

As I will discuss, this new view of emotion also implies a more general depiction of the concept of "mind," as an ongoing autopoietic and enactive *process* like that suggested by Maturana and Varela (1991). However, with or without any "subjective consciousness" proper, the terms "sentience" and "mind" are objectively justified by the chemical machinery that drives hedonic behavior even in the simple bacterium, and still evident in the cell signaling processes in multicellular organisms—mechanisms involved in genetic, epigenetic, and immune regulation—all of which rely upon a "self versus not-self" identity distinction (Peil, 2014).

The missing function of emotion: Self-regulation

Perhaps most importantly, this chapter will emphasize the historically hidden, "self-regulatory" function of the emotional system (Peil, 2014)—an ancient-hardwired function emergent with this simple-sentient mind and life itself. It will point toward an informative *self-regulatory logic* encoded in the binary nature of hedonic stimulus, an *evaluative, relational, and nonlinear* logic that preceded and remains master over our linear, rational, logical reasoning, and verbal capacities—which is why the "emotional dog" will forever "wag the rational tail" (Haidt, 2001). It will emphasize how very early on emotional sentience afforded living creatures direct participation in the evolutionary process, and its ancient—indeed universal—value system is rooted in an early structural and functional unity of *sensory-motor control* and *adaptive immunity*.

This new understanding of emotion opens the scientific door to the subject of *value* itself, discussions formerly rendered off-limits by the mistaken "naturalistic fallacy" (Moore, 1903). It suggests that such cognitive concepts as "good," "bad," "right," and "wrong" all emerge from the universal value of *bodily health*—both the *physical being* and optimal *developmental becoming* of a living organism. This universal value system is mediated by a system-wide self-regulatory logic that says *yes to this* and *no to that* via hedonic qualia, a logic that is fundamentally dependent upon the physical and mental *boundaries* between the self and the not-self world, and one that carries several levels of evolutionarily non-negotiable biological meaning. As such, our universal emotional biology is also the source of genuinely teleological—purposeful—behavior. Indeed, our most complex human emotions are ground zero for our innate spiritual proclivities, and our deeply vital, most meaningful, life experiences—from the soaring feeling of ecstatic unity with All That Is, to the bleakest, most devastating, nights of the soul.

This chapter will emphasize how emotional self-regulatory processes now unite the entire human "self-system"—a nested, fractal, multi-tiered structure—offering bi-directional, mind-body, information processing between the bottom-up genetic, epigenetic, and immune regulatory processes of the bodily landscape and the top-down identity constructs, memories, beliefs, social strategies, and habits of one's subjective mindscape. In addition, if we are not consciously attuned to the universal, bottom-up, yes/no evolutionary logic of emotional regulation, many personal and social dysfunctions are predictable, and our most salient human experiences—and purposeful longings of the soul—will remain mysterious and elusive.

Self-regulation emerges from self-organization

These offerings will turn on how this ancient self-regulatory function has emerged from the *self-organizing* dynamics of complex adaptive systems, and how everyday feeling experiences now contain three levels of information that keep us poised on the "edge-of-chaos" (Kauffman, 1993; Langton, 1990; Wolfram, 2002)—in optimal *physical, mental,* and *spiritual* states of self-balance. All of which bears directly upon how we think about the origins, features, and boundaries of personal identity, and provide new ways to interpret transpersonal ways of knowing, being, and becoming. This formerly missing science can shed new light upon the "boundaries" of identity, the cyclic cause and effect pattern of human behavior, the nature of "unconscious" processes, "collective" group dynamics, paranormal, and spiritual experiences. It can help us reframe the psychological concepts of order and disorder, as well as help us understand the role of bi-directional processing pathways, evident in conditioned attitudes, habits, immune responses, placebo (Lidstone, de la Fuente-Fernandez, & Stoessl, 2005) and nocebo responses (Hahn, 1997) in health and healing.

My hope with this chapter is that these underlying complexity dynamics can help forge a biological bridge to the social sciences, one that can help do justice to the proposal of fractal geometry as a fruitful interpretive paradigm for transpersonal psychology. For the sake of brevity, I will emphasize four of Marks-Tarlow's suggested epistemological principles, locating them within the paradigm of self-organization, in evolutionary theory, in the context of our common emotional biology and its self-regulatory imperative. I will draw connections between these principles, noting the key common feature of *feedback dynamics* and how they undergird in-forming processes in complex systems—how they serve now as informational *emotional algorithms*, the primary rules driving nature's basic control processes. I will also point out parallels to the offerings of other contributors, in hopes of helping sketch the most coherent yet multi-dimensional big picture potential of this new approach.

The first principle relates to how the fractal paradigm provides quantitative methods for *revealing patterns in nature*. To address this, I offer a general overview of systems thinking to illustrate how fractals exist as ubiquitous *structures* in nature (patterns, events, and objects) as well as *functional processes*—the cyclic, iterative, pattern-forming dynamics themselves that give rise to those structures. The process aspect of fractal patterning is where we encounter *cybernetic feedback control* mechanisms, those that deliver the most vital life-giving order, and undergird the deepest behavioral aspects of human nature.

The second principle concerns how the fractal paradigm can help elucidate the *key structural features of subjective experience*; by factoring in the implications for the experiencing subject—the self, and how cybernetic-control mechanisms instantiate the first-enactive loop of mind. Most particularly, I will emphasize how emotional experiences serve as feedback signals that are central to our own physical and mental self-organization and our ongoing self-balancing act. The addition of this new science can help distinguish the domains of aware, engaged, active ("conscious") experience from those considered to be "unconscious," hardwired in-forming and control processes, memory stores, and enfolded identity potentials.

Third, I will address how fractal insights can help model and interpret *paradoxical [binary] logic*, one that relates to the Yin/Yang dance of opposites in self-organizing systems. Most particularly nature has harnessed the edge-of-chaos balancing dynamic, and it offers each living mind an elegant self-regulatory logic—nature's "simple rules"—via the experience of pleasure and pain. This is an evaluative logic that has long been missing from science but is to be found across the great religious traditions—manifesting both as universally beneficial spiritual wisdom and as destructive religious dogma. This evaluative logic provides the evolutionary missing link for understanding the now multi-tiered information encoded within our complex human emotional sensory signals. This emotional information is essential to understanding the human psyche, with its shape-shifting boundaries, its spiritual impulses, its ongoing stability despite its creative flexibility, and our active role in the optimal developmental unfolding of our innate potentials.

Finally, I will offer some thoughts on the deeper implications of a fourth of Marks-Tarlow's principles, how fractal paradigm illustrates *observer dependence*. While speculative, this aspect of the fractal paradigm offers some intriguing conjectures concerning the enigmatic role of the relative-participant observer in quantum mechanics, as the smallest scale, physical manifestation of the process of self-organization. Considering the observing "self" in this manner might help lend meaning to any deeper or more enduring aspects of the human identity, those often associated with mystical transpersonal experiences but remain shrouded within religious trappings.

Section 1: Revealing natural patterns in time, structures in space, and functions in self

Overview, self-organizing systems: "Fractals" as verbs and nouns

To begin, nonlinear dynamics—the mathematics of complexity—emerged to address the chaotic, nonlinear, complexities in nature (those that traditional linear equations could only approximate). As major branches of this new math, both fractal geometry and chaos theory offered better ways to model the staggering complexity and pattern-forming capacities of interconnected and interdependent components of self-organizing networks. Solutions to nonlinear equations resulted not in quantitative formulas but in visual shapes, qualitative patterns traced by a computer—visual descriptions of a system's complex behavior. They embodied "the more general shift toward systems thinking in science: from objects to relationships, from measuring to mapping, from quantity to quality" (Capra & Luisi, 2014, pp. 98-99).

For our purposes here, fractals model both *function* and *form*. They are images of both process and structure, at once both verbs and nouns. A central functional tenet from complexity science concerns ongoing, reciprocally generative, dynamics between *parts and whole*s in any given system. Structurally, self-organizing systems operate both as networks and as nested hierarchies at all levels of scale, structures with horizontal, vertical, and fractal dimensions—a fractal structure. Dynamic, often recursive, activity drives emergence as local parts interact to give rise to higher level global wholes. These newly emergent wholes then *feed back* down upon those parts, acting as expanded systemic boundaries that both enable and constrain the ordered behavior of the parts that gave rise to them. One example would be how interacting molecules give rise to cells, and interacting cells give rise to tissues, organs and organ systems that then feed back chemical signals that help regulate the cellular and molecular activity.

Another functional tenet is that the parts *behave responsively.* They have the ability to respond to environmental stimuli by altering their personal states (switching between on, off, connect, disconnect, approach, or avoidance). This local self-organizing behavior is driven by simple rules that rely only upon knowledge of nearest neighbor states, without the need for any awareness of the higher whole. But these simple generic rules yield *critical states of balance* across all levels of a self-organizing system –states on the "edge of chaos" (Langton, 1990; Kauffman, 1993) that facilitate emergent properties such as information processing, collective behavior, and perhaps even the emergence of life itself (Vattay, Salahub, Csabai, Nassimi, & Kauffman, 2015). The statistical signature of these dynamics shows up as *power law distributions* rather than the normative Gaussian Curves used in the social sciences.

In the most abstract sense, these implicit rules and self-balancing processes are mathematically modelled by fractal geometry—often networks within networks, with connectivity parameters and boundary conditions as key factors. These rules are born of iterative equations, functions with cyclic *feedback,* where solutions are fed back into the next iterative round, the very heart of the "nonlinearity" and "sensitivity" of complex-dynamic systems, hallmarks relevant across disciplines and in social sciences (Eidelson, 1997).

"Positive" and "negative" types of feedback (wherein local changes can be amplified or damped), can alter the overall trajectory of the system such that it can proceed in the same direction of the change or be reversed. In a functional sense, positive and negative feedback loops are related to chaos and order respectively. All of this gives rise to structures with both *horizontal and vertical* functional dynamism, each network a nested, hierarchical, "self-similar" fractal structure, akin to a set of Russian nesting dolls.

In the most concrete sense, these self-organizing rules and dynamics are hardwired within the common biochemical-sensorimotor signaling and control mechanisms, the *self-regulatory activity* at every level of scale in multicellular organisms. These rules are relative to each functional level of "self" bounded in time and space (i.e., atoms, molecules, cells, organs, organ systems)—the interacting parts that, together, comprise the global organism (toad, bird, or human) that moves about and interacts within its external world.

In our fractal-doll metaphor, the horizontal dynamic concerns the relative boundary that demarks *internal from external* (whether it is membrane, epithelial tissue, or skin)—where each doll constitutes a "self" looking out upon its "not-self" world. The vertical dynamic concerns physical communication channels, *bottom-up and top-down* signaling cascades, flows of information, which integrate and consolidate the local information to sustain the global structure—the largest doll in the set. At every level of organization, the common binary rules (on, off, connect, disconnect) guide each local agentic part to restore and maintain its personal edge-of-chaos equilibrium, all of which keeps the global system itself similarly poised on the edge-of-chaos.

In humans, the brain is the highest level "top-down" boundary condition to have emerged, and the "mind" that it houses is the keeper and relative definer of all globally functional boundaries in the dimensions of time, space, and "self." The mind's holdings—all memories, beliefs, feelings, and social schemata—demark the collective self-identity. The brain integrates all the bottom-up (chemical) self-regulatory signals, then feeds back top-down additional identity information (beliefs, thoughts, feelings), which both constrains and enables the entire mind-body gestalt.

This bi-directionally has been noted by several other contributors, most centrally in Larry Vandervert's (this volume, chapter thirteen) discussion of the crucial role of the cerebellum in "constant optimization and automation of movement, and cognitive and emotional processing" (p. 407). His elegant offering emphasizes the missing behavioral aspects of emotional qualia, and how the prefrontal cortex's skillful manipulation of symbols and ideas is rooted in the much deeper bottom-up mechanisms of optimal-motor control, with its own "internal logic." Vandervert quite presciently links this bottom up logic with Csikszentmihalyi's (1990) concept of flow in optimal experience (see Figure 5-1). The flow model captures the mind's competence gap between the perceived challenge level and skill level, and how the emotional responses both push us with pain and pull us with pleasure toward the optimal, just right, creative-flow channel.

Indeed, the concept of flow involves both the hedonic valence (with its bottom-up logic balancing stability and change), and the most cognitively enriched, top-down, level of meaning encoded in complex feelings of anxiety (if challenge far exceed skill) or boredom (if skill far exceeds challenge). Descriptions of the experience of flow also capture how the loss of the ego-self during positive feelings of flow connotes developmental expansion of the mindscape's identity boundaries, which predicts higher levels of personal confidence and courage instead of anxiety in the face of future novel challenges.

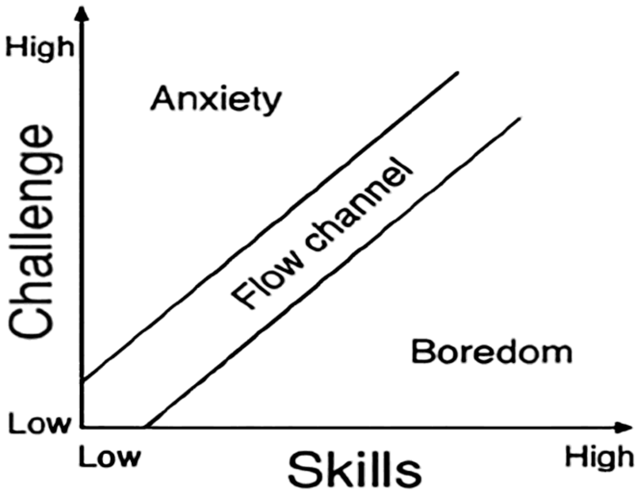

Figure 5-1. The flow channel of optimal experience. (Adapted from Csikszentmihalyi, 1990)

Vandervert also discusses how the crucial role of the cerebellum extends to "Maslow's farthest reaches of human nature"—to which I would add his *needs hierarchy* as well (Maslow, 1954). In this new view, the suite of innate universal-human needs and how they are motivationally prioritized is intimately related to the bottom-up self-regulatory evaluative logic of pleasure and pain, as well as the appraisal themes carried within the basic and complex (top-down) feeling perceptions (Peil, 2012). Indeed, Lamarck speculated long ago that the "felt needs" of organisms drove behaviors that played some role in evolution, and with what we now know about epigenetic inheritance and phenotypical development, it is clear that he deserves far more credit than history has delivered.

Section 2: Informing the key structure of subjective experience

The implications of our Russian nesting-doll metaphor bring us to the second key offering of the fractal paradigm, concerning the origins and structure of subjective–phenomenological experience. Again, I am choosing the word *sentience* in order to bracket the hard problem of consciousness, while recasting conscious awareness and subconscious processes in a new light.

Emotional sentience as ancient feedback signals

At every level within a self-organizing system, the common self-regulatory task is to mediate the optimal balance between *internal and external* realms—between "self" and the "not-self" environment, in order to maintain flexible boundaries (in both time and space) in the face of ongoing change. In living systems, this includes exploiting beneficial chaotic changes and minimizing damaging ones. In this context, hedonic qualia emerge as self-regulatory feedback signals, encoding simple rules that mediate the part-to-whole relationship within the self-system, aimed at regaining one's own local balance in the face of destabilizing change.

In terms of evolution, in this new view, the qualitative structure of subjective experience begins with hedonic, or emotional qualia. While we pretend that animals have neither subjective experience nor sense of self beyond "instinct," there would have been tremendous selection pressure for the ability of a living system to sense itself in its world, evaluate, and respond to its environment—these functional "self-regulatory" services all provided by emotional qualia.

Accordingly, our innate propensity for selfishness is neither due to "selfish genes" (Dawkins, 1989) nor original sin, but to a self-regulating genome constantly interacting within its local (physical and social) environment and adapting itself accordingly. In other words, within the paradigm of self-organization, the "self" as the fractal self-regulating agent—which is structurally an inseparable part and whole (an electron within a carbon atom, an amino acid within a DNA sequence, a gene within a genome, a genome within an organism, an organism within its external environment)—is a more primary and fundamental unit of evolution than the gene.

The very concept of "self" then is *relative*, an identity construct defined at any structural level of scale only by its own local *functional* boundaries in time and space. While such identity boundaries are demarked arbitrarily by any external observer (i.e., a physicist, chemist, biologist, evolutionary psychologist, or natural philosopher), in living systems they are functionally defined, mediated directly, expanded, and contracted adaptively by our self-regulatory emotional sense. Indeed, to the ecologically and ethologically minded post-postmodern natural philosopher, the biophysics of emotional processes suggest the more accurate Cartesian Cogito to be: "Sentio ergo sum!"—'I *feel* therefore I am!" (Peil, 2012).

Value and character in evolution

I'll note here that in ordinary parlance (e.g., Merriam-Webster Dictionary, 2006), the root "quality" in the word connotes *essential character* as well as its *value* (degree of excellence)—both of which are offered within the evaluative (feel good, feel bad) and self-relevant nature of emotional qualia. The ultimate value is physical health and well-being of the organism—the universal value system across all living creatures. This is arguably the only biologically legitimate source for evaluative words such as good, bad, right, or wrong—a crucial tether should we hope to avoid the dead-end fate of post-modern cultural relativism. Indeed, emotional qualia inform us of right states of balance, how to right ourselves to winds of change, and how to stay upon an optimal "right track" of holistic-personal well-being.

Here is where evolutionary theory intersects with moral and spiritual notions of good and evil, of divine virtue and original sin. To factor in the ubiquity and function of emotional qualia is to expand evolutionary theory to here-and-now scales of space and time. It is to honor the non-random, deliberate actions of creatures themselves that have long since been left out of the Neo-Darwinian paradigm (Diogo, 2017). Selection is ongoing, with adaptive fitness increasing or decreasing depending upon whether these agentic actions are right (optimal) or wrong (deficient) in terms of self-regulatory adaptation. Individual fitness is relative to the extent to which any given organism can accurately perceive and respond to its "felt needs" (Lamarck, 1809/2011)—its organic evaluative feedback signals. In fact, Darwin himself noted the fundamental regulatory dynamics at play in animals (Darwin, 1872/2005), capturing the functions of positive and negative feedback long before the concepts and language of cybernetics emerged (Peil, 2014). Both brain structure and animal behavior lend evidence to the ever-increasing complexity of emotional-sensory signals as we ascend the evolutionary ladder. Such observations suggest that most basic and even some socially complex emotions may be present as early as mammals (Panksepp, 2005), and that our fellow primates exhibit the rudiments of moral reasoning (DeWall, 2006, 2009; DeWaal & DeWaal, 1996), cognitive qualities formerly thought to be exclusively human.

Of course, these more complex emotional perceptions and the actively adaptive behavior they drive, are merely the latest top-down evolutionary enhancements to our bi-directional self-regulatory circuitry, forged upon the original bottom-up whole-body neural and cellular chemical regulatory activity. But as such, the original concept of "adaptation" (as largely a random, accidentally advantageous, genetic mutation) has expanded to run the full body-mind gamut from adaptive immunity, to epigenetic inheritance systems, to neural development, deliberate learning, overt social behavior, cultural creation, and mindful-personal growth. This is where the unique *mind* itself is an individual's *epigenetic phenotype*, the oft ignored *developmental diversity* in the statistical tails of our Bell Curve statistics that privilege populations and survival of genotypes.

In short, the fractal framework allows us to wed the dynamics of self-organization with evolutionary theory, acknowledging the self as the fundamental unit of evolution, and once both part and whole. It allows us to infuse our central-biological story with universal value, yet making evolution personal, honoring the necessary subjectivity, fluidity, flexibility, interweaving, and individual mediation of ever-shifting boundaries in space and time. As such, it helps us to conceptually rethink what we mean by psychological order and disorder, spiritual virtue and human evil, the personal, social and transpersonal domains, to reunite body with mind—even to recast mind itself in wholly new terms.

Of minds, brains and membranes: The three-step control loop

In this new view, the chemistry that gave rise to sentience preceded and still undergirds the neural systems and structures thought to be necessary and sufficient for "cognition." While it honors the unique functions of those later emergent enhancements, it is concordant with the autopoietic "self-making" and "enacted cognition" set forth by Maturana and Varela (1991), also known as the 4-E Mind model (Varela, Thompson, & Rosch, 1991; Rowlands, 2010).

In their story, the mind begins as an interactive and participatory *process*, born of ongoing cyclic, cybernetic, interactions between the living organism and its external world. The mind then is fully *embodied* in the organic structure and chemical processes of living tissue; it is inextricably *embedded* within its local time-space environment; it is constantly *enacted* by the actions and choices of the living agent; and it is *extended* via adaptive learning, mindful development, and niche expansion (which in humans includes all cultural ideology and social structures). But the new emotion science adds a fifth E to the 4E model, *evaluative*, as it is the doubled-barreled hedonic qualia, the embodied-emotional sensations—the good and bad feelings—that run the entire show (Peil Kauffman, 2017a).

