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Epistemology of the Neurodynamics of Mind

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

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Neurodynamics may shed light on understanding the relationship between subjective experience and scientific explorations of mind and behavior. Marks-Tarlow (2020) 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. It also raises some philosophical issues.

A basic premise of this article 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 could contribute to the progress of transpersonal methods, but need not be working tools of transpersonal practice. But I do this in the hopes that some appreciation of those aspects can be enjoyable even if one is not particularly interested in too many of their details, and to that end, I try to minimize the technical allusions and give transparent characterizations of them. It is for the curious, and maybe 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 and from some of her publications, such as 2008) as we share a fascination of the confluence of dynamical flavors of mathematics, semiotics, and the mind, and 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 on the same process. You cannot have one without the other. You can't fabricate knowledge about reality (ok, maybe there is no such thing) 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 them, thus they are parts of an organic, holistic, process, no longer to be considered as parts. This is especially true when one is concerned with the mind, because the organ of knowing is the object of investigation. Which is why Smith "Smitty" Stevens referred to psychology as the "propaedeutic science" (Stevens, 1936). Terry (this issue – and all future citations refer to her paper in this issue) states that "transpersonal psychology aimed to transcend limitations of research and methods [currently] available." 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 goes beyond self-actualization and includes 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 from subjective ways of knowing?

Some of the proto-transcendental issues have engaged earlier psychologists, from various positions, such as James (pragmatism and pure empiricism—i.e., pure experience; James, 1907; Perry, 1954) and Jung (analytic psychology; Jung, 1969), which, by the way, brings in discussions on the philosophy of science, including the analytic philosophies of logical positivism and operationalism. It has been said that analytic philosophy brought about the seeds of its own destruction (Rajchman, 1985; Rorty, 1982, p. 227), and I think that pursuit of any extreme

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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. And contrary-wise, 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 was concerned with the whole scientific process including the life and personality of the scientist, the experience of the scientist, to which operational procedures, that is, research, were but a part. But even these were subject to solipsism involved in the observational events. I would contend though, that with proper controls and experimental replication, the uniqueness of the observation can be factored out. However, uniqueness remains concerning experimental contexts, and the choice of experimental subject matters and procedures, and in the interpretation of the results.

James and Jung both brought in transcendental features to their mental ontology, James through his radical empiricism (James, 2007; Perry, 1954), and Jung via the transgenerational and synchronistic aspects of the collective unconscious and archetypes. But both promoted a reconciliation between the subjective and objective, a wedding of the two. In discussing how the *anima* brings material from the unconsciousness to images in consciousness, he 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 statement is an anathema to the general principals of scientific investigation that evolved from the positivist approach, which rested upon reliability—replications that are consistent—and validity—measurements that represent variables which first, can be defined, second can be translated into experimental procedures, and third are either of intrinsic interest or closely related to the aspects of reality that you wish them to reveal. Furthermore, they should exhibit lawful relationships among themselves, and if you are lucky, they generalize to many more situations than those from which they are initially derived. These features obviate, by definition, the uniqueness of the contextual issues, including the hope, fears, and insights of the investigator. Heraclitus’s not stepping in the same stream twice holds for James’ “stream of consciousness”. Of course, Jung’s observations of his own mind do not meet some of Steven’s criteria for being science. But in other ways, they do meet some of the scientific criteria (Jung, 1989). One of Stevens properties of operational psychology reads “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.’” (Stevens, 1939, p. 230). Of course, this is what Jung was claiming that ~~his~~ probing his own mind was doing. In the 20th century, academic psychology tended to despair 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 which he evolved from them some of the most popular ideas in analytic psychology, which still command professional and lay respect. When Loren Riggs attached mirrors on his cornea and discovered that stabilized retinal images faded and disappeared, that finding seemed more in line with Stevens requirement for the objectivity of experience as “the other one” (Riggs et al., 1953).

It has been suggested that collections of many brain cells must be involved and that networks within and between them, as in Hebbian “cell assemblies” (see Abraham, 2011, p. 25) stand at the core of integrative brain activity in cognition. Freeman’s use of Lashley’s “mass action”, and “cell-assembly”- are central to his theories and his attack on single-neuron doctrines. Difficulties in cognitive neuroscience pose serious challenges to reliability and validity.

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 (∩ hereafter) arousal function toward artistic images. The ∩-function simply describes some dependent variable that reaches a maximum between the lowest and highest values of another, independent variable. In Wundt’s case, aesthetic enjoyment reaches it maximum between the lowest and highest values of some aspects of the images being viewed, in which case competing aversive and attractive hedonic aspects (intervening variables) mediate the ∩ relationship. This ∩ is ubiquitous not only in many psychological functions, but in nature as well—for example, crop yield as a function of rainfall.

