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Why Physics? Commentary on Reflection, Representation, and Diffraction in the Analytic Process

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ABSTRACT
In her paper on “Reflection, Representation, and Diffraction in the Analytic Process,” Deborah Bryon integrates the work of physicists Karen Barad and David Bohm with nonlinear dynamics under the framework of a fractal epistemology. She examines the relevance of three forms of interaction within physics – reflection, representation, and diffraction – to the psychoanalytic dyad. By so doing, she adds complexity and nuance to the terrains of theorizing in relational psychoanalysis. This commentary supports the significance of Bryon’s paper by contextualizing it historically. Sections to follow examine the role that scientific metaphors and models play in the evolution of psychoanalytic theory. Physics is an especially good match because it involves the exploration of hidden, often invisible dimensions related to patterns in space, time, as well as atemporal expanses.

Introduction

The task of psychotherapy is incredibly complex. We therapists search for commonalities with patients, grapple with differences, and honor the absolute uniqueness of each person’s somatic, cultural, and relational background. All this takes place within the moving framework of our own relational history plus current environmental, social, and historical circumstances. When we sit with patients in real time, this mixture of intersectional and contextual factors often remains in the background – like winds helping to navigate the murky relational waters. While putting the analytic process into words is not always important during a session, when clinicians wish to think about cases, supervise, consult, teach, or engage in clinical writing, it remains important verbally to translate this complex stew of clinical action.

An important way that psychotherapists find words for nonverbal exchanges, create meaning out of experience, and forge common understanding involves the use of metaphor. Lakoff and Johnson (2008) suggest that the capacity to create metaphors is universally hardwired into cognitive development. A child’s understanding of the world begins with metaphors that are concrete and embodied, as when a toddler smears whip cream on her chin to represent dad’s beard. As cognitive abilities shift to higher levels of abstraction with development invisible, more complex notions like freedom and justice get bootstrapped along the way, each new concept straddled atop all others.

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A distinguishing hallmark of psychoanalysis compared to other forms of psychotherapy is attention to unconscious aspects of the mind within patient and analyst alike. By its very nature, the operation of the unconscious is invisible and directly unreachable. In yogic philosophy, the unconscious is represented concretely by the back side of the body, forever beyond direct sight, while the conscious mind is represented by the front side of the body, always in plain sight. Metaphors such as these help to represent the invisible, while pointing toward the outside world at the very same time as they point inwards, self-referentially, toward the creator/user of the metaphor (Marks-Tarlow, 2013).

The word "metaphor" derives from the Latin *metaphora*, suggesting "transfer" or "carry over" from one domain of experience to another. Within psychotherapy, metaphors highlight similarities and differences, while helping to make the invisible visible. Metaphors serve as a joint lens framing how we look at and with our patients, plus what we find when we do so. Psychoanalyst Arnold Modell (2003) suggests that metaphor allows us to transform unconscious into conscious experience, leading to a felt sense of meaning. Daniel Stern (1985) famously stated that the key to a successful treatment involves finding the *central metaphor*. Many papers in this journal are filled with creative metaphors (e.g., Bass, 2008; Koehler, 2011; Markman, 2011; Martela & Saarinen, 2013; Pizer, 1996).

When working with individual patients, central metaphors are highly idiosyncratic and often poetic. Whether arising in the patient or therapist, they tend to reflect unique, paradigmatic aspects of people's developmental history. In Bryon's first clinical example, a central metaphor emerged when her patient listened to a podcast retelling the story of the "Ugly Duckling." The tale re-presented the problem of feeling shamed and misunderstood, living among family and friends in continual states of humiliation and helplessness. By unearthing and metabolizing these experiences within the healing context of Bryon's strong experience of maternal care, both patient and therapist opened their hearts and were changed in the process. Bryon's clinical example points to the beauty of working with central metaphors, as they often illustrate not only the problem at hand but the path toward resolution.