Indeed, the 5E model of mind is not to be taken as mere metaphor. It fits cleanly into both the Lamarckian and Darwinian evolutionary stories, fortifying the bridge to the social sciences—at present a decaying scaffold forged by early evolutionary psychologists. In that old story, agency, emotions, and even the human mind play little if any role in evolution and are potentially maladaptive due to the "mismatch" between modern and ancestral environments (e.g., Tooby & Cosmides, 2000). This assumption dead-ends psychologists in the ubiquitous "dual process theories" (Barrett, Tugade, & Engle, 2004; Evans, 1984; Kahneman, 2003; Petty & Caciappo, 1986), wherein bottom-up and top-down information processing paths are in competitive conflict, including pitting reason against emotion. Plus, the new model honors the early chemistry upon which evolution forged the higher-neural structures, itself the bridge between emergence, self-organization, and direct-participatory self-regulation.

The 5E mind is functionally instantiated on cellular membranes long before the emergence of neural structures and complex brains and is still evidenced in creatures are simple as the E coli bacterium (Peil, 2014). Specifically, this is a three-step iterative loop, driven by a coupling of functionally positive (amplifying/blocking) and negative (regulatory) feedback processes likened to a thermostat, the same cybernetic principles utilized by engineers to control everything from thermostats, to guided missiles, to the artificially intelligent behavior of robots. The first step is 1) an ongoing *comparison* between the self and the not-self (outside world), which is instantiated by the structure of the transmembrane receptor complex (with outside heads and inside tails); 2): a *signal* is sent when imbalances occur, which; 3) triggers a *corrective response,* one that is also *fed back* into the next *comparison* (step 1 round 2)—leaving a *memory trac*e—as the recursive cycle iterates on and on.

This elegant loop of mind implies that the inaugural structure of subjective experience can be envisioned something like the following: …Q...Q…Q...Q...Q…Q (with the "Q" the feedback loop and the "..." the elapse of time between self-relevant emotional-sensory perceptions). Over eons of evolution, the time between the original loops increased substantially as neural structures emerged, and with evermore time between them came evermore perceptual awareness and the complex cognition that we associate with the conscious human mind. But the original loops—though receding into the "subconscious"—remain hard at work, erupting into consciousness only as emotions, and laden with bottom-up information.

This iterative-control loop is the functional precursor to the *action-perception cycle* mentioned by Fred Abraham (this volume, chapter six) in his discussion of neural dynamics, and (I suspect) it relates also to Wundt's inverted-U arousal function. This new view however honors the bidirectional nature of the fractal structure and reconciles the lingering question of primacy (a debate, to my mind, settled by Robert Zajonc, 1984). With this resolution, Zajonc gave the primary bottom-up affective signaling its rightful due, wherein raw-corporeal sensation rather than top-down cognitive-intention initiates perception (see Lewis, 2005, for an excellent analysis of the neurodynamics of emotion, noting three loops in the brain that now deliver the original three-step cycle). Likewise, noting the ancient roots within hedonic qualia as system-wide self-balancing feedback signals, allows us to reframe many psychological concepts (i.e., dual process theories, balance theories, conflict theories) and terms like "cognitive dissonance" (Festinger, 1959) within the paradigm of biophysical self-regulation— giving primary *emotional dissonance* its rightful due.

The key point is that *hedonic qualia* are central to each step of the enactive loop of mind, providing the signal, the behavioral response, and the evaluative memory—three functions for the price of one. In short, emotional qualia emerged with life itself, its binary logic still central to cellular signaling and on/off switching in genetic, epigenetic, and immune regulatory processes of all multicellular creatures. Feeling experiences remain our inroad to these bottom-up (body-to-mind) regulatory processes, as well as the top-down (mind-to-body) informational effects of our thoughts, beliefs, and actions choices. In terms of transpersonal psychology, this bears directly upon the notions of unconscious or subconscious processes, and potential separation or conflict between what should be smooth and integrated bidirectional-circular causality. The conscious mind plays a deliberate role that can dramatically enhance optimality in both physical stability and mental/spiritual development, or it can get in the way and interfere self-destructively.

The five-step human action cycle

Indeed, what began as a little three-step cybernetic loop moving the body in time and space with relatively little mindful awareness (yet literally in-forming the inaugural mind), has long since expanded into the following *five-step* human action cycle (see Figure 5-2). This has added three-new feed-forward (top-down) enhancements and two-new levels of self-regulatory information via the basic and complex emotions, while affording the creature ever more cognitive engagement and willful-behavioral control.

In this modern-iterative loop, both mind and body have specific self-regulatory roles, those that further bear upon our classifications of conscious and subconscious aspects of the human psyche.

Since evolution conserves and builds upon what works, steps four and five still constitute the original role of hedonic qualia, providing the bodily *evaluation* (the feedback signal that the systems is out of balance) and its coupled *corrective response* (to restore balance). These two steps are hardwired and explain why our hedonic-behavioral drivers can still get the best of us—particularly if the mind remains out of the loop, allowing emotional messages to pile up, unopened and unresolved. This is how we can remain limited to the lower range of our spectrum of emotional intelligence, driven by simplistic approach and avoidance instincts ultimately controlled by external social punishments and rewards—a secondary level of self-regulation that is largely untethered from our primary emotional imperatives. This aspect of our emotional self-regulation operates largely subconsciously, yet our aversive-painful feelings are always available to consciousness should we choose to admit and deal with them optimally.

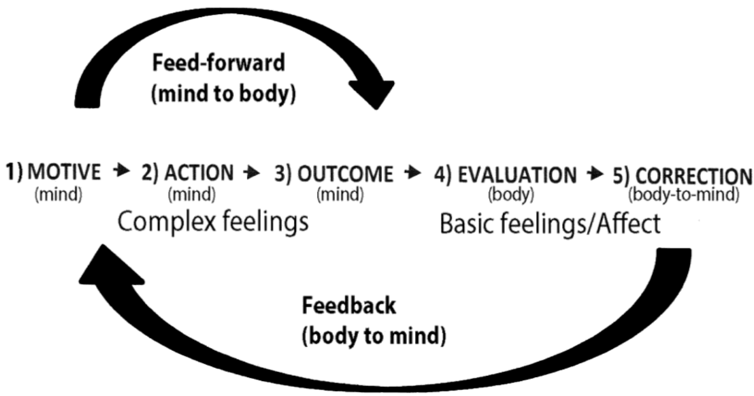

Figure 5-2. Modern feedback cycle with feedforward cognitive elaborations and complex feelings. (From Peil, 2012, 2014)

Indeed, painful emotions and their avoidant responses are our self-regulatory safeguards, attempting to save us from our own mindless, uninformed, limited, and self-destructive habits of thought and action. In fact, as psychologists are aware, the human mind can even quite literally misperceive the *outcomes* of our own actions (Peil, 2012). This is why the emotional evaluation erupts into consciousness, as upheavals in our thought process (Nussbaum, 2001) calling the mind's attention to a good or bad outcome. Likewise, the corrective response feeds back into the mindscape by way of Pavlovian conditioning, leaving its evaluative wisdom readily available should the mind ever choose to attend and unpack it.

To the degree that the mind can decipher and integrate the *informational component* of emotional-sensory signals into its schematic knowledge, beliefs, and *motivational* and *actions* strategies, the mind continues to learn, and improve through trial and error, to build competence and expand its boundaries (both empathic identity boundaries and those of one's sociocultural niche). With this comes the freedom, self-empowerment and liberation from the hardwired-behavioral safeguards—all of which reflect optimal physical, mental, and spiritual self-development, and resonate with such complex-positive emotions as confidence, courage, trust, gratitude, respect, loyalty, compassion, and so forth. In fact, this optimal trajectory is also marked by the reduced recurrence of the most complex negative emotions (anxiety, shame, mistrust, worry, resentment, contempt, hate)—those which continue to offer feedback signals about the quality of our mindscape -- ultimately, to shout about ongoing and long-term dysfunctions, and hopefully discouraging us from a self-destructive, wrong-track life trajectory (Peil, 2012).

In sum, our self-regulatory-emotional biology employs these ancient self-organizing pattern-forming principles to not only structure our emotional, cognitive, and behavioral experiences, but to forge the mind—and human identity—itself. No small gift of nature.

Section 3: Informing the binary, paradoxical, nature of experience

Implicit in the discussion so far has been the *binary nature* of emotional qualia. As Mandelbrot (1977) argued, the laws that govern the creation of fractals seem to be abundant in the natural world. Mathematics is brimming with operational binaries also (+/-; ×/÷; 0/1, toward 0 or ∞, etc.), as are physical laws and patterns at all levels of scale (up/down spins, positive/negative charge, magnetic attraction/repulsion, dynamic attractors and repellors, on/off genetic switching, and neural firing, etc.). Through the lens of Fractal Geometry, our emotional biology suggests that the fundamental binaries within hedonic sensations provide an experiential inroad to a functional *self-regulatory logic*. This is a logic driven by deeper physical (self-organizing) binary complements that give rise to many meaningful paradoxes in human experience, if not to subjectivity itself (Peil Kauffman, 2015).

In fact, quantum physicist Neils Bohr wondered if there were binary complements in biology like those in physics (Theise & Kafatos, 2013), and this new science of emotion answers with a resounding "yes!" We have already seen how the fractal paradigm comfortably houses such polar opposites as chaos and order, positive and negative feedback, self and not-self boundary distinctions, good and bad feelings, and approach or avoidance behavior, as well as the relative dimensions of internal and external, up above and down below, and of parts and wholes. Now we can get more specific.

Nature's yes/no evaluative logic of the immune system

Our double-barreled emotional qualia speak the level-independent language of self-similar fractal structures, the binary self-organizing dance of parts and wholes, of chaos and order—the in-between realm modelled so elegantly by interpenetrating-fractal boundaries between the external and the internal realms. In Marks-Tarlow's words: the "subjective feeling of fuzzy boundaries and infinite extension… the complete interpenetration of inside and outside realms" (this volume, p. 35). Evaluative feelings call our immediate attention to moments of chaotic change, dissonance at the overlap between self and not-self, move us to re-balance, keep us poised on the "edge-of-chaos" between rigid stability and overly chaotic change. Evaluative pleasure and pain inform and teach us, shouting "Yes!" to the optimal kinds of creative chaos, and a resounding "No!" to changes that will degrade the stability of the physical form and the subjective coherence of personal identity.

It is likely that this ultimate yes/no evaluative logic is rooted in an early Pangea-like structural unity between the functions of *sensory-motor control* and *adaptive immunity* (both driven by the 3-step loop of mind, although later diverging and complexifying into the nervous and immune systems respectively). Their binary, self-regulatory logic now shows up in the psychological arena as the "eustress and distress" signals of Selye's (1957) stress model, as well as in all learning processes as the unconditioned stimulus-response pair in Pavlovian conditioning, in feed-forward motivation, attitude formation, and in social reward and punishment. It also shows up in Gibson's (1982) "perception" of environmental "affordances" (things that are potentially harmful or beneficial—but highly relative to the subjective observer). The self-regulatory logic still undergirds all "action impulses"

(Frijda, 1988), animal drives, and human motivations (Bolles, 1991), as well as all evaluative semantic components of language. Pleasure and pain are arguably among the deepest and most meaningful, yet paradoxical, binaries of the human experience, rippling upward to inform many of our enduring spiritual and religious assumptions and practices.

Binaries, balances, and religious wisdom

Acknowledging the binary dance of opposites at work in nature has long been a theme in Eastern religion, most particularly in Taoism. The word Tao literally means "the way"—the ultimate creative principle that gives rise to and nourishes everything in the cosmos. The Tao as a spiritual process also captures our alignment with its cycles and flows in time, its Yin/Yang polarities, and the balancing dynamics that allows us to cope with the hardships and uncertainties of life—much of which bubbles up from our emotional biology.

Our emotional biology is also captured in the wisdom from Buddhism. We are told that: 1) All suffering flows from craving and aversion; 2) That our minds are the main source of our own fulfillment and happiness, as well as our emptiness and despair; 3) That awakening involves the spiritual practice of Dharma, the constant inner struggle of "replacing previous negative conditioning or habituation with new positive conditioning" (Dalai Lama & Cutler, 1998). This includes: 4) Contemplative transcendence of "the self" (its egoistic limits); and 5) Our actively intentional alignment with the "right" ways of being and becoming. Likewise, Confucius believed that human beings are individuals in relationship with the universe whose sole purpose is to maintain harmony. Systems science of course has helped put flesh on the bones of these time-honored Eastern ideas, culminating in the identification of the self-regulatory function of emotion.

This new emotion science also illuminates the resonant-spiritual values and moral standards that ripple across the great Western (Abrahamic) traditions of Judaism, Christianity, and Islam. It opens wide the broad overlapping frontiers of human spirituality where East has long co-mingled with West. Indeed, as we systematically filter away the superfluous dogma and causal misassumption from religious traditions the world over, what we find is the perennial *wisdom of the heart*—that all remaining divine processes and "fruits of spirit" are associated with optimal self-regulation and such complex positive emotions as courage, gratitude, devotion, faith, love, and compassion. It is these desirous feelings that mark our biological teleological trajectory, toward a personalized yet universal True North of meaning, virtue, cooperative success, and healthy, eudemonic, authentic (Seligman, 2002), and mature happiness (Wong, 2011).

However, there have also been some pre-emptive mistakes offered from both Western and Eastern religion that have obscured the actual biological information offered by our emotional experiences—the evolutionary logic encoded in binary pleasure and pain. Such mistakes have given rise to some underlying, yet limited, assumptions still carried within the accepted tenets of our psychological theories and traditions. Most particularly, our hedonic feelings and behaviors have been associated with *spiritual deficiency* and the concept of "original sin"—if not "evil" itself. While largely due to the misunderstood safeguarding functions of the negative emotions, this undermines (and in some cases negates) the biologically based value system and justifies displacing internal regulatory authority to outside intermediaries (religious, legal or otherwise), usurping —if not negating—the innate self-regulatory authority.

Indeed, as it concerns emotional pain, we have long been blaming the messenger, while remaining oblivious to its informative messages. To the degree that individuals have internalized the misassumption of inborn sin as part of their human identity, they have placed themselves in an unnecessarily schizoid double-bind situation, one that predicts a dysfunctional, self-effacing, self-negating variety of paradoxical experiences, not to mention serving as an excuse for immature, unbecoming, unregulated, self-destructive behavior.

In short, while there are indeed deep-binary principles involved in self-organizing dynamics, not all binaries are created equal. In this new view the *good and evil* dichotomy is a false-cultural construct rooted in a misunderstanding of the evaluative meaning in pleasure and pain, and how *they work together to regulate the self*. We have been told to equate selfish with bad and evil, and self-less with good and virtuous, when in fact biologically both represent unbalanced states.

Binaries and evolutionary logic

We have already mentioned the universal yes/no evaluative logic that is rooted in the health and well-being of the organism, the proximate reason why we are hardwired to feel emotional distress and eustress, and to learn the hard way via Pavlovian punishment and reward. But there are two more foundational-biological binaries mediated by pleasure and pain, the ultimate evolutionary binaries that can help disentangle us from the misguided socially dysfunctional notions of good and evil.

The first concerns the fractal nature of the self, wherein the self is both part and whole. What this means is that the ultimate, bottom-up chemically instantiated identity of a living system has both *individual* and *collective* aspects. In fact, just as we can observe hedonic behavior across all living systems, we can also witness both "*me"* and *"we" identity states* that elicit *autonomous* and *social* regimes of behavior, respectively. We see this not only in social species (from mammals on up) but in the cooperative and competitive social behaviors of reptiles, birds, fish, insects, and even bacteria.

In fact, the phenomenon of "quorum sensing" (Bassler, 1999) in bacteria uses the same ligand receptor signaling mechanism as that of sensory-motor control. Quorum sensing is how bacteria identify, communicate, and cooperate with members of their own species, how they talk to each other and coordinate collective action in defensive or aggressive action (such as against antibiotics or other bacterial species). But bacteria also use other (slightly fancier) peptides that serve as auto-immune markers for "self" across members of a given species. When enough of "we" is present in the environment, individuals switch into cooperative-communal mode. This implies that the dual aspects of self-identity have been present since very early on in our evolutionary history. The implication is that me/we identity paradox is mediated by the raw pain and pleasure respectively and undergirds any dichotomous "us/them" patterns of kinship and tribal competition. Unfortunately, together with the good and evil dichotomy, the us/them dynamic provides a central-motivational foundation for much of the dehumanization of our fellow human beings we perpetuate upon one another.

The interpenetrating boundaries of the fractal paradigm offer an intuitive inroad to these biologically deep me/we binaries of identity, allowing us to see how self and other are constantly redefined and mediated directly by first-person positive and negative emotional experiences, and how this drives the third-party punishments and rewards —the social feedback signals—we level upon one another. In terms of developmental psychology (which we will discuss in a moment), the dual identity construct relates to much of the "attachment" phenomena (e.g., Ainsworth, 1978), as well as to an optimal development of the "we" identity that empathically expands over time, in ever broader circles as Peter Singer (2011) suggests. This bears directly upon our moral notion of selfishness and selflessness.

The ultimate evolutionary logic: Dual self-regulatory purposes

The good news is that although science has long remained silent on values (while religion remained stymied by the problem of "evil"), Neils Bohr saw a bigger picture. Bohr (1933) emphasized the uniqueness of life in terms of organization (structure) and teleological purposefulness (function), noting the binary complementarity between *self-preservation* and *self-generation*. Had Bohr been privy to the fractal paradigm, he may have further reframed functional teleology in the context of dynamical "attractors" and "repellors" in "state space"—the idea that, due to the collective behavior of parts in a self-organizing system, the trajectory of the entire system flows toward some locations in the global whole and away from others.

But Bohr was prescient, for ultimately pleasure and pain undergird two "right and good" self-regulatory imperatives, or self-organizing attractors —*purposes*—if you will, very similar to those he proposed. These are two purposes implicit in the logic of natural selection, which have never been given their proper due. Their complementary purposes that have remained shrouded within muddled, supernatural, and biologically unjustifiable notions of good and evil. These binary functions are related directly to chaos and order, being and becoming, pain and pleasure, central to decoding and deciphering the rich informational content delivered by our complex emotional perceptions. They are the underlying Darwinian algorithms that give rise to all higher-level binary meaning:

The first imperative is self-preservation of the body proper in the immediate environment (Darwinian "survival" plus plenty of self-regulatory nuance). It includes the autopoietic beginnings, the self-making, and orderly self-regulatory activity required to sustain a complex-adaptive system "far from equilibrium"—living systems resisting the inevitable fate of entropic death. Since "the self" is the very unit of the self-organizing process, self-preservation is a top, primary, and non-negotiable self-regulatory priority. It should be no surprise then that the "me identity" will always eclipse the "we identity" if it is violated, compromised, or excessively limited by oppressive social constraints.

Indeed, the self-preservative imperative is mediated largely by pain and the *basic negative emotions*, our distress signals of *sadness, fear, disgust, and anger* and their coupled autopilot fight and flight defenses and competitive-social behavior. Their appraisal themes (*loss, danger, contamination, and obstacles to agency*, respectively) link them directly to Maslow's (1954) top-priority needs for physiological well-being and psychological safety, adding in the autonomy, liberty, personal empowerment, and healthy social boundaries required of a self-regulating organism. Such themes can be found across the psychological literature, in discussions of the role and development of affect (Carver & Scheier, 1990, 1998, 2011; Hollinger, 2008; Tomkins, 1984). Ultimately self-preservation is about retaining long-term stability in the face of ongoing chaotic change.

The second imperative is that of *ongoing self-development*, which largely concerns *adaptation of the mind and one's social sphere*. But, as Bohr suggested, it also concerns the ongoing and creative aspects of self-generative growth, reflecting what we now know to be the *epigenetic* aspects of development. It is rooted in exploiting the opportunistic benefits of chaos for optimal growth, without compromising long-term stability. To the conscious human, the self-developmental imperative is about building optimal schemata, empathic-social connections, and participating in cooperative-creative culture It is largely mediated by *basic joy*, the approach mode of behavior, cooperative social connection, and the complex-positive emotions.

Purposive, right responses to emotional stimulus

Optimal self-development is about utilizing all available emotional sensory information to choose "right responses" (Peil, 2012), the mindful alternatives to hardwired fight-and-flight reactions. But they are not about "being right" in any morally prescriptive sense. They are about rebalancing, regaining alignment with our environment, "righting ourselves" in response to every emotional event like a captain would right his sailboat to winds of change. "Right" responses are deliberate-action strategies that change either the *internal environment*—our minds, through *deliberate learning*—or the *external* environment, our worlds through *communication* (use of language) and *creative self-expression* (e.g., "work," building and improving culture). Both develop and expand the self—our top evolutionary priority these days.