Conflict theory was further developed by a behavioral, physiological psychologist, Neal Miller (1959), in the 1930's. He was studying rats in mazes in an attempt to provide a behavioral model for a phenomenological personality feature, namely Freud's "reaction formation". He did this with a learning paradigm where 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 immobile before reaching the ends of the maze, showing some instability, often oscillating near that point of immobility at first. Again, the ∩. Berlyne (1971) made a career of studying such phenomena (and also of studying curiosity), and one feature he studied was the complexity of the stimuli used to simulate aesthetic images. He invoked Wundt in explaining his ∩ findings. Others got similar results, and several mathematical theories were developed to explain them, but the stimuli used in these experiments were quite crude. Subsequent studies have use more aesthetic images and more sophisticated mathematical theories (Abraham et al., 2011; Aks & Sprott, 1996; Draves, Abraham, Viotti, & Abraham, 2008; Mitina & Abraham, 2003).

These new studies used "chaotic" or "strange" attractors as stimuli—mathematically—generated images which enabled two things pertinent to the thesis of objective analysis of experience. The first is that they provide an objective metric, the fractal dimension, of the complexity of the images, the independent variable. Secondly, they provided a more authentic aesthetic experience, the measurement of which constituted the dependent variable. This combination, we feel, provides a more adequate science of experience; a more convincing validation of the ∩ relationship of aesthetic experience to complexity.

When several factors interact, whether measures of some real process, or constructs in mathematical models, their behavior follows a path that evolves over time, such that they tend to form complex patterns ("attractors") of varying degrees of complexity. Some forces tend to make the path converge to the attractor, while other tend to force it do diverge from it. For Wundt, Berlyne, and our work, these forces appear to be the opposing, conflicting forces of pleasantness and unpleaseantness of the images, arising from their complexity (and likely other factors). The aesthetic experience is optimum when these forces of convergence and divergence within an attractor-space are properly balanced for a given individual. The fractal dimension, in other words represents that ratio which produces the most enjoyable approach to the perceptual attractor, and typically is within a midrange of fractal dimensionality. Mitina discusses related personality traits (Mitina & Abraham, 2003).

Our studies (Abraham et al., 2011; Mitina & Abraham, 2003) contained another feature differing from others' studies, in that we asked the subjects to rate the complexity of the images, which not too surprising gave nearly identical ∩ functions. Thus, aesthetic and complexity judgements are linearly correlated, which raises the question of which is primary, the complexity of the percept or the act of appraisal of the aesthetic? The question of primacy of various factors is at the foundation of much cognitive neuroscience, which suggests a holistic interpretation is most evident in the "Action-Perception Cycle" of Freeman (2000, 2007) and the "Perception-Action Cycle" of Fuster (2004, 2017).

Neurodynamics of Phenomenology

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 and imputed brain-mind operations in research using mathematical evaluation of 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 neuroscientist are pretty much still at it, but with much more sophisticated experimental and mathematical tools. They use various measurements of brain activity, mostly electrophysiological and neuroimaging. I will take the iconic program of Freeman as an example (Freeman & Skarda, 1985; Skarda & Freeman, 1987; Freeman, 2000, 2007; see also Abraham, 2017, 2020; Liljenström, 2018). His program is predicated on a few basic viewpoints: (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 be measured from micro-, to meso-, to macroscopic levels, spatially and temporally; (6) These communications are interactive (centrifugal-centripetal loops); and (7) These networks can be considered as self-organizing, dynamical systems.

Freeman and his colleagues used a quintessential learning situation with odors as stimuli, and made EEG measurements on an innovational dense 8x8 array of electrodes on the olfactory bulb. Initially he was asking the question, is there a spatial (topological) mapping that discriminates one odor from another, the way auditory maps spatially in the brain (tonotopically), vision with a color mapping, somatosensory with a homunculus. They noted two types of EEG patterns, one in bursts, in synchrony with breathing and with a peak within the gamma range (above 25 Hz). The other one a messy mix of frequencies similar to a normal EEG. They analyzed these bursts, and plotted 3D maps of the amplitude of various parameters of the EEG over the surface of the bulb being recorded, and found that while there might have been a hint of coding for the different odors, the maps could be quite variable. Karl Pribram once mentioned to me (*ca.* 1990?) that this variability was a serious failure in reliability. At that time, I agreed as I had already noted that. But, as I shall soon show, this variability led Freeman to his principal conjectures about the relation of phenomenology to brain functioning.