Whereas idiosyncratic metaphors are necessary to capture the uniqueness of individual patient characteristics, collective metaphors are necessary to capture what transpires more broadly at the level of theory. The essence of Bryon's paper involves terminology and concepts from physics as a foundation for understanding relational dynamics between patient and therapist. She draws upon Barad's treatment of the quantum behavior of light as foundation. The significance of light in Karen Barad's (2007) work is deeply intertwined with both her physics background and her philosophical framework. Light functions as a metaphor, a physical phenomenon, and a conceptual tool to bridge physics, ontology, and epistemology. In her paper, Bryon likens the concept of *reflection* to similarities between therapist and patient conveyed through empathy and mirroring (a literal reflecting back to patients). The concept of *representation* captures differences that fall into the gap between static symbols of interpretation and dynamic, embodied clinical moments. The concept of *diffraction* adds complexity to relational exchanges by involving patterns of interference and entanglement when lines of light from two locations interact at a location opening the complexity of that location to inspection. Diffraction highlights how phenomena are co-constituted and inseparable from their relational contexts, contrasting with reflection by requiring agency while carrying the potential to produce new and unpredictable patterns.

Metaphor and the origins of psychoanalysis

From the inception of psychoanalysis, Freud envisioned grounding psychology within the field of neurology (1895). Yet the science of the times hadn't advanced sufficiently to support such ambition. One of the earliest influences of science on Freud's theories evolved from Newtonian physics. Psychological processes were imagined to be mechanistic, predictable, and striving toward equilibrium, much like physical objects obeying the laws of motion.

To model unconscious processes and dynamics of mind, Freud drew heavily upon the hydraulics of the steam engine, the gold standard of technological advance at the time. He likened the conservation and distribution of mental energy to equilibrium thermodynamics of fluids and gases. For example, that psychic energy can be repressed or "bottled up" echoes physical concepts like pressure and force. Just as pressurized gases can build up and forcefully release, so too can repressed emotions and desires erupt into consciousness, at times manifesting as neurotic symptoms or dreams. Freud's physical analogy made it easier to explain the workings of the unconscious to patients and the broader public.

Underlying these metaphors, Freud's drive theory was both reductionistic and a one-person model. Psychoanalysts were not considered part of the system but instead were viewed as outside observers, much like scientists sitting outside of their experiment. The patient's mental energy, or libido, was conceived to arise internally and either repressed or expended in parallel to how energy works in physical systems. The concept of catharsis suggested relief from the buildup of inner tension through emotional expression, believed to bring the internal system back to equilibrium.

Every metaphor has its uses as well as its limitations, depending upon the degree of similarity and difference between the metaphor and the object or process it is mobilized to re-present. A decrease in internal tension in a patient often does accompany the release of emotions previously unexpressed. Yet, emotional expression can also have the opposite effect, as for example in cases of chronic anger. While expression may "let off steam" in a seemingly regulated way at the moment, it is just as likely to "rev up the engine" for more expression and discharge in an unregulated explosion.

Limitations of reductionism

Significant limitations exist to metaphors and models drawn from the physics of Freud's era due to the reductionist paradigm at its foundation. In place within all the natural sciences since antiquity, reductionism is problematic with respect to complex systems. The essence of reductionism is the assumption that all complex phenomena can be broken down into constituent elements such that each element can be analyzed separately to understand how collective processes work. Within the history of science broadly, this tendency to divide complex wholes into underlying parts was a necessary foundation for incipient knowledge. Within every field, underlying parts must be identified and labeled before it becomes possible to attain a more complex understanding of how the parts work together. In medicine, for example, an understanding of anatomy precedes the study of how various organ systems interact. Within ecology, plants and animals must be identified and labeled before their interrelationships can be studied effectively.

Conceptually, reductionism goes hand in hand with Cartesian dualism, by which natural boundaries are presumed clean: historically, mind is seen as separate from brain, brain from body, each person from the next, and people from their social, cultural, political, and historical contexts. Such underlying assumptions promoted Freud's intrapsychic, structural stance. Meanwhile, Freud's patients were presumed to share fixed developmental trajectories, common to all genders and cultures.

Reductionism also goes hand-in-hand with linear assumptions about repeatability, predictability, and control, which lie at the basis of many empirical methods within psychology and medicine, including clinical trials. In psychology, linear assumptions about underlying variables include the expectation of full independence from one another. Linear assumptions lead to normative statistics, by which population variability gets reduced to the mean, or central tendencies. When using linear methods, statistically significant results apply to the group, not the individual, while all too often capturing very little of the underlying variance (in the social sciences, .05 tends to be the significance cutoff).