Without officially acknowledging it, we have been using these "right" responses all along, for kinder, gentler and more personally accountable and socially amenable ways of maintaining long-term balance and well-being. We have adopted them because they feel better, lower our stress levels, and deliver better health, happiness, and social cohesion than simply fighting or running away. In fact, our emotional dynamics suggest that our first go-to response should be a*ctive learning*: inquiry, seeking out new information, observing, listening, assimilating and accommodating new schemata into the mindscape. If, despite such ongoing efforts, the same painful signals keep emerging under similar circumstances, then our second go-to would be *communication and creative expressions* that advocate for and build a more open, enriched, and opportunistic environment.

While these kinds of responses should cover the lion's share of all painful events, when they remain insufficient, nonviolent versions of the fight and flight responses may become necessary. They are appropriate when biologically non-negotiable needs remain unmet and inviolable personal boundaries are breached. They move us to temporarily disconnect, to contract and defend our boundaries, to honor our rightful sense of equitable human dignity, opportunity, and justice.

However, our bodily defensive responses are not appropriate should they extend to preserving the boundaries of *a limited mind*—the familiar ego defenses universally decried in most religious traditions. The natural penalty for preserving instead of developing a limited mindscape is the emergence of evermore complex negative-emotional experiences—the self-made distress of human suffering. For if we fail to honor the messages contained in our pain, we are vulnerable to the more wrong-track, self-destructive trajectory, with the amount of complex suffering commensurate with the degree that nature is selecting against us.

Indeed, the right or wrong nature of response to self-relevant emotional events is where the revelations from our emotional biology reconnect with abnormal, personality, humanistic, and "positive" psychology (Seligman & Csikszentmihalyi, 2000), as well as with specific cognitive, psychosocial, moral, spiritual, and developmental-stage models offered historically (i.e., Erickson, 1968; Fowler, 1991; Gilligan, 1993; Kohlberg, 1967; Piaget, 1952). The optimal right-track trajectory is punctuated (as Erickson implied) by the stage-like emergence of a predominance of the complex positive emotions (rather than complex negative ones), such as: trust versus mistrust; confidence versus shame/doubt; gratitude versus resentment; admiration versus envy; humility and pride versus arrogance; and forgiveness/compassion versus dehumanizing contempt/hatred (Peil, 2012). Fowler's (1991) model of spiritual development is particularly poignant in that "personal accountability" (e.g., optimal self-regulation) is a major transition. Higher still is the "resolution of paradox" (e.g., decoding the many layers of binary logic mentioned), before culminating in the final stage of "universality," also as our emotional guidance implies.

The key point is that pleasure and pain work together, united in helping us to expand and contract our identity boundaries, connecting with our social others (honoring the we-self) in optimally collective social wholes, yet disconnecting if our health, individuality or autonomy (the me-self) are compromised. The natural outcome of mining the information within our emotional perceptions and responding accordingly, is that we stay on the right track of ongoing development, fulfilling a third imperative of *self-actualization* of all innate genetic, if not quantum, potentials—which I turn to shortly.

The multi-dimensional nature of the self being regulated

In sum, these binaries, these dancing, paradoxical opposites, inherent in the natural self-organizing dynamics of matter in motion, show up in human experience, reflecting the "self-regulatory" function of emotional sentience. Self-regulation is a function now ranging from the early auto-poetic self-making to the now complex functions of balancing, unification, preservation, development, and actualization of all aspects and potentials of a human self-identity—body, mind, and whatever else may ultimately exist.

Indeed, acknowledging both the animating and guiding functions delivered by the emotional system, from its deep biological roots to its delivery of universal fruits of spirit, gives us new and scientifically supportable ways of thinking about any additional identity components such as *spirit* and *soul* (while helping steer clear of New Age flapdoodle). A definition for "spirit" can begin with the emotional system itself, all the observable-biophysical mechanisms that comprise the life-giving self-regulating process, as the source of the subjective-feeling experiences, the urges and insights it yields. This can honor and contextualize most common uses of the word, while emphasizing its physical, embodied nature (for when those processes stop, death occurs).

"Soul" then can first be used to capture any yet-to-manifest identity *potentials,* as well as a categorical placeholder for any legitimately enduring, transpersonal, or mystical aspects of identity not otherwise covered by the terms body, mind, or spirit. It is a category that honors the rich variety of religious experiences, those that are often accompanied by the most complex and deeply meaningful feelings.

But whether for scientific study or personal enlightenment, it will be the feeling perceptions themselves, both the experiences they yield and the information they carry, which will hint at and guide rigorous and sober inquiry into the multi-dimensional nature of the self. While they have been largely overlooked by science, our complex human-emotional perceptions (trust, mistrust, confidence, shame, admiration, envy, gratitude, resentment, compassion, contempt, love, and hate) now encode *three levels of self-regulatory information*, (the binary logic of hedonic qualia, the universal needs of the basic emotions, the personalizations of the complex feelings)—an evolution of complexity commensurate with the triune structure of the vertebrate brain (MacLean, 1990).

Yet each new level is contingent upon and inseparable from the previous stratum from whence it emerged. Complex emotions (largely associated with "high road" cortical processing—LeDoux, 1989) are the most personal and culturally shaped, yet inseparably dependent upon the lower road limbic centers associated with the universal-basic emotions. All of them are still anchored in cerebellar pathways, and in the whole-body chemistry—including neuropeptides and endocrine hormones known as the "molecules of emotion" (Pert, 1998), which speak the ancient-binary language of affect.

In terms of complex systems, feelings pull triple duty: Their binary qualia and basic appraisals serve as *intrapersonal* evaluative feedback signals (bottom-up internal messages from body to mind about the body in the world and the mind's adaptive schemata). They move us to approach or avoid, to expand or contract, to connect or disconnect in our local social networks. Their complex blends and shades, their empathic resonance and social contagion provide a higher *interpersonal* level of feedback, a language of social judgment, reward or punishment—of accepting, honoring, and bonding or blaming, shaming and shunning. Together, these two levels of feedback provide the personal and the nearest neighbor information, defining the "simple rules" that give rise to complex human behavior.

But their source may go deeper still. This is where the infinite depth of fractal structures—and the concept of "the Self" (with a capital S)—become the most intriguing, where we encounter the hard problem of consciousness, the nature of "the self," and new ways to contrast and distinguish ordinary with altered and mystical states of consciousness. While highly speculative, this line of thinking goes straight to the heart of what it means to be "trans-personal."

Section 4: Fractal measurement illuminates observer dependence

The thermostatic function in the chemical loop of mind is more than mere metaphor, for it is ultimately rooted in the laws of thermodynamics (the conservation, transformations and flows of energy), as well as the electroweak and gravitational forces that dictate the behavior of matter in motion. In fact, all of chemistry is driven by the orderly behaviors of electrons, behavior governed by *quantum mechanics.* When we enter this domain, we encounter the strange and spooky features of the world at the smallest scales of time and space. Here we find boundaries even more interpenetrating, fuzzy, and nebulous, and encounter quantum principles of nonlocality, entanglement, superposition, complementarity, and the enigmatic role of the observer.

Of quantum and classical physics

While physicists do not yet know how to reconcile classical relativity with quantum mechanics, we still find our binary complements, a toehold in this strange land, and the assurance from the fractal paradigm of self-similarity across all levels of scale. One cannot help but wonder: Might there be an ultimately deeper source of the information delivered by emotional sentience? Might the binary language within hedonic qualia, the dynamic balancing act between chaos and stability, go all the way down?

Indeed, the complements in physics that made Neil's Bohr wonder about higher binaries in biology are known as *conjugate variables*. These are the mathematical commonalities across all of physics, undergirding all irreversible processes evident in gravity, fluid dynamics, electromagnetism, as well as quantum mechanics. Conjugate variables are mathematically defined in such a way that they become Fourier transform[3] duals; inseparably paired opposites such as Heisenberg uncertainty relationships, wherein only one can be observed at a time but imbalances in one instantaneously drive changes in the other. These include position and momentum, time and frequency, velocity potential and probability density, and many more—including the very conjugate of energy and time in

[3] The Fourier transform decomposes a function of time (a signal) into the frequencies that make it up, in a way similar to how a musical chord can be expressed as the frequencies (or pitches) of its constituent notes. They are utilized in nonlinear modeling of brain activation by fMRI (Lange & Zeger, 1997).

quantum mechanics. Conjugate variables are also employed in the super-positioned Q-bits[4] of quantum computing to exploit the weirdly wonderful features of the micro-world.

But conceptually, all these conjugate variables boil down to one grandfather duality: How "derivatives of action" reciprocally create "events of differentiation." In other words, at the very bottom, we find the cyclic causal loop between dynamic action and the creation of new events (events which feed back to alter the dynamic action, which creates a new event, and on and on…). Notice that there is no *permanent structure* in this story, only the process of creative change itself. Here we encounter Gregory Bateson's definition of information: "The difference that makes a difference" (Bateson, 1979)—a creative in-forming process not unlike the never-ending dance of Yin/Yang opposites known as the Tao. But it is from among these ever churning, ever-changing "events" that the classical world that we experience somehow emerges. What if, as the fractal paradigm suggests, this in-forming engine of change operates across all levels of scale, part of the causal mechanism on both quantum and classical realms?

Binaries, quantum mechanics, fractals and the complex plane

Perhaps not coincidentally, mathematically, both fractal geometry and quantum mechanics draw upon the *complex plane*—which includes "imaginary numbers." The equation for the Mandelbrot Set itself, $F(z) = Z^2 + C$, forges the exquisite fractal structures by feeding back into itself, squaring its own output solutions, adding with each iteration a new factor (C) that contains both a real and an imaginary component. While imaginary numbers may be nothing more than pure human conventions, the precision and predictability they yield for quantum mechanics seems undisputable—bringing to mind Wigners' (1960) question of "unreasonable effectiveness" of mathematics in the natural sciences.

So, the Platonist in me wonders: What if the complex plane somehow captures the still mysterious process, force, or mechanism that unites and integrates the quantum and classical worlds? What if the granddaddy "derivatives of action" are quantum in nature—possible, imaginary—and its complement the "events of differentiation" are classically actualized and

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[4] Unlike classical computing, quantum computing use something called a "qbit". It is like a bit, but it is in a superposition between "0″ and "1, the analog shades of grey in fuzzy logic (Kosko & Toms, 1993) between the digital black and white of 0 and 1.

"real"? Might this suggest that the ubiquitous dance of complementary opposites might all flow from a deeper interactive dance *between quantum and classical realms* themselves? What might this mean for the experience of human being, thinking, feeling, and doing?

Two ways of knowing?

Following the ideas of physicist David Bohm, Paavo Pylkkanen (2014) suggested that using analogies from quantum mechanical processes can help us understand thought processes and vice versa. He suggested a distinction between *logical* thought processes, which have features of classical physics (fixed and distinct concepts; Aristotelian logical rules) and *general* thought processes, which have more quantum-like features (holistic, unbounded, unpredictable, and creative, to which I would add fuzzy logical rules that allow degrees of superposition between polar opposites).

This echoes Polyani's (1958, 2009) distinction between *explicit* (outer, logical, predictable) and *tacit* (inner, holistic, intuitive, creative) ways of knowing, and much more generally the binary-functional distinctions attributed to the *left* and *right* hemispheres of the human neocortex, respectively—all of which might be Bohr's brand of complementary pairs in the *realm of psychology*. The paradoxical Heisenberg uncertainty relation is captured in Polyani's quip: "We know more than we can say", and in Pylkkanen's: "There might be part of our human being that is simply so holistic and unpredictable that it is difficult to capture in terms of conceptual and logical thought" (Pylkkanen, 2014).

In this view the structure of consciousness depicted on page 14, …Q...Q…Q...Q...Q…Q (with the "Q" the feedback loop and the "..." the elapse of time between self-relevant emotional sensory perceptions), may take on additional meaning. The "Q' of the feedback loop can also now represent the *quantum* contribution to the stream of consciousness, and the "…" of the lapsed time—the *classical*. Perhaps then, mystical, dream, transpersonal and psychotropically induced states of consciousness are more quantum in nature? Might it be that the "towards infinity" direction in the Mandelbrot set is toward the quantum, and the "toward zero"—the classical? Yet all the self-similar action happens at the boundary—where our ongoing dance of opposite ways of knowing taps both the real and the infinitely imaginable.

Might the quantum dimension be something akin to the Platonic realm, existing "between cracks," yet readily available, there for the intuitive taking? While words may fail, the glorious fractal image of Newton's Method offered in Marks-Tarlow's (this volume, Figure 1-12, p. 44) speaks volumes.

New binaries of decoherence and recoherence?

The glorious image of Newton's Method connotes what my husband, Stuart Kauffman, has proposed. Taking Heisenberg's notion of "potentia" seriously, he replaces Descartes Res Cogitans (the mind-stuff that interacts with Res Extensa, the body-stuff) with *Res Potentia*, a realm of ontologically real "quantum possibles" (Kauffman, 2014; Kastner, Kauffman, & Epperson, 2017). This is a fully interpenetrating, unifying, nonlocal realm, tucked everywhere and everywhen within the fractal boundaries of the classical realm.

The proposal includes the notion of *recoherence* as a binary complement to the *decoherence* associated with the classical realm, decoherence being the most well-known attempt to explain the quantum to classical transition. But in addition to simply collapsing to one classical state (e.g., losing the quantum information as decoherence set in), in the presence of recoherence the system has the ability to hover back and forth, poised between both realms, perhaps on the edge-of-chaos (Vattay et al., 2015).

Depicted mathematically on the complex plane, this would be the vertical movement up or down the imaginary (y) axis (see Figure 5-3 below). The higher up the imaginary axis, the more the system is re-cohering into the fluid realm of the quantum possibles, and as it lowers to zero, it decoheres into the classical actuals of our experience. If something like this is actually part of the mechanistic furniture of the universe, it would suggest that living systems are privy to and exploiting both quantum and classical levels of information.

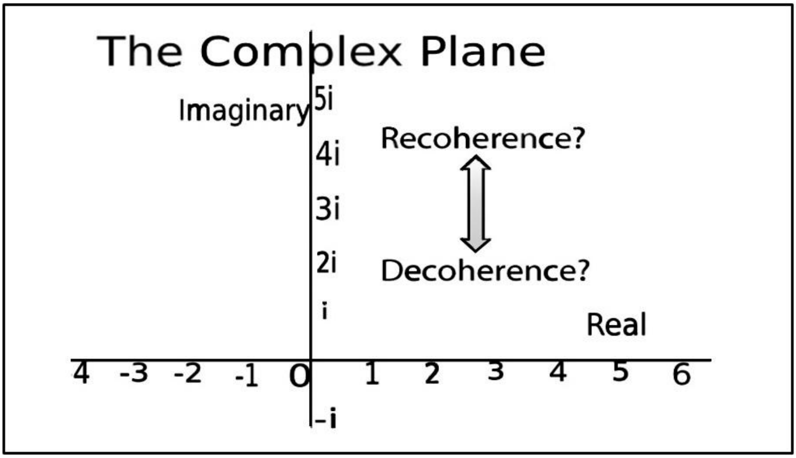

Figure 5-3. The complex plane with proposed recoherence and decoherence on the imaginary axis, more 'actual' approaching zero. (From Peil, 2012, 2014)

Quantum mechanics and the Mandelbrot equation

To further play with these ideas, let us now imagine that living systems do depend upon both quantum and classical processes, and see if the Mandelbrot equation can offer additional insight. Let us suppose that the left side of the equation *F(z)* represents the quantum domain and the right side, $Z^2 + C$, the classical domain. As symbolic of both the imaginary and the real component, C then would be the outcome of that unifying mechanism (e.g., Kauffman's recoherence and decoherence), and the information it connotes is that which is fed back from the classical world to the quantum. So, in the iterative functional conversion from quantum to actual, *(z)* might well represent the *amplitude of the Schrodinger Equation,* a wave of possibilities, subject to the Born rule on the other side (wherein the amplitude squared gives the probability of any actual event (e.g., spin up or spin down). Hence, the Mandelbrot Equation, $F(z) = z^2 + C$, would represent the whole ongoing, interactive creative process, with the equal sign itself connoting the inherently lawful balance and stability. Once again, words may fail, but I hope the intuitions are clear.

But if something like this were to be the case, it would help explain the findings from the new field of quantum biology (Lambert et al., 2013). Nontrivial quantum effects have been suggested to play roles in light harvesting (photosynthesis), respiration, DNA repair, magnetic reception, bird navigation, and olfaction—the sense of smell—which of course carries within it our ancient hedonic qualia. Given the bi-directional information processing paths in a fractally nested-living organism, it would also imply that the top-down path (brain, to organs, to cells) would be more stable, predictable, and classical, while the bottom-up (atoms, to molecules, to cells) would be more fluid, stochastic, and quantum. These bi-directional paths might also be represented in the bilateral hemispheres of the vertebrate brain but would surely have first emerged in cellular membranes. If this scenario is closer to home than our existing assumptions, it would put an entirely new spin on how we think about genetic and epigenetic regulatory processes, as well as of psychological order and disorder in the human experience.

Self, not-yet-self potentials, and self-actualization within a participatory universe

What then of the role of "the self" in all this physical self-organizing dynamism? As mentioned, the chemistry that occurs on cellular membrane instantiates the 3-step thermostatic loop of mind, one that yields sensori-motor control in response to self-relevant changes. It warrants the name *emotional sentience* because it delivers perception of hedonic qualia in both the signal and response, which also feeds back into memory for the next round—helping build an inaugural form of mind, still observable in the simple bacterium. Might this chemistry be enough to solidify the analogical link (al la Bohm and Pylkkanen) between thought processes and quantum-mechanical processes?

Well, no. Sentience does not equal consciousness. For upon closer examination of the chemical machinery, the first step of the cycle, the ongoing self/not-self comparison, relies upon the fundamental *capacity to observe* (e.g. "consciousness" in the hard-problem sense of the word; Chalmers, 1995). While consciousness itself has not yet been adequately explained, without it living systems would be devoid of genuine free will, with subjective experiences only empty, epiphenomenal reflections of deterministic processes. Due to the causal closure of classical physics, in a strictly classical world any kind of mind would have "nothing to do, and no way to do it" (Kauffman, 2016).

Of sensation and measurement

Might it be instead that our subjectivity is part of this creative self-organizing in-forming process itself? This is the deeper implication of Marks-Tarlow's epistemological principle of how fractal measurement illuminates "observer dependence," where we see depends upon how we look, including our scale of observation plus other qualities of ourselves as measuring devices (Marks-Tarlow, Chapter One, this volume).

A stronger take is that consciousness itself plays a mediating role in the interactive dance between quantum and classical realms (Kauffman, 2016; Peil Kauffman, 2015). Might it be that, when living systems sample, sense, or otherwise perceive their environment, this might be the "measurement" that collapses the wave function? Quite literally enacting, collapsing, singular-classical events from infinite-quantum possibilities? Might it be that our hedonic self-corrective responses may include some energetic efficacy (perhaps via constructive or destructive interference, flipping of spin, etc.) that lawfully feeds back, playing a direct role in the tweaking of quantum possibles up or down, forging stronger or weaker probabilities in the "adjacent possible" (Kauffman, 2000), or leaving there the deepest kinds of memory traces of real world actuals? Such a scenario would shed some light on such notions as the Jungian collective unconscious and provide some scientific scrutiny and sophistication to religious narratives.

Panpsychism and the Self

Indeed, many have suggested that what I am calling "sentience" goes all the way down—in something akin to a Leibnizian (1714/2014) or Whiteheadian (1927/1979) panpsychic universe (Skrbina, 2017), where consciousness— including feeling—is inherent in all matter. But, with this new science, given that positive and negative valence are associated with chaos (change) and order (structure) respectively, and nothing but change occurs in the quantum domain, this would imply the presence of positive valence (e.g., desire, joy, love), but not necessarily the negative pains of actual classical experience.

My favorite of these panpsychic views has been set forth by Theise and Kafatos (2013, 2016), to which I will add my own enhancements as described previously (shifting more toward a more physical monism, afforded by the suggested quantum and classical interactions). In their model, everything bubbles forth from within a fundamental monistic ("nondual") awareness. In terms of both subjective perspective and personal identity, I might call this ultimate foundation the Self with a capital S, and recognize it as what others may call God. In keeping with the scale independent self-organizing dynamics, the Self is fundamentally at once both part (with personal subdivisions) and whole (non-locally interconnected, unified). Theise and Kafatos described a mathematical symmetry-breaking dynamic wherein the unbounded Self, can parcel itself into infinitely many local subject/object subdivisions while forging local and relative self/not-self boundaries. Their model is very much in keeping with how our self-regulatory emotional sense operates, given the ongoing self/not-self comparison, and what our most complex, spiritually inspiring, and transpersonal feelings suggest about the multidimensional nature of the psyche.