Freeman noted that these two types of EEG patterns often alternated, and that one of them could be viewed as a cyclic (periodic attractor) and the other messier (chaotic attractor), and thus be suspected of involvement in the evolution of thought processes in the brain. These would comprise a series of transitions (bifurcations), with relatively stability between bifurcations and instability near the bifurcations. He summarized a sensory, perceptual, motor, and cognitive aspects of the system in a schema he called the "Action-Perception Cycle," which he also calls the "intentional arc". Goal oriented intention is involved in the interactions, that is, sensation becomes important because the person is forming attractor landscapes which modulates all aspects of the interactions involved (Freeman, 2000, 2007).

Skarda (2018) emphasizes that it is best to think of the process as holistic. Fuster (2017, appendix 1) proposes 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 going in the Cycle, particularly in the cortical-sensory "preafference" loop, which can bifurcate to low-dimensional (nearly cyclic), with the sudden appearance of an unexpected stimulus. I have suggested that sometime one (sensory/perceptual), sometimes the other (intentional, coritco-cognitive) aspect may be primary in the initiation of the cycle (Abraham, 2017). A more contemporary example of such bifurcational behavior occurs at the microscopic (microelectrode) level in monkey prefrontal cortex in studies of working memory (Spaak et al., 2017). Freeman's debt re intentionality to his mentor, Karl Pribram (Miller, Galanter, & Pribram, 1960)., can be seen his definition:

> 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. There may be several different systems active at the same time. 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 Abraham, 2017; Fingelkurts et al., 2017; Freeman & Holmes, 2005; Kelso & Tagnoli, 2017; Liljenström, 2017; Mannino & Bressler, 2017).

While Freeman 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 am not fond of the term "consciousness." and prefer to use "levels of awareness." A picky concern, but this avoids the binary implications in some uses of the terms "conscious" and "unconscious."

So where does the idea of fractal come in? Simply in 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 is designated as its "fractal dimension" and "Lyapunov Sprectrum" (Abraham, 2014; Abraham, Abraham & Shaw, 1990; Abraham & Shaw, 2005; Marks-Tarlow, 2020 [this issue]). 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 equivalant of "complexity") introduced into units [neurons] in a model of the olfactory system (Liljenström, fig. 8, p. 61). 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.

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 cabal conjecture, 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, developing research methods that defy the difficulties involved. Much of it has been directed to Vygotsky's (1987) concepts the socialization in children, which played an important part in the development of thought in children (e.g., Cole & Wertsch, 1996)., and vice versa, an interactive process, not unlike Freeman's and Fuster's cycles discussed previously, which are obviously involved in speech development. Ferneyhough 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. (Ferneyhough, 2017, p. 77)

Thus, dialogue is a self-organizational system. In public speaking, 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 highlighting a metaphor similar to one oft used by Freeman, "a jazz combo, which does not need a conductor" (Vitello, 1917, 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 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 in visual perspective, and 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 in the Freeman cabal (those mentioned in Abraham, 2017), much of it in the mesoscopic level of measurement. At any rate, this work shows that subtle nuances of mind can bring objective methods to bear on mental activity. It especially shows that differences in brain activity, even if there is much left to elucidate in terms of micro- and mesoscopic dynamics, gives credence to conjectured aspects of distinguishing nuanced functions of thought. There is progress in the neuroscience of the dynamics of mind.

Creativity

A final word about creativity. The brain, mind, and body are entwined holistically (Marks-Tarlow, this issue). The stream of this process meanders a trajectory varying from more creative processes to more focused processes. That is, they vary between high-dimensional chaotic processes arising from instability and greater aspects of divergent thinking and more stable low-dimensional chaotic, nearly periodic or static attractive conditions (Abraham, 1996, 2007; Abraham, Krippner, & Richards, 2012; Guilford, 1959; Gardner, 1993). These self-organizational processes are necessarily involved in creativity, such as that of improvisation in playing jazz, comedy, and speech. They are also evident in psychotherapy, transpersonal and otherwise, and psychotherapy in turn depends on the brain-mind processes we have discussed, which itself represents the fractal property of similarity across scale that Terry has so well described.

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About the Author

Fred Abraham, PhD, was a cognitive neuroscientist at UCLA's Brain Research Institute Abraham is a pioneer in the application of chaos and dynamical systems to the field of psychology who co-authored *A Visual Introduction to Dynamical Systems Theory for Psychology* (Ariel Press; 1990), as well as co-edited *Chaos Theory in Psychology* (Praeger; 1995). Abraham's commentary is entitled "Epistemology of the Neurodynamics of Mind," in which he suggested that an ontology of mind is entangled with the epistemology of mind, with both necessary to confront the gap between objective and subjective ways of knowing , especially with the use of cognitive neuroscience research strategies.

About the Journal

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