A big problem with reductionist assumptions and linear methods is that they privilege the separate quality of each phenomenon at the expense of relational and collective aspects. While reductionism remains useful for manipulating mechanical objects, it hits severe limitations when dealing with natural systems, both inorganic and organic (Marks-Tarlow & Shapiro, chapter ref). The failure of reductionist science to capture the complexity of clinical work is obvious to any practitioner perpetually steeped in conditions of uncertainty, ambiguity, and paradox. Indeed, the lacuna between felt experience and scientific theory of the 19th and early 20th century led to a period during the 1980s and 90s when many psychoanalysts identified as post-modern and rejected science altogether under the name of "scientism," relegating science to just "another language," no different from any other. Within psychoanalysis, this postmodern position jettisoned objective and material levels in favor of closing off the hermeneutic circle surrounding subjective and intersubjective meaning making, an argument still made by some contemporary psychoanalyst thinkers (e.g., Blass & Carmeli, 2007; Spence, 1993).

Science has progressed greatly from Freud's era to the present. Slowly, over time, central psychoanalytic metaphors have evolved significantly as theorists embrace more systemic and holistic perspectives. Contemporary psychoanalysis has moved from viewing therapists as static, neutral, objective observers toward dynamic, fully engaged, co-creative participants. This shift is reflected in New York psychoanalyst Benjamin Wolstein's (1995) five metaphors describing the psychoanalyst's psyche: mirror, blank screen, neutral interpreter, participant observer, and coparticipant therapist and patient.

Contemporary science

During the 20th century, an important scientific development occurred that influenced psychological theory and the evolution of its metaphors and models – the emergence of systems theory, the general framework for studying the structure and behavior of interconnected elements in any system, whether biological, ecological, social, or mechanical. Systems theory, developed by Ludwig Von Bertalanffy (1950) among others, emphasizes how complex systems are composed of interrelated parts that collectively produce emergent behaviors. This new branch of science examined how system components interact, how information and energy flows throughout the system, and how patterns of change emerge over time.

Within psychology, systems theory was applied to understand individuals within the context of larger, interconnected systems rather than as isolated entities (Martela & Saarinen, 2013). The more that human behavior was conceived to be influenced by interactions within various systems – familial, social, and cultural – the more Freud's drive theory fell to the wayside. Murray Bowen's (1961) *family systems theory* was a holistic theory that posited family members as fundamentally interconnected, with the behavior of each affected by and affecting the entire family. Urie Bronfenbrenner's (1977) *ecological systems theory* suggested that human development is influenced by several overlapping social systems, from immediate family and school (microsystem) to broader cultural and societal influences (macrosystem). The model helped psychologists assess how different environmental layers influence individual behavior and development. More recently, the study of *interpersonal neurobiology* as originated by Allan A. Schore (1994) embraces a system perspective by conceiving of the mind/body/brain as a single system emerging out of primary relationships with others. While initially rejected by some psychoanalysts, the popularity of interpersonal neurobiology has soared over the past couple decades, as evidenced by the popularity of A. H. Schore's (2011) paper in this journal.

The second important scientific development to influence psychological theory and its metaphors during the 20th century was *cybernetics* and *information theory*, both of which emerged from electrical engineering and physics by scientists like Norbert Wiener (Rosenblueth et al., 1943) and John Von Neumann (1948) in the 1940s. Cybernetics involves the study of communication, control, and feedback in systems and is often considered a subset or specific application of systems theory. Whereas systems theory provides the overarching framework for studying a system's organization and complexity, cybernetics offers a practical toolkit for understanding how systems maintain balance, adaptation, and change through feedback loops.

Cybernetics initially focused on mechanical and biological systems, but the field has since expanded to include social and organizational systems. Cognitive psychologists, such as Gregory Bateson and George Miller, employed cybernetic concepts such as feedback loops, control systems, and information filtering to explain behavior and thought processes. The brain was modeled as a computing machine that processes inputs and outputs and reflects broader technological advances. The mechanical metaphor remains in common use today, as for example when contrasting the *hardware* of the brain with the *software* of the mind or culture.