Best of all, their model notes three-universal components that occur on all levels of scale: 1) *Interactivity*, between and within all parts and wholes, the ongoing dynamic connections, disconnections, reconnections, overlaps, and attractors in collective state space, as well as ongoing, fuzzy, interpenetration between the Self/Not-self; 2) *Complementarity*, our dance of Yin/Yang opposites, our grand-daddy churning of action and creative change; and 3) *Recursion*, the iterative, self-reflexive, cyclic nature of feedback, the engine driving the creation of fractal structures. Once again, all strikingly similar to the pattern-forming dynamics conducted by the Mandelbrot equation.

In such a scenario the deepest fundamental *comparison* in the loop of mind (comparing the self versus not-self external environment), and now symbolized by the C in the Mandelbrot equation, the ultimate comparison might be between the Self and the perhaps infinite *Not-Yet-Self* possibilities—giving quite literal meaning to the functional self-regulatory outcome of Self-actualization. Indeed, beneath the level of the living system, the imperative for stable self-preservation is meaningless, as form itself emerges from the deeper creative dance of change. In short, all that remains is the *developmental regime* and the *positive emotional spectrum*, a possible biophysical source of the ecstatic bliss of "nonbeing," the rapturous dissolution of the ego self into a greater unified Self, or of the ecstatic reunion with God as Love—all of which remain transpersonal mysteries.

Conclusion

For all these reasons, I find that fractal geometry does indeed provide a holistic, flexible meta-framework for Transpersonal Psychology. Bolstered by the new science of emotion, my enthusiasm goes further still. The profundity of fractals, and the fundamental self-organizing dynamics that undergird them, offer *ontological* utility that can also inform biology, evolutionary theory, the science of consciousness, as well as move the question of "values" themselves within the domain of science.

We have seen how the fractal paradigm can help reveal natural patterns in space and time, the link they provide to self-organizing dynamics, and the cybernetic feedback and control processes utilized by living systems. We have seen their principles in the chemistry and neural structures across the animal kingdom, forging the very structure of subjective experience, defining self-identity, building an enactive mind, allowing creatures to optimally regulate their own behavior and to ultimately participate in natural selection. We have discussed how they show up in human experience, how the ancient inaugural self-making systems have expanded over evolutionary time to the modern 5-step action perception cycle. We have gestured toward what this all might mean in the context of religious traditions and moral reasoning.

We noted the central importance of iteration and cyclic interaction in living processes, including perceptions of time and space. Likewise, we have noted the common dance of Yin/Yang opposites across all levels of a self-organizing system. This is the dance that undergirds the binary structure of hedonic qualia—good and bad feelings and the many layers of evaluative, algorithmic information they carry. This dance includes the non-negotiable evolutionary logic, a logic that undergirds our notions of value itself, but one that has largely fallen upon deaf ears. The fractal, as both process and structure, has helped elucidate the bi-directionality of information flows, orientation to horizontal and vertical dimensions within the nested organization of living organisms.

The fractal perspective opens a vista upon a much broader evolutionary paradigm, one that honors our physical-creative efficacy and our active participatory role in our own evolution; one that can help elucidate the personal, social and spiritual meaning encoded within our perceptual experiences, behaviors, and the structure our human psyche; one I've dubbed the Emo-Etho-Eco-Evo-Devo model (Peil Kauffman, 2017b). This perspective liberates psychology from the shackles of genetic determinism, "mismatch" theory (Tooby & Cosmides, 2000) and the ongoing paradoxes that have historically left emotion undefined and scientifically neglected. While based on solid science, it allows us to transcend the strictly emergent "epiphenomenal" consciousness born of brain processes, lacking in genuine free will, wherein subjective experience itself is meaningless, and even our most insightful thoughts, experiences, and complex pleasures serve little more than sexual reproduction. This approach acknowledges the universality of our human spiritual proclivities, honoring the common stand of religious wisdom from both East and West, yet providing a biophysical backdrop against which to critique the efficacy and accuracy of time-honored dogma. It also honors the bodies of ancient philosophy (e.g., from China, India, Africa, and Indigenous populations) missing from Western philosophy, while tethering cleanly to Grof's (2008) ontological realism for the transpersonal phenomena.

Furthermore, if the deeper speculations reflect similar mathematical elegance in terms of the deeper physics, reflecting Wigner's (1960) "unreasonable effectiveness of mathematics in the natural sciences"—there are quite profound implications for what it means to be human in a fully participatory, self-actualizing universe. They imply that we not only have an apportionment of creative capacity as individuals and en masse, but also possess the innate guidance to use it optimally.

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CHAPTER SIX

EPISTEMOLOGY OF THE NEURODYNAMICS OF MIND[1]

FREDERICK DAVID ABRAHAM[2]

> *In complexity theory—the science of sensitive dependence, unpredictability, self-organization, and turbulence engendering change—strange attractors activate new order out of chaos. "Chaos underlies the ability of the brain to respond flexibly to the outside world and to generate novel activity patterns, including those that are experienced as fresh ideas," Freeman wrote (1991). Ultimately, attempts to logically dissect or analyze creativity collapse, because mechanisms of novel pattern-generation are inaccessible to scientific rules of knowing.* (The artist, Diane Rosen, 2017)

Neurodynamics may shed light on understanding the relationship between subjective experience and scientific explorations of mind and behavior. Marks-Tarlow raises this as an issue in the history of transpersonal psychology. I focus on this issue in the tradition of Freeman's neurodynamics and related cognitive neuroscience rather than the transcendental aspects of transpersonal psychology. This involves some basic concepts of dynamical systems. It also involves electrophysiology and neuroimaging and other tools of modern neuroscience. And it raises some philosophical issues.

A basic premise of this chapter is that phenomenological/experiential and objective/empirical approaches inform each other while informing our concepts of reality, mind, and transpersonal transactions. I believe that some nuances of science, most conspicuously from neuroscience, could contribute to the progress of transpersonal methods, but need not necessarily be working tools of transpersonal practice. For example, neuroimaging of

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the brain may help us understand how the brain is involved in mental transitions (mind-wandering) but may not be required for a patient in therapy. However, familiarity with research could help the therapist and patient understand some features of the mind and how to control them. Additionally, some appreciation of those aspects can be enjoyable even if one is not particularly interested in too many of their details. To that end, I try to minimize the technical allusions and try to give transparent characterizations of them. Consideration of these aspects may satisfy curiosity and may motivate further inquiry. I think this view is syntonic with Marks-Tarlow's desire to explain fractals as relevant to the transpersonal mission.

I have long been an admirer of the writing of Terry Marks-Tarlow since 1991 by personal contact at conferences, through the internet, and from some of her publications (e.g., 2008). We share a fascination of the confluence of dynamical flavors of mathematics, semiotics, and the mind. Thus, I welcome with pleasure, the invitation to comment on these matters.

Epistemology and ontology—A yin/yang entanglement

Epistemology and ontology are inseparable, two perspectives of the same process. You cannot have one without the other. I consider ontology as representing our concepts of reality, and epistemology as the study of how we arrive at those concepts. You can't fabricate knowledge about reality unless you have some concept or commitment to the nature of reality; and your concepts about the nature of reality are under constant revision as you continue to investigate it. There is an ongoing dialogue between epistemology and ontology; thus, they are parts of an organic, holistic process no longer to be considered separately. This is especially true when one is concerned with the mind, because the organ of knowing is the object of investigation. Thus, "Smitty" Stevens referred to psychology as "propaedeutic," meaning that it is the science of science (Stevens, 1936, 1939).

Marks-Tarlow states that "transpersonal psychology aimed to transcend limitations of research and methods [currently] available" (this volume, chapter one). For transpersonal psychology, transcendence is not only related to going beyond the limitations of current research methods, but also to the achieving of "peak experiences," and to Maslow's "fourth force in psychology," which surpasses self-actualization to include mystical, ecstatic, and spiritual states of mind (Maslow, 1988). So, there is an ontology of mind that is entangled with its epistemology, which confronts the gap between objective and subjective ways of knowing. How do we resolve the problem of reconciling the scientific modes of investigating mind with subjective ways of knowing?

Some of these transcendental issues have engaged earlier psychologists from various viewpoints, such as James' "pragmatism" and "pure empiricism" (i.e., pure experience; James, 1907; Perry, 1954) and Jung's analytic psychology (Jung, 1969), which comments on the philosophy of science. Relevant philosophies include the analytic philosophies of logical positivism, an early 20th century philosophy of scientific method and its social uses (Neurath, Carnap, & Morris, 1938), as well as operationalism, which posits that the meaning of scientific propositions depends on the operations used to define them (Bridgman, 1927). It has been said that analytic philosophy brought about the seeds of its own destruction (Rajchman, 1985; Rorty, 1982). I think that pursuit of any extreme position does the same: to take a purely subjective route to knowledge about the mind cannot escape discovering that by itself, it cannot be trusted, it needs some additional evidence. Similarly, to take a purely operational view forces one to concede that much is lost in ignoring the uniqueness of personal knowledge.

Bridgman himself went through a remarkable and passionate evolution following his original pronouncements of operationalism (Bridgman, 1936). He became concerned with the whole scientific process, including the life and personality of the scientist, the experience of the scientist, of which operational procedures, that is, research, were but a part. He recognized this view as solipsism, in the need to incorporate subjective experience of the observer into empirical observations. One might contend though, that with proper controls and experimental replication, the uniqueness of the observation can be factored out. However, uniqueness remains concerning experimental contexts, the choice of experimental subject matters and procedures, and in the interpretation of the results. The importance of this critical feature of uniqueness becomes amplified when the subject matter of the research deals with rare or difficult-to-replicate events, such as mystical, paranormal, or mind-wandering, "flow," "peak," and time-dilation experiences. The scientific process is clearly self-organizational.

James and Jung both brought in transcendental features to their mental ontology, James through his radical empiricism (James, 1907; Perry, 1954), and Jung via the transgenerational and synchronistic aspects of the collective unconscious and archetypes. Both promoted a reconciliation between the subjective and objective, a wedding of the two. James could be considered a forerunner of post-modernism in his rejection of absolutes and ideologies. This approach enabled him to show that meaning derives from personal self-organizational processes involving both objective and phenomenal aspects. "How to conceive experience so that it could retain both sets of properties, composing both the immediate and the transient life of the subject and the stable world of common objects–that was James' problem" (Perry, 1954, p. 279). The centrality of James' concept of the "stream of thought (consciousness)" depended on this ontology. Peirce's semiotic concept of the "interpretant," which represented experience in his famous semiotic triangle of signifier-interpretant-object, depended on a similar ontology (Peirce & Welby, 1908/1977) as in Figure 6-1.

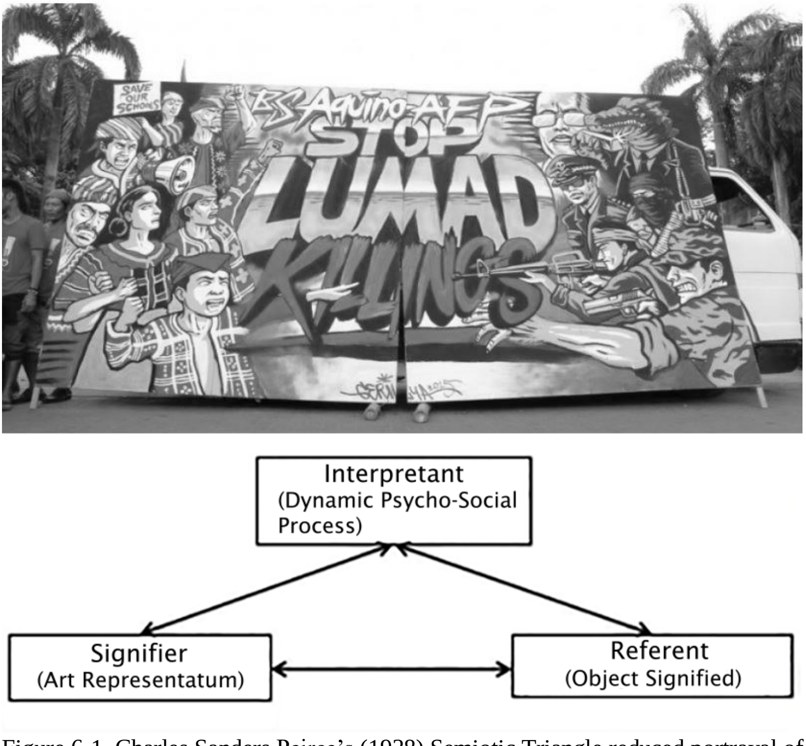


Figure 6-1. Charles Sanders Peirce's (1938) Semiotic Triangle reduced portrayal of complex dynamical networks into a triangle. Representatum: Street art protesting treatment of the Lumad─minority tribes of Mindanao, Philippines. The unique individual subjectivity in the interpretation of the art is embodied for my wife, for example, from her extensive time collecting music from many of the tribes of the Lumad (Magdamo, 1957-8). Art produced by a student art collective, Ang Gerilya (The Guerrilla) of the University of the Philippines. Photo from the Facebook page of Sim Tolentino (Mong Palatino, 2016).

Jung was transcendent in a couple of ways. One was in his frequent use of the reconciliation of opposites, thus transcending each of the opposites, the principal pair of opposites being consciousness and unconsciousness. The other was unlike James in embracing spirituality as seen in his acausal principal, a principal of instantaneous quantum-cosmological communication that could affect the mind as exhibited in paranormal phenomena. James chose to reject spirituality as being too ideological and fixed, as it is in most religions' basic beliefs (James, 2012; see also Perry, 1954, chap. XXX; Goodman, 2017).

In discussing how the feminine archetypal *anima* (the unconscious feminine aspect of a male) brings material from the amorphous unconsciousness to images and thoughts in consciousness, Jung states, "For me, reality meant scientific comprehension. I had to draw concrete conclusions from the insights the unconscious had given me" (Jung, 1989, p. 188). This was Jung's attempt to reconcile the objective and the subjective. This statement is an anathema to the general principals of scientific investigation that evolved from the positivist approach, those of reliability, validity, and objectivity. Reliability demands replicability of the phenomena being investigated. Validity demands that events measured represent those they purport to measure. Objectivity means the observational methods are independent of the events to be measured, and vice versa.

Furthermore, scientific results should exhibit lawful relationships among different variables. If one is lucky, the results generalize to many more situations than those from which they are initially derived, as noted by Robert Boyle, circa 1750 (Wooten, 2015, pp. 387-389). These features obviate, by definition, the uniqueness of the contextual issues, including the hopes, fears, and insights of the investigator. Heraclitus's maxim of not being able to step in the same river twice holds for James' "stream of consciousness." Of course, Jung's observations of his own mind do not meet many of Steven's (1939) characterizations of operationalism, but they may meet one of them. "What becomes acceptable psychology accrues only when all observations, including those which a psychologist makes upon himself, are treated as though made on 'the other one'" (p. 230). Of course, this is what Jung claimed to be doing when he was probing his own mind. When Loren Riggs attached mirrors to his cornea, he discovered that stabilized retinal images faded and disappeared—a finding that seemed more in line with Stevens' suggestion for the objectivity of experience as "the other one" (Riggs et al., 1953).

In the 20th century, academic psychology tended to denigrate introspection, as it allowed personal biases to unconsciously infect both data and interpretation, which is evident in Jung's description of his personal experiences. Despite this, out of his own subjectivity, Jung evolved some of the most popular ideas in analytic psychology, which still command professional and lay respect.

Aesthetics, conflict theory, and fractals

Wundt (1874) developed a conflict theory of aesthetics in which differential strengths of aversive and attractive response curves led to an inverted-U (∩-function hereafter) arousal function toward artistic images. The ∩-function is a nonlinear equation that simply describes some dependent variable that reaches a maximum between the lowest and highest values of another, independent variable, as in hunger vs. hours of food deprivation. In Wundt's case, aesthetic enjoyment reaches its maximum between the lowest and highest values of some aspects of the images being viewed, in which case competing aversive and attractive hedonic aspects (hypothetical or intervening variables) mediate the ∩-relationship. This ∩-function is ubiquitous not only in many psychological functions, but in nature as well (e.g., crop yield as a function of rainfall). The ∩-function is like Theravada Buddhism's "middle way" between the addictions of indulgence of sense-pleasures and of self-mortification. Figure 6-2 shows the two opposing hedonic tendencies—aesthetic attraction and aversion (top and bottom curves), and their sum as a ∩-function (middle curve), seen in aesthetic appreciation as a function of the arousal level of the image.

Conflict theory was further developed by a physiological psychologist, Neal Miller (1959), in the 1930's. He was studying rats in mazes, trying to behaviorally model a phenomenological-personality feature, namely Freud's *reaction formation*, which is similar to Jung's *enantiodromia* (Abraham, Abraham, & Shaw, 1990; Jung, 1969). Miller used a learning paradigm wherein thirsty rats learned that both shock and water lay ahead at the end of the maze. The conflict of aversive and positive gradients left the rats either indecisively oscillating irregularly back and forth, or immobile, short of the end of the maze, with the distance from the goal related to the arousal potential of the goal.

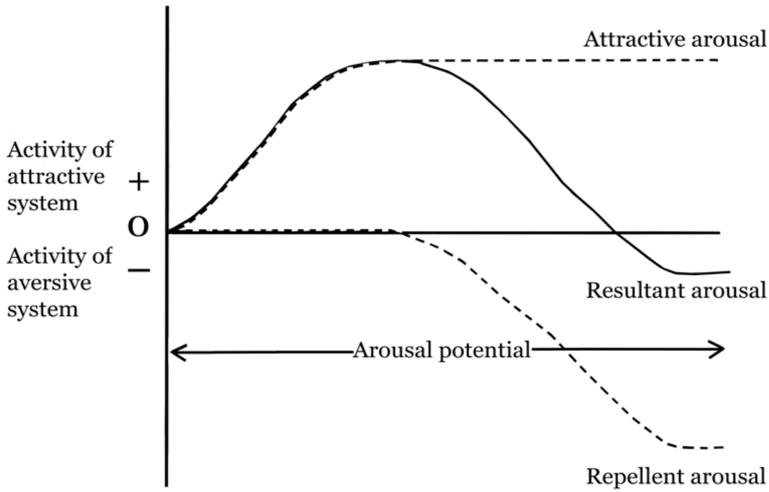


Figure 6-2. This figure depicts how the different amounts of positive and negative affect elicited by a perceptual field (dashed lines) as a function of some feature of that field (horizontal axis, arousal potential) result in the actual amount of arousal (solid curve, resultant arousal). Adapted from Berlyne's (1971, p. 89) modification of Wundt (Berlyne, 1971, p. 89) by Fred Abraham as rendered by Terry Marks-Tarlow.

Berlyne (1971) made a career of studying such phenomena. One feature he studied was the complexity of the stimuli used to obtain aesthetic judgments. He invoked Wundt in explaining his results. The stimuli he used in these experiments were quite crude (some of them are in Figure 6-3). Participants in his studies rated these stimuli as to their complexity. These ratings were analyzed by various canonical psychophysical methods to identify scales of basic complexity factors. These subjective scales were then used as independent variables when obtaining aesthetic judgements to these stimuli.

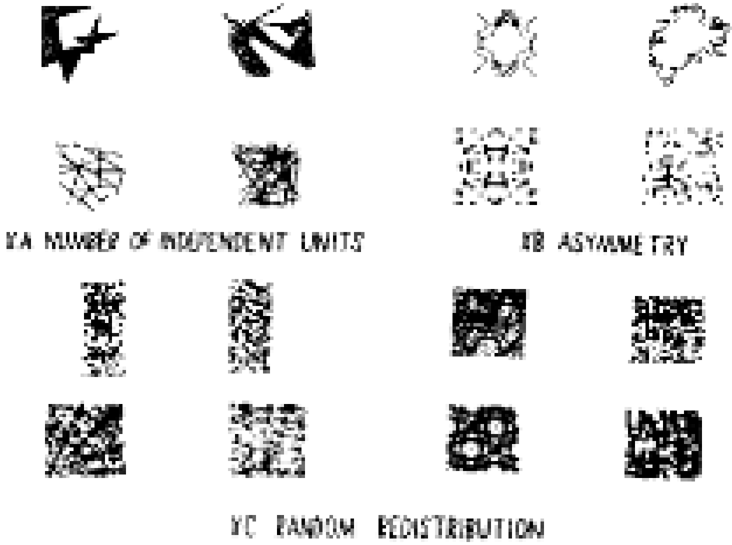


Figure 6-3. A few images from Berlyne (1971, p. 199) varying in non-quantified complexity

Since Berlyne's images were somewhat impoverished aesthetically and his independent variable was subjective, Aks and Sprott (1996) sought to study aesthetics using chaotic attractors as images (images formed by mathematical theory). These images were more aesthetic and their complexity quantified using the fractal dimension, D_2, which provided an objective independent variable for their studies. Their images were in black and white, but Sprott (2003) subsequently improved them aesthetically by adding a third dimension to the 2D images being colorized, which we used to generate images for our studies with programs he modified for these psychophysical studies. These images are generated by equations from non-linear dynamical system, such as those in Figure 6-4. (Abraham et al., 2010; Draves, Abraham, Viotti, & Abraham, 2008; Mitina & Abraham, 2003).