Nonlinear models

The more holistic vantage point evident in systems and cybernetic theories arose in tandem with Einsteinian physics which brought the centrality of nonlinear processes to the forefront. Newton's universe was both mechanistic and linear, leading to the central metaphor of a *clockwork universe*. By contrast, Einstein's universe was holistic and nonlinear, characteristics most apparent at the extremes of huge cosmic expanses or tiny quantum scales. Because the elements of nonlinear systems are *interdependent*, they cannot be easily pulled apart without destroying the system at large. When a linear system is nudged, the output is directly proportional to its input. When a nonlinear system is nudged, the output is disproportional to its input: either a tiny nudge can have huge effects or a huge shove can prove negligible. Within psychotherapy, the nonlinearity of therapist/patient communication is readily apparent. At times a therapist's offhanded, throw-away comment can feel life changing to a patient, while at other times a therapist's carefully constructed, brilliant interpretation lands on deaf ears.

The linear aspect turns out to be a tiny, mostly human-made corner of our otherwise nonlinear universe. The physics of Einstein eschewed possibilities for certainty in favor of indeterminacy and statistical probabilities. Paradox and observer dependence came to the forefront when quantum particles were observed to exist in opposite states, as either particles or waves depending upon how they were observed. Ambiguity and unpredictability were inherent in the metaphor of Schrödinger's Cat, placed in a sealed container with a mechanism possessing a 50% chance to kill the cat based on the decay of a radioactive atom. The cat is considered simultaneously both dead and alive until the box is opened and the cat observed.

The statistical nature of Einsteinian physics began a new era of embracing fundamental uncertainty. Yet, even Einstein was famously bothered by this conclusion, declaring that "God doesn't play dice with the universe" to which Neils Bohr famously replied, "Stop telling God what to do!" (Marks-Tarlow, 2013). Metaphors and models derived from quantum mechanics suggest that human decision-making might involve probabilities and uncertainties, much like quantum particles. Barad's new physics-based epistemology and Bryon's paper attend to the behavior of light within the quantum realm, wherein space and time follow different principles, and entangled processes are the norm.

Physics in our everyday world

Einstein's physics disrupted the illusion of attaining complete understanding, control, and predictability at the edges of human existence. The discovery of *chaos theory* by meteorologist Edward Lorenz in the 1970s (Gleick, 2011) completed the shattering of this illusion regarding complex systems in our everyday world. Lorenz was interested in harnessing the computational powers of the computer to model the weather. To do so, he ran sets of looping differential equations, whose end products were recursively fed back, over and over, to simulate different weather conditions over time. One day, after re-running a batch of slightly rounded-off equations, Lorenz discovered that even the tiniest difference in starting conditions of underlying variables led to wildly different results over simulated time. Rather than toss out these results as an error, Lorenz realized he was onto something big. The fact that infinitesimal differences in initial conditions led to huge and unpredictable differences over time broke the back of strict determinism (Lorenz, 2000; Vernon, 2017).

Chaotic dynamics are rampant in our everyday world, which brought uncertainty and unpredictability to the forefront (not to mention explaining why weather forecasters are the butt of so many jokes). By the end of the 20th century, the epistemological container of reductionism had broken open. Ilya Prigogine and Stengers (1997), the Nobel biophysicist and an originator of complexity theory, hailed the advent of nonlinear dynamics as the "end of the deterministic clockwork Universe" – a reductionist illusion that may have helped us build complex machines, yet never existed in the real world in the first place.

A critical insight from chaos theory highly relevant to psychoanalysis and psychology at large involves the necessity of separating faculties of understanding from those of prediction and control (Marks-Tarlow, 2013). Implications are profound for psychological researchers and therapists alike: even if we can perfectly model a complex system within the present moment, we can never precisely predict or control the behavior of that system in the future; the further ahead in time, the less predictable and uncontrollable conditions become.

Whether in the form of chaos theory or quantum mechanics, the ubiquitous presence of nonlinear processes annihilates the utility of the medical model for strict diagnosis, treatment planning, and prediction within long-term psychotherapy (Marks-Tarlow, 2011). Within open-ended treatment, evolved metaphors and models reinforce the need for spontaneity and improvisation (e.g., Ringstrom, 2001). They require the shift from fixed ideas to dynamically changing understandings. Finally, the therapeutic process does best with *alive metaphors* that are co-created, self-organizing from *alive communication* in the moment (Fogel & Garvey, 2007).

Complexity models

Complexity theories in the late 20th century highlighted the abundance of nonlinear processes in the world around us (Feldman, 2019). Weather systems, neural networks, perception-action coupling, social behavior, and stock market dynamics all exhibit *non-linearity*, where the system's sensitive dependence on initial conditions renders precise predictions of systemic behavior fundamentally impossible. Complex adaptive systems such as brain/body/mind evolve and *self-organize* in non-linear ways to exchange energy, matter, and information with their environment. Small perturbations in individual development and psychotherapy can result in large effects, while large perturbations may have little or no effect at all. Precise trajectories in nonlinear systems are unpredictable, even in principle.

Complexity science highlights variability and adaptability over regularity and stability. This brings non-reproducible, idiosyncratic events into central focus, revealing how fully relational the universe really is (Byrne & Callaghan, 2013). Meanwhile, fractal science highlights self-similar, recursively enfolded, meta-patterns at all levels of spatial and temporal organization (Schroeder, 2009). Historically, regularity and stability have been elevated as hallmarks of mental and physical health. Consider standardized psychological tests like the WAIS and MMPI whose flat, normative lines rule out the absence of psychology. Such measures are useful in some ways, yet they can stereotype people while offering illusory constructs out of accord with individual and cultural dynamics.

Complexity theory (e.g., Bak, 2013; Waldrop, 1993) represents a more recent evolution of physics under the umbrella of nonlinear dynamics. With this development, different standards of physical and mental health have emerged. Scientists (e.g., Bassingthwaighte et al., 2013; West, 2012) now recognize that when a little bit of chaos is injected into physiological and mental systems, the resulting slight instability is actually the hallmark of health. Paradox lurks underneath the surface of these new standards, as regularity and stability emerge from underlying chaotic irregularity (Marks-Tarlow & Shapiro, 2024). A number of psychoanalysts have written about the direct applications of complexity theory to psychoanalytic theory (Bass, 2008; Coburn, 2009; R. M. Galatzer-Levy, 2017; Harris, 2009; Leffert, 2008; Miller, 1999; Moran, 1991; Palombo, 1999; Pizer, 1996; Tyson, 2005).

Whether in the body or the mind, optimal health requires the balance between variability and meta-stability. Within the body, the sweet spot of complexity exists in the realm *between* chaos and order. This is true at multiple levels, whether we consider the beating of our hearts, the gait of our walk, or neurons firing in the brain (Goldberger et al., 1990; Kumar, 2012; Tognoli & Kelso, 2014). In the mind, similar conditions hold. Mentally, we need enough regularity for a stable foundation and communication to occur plus enough irregularity for creativity, novelty, and change. Too much variability and instability will destabilize the capacity for effective self-organization, such as occurs with psychosis or excessive impulsivity. Too much regularity leads to rigidity in thought processes and behavior, such as occurs in obsessive rumination and compulsive re-enactments (D. Siegel, 2006).

The embrace of models and metaphors derived from complexity theory and nonlinear dynamics is evident in the work of psychoanalyst Robert Stolorow (1997) who introduced the model of "dynamic, dyadic, intersubjective systems" in his conceptualization of therapeutic interaction. The work of William Coburn (2009) emphasizes the importance of context. Martin Seligman (2005) emphasizes the importance of dynamical systems theory as a meta-framework for psychoanalysis. Meanwhile, a switch from an equilibrium to a non-equilibrium thermodynamic perspective has created a sea change in our field. The open exchange of information and energy across porous boundaries means that relational psychoanalysts no longer assume the therapist has to *do* something for change to occur. Instead, simply being together amidst highly engaged, often charged, intellectual, emotional, and relational exchanges can be enough for novelty to self-organize from within the relationship itself, emerging in the fertile space between the two co-participants.

Entanglement

Within physics, the capacities for what Einstein famously called the "spooky action at a distance" of quantum particles refers to quantum entanglement, a phenomenon where two or more particles become so deeply linked that the state of one particle instantly influences the state of the other, no matter how far apart they are. Key features of entanglement include:

- *Instantaneous connection*, even for particles light years apart.
- *Nonlocality*, where quantum effects propagate over huge expanses of space or time and appear to defy laws of classical physics.
- *Correlation without communication*, where change in one particle doesn't "send" information to the other, as no signal is transmitted, but instead, their states are inherently correlated due to a shared quantum history.
- *Violation of classical intuition*, in classical systems, objects have definite properties independent of observation, whereas in entangled systems, properties of the particles aren't definite before measured, and the outcome for one particle determines the other's state.