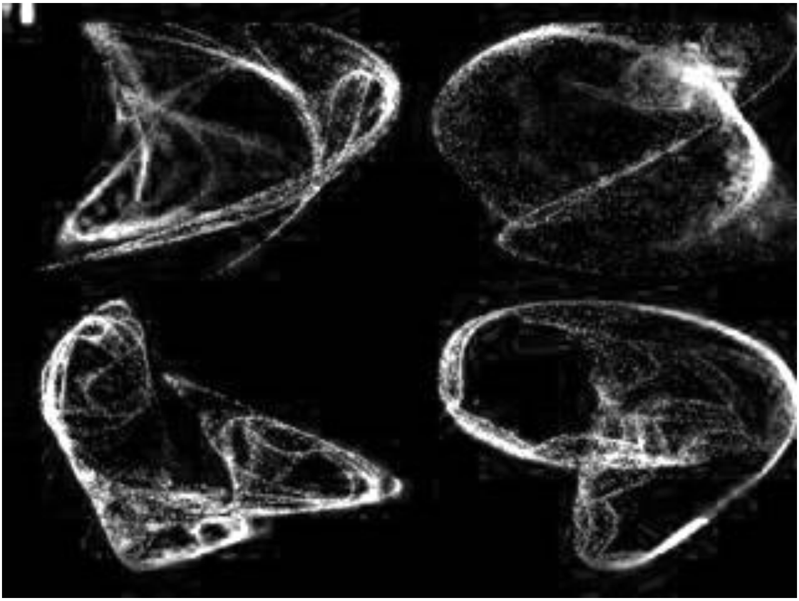


Figure 6-4. Four images from Abraham *et al*. (2010) with an average fractal dimension of 1.54, judged optimally aesthetic. The third dimension perpendicular to this plane is exhibited by colorization, missing in this printing, but can be viewed in color in Abraham et al. (2010), and at http://www.blueberry-brain.org/silliman/jemstim.htm

Our studies looked at aesthetic judgments as a function of objective complexity, D2, shown in Figure 6-5 which is the epitome of a ∩-function.

Our studies (Abraham et al., 2010; Mitina & Abraham, 2003) also asked the subjects to rate the complexity of the images. Results revealed a nearly identical ∩-function as for the aesthetic ratings revealed in Figure 6-5. Thus, aesthetic and complexity judgements are linearly correlated, which raises the question of which is primary, the mathematical complexity or the perceptual complexity of the image? These and Berlyne's results suggest that the perceptual aspect is more dominant. This conclusion follows Fuster's (2004, 2017) contention over Freeman's (2000, 2007) on the nature of the integrative activity of the brain when new stimuli are presented. So, we next turn to neurodynamics in the quest to integrate objective with subjective features of experience.

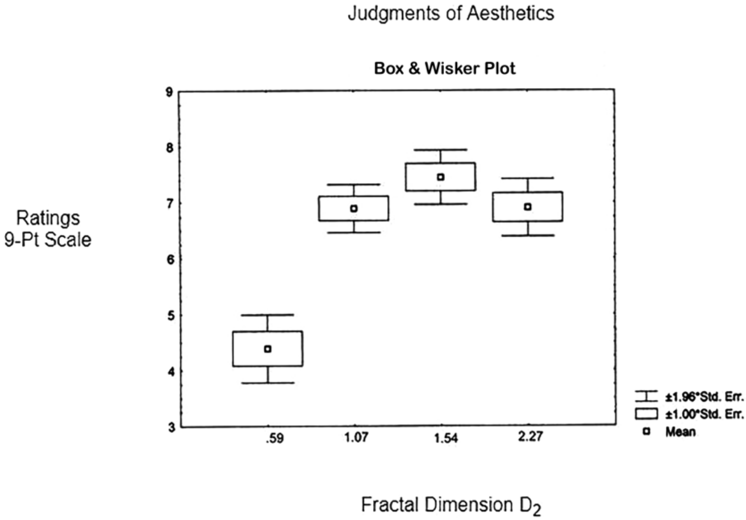


Figure 6-5. Aesthetic judgments as a function of D2, a measure of mathematical complexity, which exemplifies a ∩-function (from Abraham et al., 2010, Figure 2). Thus, the fractal dimension is the horizonal axis, arousal potential, and the aesthetic ratings represent the resultant arousal of the solid curve of Figure 6-2.

Neurodynamics of phenomenology

The neurodynamics of cognition must necessarily investigate the integrative functioning of the nervous system and its interaction with environment (Skarda, 2017). The *Action-Perception Cycle* of Freeman (2000, 2007) and the *Perception-Action Cycle* of Fuster (2004, 2017) illustrate overviews of such processes.

While Galen may have been the first to suggest the brain as the locus of the mind, Wundt may have been among the first to attempt to measure the extent of the brain's influence on decision-making behavior. He used reaction-time measurements (time taken between stimulus and simple response). He evaluated differences in the reaction-times attributable to different cognitive components of various tasks. For example, the time for a choice reaction minus the latency for a simple reaction could yield the time the brain uses to distinguish which of two lights turned on. Modern cognitive neuroscientists are pretty much still at it, but with much more sophisticated experimental and mathematical tools (Eliamil et al., 2016;

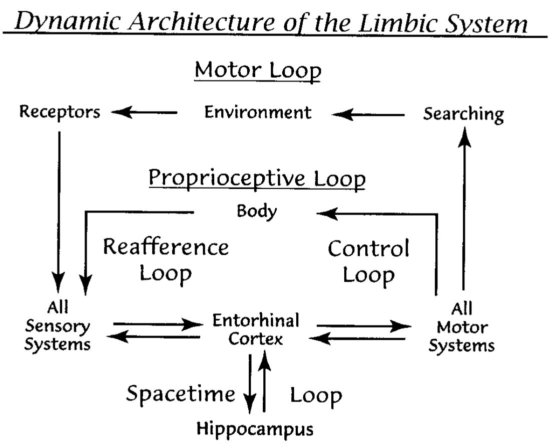
Fuster, 2001; Libet et al., 1983). Since the 1980's there have been an explosion of integrative neurocognitive studies using various measurements of brain activity, mostly electrophysiological and neuroimaging, across micro, meso, and macro levels of investigation.

I will take the iconic program of Freeman as an example, mostly at the meso level (Freeman & Skarda, 1985; Skarda & Freeman, 1987; Freeman 2000; Freeman, 2007; Kay, 2017; see also Abraham, 2017; Liljenström, 2017). Freeman's program is predicated on a few basic premises: 1) The collective activity of nerve cells in a given region (nucleus or area) is more important than the activity of any particular cell; 2) Within a given region, there is a subset of cells that are more likely to be used in a particular mental activity: 3) This subset may vary from one instance to another; 4) Different (and possibly overlapping) subsets may be utilized by different mental functions; 5) Interconnection and thus communications within and between regions form functional networks, and some of their activities can be meaningful and measured from micro-, to meso-, to macroscopic levels, spatially and temporally; 6) These communications are interactive (centrifugal-centripetal, afferent-efferent, recurrent, or feedback loops); and 7) These networks can be considered as self-organizing, dynamical systems.

Freeman and his colleagues used quintessential learning situations with odors as stimuli. They made EEG measurements with an innovational small 8 x 8 array of electrodes on the olfactory bulb of rabbits. Initially they were asking the following question: Is there a spatial (topological) mapping that discriminates one odor from another, the way the auditory system maps the frequency of sounds spatially in the brain (i.e., tonotopically), and the visual system maps the visual field, and the somatosensory system homuncularly maps the body surface and the vibrissal field. Topologically distinct mapping of odors does not occur. However, topological changes do develop with discrimination learning in the cortex. They noted two types of EEG patterns, one almost cyclic within the gamma range (above 25 Hz). The other was chaotic, similar to a normal EEG. The cyclic pattern represented learned reaction to a conditioned stimulus, the chaotic pattern represented a state of readiness. The chaotic activity between instances of the learned behavior was due to the widely distributed functioning of other multiple tasks the brain was performing while not being dominated by the learning task.

Freeman followed the development of these alternating types of EEG patterns that exhibited changes during the course of learning. These different patterns can be depicted graphically as visually distinct "attractors." This development manifested a series of bifurcations (sudden transitions between attractor states exhibited by a system), with relative stability between and instability near the bifurcations between cyclic and chaotic attractors. He summarized sensory, perceptual, motor, and cognitive aspects of the system responsible for the discrimination learning in a schema he called the "Action-Perception Cycle," which he also called the "intentional arc." Goal-oriented intention is involved in the interactions; that is, sensation and intention interact because the animal is forming holistic interactions within most aspects of the cycle (see Figure 6-6), which self-organizationally modulate all aspects of the interactions involved (Freeman, 2000, 2007).

This characterization of alternating periods of background or intentional chaos followed by near cyclic activity is finding new life in contemporary neuroimaging studies of the Default Mode Network (DMN), a neural system mentioned in cognitive research (Ferneyhough, 2017; Alderson-Day et al., 2016) and reviewed in the next section. The DMN reflects various metastable/meta-unstable brain activity but gets recruited into more coherent action when a particular mental task demands it.



Freeman's fundamental diagram of Action-Perception Cycle (also known as the Intentional Arc).

Adapted from Freeman

(2000, p. 102).

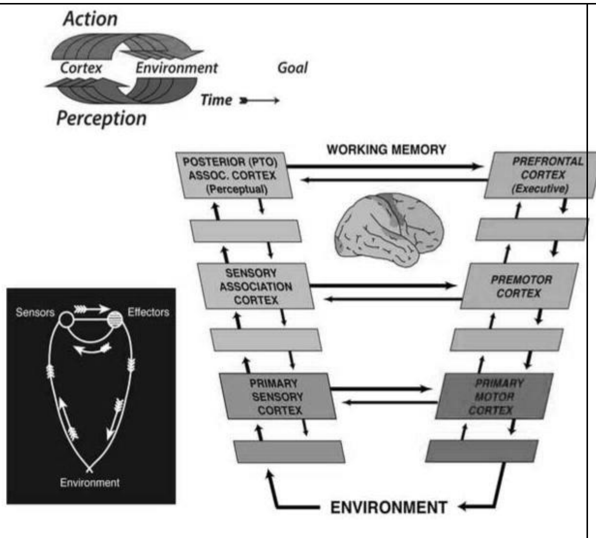
	Fuster's fundamental diagram of the Perception-Action Cycle. Fuster (2012, 2017). By permission of Joaquin Fuster.

Figure 6-6. Network diagrams of Freeman's (above) and Fuster's (below) neurocognitive cycles.

Skarda (2018) emphasizes that it is best to think of Freeman's Action-Perception Cycle as holistic. Fuster (2001; 2004; 2012; 2017, appendix 1) proposed a similar "Perception-Action Cycle," differing from Freeman's, according to Kozma (Kozma & Noack, 2017), by emphasizing sensation as initiating such a sequence, rather than intention doing most of the initiation.

There may be high-dimensional (chaotic) attractors occurring in the Cycle, particularly in the cortico-sensory "pre-afference" loops, which can bifurcate to low-dimensional (nearly cyclic) activity (Kay, 2017). In systems' theory, bifurcations occur when there is instability in the system (Abraham, Abraham, & Shaw; 1990; Abraham, 2014). With respect to the Freeman-Fuster difference suggested by Kozma, I have suggested that sometimes one (sensory/perceptual), sometimes the other (intentional, cognitive) aspect may be primary in the initiation of the cyclic activity (Abraham, 2017). A more contemporary example of such bifurcational behavior occurs at the microscopic (micro-electrode) level in the monkey prefrontal cortex in studies of working memory (Spaak, *et al.*, 2017). Note that the neurocognitive cycles on a macro-temporal scale are different from the cyclic or periodic activity within the EEG and microelectrode measurements at meso- and micro-temporal scales.

Freeman's tribute to his mentor, Karl Pribram (Miller, Galanter, & Pribram, 1960) can be seen in his definition of intentionality:

> Intentionality is the circular process of generalization/abstraction of input and specification/concretization of output by which brains achieve understanding of their environments through the cycle of prediction, action, sensation, perception, and assimilation by learning. (Freeman, 2007, first sentence)

An overall picture of brain functioning is that there are integrative systems of many distributed brain areas and events. Many different systems are active at the same time working away at different tasks. Some may use shared areas and processes as well as unique areas. There may be switching between their relative dominance in mental activity; instabilities are responsible for these bifurcations to stable dominance of one or a few systems ("metastability;" see Freeman & Holmes, 2005; Abraham, 2017; Kelso & Tagnoli, 2017; Fingelkurts et al., 2017; Liljenström, 2017; Mannino & Bressler, 2017). Kay (2017) has studied the learning paradigm of Freeman and found various attractors related to nuances of brain activity. Many of these exhibit EEG activity in the beta and gamma frequency ranges. For example, she states:

> We have shown that the difficulty of discriminating an odor contributes to the neural processing mode by modulating the strength of gamma oscillations (40-100 Hz). Gamma oscillations are functionally and positively linked to discrimination of closely related odorants. We know that changes in gamma oscillations amplitude tell us something about the way in which the OB [olfactory bulb] processes odors. Freeman showed that gamma oscillations give us a measure of cooperativity and precision in the population of mitral and tufted cells, the principle neurons in the OB. Top down input to the OB from many other brain regions serve to desynchronize gamma oscillations, providing for stability and aperiodicity in the network, and this provides a mechanism by which higher order inputs can adjust the way in which OB neurons respond to odor information. (Kay, 2017, p. 43)

While Freeman (2000) felt the qualia of experience lay beyond the reach of neuroscientific observation, he did feel that investigation of this intentional arc would elaborate the neurodynamics of the mental activity that supported such qualia. The mental activity need not be conscious, in fact he suggested that it is mostly unconscious and intermittently becomes conscious. (I prefer to use a continuum of "levels of awareness.")

So where does the idea of fractal come in? Simply in the fact that chaos, which is involved in most mental, behavioral, and neural processes, has fractal properties. The most frequently used mathematical characterizations of the complexity of a chaotic attractor are designated as its "fractal dimension" and "Lyapunov Spectrum" (Abraham, 2014; Abraham, Abraham & Shaw, 1990; Abraham & Shaw, 1992; Marks-Tarlow, this book). The fractal dimension measures how much of the space a trajectory fills, and the Lyapunov spectra measure the degree of convergence to the attractor, and divergence away from it along each dimension of the space. Liljenström has shown an ∩-function of the rate of convergence to a stored limit cycle memory state as a function of different levels of noise (I am taking "noise" as an equivalent of "complexity") introduced into units (neurons) in a model of the olfactory system (Liljenström, 2017; see Figure 6-7). This could indicate that, just as with aesthetics, optimal levels of complexity in brain function may facilitate or be indicative of optimal evolution of thought and action.

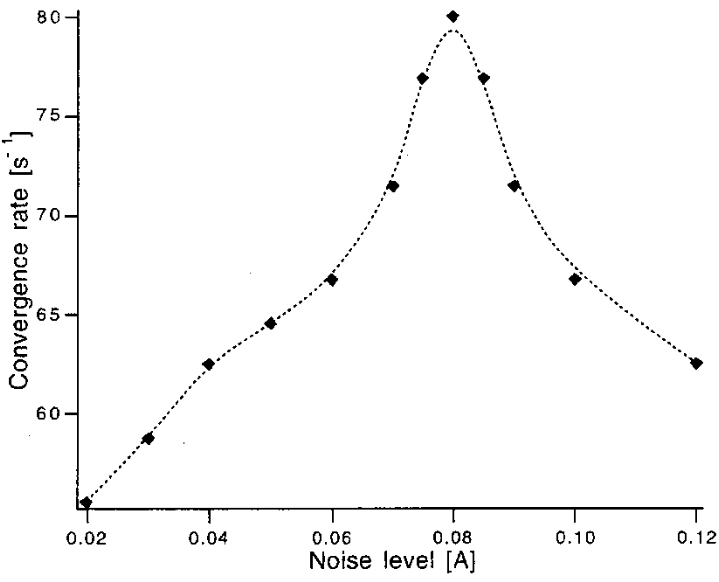


Figure 6-7. Liljenström's (2017, Figure 8, p. 43). The graph shows the rate of convergence to a stored limit cycle memory state, when a version of the theoretical pattern is injected with different amounts of noise presented to the network, plotted for various noise levels. A maximum rate is obtained for an optimal noise level.

In summary, we might say that studies show that brain and mind undergo dynamic metastable variability over time, which we attribute not to measurement error but to perturbations of mental and neural activity that possess measurable fractal/chaotic properties. Some, as Freeman (2000, 2007) and many of his colleagues' conjecture, assert that intentionality must be a major feature of the stream of mental and neural activity. But can we conjure up experimental designs that come closer to the confluence of the objective means of investigation and the phenomenology of mental activity? I offer one example of a clever type of experimental design that purports to do just that. It involves measurement of brain activity in humans while their thinking is under intentional control.

Inner speech (talking to one's self silently), has been studied intensely over the past 20 years or so, and research methods have been developed that defy difficulties involved. Much of it has been directed to Vygotsky's (1934/1987) concepts about socialization in children, believed to play an important role in the development of thought (e.g., Cole & Wertsch, 1996). Ferneyhough (2017) nicely précises Vygotsky:

> Children deliberately repurpose words that they have previously used successfully in social interactions with other individuals. Instead of regulating the behavior of others, they were getting the hang of using language to control themselves. (p. 77)

Thus, dialogue is a self-organizational system. In conversations, people regulate each other. In inner speech and private speech (speaking to oneself out loud), one is controlling oneself. This is also like Vitello's metaphor, similar to one oft used by Freeman, that the brain "is like a jazz combo, which does not need a conductor." (Vitello, 2017, p. 163).

Experiments led by Ferneyhough's colleague, Alderson-Day (Alderson-Day et al., 2016) compared "dialogic inner speech" to "monologic inner speech." Neuroimaging (fMRI) revealed that both would activate brain networks involved in speech (left frontotemporal language regions), but that the dialogic condition involved additional areas "associated with a widespread bilateral network (part of the DMN) including left and right superior temporal gyri, precuneus, posterior cingulate and left inferior and medial frontal gyri" (Anderson-Day et al., 2016, p. 110). These areas are also associated with switching visual perspective and with socializing. Again, there is an analogy and perhaps the implication of support from the macroscopic level of investigation (neuroimaging), of the kind of metastable switching involved in the findings of the various authors mentioned among Freeman and his colleagues (see Abraham, 2017), much of which is evident in the mesoscopic (mid-range) of spatial and temporal parameters used of neural measurement. At any rate, this work shows that subtle nuances of mind can bring objective methods to bear on mental activity. And it especially shows that differences in brain activity, even if there is much left to elucidate in terms of micro- and mesoscopic dynamics, give credence to conjectured aspects of distinguishing nuanced functions of thought.

Creativity

A final word about creativity. The brain, mind, and body are entwined holistically (Marks-Tarlow, this volume, chapter one). Creativity seems also to wax and wane between high-dimensional chaotic processes arising from instability with its greater aspects of divergent thinking and more stable low-dimensional chaotic, nearly periodic- or static-attractor conditions (Abraham, 1996, 2007; Abraham, Krippner, & Richards, 2012; Guilford, 1959; Gardner, 1993). Thus, creative endeavors may entail dynamics similar to those revealed in brain research. Self-organizational processes are necessarily involved in creativity, such as improvisation in jazz, comedy, and speech. Self-organized improvisation is also evident in psychotherapy, transpersonal and otherwise. Psychotherapy, in turn, depends on the brain-mind processes discussed in this chapter, illustrating the fractal property of self-similarity across scale that Marks-Tarlow has so well described.

Conclusion

All disciplines of serious inquiry, but especially psychology and philosophy, have wrestled with the reconciliation of personal experiences with objective processes that may be involved as necessary, but not necessarily sufficient conditions for supporting the propositions purporting to represent truth.. It is interesting to note that even the most formal concepts from semiotics, linguistics, mathematics, and logic that are condensed into Peirce's triangle focus on this conjunction of the subjective (interpretant) and the objective (representamen, referent). Whether contemplating the aesthetics of an image or contemplating the complexity of representing the processes involved in mental or social activity, there are optimal levels of mental states and conceptual explanations for them.

> A map is not the territory it represents, but, if correct, it has a similar structure to the territory, which accounts for its usefulness. (Korzybski, 1933, p. 58.)