Within relational psychoanalysis, most clinicians have tales of what feels like "spooky action at a distance" with patients, especially under high arousal conditions. While it is tempting to use concepts like quantum entanglement to model uncanny knowing (e.g., de Peyer, 2016;

Mayer, 2007), a limitation of metaphors derived from quantum realms involves the differences in how objects behave when they cross the "quantum-classical boundary:" quantum effects become negligible and classical physics dominates as the system becomes larger and contains more particles. That said, Stuart Hameroff, an anesthesiologist, and Sir Roger Penrose, a physicist, have collaborated (Hameroff & Penrose, 2014) to posit consciousness to arise from quantum processes within brain neurons. Their model suggests a central role for microtubules (protein structures within neurons maintaining cell shape and facilitating intracellular transport). Although still speculative, these scientists propose microtubules to function as quantum processors enabling quantum computations contributing to conscious experience.

Fractal dynamics and fuzzy boundaries

Whereas Einstein's physics captures entanglement within quantum realms, fractal geometry models entangled processes in our everyday world, including how two mind/body/brain systems can operate as a single entity during psychotherapy. Fractal geometry is a newly discovered (Mandelbrot, 1982) aspect of nonlinear dynamics best suited to model the complexity, irregularity, and uniqueness inherent in nature's interdependent ecosystems.

Fractals are objects whose patterning exists on multiple levels such that the pattern of the whole characterizes the pattern of the parts, either perfectly or approximately, whether across space or in time. Imagine a series of Russian dolls, each possessing a similar shape and coloring. Each doll is recursively nested within the next, all contained within the largest – a classic example of a physical fractal. In nature, the V-shape of a tree's branching pattern is another classic example. Because the essence of the whole defines both qualities and quantities of the parts, fractals are holistic objects. Psychologically, the concept of personality has a fractal feel, in describing how the *essence* of a person gets recursively enfolded into various moments and stages yet persists over time, despite frequent changes in the underlying parts.

Freud unwittingly used several fractal metaphors in his thinking. His iceberg (a natural fractal) model of the psyche's topography is a good example, where only a small portion is visible above the water (the conscious mind), while the vast majority remains hidden below the surface (the preconscious and unconscious mind). Or consider Freud's metaphor of the onion, suggesting that the mind consists of multiple layers, each representing different aspects of the psyche. One may peel away layer after layer to uncover increasingly hidden and profound elements of the self.

Daniel J. Siegel (2022) suggests our culture reifies people and processes through the language of nouns. By contrast many indigenous cultures retain variability and the dynamics of change through the language of verbs. The capacity to retain variability, adaptability, and change is built into the very essence of fractals whose growth and action emerges *in the spaces between* ordinary dimensions. Indeed, another hallmark quality of fractal math is the capacity for infinite variability injected *in between* the finite dimensions of our everyday world. Freud's onion metaphor points toward the infinite by suggesting one can peel away layer after layer, yet never reach a central core.

Most features of nature are fractal objects that emerge in the spaces between ordinary dimensions. Clouds collect in the infinite spaces between zero-dimensional points and one-dimensional lines. Rivers exist in the infinite expanses between one-dimensional lines and two-dimensional planes. Mountains get sculpted within the infinite spaces between two-dimensional planes and three-dimensional solids. Meanwhile, contemporary metaphors within relational psychoanalysis also attend to creative emergence in the sp*aces between*, such as D.W. Winnicott's (1991) notions of *transitional space* and *objects*, or Jessica Benjamin's notion of *thirdness* (Benjamin, 2004).

The complexity of a fractal resides at its edges, and all natural boundaries tend to be fractal, such as the dynamically moving edge of where the sea meets the shoreline. Much like the sea is open to the shore and the shore to the sea, such that the two sides interpenetrate each other's territories, fractals possess fuzzy, jagged edges, rather than clean or smooth ones. What you see in a fractal depends upon how you look at it, which means these fractal edges are also observer-dependent. In nature, the scale of observation determines the features and level of complexity one observes. Observer-dependence is also evident in the infinite variability possible in how a mathematical fractal can be rendered by computer, related to how its features are highlighted. It's quite evident how observer-dependence relates to people – what you see depends upon how you look. What is more, people also possess the nonlinear, paradoxical quality that the closer you look at a person's psychology, the more there is to see.