Two aspects of dynamical and fractal theory have metaphorical relevance to these explanations. One is that most patterns (attractors) within these explanations involve bifurcations between different degrees of complexity, sometimes quantifiable by their fractal dimension. The complexity of these attractors is governed by both convergent and divergent forces at play in the interaction of the many components of the process. The other, is that, as with formal math-generated fractal images, we see some features being replicated across levels of descriptions. We see this with the spatial-temporal properties of feedback loops in the brain among micro-, meso-, and macroscopic measurements, as in Freeman's and Fuster's loops that range from very local to the whole brain. Their work, and those of contemporary neurophenomenology, as with the work of Kay, Day, Fernyhough, and Eliamil, bring these properties back to the issue of getting some objectivity into the quest for understanding personal experience.

Chapter Dedication

To Franco F. Orsucci who has an unlimited passion for integrative science, for its psychological and social implications, and for philosophy, including postmodern concepts, semiotics, math, and literature (Orsucci, 2008). He created the *Mind Force Conference* and the journal *Chaos and Complexity Letters*. See Orsucci (2008) and Freeman & Orsucci (2017).

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CHAPTER SEVEN

FRACTALS TRANSCENDENT: BRIDGING THE TRANSPERSONAL CHASM[1]

WILLIAM SULIS[2]

Introduction

Wikipedia defines Transpersonal Psychology as: "a sub-field" or "school" of psychology that integrates the spiritual and transcendent aspects of the human experience with the framework of modern psychology. It is also possible to define it as a "spiritual psychology." The transpersonal is defined as "experiences in which the sense of identity or self extends beyond (trans) the individual or personal to encompass wider aspects of humankind, life, psyche or cosmos." It has also been defined as "development beyond conventional, personal or individual levels" (SIC).

Human beings seem to be the only animals on the planet that persistently and consistently attempt to transcend the boundaries of their physical existence, whether through the creation of technologies that expand their physical capabilities; through media, particularly the varied expressions of science fiction and fantasy, which provide a vicarious experience of the transcendent; or through culture and religion, which promise transcendence through paranormal experience, the numinous or an "after-life."

During his first visit to America, the Dalai Lama pointed out how dissatisfied people were with themselves, how they seemed obsessed with remaking themselves, and how the pursuit of material wealth failed to ease

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this deeply embedded pain (Andersson, 1980). Dissatisfaction with self takes many forms depending upon the object targeted as its cause. Body as cause can be observed in psychosomatic illness, body dysmorphism, excesses of cosmetic interventions, both surgical and pharmacological. Mind as cause can be observed in obsessions, anxiety, depression, addictions, and recreational drug use. Society as cause can be observed in anarchism, nihilism, mysticism, extremism and the rejection of reason. Healing of the self is sought through obliteration of the object believed to be responsible for the dysfunction. In turn, the self is often idealized, idolized or exaggerated. Its endless promotion in Western culture has given rise to an epidemic of pathological narcissism (Twenge & Campbell, 2009). Western culture provides another exit through the rejection of reality. Hedges (2009) suggests that the desire to escape reality has become a defining force in the West.

The past decades have seen an explosion in self-help, self-development, self-enhancement and self-transcendent books, magazines, workshops, courses, and products. It is not apparent that people feel any better about themselves as a result (Hillman & Ventura, 1992).

The oldest transpersonal psychology would appear to be that of Buddha, introduced about 2600 years ago (Nanamoli & Bodhi, 1995). The earliest dharma texts reveal Buddha as perhaps the first general psychologist and psychotherapist. He offered a model describing the dynamics of subjective experience. He had a specific goal, understandable to all therapists, of comprehending and relieving human suffering in the here and now. He understood suffering to be a psychological state. He developed a psychological technique for its examination and for its cessation. He emphasized three characteristics of all subjective experience: its transience, its unreliability, and its origination outside of "self." This is remarkably consistent with modern thinking in neurophysiology.

Modern transpersonal psychology began with William James but has never gained much traction in mainstream psychology. Nowadays mindfulness practice is mostly exploited as a technology. Spiritual (and ethical) dimensions of experience are mostly ignored. There remains a wide chasm between mainstream (scientific and evidence-based) psychology and transpersonal psychology. Humanistic psychology is one area which attempts to bridge the chasm. Psychiatry has for the most part ignored or pathologized transpersonal experiences, although that might begin to change should psychedelic drugs become part of the therapeutic armamentarium.

One source for this chasm lies in the distinction between subjectivity and objectivity. Psychological phenomena are commonly divided into subjective and objective, the former term generally used in a pejorative or dismissive manner. Scientific psychology has long claimed to focus upon objective phenomena, such as observable behaviour (even though the observation of behaviour frequently involves interpretation, which is subjective). Transpersonal psychology emphasizes psychological experience, which is inherently subjective. Objectivity has long been thought to give some kind of independence from the observer. This independence is used to justify the attribution of "real" being given to the "objective." In contrast, the "subjective" is considered suspect—fantasy, conjecture, opinion, interpretation—but not "real." Reality, however, is a lot subtler; and as oft stated, nature does not give up her secrets easily.

Experience is intimately linked to awareness and perception. Research into the neurophysiology of perception has revealed that it arises from an interaction between information coming to the brain from sensory receptors and information arising within higher levels of sensory and association cortices. Every perception consists of an interaction between objective (external) and subjective (internal) factors. To varying degrees, every psychological experience is subjective. Buddhist psychology emphasizes the idea that every psychological experience is conditional, depending upon conditions arising in the moment within body/brain/mind and within the external environment. Subjectivity and objectivity seem better applied to categorizing the conditions which give rise to a psychological experience than to the experience itself. Objective conditions might be thought of as those conditions which can be shared among two or more individuals, or which could be registered by some passive apparatus. Subjective conditions are those which are unique to a particular individual and which cannot be shared or registered by an active agent.

Adding complexity to the discussion is the concept of intersubjectivity, which describes psychological aspects of dyadic and group interactions. Through interaction, the members of a group may develop similar beliefs, attitudes, emotional responses, and so on. Thus, certain content of personal experiences of group members may acquire common features shared by the group. Although this content forms part of a subjective experience, the fact that it can be shared through group interaction suggests that it can be considered to be objective, at least in the abstract. Just as the members of the group might perceive an object in the environment so they perceive a group property, which is the shared characteristic. This characteristic becomes objectified through its instantiation by the group and its capacity to be shared through group processes. The personal experiences of the individual group members remain subjective since they cannot be directly observed by other group members.

The interplay between internal (subjective) and external (objective) factors in perception has been brilliantly modeled by Stephen Grossberg in his Adaptive Resonance Theory of perception (Grossberg, 2013). This theory not only describes the dynamics of perception in great detail, but has also been able to model every known perceptual illusion and to make accurate predictions.

Objectivity of conditions does not imply independence from those conditions. There is the problem of contextuality. Observations, even of objective conditions, depend upon context. In physics, for example, the very possibility of carrying out a measurement can depend upon what measurements have taken place previously (Sulis, 2017a). In biomedical experiments, results may depend upon the sex of the handlers of the test animals (Harris, 2017). Contextuality arises because of the existence of various (sometimes extremely subtle) departures from statistical independence among collections of processes. This proves to be an important fact when considering fractals as will be discussed later.

Contextuality in many forms has been observed in psychology for quite some time. It shows up in the estimations and measurements of outcome probabilities. Subject's estimates of probabilities in the iterated Prisoner's Dilemma game for various event spaces often failed to follow the Kolmogorov additivity law in probability theory (probabilities add to 1), instead appearing to be sub-additive (meaning probabilities sum to less than 1). Tversky and Koehler suggested the first explanation of this effect in terms of Support Theory (Tversky & Koehler, 1994). An alternative explanation in terms of mental "noise" has also been offered (Hilbert, 2012). Some experiments have demonstrated the occurrence of super-additive probabilities, in which the total probability over a set of events is greater than 1 (Idson, Krantz, Osherson, & Bonini, 1999).

Contextual probability theory (Khrennikov, 2010) takes into account all of these different possibilities, providing a unifying perspective although it is little known outside of the foundations of physics and quantum cognition (Asano et al., 2014; Busemeyer & Bruza, 2014).

Dzhafarov has written extensively about the issue of contextuality in psychological systems (Dzhafarov, 2016; Dzhafarov, Kujala & Cervantes, 2016; Dhafarov, Zhang & Kujala, 2015). He points out that contextuality is a ubiquitous feature of potentially every measurement situation. He calls this fundamental contextuality as follows—"contextuality by default." The contextuality observed in psychology does differ in important respects from the contextuality observed in quantum mechanics (Cervantes & Dzhafarov, 2017; Dzhafarov et al., 2015), but it still requires extensive modification of our standard probabilistic and statistical tools to address properly. Contextuality also poses serious problems in the biomedical sciences (Sulis, 2017a). One important implication of the existence of contextuality is that one cannot take for granted that one can arbitrarily combine the results of measurements obtained from different experiments, even if the same variables are being measured. This is particularly important for meta-analysis methodology.

Another serious challenge to simplistic notions of objectivity arises from studies in condensed-matter physics, which has shown us that the mere ability to measure a property does not mean that such a property "exists." Traditionally, researchers would measure a particular property on different samples of some material. Slight differences in the measured value would be attributed to random error and the mean value would be accorded the status of *the* value of the property (for those conditions). This does not always work. There are certain materials upon which specific measurements have been made, resulting in different values for the presumed "property" which do not cluster around a stable average value. This occurs even though other materials give definite values whenever this "property" is measured. An example is the failure of reproducibility of the spectroscopic properties of certain metallic oxides and intermetallic compounds (Laughlin, 2005). Only later was it realized that the material reacted to each measurement situation differently, with the result that there was no consistent response which could form the basis for a "property."

Physicists have learned that nature has many ways of hiding its truth, even in the most objective of observational situations. Cohen and Stewart (1994) and Laughlin (2005) provide several examples. Cohen and Stewart described "complicity" and Laughlin described "stable protection," in which emergent phenomena hide or mask underlying microscale dynamics. An example of this is fluid dynamics, which can treat a fluid as a continuum even though it is composed of a myriad of particles. The converse is also possible. Cohen and Stewart called this "simplexity," while Laughlin called it the "deceitful turkey effect." This is a situation in which emergent phenomena create an impression of a stable-microscale dynamic where none actually exists. Laughlin describes string theory as an example of a deceitful turkey (Laughlin, 2005). Single scale analysis will never detect either of these situations.

While mainstream psychology speaks disparagingly of subjective experience, the zealous attachment to the idea of objective experience belies the fact that dealing with objective conditions requires just as much care in experimental design, hypothesis development and testing, statistical analysis, and formal modelling as does dealing with subjective conditions. There is no such thing as a free lunch, and limiting the scope of study to objective conditions does not necessarily give the researcher any superiority. Several alternative models are being investigated to deal with the kinds of problems that contextuality engenders. These include Dzhafarov's contextuality by default (Dzhafarov, 2016; Dzhafarov, Kujala & Cervantes, 2016), Khrennikov's contextual probability theory (2016), Trofimova's functional constructivism (2001a, 2001b, 2002, 2016a, 2017) and Sulis's Process Algebra model (Sulis, 2014, 2016, 2017a, 2017b, 2017c, 2017d).

So long as one does not fall into the trap of romantic scientism (Brown, Sokal & Friedman, 2014), transpersonal psychology can be just as scientific as any "objective" field in mainstream psychology.

The exploration of natural phenomena often begins with the judicious (and sometimes serendipitous) use of metaphors. The physical sciences have been spectacularly effective in using metaphors derived from mathematics. Failures can be equally spectacular. The central aim of this paper is to present the idea of fractals as understood in mathematics and to offer some suggestions about the how the concept of fractals may be effectively used to further the goals of transpersonal psychology.

The use and misuse of mathematical metaphors

Mathematics is a lot like the European Union: a diverse group of languages and cultures united towards achieving common goals. Mathematics is usually subdivided into two broad factions: geometry and analysis, with algebra serving as an emissary between the two. Geometry relies largely upon imagery. Geometric results often describe relationships between shapes—exploring the meaning of ideas such as similarity and difference. Proofs in geometry are usually motivated by images and sometimes even successfully argued through their use. Analysis, on the other hand, places much more emphasis on computations, on the receiving of some quantity. Imagery is sometimes used to motivate a proof, but in the end the argument is won through calculations. Algebra is the formal study of relationships generally and serves as a kind of universal language which both geometry and analysis utilize in their arguments.

Mathematics is arguably one of the supreme achievements of human civilization. Its principal goal is to formalize and examine deeply the concept of relationship as broadly conceived. Its power lies in its generality and abstract nature, permitting it to be applied to a wide range of entities, formal and natural, whenever a relationship among them can be defined. The central role played by the concept of relation is reflected in the formal structure of mathematical logic, which consists of formal language describing relations.

The success of mathematics in the physical sciences lies in the fact that the fundamental concepts which physicists use to understand dynamics are relational. Only relative position, relative velocity, relative energy, and relative momentum play roles in the equations of physics. Mathematics provides a natural language for describing these relational aspects of physics.

Physics often uses mathematics metaphorically, but these metaphors are carefully selected so that mathematical deductions result in calculations that can be matched to observation. One of the harshest criticisms in physics comes from Wolfgang Pauli and consists of the judgment that a theory is “not even wrong” (Peierls, 1960). This is a situation when it is not possible to falsify the theory, so that there is no means in principle through which the theory could be tested. String theory is widely hyped, but in all probability is an example of such a theory (Woit, 2006). Science advances through failure, not through success. Physicists are warned not to reify the mathematical structures that are used in their theories (Mermin, 2016). Reality is not the model and the model is not reality.

Mathematics is the only domain of human knowledge in which one can know with absolute certainty that a result is true or false. When mathematics is applied outside of the physical sciences, due diligence must always be applied to ensure that there is a faithful correspondence between the mathematical relationships and the relationship among the entities being modeled. No matter how accurate the mathematics, without that correspondence it is illegitimate to draw any connection between mathematical derivations and real phenomena. In such a case the mathematics provides at best a cartoon of reality. This can be well meaning, as occurred with Penrose's model of consciousness (1989), but it can also be deliberately disingenuous.

Turning to transpersonal psychology, the goal is not to mathematize subjective experience. That would be nonsensical. The application of mathematics to subjective experience requires careful observation and experimentation to identify what characteristics serve to distinguish one subjective experience from another, and then to determine what relationships exist between these characteristics. This approach has proven highly successful in perceptual psychology and is being applied to the study of temperament (Trofimova, 2016b). The purpose of this paper is to explore some of the ways in which the mathematical concept of fractals might give insight into the phenomena of transpersonal psychology. First, fractals will be described, followed by a discussion of some of the ways in which they can be generated. Then some possible ways that they can be applied to the study of transpersonal psychology will be discussed.

Fractals described

Mandelbrot described the field of fractal geometry as a "virtual discipline" (Mandelbrot, 2002, p. 18-19). He felt that the field was too broad in its symmetries, geometries, mechanisms and applications to be encompassed by a single specific definition. The discussion here is meant to describe what it means to be a fractal without any attempt to define this.

Since the publication of Mandelbrot's, *The Fractal Geometry of Nature* (1977), most people—when they think of fractals—think of the Mandelbrot set, a remarkably beautiful computer-generated image that can be enlarged infinitely often, so as to yield level and after level of similar appearing details (see Figure 7-1). Fractals were first discovered near the turn of the 19th century during explorations of the extreme limits of the concepts of continuity and differentiability. Treated as pathological monsters by mainstream mathematics, they languished for nearly a century until their re-discovery by Mandelbrot in the early 1960's. Fractals are true children of the computer age. Indeed, modern computer graphics would probably not exist were it not for fractal geometry. Millions of people would not pay Hollywood to see computer generated movies were it not for the resemblance between fractals and naturally occurring structures.

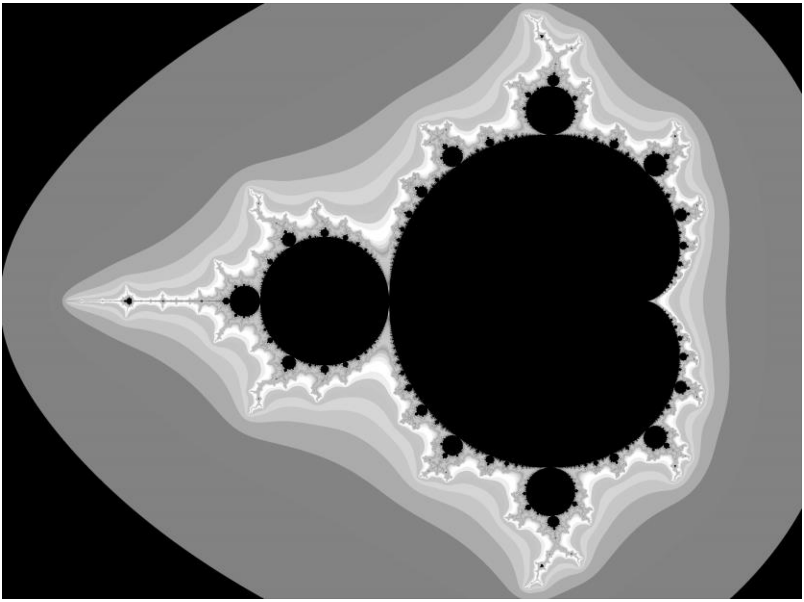

Figure 7-1. The Mandelbrot Set

There is a temptation towards hyperbole, thinking that fractals describe *the* geometry of nature. This was once thought true of Euclidean geometry before the discovery of Riemannian and Lobachevskian geometries. The truth is that all of these geometries describe some aspects of nature but none of them describe all of nature.

The focus of much of modern mathematics has been on the concept of smoothness. This can be seen in Euclidean geometry and its emphasis on straight lines. The idea of continuity formalizes our intuitive ideas about wholeness—the absence of breaks or gaps. Differentiability describes smoothness—the absence of sudden jerks, hesitations, bumps or crevices. The concept of a smooth function in mathematics is a function that possesses derivatives of all orders. It is infinitely differentiable. It is smooth, and its derivative is smooth, meaning the derivative of its derivative is smooth, and so on ad infinitum. If one examines a smooth function with a microscope, then as the magnification increases, the function looks more and more like a straight line.

According to Mandelbrot, fractals represent a first step towards a theory of "roughness." Mandelbrot noted that much of physics (and sometimes mathematics) has been inspired by the attempt to understand certain subjective experiences such as heaviness, hotness, loudness, and brightness (Mandelbrot, 2002). He noticed that most objects in the physical and biological realms were not smooth and saw roughness in those early pathological functions that mathematicians had so assiduously dismissed. The Weierstrass function (Figure 7-2), for example, is continuous, but is nowhere differentiable. It is the very antithesis of smooth. The function varies so erratically and so violently that there is no point in its domain of definition where it is possible to determine a derivative. That means that there is no point at which a straight line drawn from the value of function at the point comes even marginally close to approximating the function. For the interested reader some of the technical details involved in the construction of such functions is provided in the mathematical appendix.

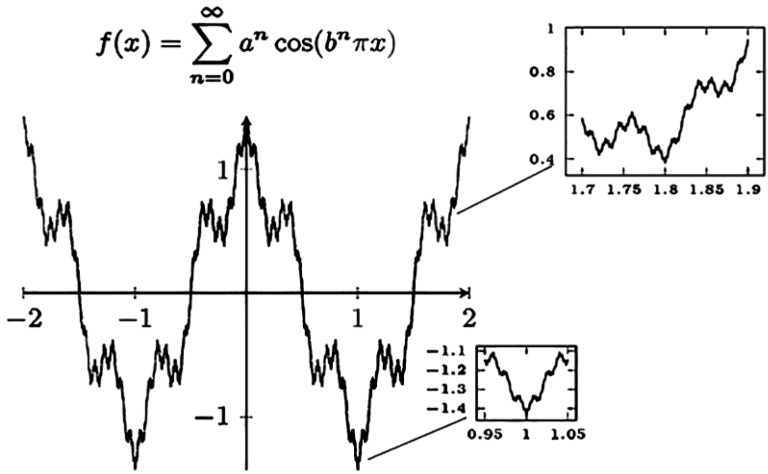

Figure 7-2. A cartoon of a Weierstrass function. This is similar to the sawtooth function but uses cosines instead of triangles. The insert shows a small region of the function magnified. (Courtesy of Google Commons)

Mandelbrot stated that "fractal geometry is *the study of scale-invariant roughness* (SIC; Mandelbrot, 2002, p. 9). Intuitively, scale invariance means that as one magnifies the graph of a curve, the curve looks more or less the same. This can be seen in the inserts in Figure 7-2 showing two magnified regions of the curve. A smooth curve is not scale-invariant. The graph of the Weierstrass function is scale-invariant.

Fractals are commonly described as mathematical objects whose dimension is fractional. Classical mathematical objects such as points, lines, surfaces, and volumes have dimensions 0,1,2,3 respectively, all integers. The idea of a fractional dimension is subtle. Normally we think of dimension as the number of numbers needed to assign a relative position to some object, whether it be in space, time, intensity, temperature and so on. In fractal geometry, the notion of dimension comes from a scaling law, which describes how some feature changes as a scale parameter is changed. For example, fix the resolution on a map and measure the length of a coastline. Then increase the resolution and measure the length again. Do this for many different resolutions and plot the length L of the coastline as a function of the resolution r, L=f(r). In general, the function f will take the form of a power law, so $f(r) = Ar^{-D}$. D is called the dimension and corresponds to the usual value of dimension in the usual cases.

The name fractal comes from the fact that the vast majority of fractals possess a fractional dimension, which clearly distinguishes them from the usual geometric shapes. However, it is not absolutely necessary that this be the case. For example, the graph of F(1, x), has fractal dimension 1. Mandelbrot considers it a borderline fractal. Mandelbrot emphasized that the defining property of a fractal is not its dimension but rather another geometrical property called *self-affinity*. In Euclidean geometry there is the notion of similarity. Two figures, such as two triangles, are similar if one can be mapped onto the other by either shrinking or enlarging it and then moving it over top of the other.

Self-similarity occurs when the whole of a function can be mapped onto a region of itself by either shrinking or enlarging it. Self-affinity is a more general relationship which has no simple definition since it comes in many different forms (Mandelbrot, 2002). The distinction between self-similarity and self-affinity is important. Self-similarity produces beautiful images, but it is a rare phenomenon, restricted mostly to highly contrived mathematical models. As Mandelbrot emphasizes throughout his writings, self-affinity is the more general concept, which has applicability to natural phenomena. Self-affinity, however, is also the subtler concept and requires much more careful analysis. An example of one type of self-affinity, dyadic bridge self-affinity, is given in the mathematical appendix.

The mathematical representations of both smoothness and roughness must be considered as ideals, or archetypes. They assume perfect measurements, perfect information, infinite detail, extending throughout all of space and time. No natural system is smooth or rough in the mathematical sense, but it can be approximately smooth or rough to a sufficient degree.

Another important feature of fractals is that they are highly variable. They fluctuate. More importantly they fluctuate so much that they have infinite variance and sometimes infinite means as well. This is of great importance when the fluctuations can mean great profit or great loss, or the difference between health and illness. Measuring variability is important for the detection of fractal structure. Plotting the frequency of appearance of these fluctuations as a function of their size, one obtains a *fluctuation curve* (or fluctuation spectrum). Other measures can also be invoked, such as local correlation or entropy. Figure 7-3 shows a variety of time series ranging from simply periodic through chaotic, on to colored noise and ending with white noise. The figure illustrates the progression from regularity to randomness. The time series are arranged according to their recurrence period density entropy (Little et al., 2007). Given some discrete probability p, the entropy is given as $H= - \Sigma_n p(n)\log p(n)$. The probability density is estimated by choosing a point, examining the time series and forming a histogram of the time taken for the time series to return to a small neighborhood surrounding the point, and then doing so for every point.

H=0 for periodic time series and H=1 for white noise. For fractal time series, H is generally greater than ½.

Standard teaching in statistics courses, particularly in psychology and psychiatry, would assert that the probability distribution of the fluctuations should follow a Gaussian distribution, since they should represent the variation about some mean. This in turn leads to the prediction that small variation is common while large variation is extremely rare or effectively non-existent. The invariable return to the mean is understood as a marker of equilibrium, of homeostasis, of the proverbial "invisible hand of the free market." This might be true of isolated, simple-linear systems but not for open, complex systems. This was brought home in dramatic fashion in 2007-8, when a large fluctuation in the stock market collapsed much of the global economy. Complex systems generally have fluctuation curves of the form $1/f^{\beta}$. These curves have infinitely long tails, which implies that, although variations of large size are rare, they are guaranteed to occur at some time in the future. Fractals typically have fluctuation curves of this form and this is one of the most important signatures of a fractal.

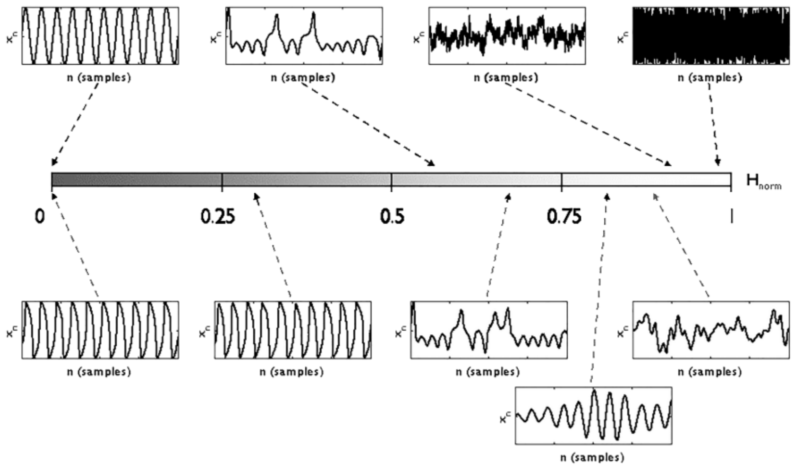

Figure 7-3. Different time series ordered by their recurrence period density entropy H. From left to right they transition from fully periodic, through driven periodic, to fractal time series, ranging from chaotic, through colored noise all the way to white noise. (Courtesy of Google Commons)

An additional feature of fractals that is worth mentioning concerns the notion of distance within a fractal. Just as the real number system describes distance in Euclidean geometry, so distance within fractals is described by another number system called the p-adic system. Here p is some prime number. Every real number can be represented in a decimal expansion of the form $x = \Sigma^{\infty}_{n=m}\, a_n\, 10^{-n}$, with the numbers extending to the right, for example 1234.123456…... Every p-adic number has a representation as an expansion of the form $\Sigma^{\infty}_{n=-m}\, a_n\, p^n$, with the number extending infinitely to the left, for example, …..654321.4321. Using these numbers, it is possible to define a concept of distance on a fractal, and for each p the set of p-adic numbers has the structure of a fractal. Thus, if the elements of the collection under consideration can be endowed with a "distance" relationship, and this distance measure has the structure of a set of p-adic numbers for some prime p, then the collection has the structure of a fractal. Note again that is the relationship between entities, which is important for understanding both structure and creation. The creation of fractals is the focus of the next section.

Fractals created

Fractal images can be beautiful or ugly, interesting or boring. The significance of fractal structure for a psychologist or psychiatrist lies not in aesthetics but in causation. The appearance of a fractal structure suggests the presence of some form of randomness. This randomness may be *stochastic* (multi-valued, governed by a probability distribution), *deterministic* (such as sensitive dependence on initial conditions in chaos), or *non-deterministic* (dependent upon a choice by an agent).

Mandelbrot describes 3 types of randomness: mild, slow, and wild. *Mild randomness* is that which is typically described by Gaussian models. Such randomness follows the law of large numbers, the central limit theorem, Fickian diffusion, and the property that as time progresses, the past and future averages become increasingly close to being statistically independent (Mandelbrot, 2002) (see the mathematical appendix). Mild randomness appears when local effects predominate, so that relative contributions to various sums or integrals are negligible, even if large. *Wild randomness,* on the other hand, is what is observed in turbulence and in economics (for example, stock markets). Wild randomness violates at least the third property above, and sometimes the last two or even all three (Mandelbrot, 2002). Wild randomness appears whenever global effects predominate, so that large contributions cannot be ignored, and sums and integrals become non-existent or infinite (Mandelbrot, 1999). Wild randomness is best described using fractals and multifractals.

Slow randomness fits somewhere in between these two extremes. It appears whenever locality dominates in asymptotically large systems while globality dominates in small systems (Mandelbrot, 2002). Unfortunately, slow randomness appears to be ubiquitous in psychology, psychiatry, and medicine more generally, where globality (that is personal history) dominates within single individuals and tends to diminish in populations, which can lead to a great many problems in diagnosis and treatment.

The important question when faced with a fractal is to determine its mechanism of generation. A major problem with such determinations using only the fractal structure is that in the natural world, all fractals are ultimately limited in some manner. The sample may be too small, or information may be limited. Since everything in nature is finite, infinity-dependent models may fail to fit the observations. One can mistake a fractal for a non-fractal, because the system has not generated enough detail. One may mistake a non-fractal for a fractal because one is looking at a very long duration transient (that is, non-regular behaviour that appears before the regular behaviour manifests). Worse, the dynamics may be contextually dependent, and so any probabilistic structure may be non-stationary (i.e., variable over time). In the end, there is simply no substitute for hard work and a multi-disciplinary, multi-level analysis of the phenomenon, testing simple models and increasing the complexity as new information guides one's efforts.

There are so many different mechanisms for generating fractals that it is doubtful that a universal theory will appear. One conclusion that can be stated with confidence is that whenever fractal structure appears, one can rule out a linear-deterministic process as the generator of such behavior. This means that most of our traditional tools for data analysis and modeling need to be set aside. The use of a linear model, however much variance it might "capture," will still provide misleading results because it can never accurately represent the actual dynamics responsible for generating the fractal. Clinical intuitions drawn from observations of linear behavior can go horribly wrong when applied to fractals. For example, it is often believed that a small event can only result in a small effect, anything to the contrary gets dismissed as hysterical. Prior to the economic collapse of 2007-2008, it was widely believed that such an event was impossible, since that is what the transitional (non-fractal) models asserted.

There are many mathematical techniques for creating fractals, although most are not dynamical. The function F(D,x) defined above uses a technique termed midpoint displacement, which has several variants involving either adding or removing structure. The familiar Cantor set is formed by subtracting line segments from "middle thirds" (see Figure *-4, top), while the Sierpinski triangle is formed by adding little triangles to middle thirds (see Figure 7-4, bottom).

A dynamic technique invokes a random walk (see the mathematical appendix). For a one-dimensional Gaussian random walk, one imagines a particle which can move left or right at time t by any distance, which can be chosen at random from a Gaussian distribution with mean 0 and variance |t|. A more complicated procedure leads to fractional Brownian motion.

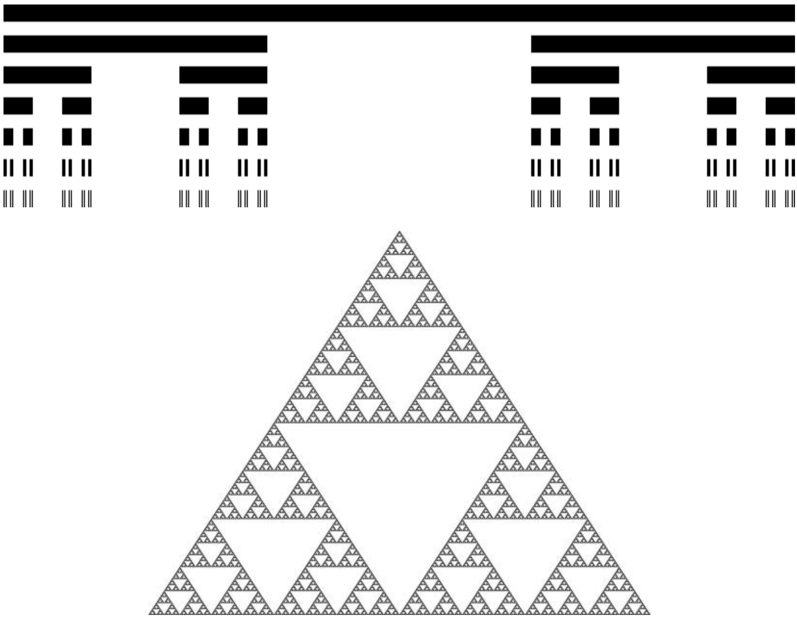

Figure 7-4. Cantor set (top) and Sierpinski triangle (bottom)

Another dynamic technique is to study the *attractor* of an iterated function system (Barnsley & Demko, 1985). An attractor is the set of points to which the trajectories trend as time passes indefinitely. An iterated function system is a collection, usually finite, of nonlinear self maps (see the mathematical appendix) acting on the same space, real or complex, bounded or unbounded. Since each function maps the space to itself, either the same or a different function may be applied subsequently. The fractal of interest is the attractor for this dynamic. This is the set which is contained in all possible iterates of the space. Another way to think of it is that it is the fixed point of the iteration process. It is the only set that is left unchanged by the action of the iterated function system. The iterated function system consisting of the single nonlinear function (logistic map) $f(x) = \mu x(1-x)$ acting on the interval [0,1] is the archetypal example used in countless textbooks. One can plot the trajectory of a single point, say 0.234, as a function of the value of μ, thereby obtaining the famous bifurcation diagram (see Figure 7-5) illustrating the transition to chaos. For a fixed value of μ giving rise to chaotic dynamics, the set of bounded trajectories has a fractal structure (usually that of a Cantor set).

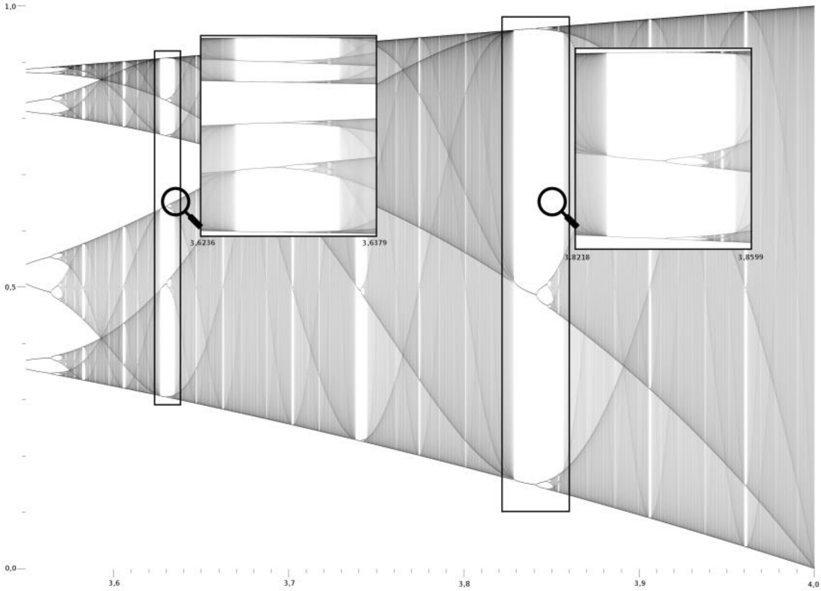

Figure 7-5. A bifurcation diagram for the logistic map. The x-axis gives the value of the control parameter. The y-axis shows the attractor of the dynamics for the given value of the control parameter. Note how the period of the attractor doubles. Note as well the appearance of a strange attractor (chaos) after a period 3 attractor appears. (Courtesy of Google Commons)

The famous Mandelbrot set (see Figure 7-1) is constructed in such a manner. It consists of the complex numbers c for which the trajectory from $z = 0$ under the iterated function $f_c(z) = z^2 + c$ does not diverge, but instead goes to infinity. The boundary of this set is one of the most beautiful and complex (forgive the pun) mathematical objects that can be easily visualized. Note that the Mandelbrot set is *not* a trajectory nor is it an attractor. Instead it lies in the control space defined by the values of c. A control parameter does not generate a particular trajectory. Instead a control parameter defines particular dynamics. These dynamics can be observed by selecting a particular value for the state parameter, z, and then watching its subsequent trajectory unfold under the action of the Mandelbrot map. This is very important to understand for psychology. The control parameter c acts like a context which specifies a particular dynamic, or which disposes the system to act in a particular way given a particular state. A classic example of a control parameter in psychology is level of arousal.

Another important source of fractals is the dynamics of complex systems (Sulis, 2017b). Complex systems consist of multiple interacting subsystems. The interactions are usually non-linear and informational. The non-linearity weaves the information into forms that ultimately give rise to collective behavior that transcends that of the individual component systems (Sulis, 1997b). This emergent behaviour acquires its own symmetries and laws, which are not direct or simple extrapolations, or consequences, of those that constrain the individual component systems (Sulis, 1993, 1995a, 1995b, 2007). The human brain is considered to be one of the most complex systems known to date. Organisms as a whole also constitute complex systems. Social insect colonies, even though they are composed of freely moving individuals, also form complex systems, which collectively can implement decision making that rivals that of humans (Sulis, 1996, 1997a, 1997b, 1997c, 2009).

Cellular automata are simple models of complex systems which are capable of generating fractal structure even when only a few component systems are involved. A cellular automaton consists of a collection of cells, each of which can be in any one of a set of states, a rule that assigns a neighbourhood of cells to each cell, and a rule which specifies how the state of a cell changes given the current state of the cell and of the cells in its neighborhood. One starts with some initial configuration of states and then allows the automaton to evolve under the dynamics specified by its rule, generating a spatio-temporal pattern (Figure 7-6). Wolfram (2002) studied the behavior of each of the 2-state, 3-neighbour rules, classifying them into 4 groups depending upon the patterns that they generate: fixed, linear, complex and chaotic. The complex and chaotic rules generate fractal patterns. Many of the chaotic rules generate self-similar patterns (at least when initialized in some particularly simple configurations), while the chaotic rules generate random appearing patterns that are at best self-affine.

The behavior of a system of just 100 components is extraordinarily complex. Yet psychologists believe that the behaviour of a brain having 30 billion neurons and 70 billion glial cells can be described using just a few characteristics. For example, adherents to the Five-Factor model of personality believe that all of human psychological diversity can be explained using only 5 supposedly independent dimensions (Trofimova, 2016b). At the very least, the study of fractals might introduce a bit of humility into psychology.

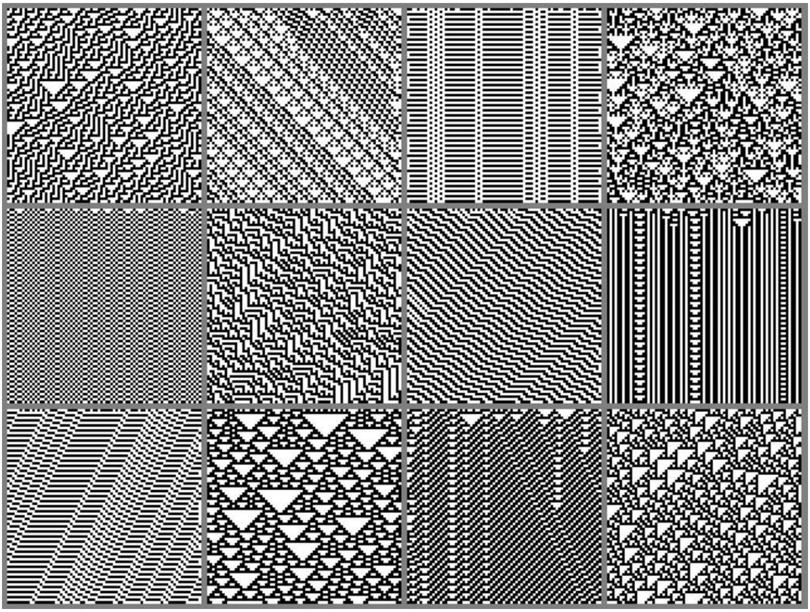

Figure 7-6. Typical spatio-temporal patterns generated by different cellular automaton rules. Note the self-similarity of several patterns. (Courtesy of Google Commons

Fractals applied

The application of fractals to the study of transpersonal psychology is in its infancy. Indeed, the application of fractals in psychology generally is quite limited. Thus, this section is mostly speculative. Three suggestions appear promising for a scientific approach, and they will be addressed in turn.

Direction 1) *Transpersonal psychology could assume that transpersonal experience is a particular form of neurodynamics, or perhaps brain-body dynamics, and attempt its study through neuroscientific methods.*

Unless one wishes to assert that awareness (and self) can exist independent of the physical body, then it is stating the obvious to assert that awareness must supervene upon the activity of body/mind. To state this is not being reductionist, since no position on causation or on causal influences is being taken. Awareness and self, indeed all psychological phenomena, appear to be emergent from body/brain dynamics, and that dynamics is a consequence of an overwhelmingly complex array of interactions from the level of the gene, through neurotransmitters, neuropeptides, hormones, to neural action potentials, and then upwards through neuronal networks to psychological states themselves, and on to societies, cultures and the physical environment. Causal influences act bottom-up (e.g., psychedelic drugs), top-down (e.g., learning) and horizontally (e.g., formation of subcultures). Identifying single causes for such complex phenomena is not merely simplistic, it is manifestly lacking in explanatory merit. The appearance of fractals reminds us of the enormous complexity of the dynamics involved and the necessity for a multilevel, multi-disciplinary approach to research. Their presence does not specify the nature of the dynamics, but it certainly will not be linear. It may be stochastic or chaotic, or “edge of chaos” (Wolfram, 2002), but it will not be linear.

The Buddhist psychological concept of conditions is much to be preferred to the concept of cause. The notion of cause is simply too limiting. Causes are usually considered to be unitary. The relationship between cause and effect is usually thought to be direct; the presence of the cause guarantees the effect. Instead, one should speak of causal conditions or causal influences instead. These causal conditions generally involve a multiplicity of interacting factors, in which different patterns of interaction are associated with different effects. Causal conditions are those that can be observed to make a difference, whether or not the presence or absence of any single condition results in a change in the observed phenomenon.

There is an element of randomness or indeterminism at all levels. At the lower levels it is well known that the dynamics appear to be stochastic. The release of neurotransmitter from individual neurons is stochastic (Gerstein & Mandlebrot, 1964). The firing pattern of a population of neurons in response to a stimulus, or of a single neuron in response to repeated applications of the same stimulus, is stochastic (Shadlen & Newsome, 1994). It is known that most receptors in the brain are of the G-protein coupled type (Kandel, Scwartz, & Jessell, 2000), which implies that the neuron does not directly stimulate the dependent neuron but instead modulates its dynamical response to direct stimulation by other neurons. Studies of the lobster stomatogastric ganglion (Harris-Warrick, Marder, Selverston, & Moulines, 1992) have shown that this ganglion functionally rewires itself in response to hormonal signals from the gut, enabling it to control all of the various motions of the gut with only 50 neurons. There is abundant evidence that various mental functions—movement, emotion, memory, cognition—are spontaneously generated from current conditions, potentially using different neurons and pathways each time (Barrett, 2017;

Edelman, 1987; Freeman, 2000, 2001; Whiting, 1983). There is also abundant evidence of power law scaling at a variety of levels within the neuroaxis (Brown & West, 2000; Kello et al., 2010; West, 2006). All of this suggests that slow or wild randomness might appear at some levels up the chain from gene through body/brain to culture.

Thus fractals, and particularly the implications arising from their presence, should play a fundamental role in modeling the dynamics of body/brain, which forms a foundation upon which to build dynamical models of successively higher levels of phenomena, including those of transpersonal psychology. The generative nature of psychological phenomena attests to their complexity, and so a study of the mechanisms generating fractals should provide insights, or at the very least toy models upon which to develop insights, which can guide the development of more effective models of psychological processes, including transpersonal phenomena.

One very important consequence of an understanding of fractals, and of even a few of the mechanisms giving rise to them, is a change in our intuitions about cause and effect and about the nature of variability in behaviour. Our common sense intuitions have become ever more influenced by the artificial environments that have been constructed by humans, with their straight lines and seeming permanence and predictability. Machines are constructed to be stable, and to operate within linear regimes, so that cause is directly proportional to effect. This enables humans to more easily control them. But these are not the intuitions that are needed to deal with natural environments, bodies, or psyches, where slow and wild randomness is in abundance.

Direction 2) *Transpersonal psychology could assume that transpersonal experience is a particular form of subjective experience and attempt its study psychologically.*

Previously it was suggested that all psychological experience is subjective experience, and that the adjectives subjective and objective should apply only to the conditions which elicit psychological experiences. Taking a realist stance, the conditions which elicit transpersonal experiences would appear to lie within the subjective category. Although people may share the same physical experience, whether it occurs in a church, sacred site, meditation hall, or so forth, some may have a transpersonal experience (which may be unique to each person), and others not. This can be true even though each participant could be capable of describing the physical details of the site and what transpired there. It thus seems reasonable to at least conjecture that a transpersonal experience is a subjective experience arising from subjective conditions. This makes for challenging science.

An approach that appears promising again takes its inspiration from Buddhist psychology. In Buddhist psychology, mind is considered to be just another sense organ, whose sense object is form. In meditation, the contents of mind are treated in the same manner as the contents of the other sense organs: they are noted, and then disregarded. Attention is focused on gaining insight into the three characteristics of all subjective experience: transience, unreliability and non-self. The latter is a subject of great debate and complexity but in simple terms it refers to the idea that subjective experience is an emergent phenomenon arising from the activity of body-brain, not of self, which itself is an emergent aspect, as is self. The self documents awareness of experience and becomes a condition underlying future action. In meditation the focus of awareness is on the dynamical characteristics of all experience regardless of its source. Content is secondary, unless it becomes an impediment to achieving this primary goal.

In psychology, a great deal of time and effort is spent understanding the mechanisms whereby specific content becomes registered in subjective experience (for example learning specific material in school). This is much easier when the content to be learned forms part of a set of objective conditions which can be shared by researcher and subject alike. It is much more difficult when the content arises from subjective conditions which, by their very nature, may be inaccessible to (and therefore uncontrollable by) the researcher. Subjective content is particular and specific—what is commonly referred to as a rare or singular event. On the other hand, the processes which give rise to content and to subjective experiences, are much more likely to be universal, since they more likely reside in the dynamics of body/brain.

Buddhist wisdom teaches us to “follow the process.” Independently from Buddhist teaching, neuroscientists have followed this path in their studies of the neurodynamics underlying meditation. The most consistent finding to date has been an alteration of activity in the *default mode network* (Garrison, Zeffiro, Scheinost, Constable, & Brewer, 2015). Hasenkamp, Wilson-Mendnhall, Duncan, & Barsalou (2012) followed the course of meditation by having subjects press a key whenever they detected mind wandering and immediately before returning to sustained attention. They found that mind wandering was associated with activity in the default mode network (medial prefrontal cortex and posterior cingulate cortex), awareness of wandering was associated with activity in the *salience network* (anterior insula and dorsal anterior cingulate cortex), and sustained attention was associated with activity in the *executive network* (dorsolateral prefrontal cortex and lateral posterior parietal cortex). Sadly, although they found anatomic correlates, they did not study the dynamics of these processes, but that could be done. For example, a plot could be made of the time intervals between key presses, from which a fluctuation spectrum could be derived, and scaling properties analyzed. This would provide a means of observing whether the timing of attentional shifts follows a pattern of mild, slow, or wild randomness. If fractal structure exists in the timing, this would provide one means to demonstrate it. Modern models of mindfulness processes are emerging (Vago & Zeidan, 2016) and would be well served by an inclusion of dynamics.

Another insight concerning transpersonal experience came from the book of Jill Bolte-Taylor (2008), a neuroscientist who experienced a left cortical hemorrhagic stroke and survived to write about the experience. In the absence of left-sided function, she had many experiences that could be considered transpersonal. In contrast, Johnstone et al. (2012) studied subjects with traumatic injury to right parietal regions and, again, experiences of a transpersonal character were reported (see also Flor-Henry, Shapiro, & Sombrun, 2017). Again, the dynamics of these regions was not studied, but it could be, and a knowledge of fractals and their relationship to dynamic could prove invaluable.

Direction 3) *Transpersonal psychology could focus on transpersonal experience as normative, creative and adaptive, and attempt to devise intervention methods which utilize such experiences as a resource in aid of therapy.*

This final section departs from the scientific attitude which informed the previous sections and turns to art, particularly the art of psychotherapy. Psychology, like the Roman god Janus, is two-sided; there is scientific psychology with its focus on scientific rigor and fundamental knowledge, and there is clinical psychology with its focus on finding effective interventions to relieve mental distress and promote healing. There are myriad ways in which an understanding of fractals could serve the practice of psychotherapy. Here the use of fractals is entirely metaphorical and so care will be taken to avoid the pitfalls in the use of mathematics metaphors as previously suggested.

There are three players in psychotherapy. There is the patient, the therapist, and the patient-therapist dyad. Consider first the therapist. The therapist's goal is to create conditions which increase the likelihood that a change can take place within the patient which will help to ease his or her distress (and perhaps lead to greater effectiveness in his or her life). An understanding of the process of change and the factors that facilitate this process is critical to the therapist. Therapists need to identify those factors that can be influenced and which in turn can make a difference. They need to understand the effects that changes in these factors will produce and to look for their signatures in the reports of the patient. They need to be able to correctly interpret patient reports in terms of the consequences for their dynamics and the possibility of change.

For example, stability is often considered to be one goal of therapy. People suffering illnesses are considered unstable, while normality is equated with stability. Mathematically, however, stability refers to resistance to change; so patterns of behavior may be highly fluctuating, yet stable. Indeed, illness is often profoundly resistant to change and excessively stable. To induce change it is usually necessary to induce variability, and the form of the variability can tell us much about what is happening dynamically. Fluctuations that have a Gaussian flavour may be no more than noise. They perturb the patient but do not change the dynamics, and their inherent stability will bring them back to baseline. It is not real change. The new appearance of fractal variability (or at the very least 1/f scaling), on the other hand, can be an indicator of a change in the underlying dynamics. It can be a marker of a transition from one dynamical state to another. This can be a signal to the therapist that a real change is taking place and that their interventions are being effective. New technology such as Fit Bits and mood trackers may enable therapists to record pertinent aspects of their patient's behavior over extended periods of time. From these time series, particularly if suitable proxies for mood states have been chosen, it may be possible to measure their fluctuation properties.

For the patient, an understanding of variability can be a source of comfort. Learning that some kinds of variability can be healthy and desirable can be liberating. Learning to recognize new variability as a sign of change, and not as an indicator of greater dysfunction, can help to reduce resistance. Folk psychology is full of inaccurate, unhelpful, and downright damaging beliefs. The more the patient can understand the nature and dynamics of subjective experience, the freer they can become. Pictures of temporal fractals can show patients (and therapists) what variability looks like, Buddhist psychology, with its emphasis on understanding the nature of subjective experience free of judgment, can be a powerful ally in facilitating chance. Helping a patient to move past the content of their subjective experience can be one facilitator of change. Depressive and anxious content tends to be self-reinforcing, leading to behaviors that reinforce the content; down the rabbit hole the patient goes. Breaking this cycle can be critical to allowing patients to transition out of illness.

Psychology has traditionally focussed on the content of subjective experience. Patients are encouraged to seek out the "causes" of the distressing content. In the case of post-traumatic stress, the precipitating incident might appear obvious. For most illness states, however, no clear-cut event can be found. The initial instance of illness is not necessarily caused by the conditions present at the time of onset. They might contribute, but they might also be entirely incidental. The discussion previously about the complexity of the dynamics of the body/brain/environment system should make it abundantly clear that most of the conditions are outside of our ability to perceive them. We can create a convincing story of causation at a psychological level, but we cannot know that the story captures an important factor.

Memory, including autobiographical memory and sense of self are mental constructions, arising out of myriad conditions across all dynamical scales. They serve both personal and social goals. As a result, we tend to fixate at a particular level of understanding, but for too many illness states. Such an understanding offers little in the way of opportunities for change. The narratives are all too often reified, made into some form of absolute truth. We can analyze the narrative in endless detail, or we can try to replace the narrative with a new narrative that is supposed to be more liberating. Yet, either approach runs the risk of forcing the patient to re-experience the narrative, which only tends to reinforce it in memory. This does not free the patient; it only makes the illness state more stable.

Buddhist psychology offers a way out of this bind. By focusing on the processes that give rise to subjective experience, a patient may gain the insight concerning the constructive and conditional nature of their own subjective experience. The realization that these processes act without the intervention of self and, moreover, that self is itself a subjective experience with all the same characteristics, can help the patient bring these experiences down to earth. The reification can be removed, and subjective experiences can be seen clearly for what they are: transient, imperfect, conditional, and not reflective of self. This can create the mental space to allow these experiences to fade and to break the habit cycle which conditions them again and again. Real change becomes possible. Learning the nature of subjective experience and our personal narratives does not diminish or devalue them, nor does it deny their significance in our lives. It does, though, alter our relationship to them going forward. The patient may realize that they have a choice, that they have alternatives. Sometimes they may realize that they have no choice, and stop thinking that they do, thereby ridding themselves of frustration and despair.

It is here where images of spatial fractals might be of value. Spatial fractals, with their self-similar and self-affine geometry, paint vivid images of self-reflection and self-repetition. One can provide the patient with an image of the rabbit hole, of a pattern endless repetition throughout their world. Showing images of the changes in geometry as control parameters change can vividly illustrate the ideas of using control parameters to bring about change. That may, in turn, help patients to understand the nature of the conditions that are being sought within the therapeutic process. It may not accurately capture the dynamics at play, but it nevertheless can serve as a useful metaphor for the dynamics of change, so long as no claims are made about it being an accurate depiction of what transpires within the psyche.

For the patient-therapist dyad, the value of a fractal perspective in the dynamics is that it is a complex interaction, which, if it is to be effective, should neither be rigidly stable (so no change can occur) or wildly chaotic (where nothing can persist). The dynamic needs to reside somewhere in the middle: within that range termed “edge of chaos” or “slow randomness.” There needs to be variability but also persistence, so that the patient has time to process what is being learned and the therapist has time to appreciate the nuances of the dynamics and identify the relevant control parameters. A comparison between smooth curves and fractals might be useful here. Smooth curves illustrate rigid stability. Fractals illustrate wild randomness but self-similarity. In the dyad, these two paths are probably best avoided, and a path of slow randomness with its mixture of stability and variability, of gradual change may be preferred. The images may help the patient and the therapist to develop intuitions into slow randomness. These intuitions might foster research to understand the vast wealth of dynamics underlying slow randomness.

Conclusion

Can fractals help cross the transpersonal chasm? The main argument in this chapter is that all psychological experience is ultimately subjective experience, and so the distinction between so-called mainstream psychology and transpersonal psychology is perhaps not as broad as advocates of the former might assert. The crucial distinction is that mainstream psychology focuses on what are presumably objective conditions underlying subjective-psychological experience, while transpersonal psychology embraces subjectivity in both experiences and conditions. The foray into fractals is not meant to suggest that transpersonal experiences are somehow fractal, self-similar, or self-affine. It is meant to show that, by focusing upon the relationships between subjective experiences rather than the experiences themselves, it becomes possible to develop mathematical metaphors that are more than mere window dressing, more than romantic scientism, providing a possible first step towards a scientific study of subjective experience.

The search for signatures of fractals in transpersonal phenomenology can provide insight into the nature of the dynamics underlying the generation of these phenomena. The search for symmetries and other consistent relationships can enable the development of mathematical tools which may aid in teasing out important features of the dynamics. This in turn can guide researchers in their studies. Detecting the presence of fractal structure, whether in time, space, or in some other metric, can move researchers away from a simplistic and misleading dependence upon linear statistics and linear models, towards nonlinear and complex-systems models having greater fidelity and accuracy in health and psychopathology. This in turn, can lead to intuitions that more accurately represent the dynamics of the phenomena in question; and that in turn can improve the conduct of therapies aimed at altering such dynamics.

To achieve these goals, however, requires that fractal ideas be used cautiously and meticulously, based upon the slow accumulation and analysis of evidence, involving multiple levels of phenomena and multiple disciplines, and not just treated as another fad dismissed whenever the next fad might come along.

Mathematical Appendix

The Weierstrass Function: The Weierstrass function was mentioned as an example of a continuous, nowhere differentiable function, and thus a fractal curve. The basic technique for defining such a function can be illustrated using an example from Mandelbrot (2002, p. 101). We shall define the function as an infinite sum of functions defined on the real line. The initial function, σ, is defined as follows. For even integers x, set $\sigma(x)=0$. For odd integers x, set $\sigma(x)=1$. For y lying in the interval between two adjacent integers, n, m, (i.e. y lying in [m,n]), set $\sigma(y)=\sigma(m)+\sigma(n)(y-m)/(n-m)$. The function σ consists of a series of straight lines, of alternating slope 1, -1, depending on whether the left end-point of the interval is even or odd respectively. It looks like a series of saw teeth, hence the nickname of sawtooth function. Now for each integer k, define a new function $\sigma_k(y)=\sigma(2^k y)$. This function resembles the original sawtooth function except that the intervals now take the form $[m/2^k, n/2^k]$. We say that the function has been rescaled by the factor 2^k. Now consider the function $F(D,x) = \Sigma^{\infty}_{k=0} w^k \sigma_k(x)$ where $w=2^{D-2}$. The factor D is called the dimension of the function and takes values in the interval [1,2). This function is continuous but is nowhere differentiable.

The graph of this function, that is, the collection of points on the real plane given by{x, F(D,x)}, is an example of a fractal. Figure 7-7 illustrates the Takagi curve, obtained when D=1. Several features of this graph are worth noting. First of all, it resembles random motion, such as Brownian motion, or stock market fluctuations. Second, if one zooms in on a small section of the graph as depicted in the figure, the selected section bears a striking resemblance to the larger graph. Third, the dimension of the graph is D. (For the technically inclined, the box dimension of this function is D locally, 1 globally, while its Hausdorff-Besicovitch dimension is D).

Self-Affinity: Self-affinity, in one of its many forms, can be illustrated using the function F(D,x). Mandelbrot (2002, pg 103), defines $F_j(D,x) = \Sigma^j_{k=0} w^k \sigma_k(x)$. Notice that $F(D,x)-F_j(D,x) = w^j F(D,2^j x)$. Mandelbrot calls this a dyadic bridge of length 2^{-j}. This dyadic bridge is just a rescaled version of the function itself. One can also see that $\Delta = F_k(D,x) - F_{k-1}(D,x) = w^k\sigma(2^k x)$ which again is just a rescaled version of σ.

Examining the definition of F(D,x) it is obvious that it is defined as an infinite sum of rescaled versions of σ. This is what is meant by dyadic bridge self-affinity. F(D,x) is not, however, self-similar. We can obtain a self-similar function related to F. Define $F^*(D,x) = \Sigma^{\infty}{}_{k=-\infty} w^k \sigma_k(x)$. Then $F^*(D,x) = h^{-(D-2)}F^*(D,hx)$ if $h = 2^p$ for some integer p. $F^*(D,x)$ is self-similar.

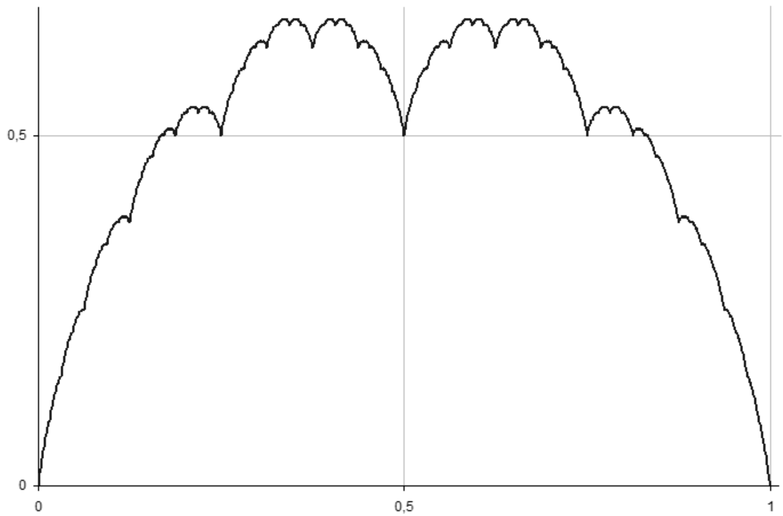

Figure 7-7: The Takagi curve F(1,x). (Courtesy of Google Commons)

Law of Large Numbers: This says that as the number of samples increases, the average of the samples tends towards the expectation value.

Central Limit Theorem: This states that as the number of samples increases, the distribution of the average becomes Gaussian, with zero variance.

Fickian Diffusion: In a random walk X(t), $\Sigma^t{}_{n=0} X(n)$ is proportional to $t^{1/2}$.

Random Walk: This is motion in which the movement from one position to the next is a random value determined by some probability distribution, usually Gaussian. Figure 7-8 gives an example of a random walk.

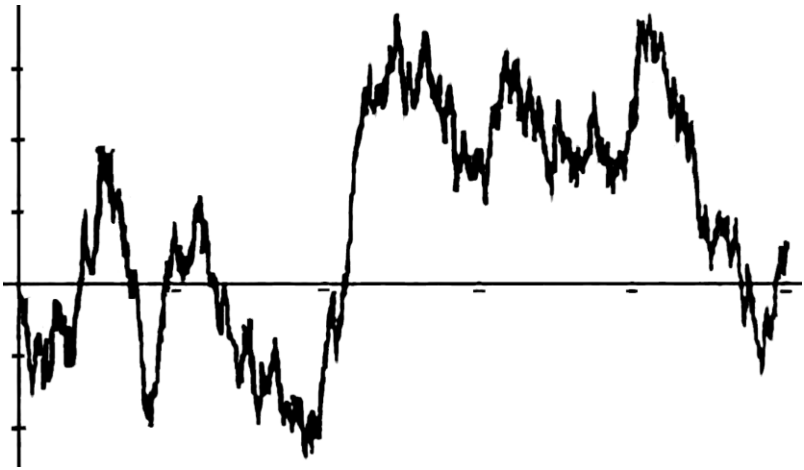

Figure 7-8: The trajectory of a Gaussian random walk. (courtesy of Google Commons)

Nonlinear Self Map: A map is simply a function from one set (domain) to another set (range). It is linear if the value of a sum is the sum of the values. It is nonlinear if it is not linear. It is a self map if the domain and the range are the same set. For example, the function f(x) = ax(1-x) is a nonlinear self map on the set [0,1] provided that it lies within the range [0,4]. Iteration means applying the function repeatedly, such as f(f(f(x))).

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