The complexity of a fractal lies at its fuzzy, jagged and interpenetrating edges. Within most natural systems fractal boundaries serve as permeable filters that allow for selective exchange (R. Galatzer-Levy, 2020). Consider cell membranes that let in nutrients but not toxins. Psychological boundaries are also a good example. Each person filters information according to their own perspective, receiving some of what another person intends or doesn't intend to communicate, but not all. Within psychotherapy, the more open we are with patients and our patients with us, the greater the relational exchange and the higher the potential for deep change.

I suggest that *fractal consciousness is the essential activity at the core* of clinical intuition. Fractal consciousness is a holistic faculty by which clinicians derive a sense of the whole person from "thin slices" of exposure (Marks-Tarlow, 2013; Marks-Tarlow & Shapiro, 2021; Marks-Tarlow et al., 2020). This perspective provides a fitting underlying foundation for relational psychoanalysis. Fuzzy boundaries between self and other help model how the action of psychotherapy emerges from the openness of exchange.

My earlier writings (e.g., Marks-Tarlow, 2012, 2014) concentrated on *local* faculties of intuition that operate when people sit face to face in the same space and time. More recent writings delve into nonlocal levels of clinical intuition, which includes uncanny types of knowing (de Peyer, 2016; Petrucelli, 2018) that allow us to perceive events that are separated in space and time, like flashes of accidents happening to a loved one in a distant land, precognitive dreams, or synchronistic occurrences. I get bolder about describing nonlocal forms of intuition (e.g., Marks-Tarlow, 2024; Shapiro & Marks-Tarlow, 2021) as my confidence grows that I can model them scientifically.

My foundation for modeling uncanny events is a fractal epistemology (Marks-Tarlow & Shapiro, 2024; Marks-Tarlow et al., 2020), a novel conceptual system that contrasts with the reductive episteme in place since antiquity. Drawing from natural fractal patterns, the fractal epistemology posits open, fuzzy, interpenetrating boundaries between various realms, including mind/brain, brain/body, body/world, and self/other. Not only do these edges promote open yet filtered exchange, but the *interpenetration* at the borders suggests that each side is enfolded within the other side. The body is enfolded in the world, while the world is enfolded in the body. Within psychoanalysis or life in general, when two people are intimately connected, each is thoroughly enfolded within the other.

Advanced neuroimaging techniques, such as functional near-infrared spectroscopy (fNIRS) now allow for simultaneous measurements in two or more brains in naturalistic contexts, enabling meta-reductive two-person perspectives (Valencia & Froese, 2020). The recent area of *hyperscanning* (simultaneous measurement of two brains) has been exploding within multiple fields of social psychology (Montague et al., 2002; Tsoi et al., 2022), developmental psychology (Bi et al., 2023; Nguyen et al., 2020), and clinical psychology (Atzil & Gendron, 2017; Crum, 2021).

Within psychotherapy, empirical research from synchrony studies, whether in the brain or other physiological processes, validates the fuzziness of boundaries at the nonverbal, somatic levels. The closer and more intimate the relationship, the more the bodies, minds, and brains tend to move into synchrony with one another, often beneath the level of conscious awareness (Zhou et al., 2024).

Previous awareness of the importance of the therapeutic relationship (e.g., Norcross & Lambert, 2019) is confirmed by hyperscanning studies that reveal the centrality of synchrony, or coupled dynamics, between people. Muñoz (2024) suggests that scientists need to revise their view of the mind/brain relationship to adequately integrate the influence of human interactions on the neurobiological underpinnings of cognition. All forms of synchrony amount to self-similar resonances across open boundaries. Koole and Tschacher (2016)'s model posits that interpersonal physiological and neural forms of synchrony lie at the foundation of therapeutic bond, translating intersubjectively into feelings of trust, attunement, and the emotional experience of "feeling felt." Within relational psychoanalysis, a fractal epistemology provides a scientific framework for the uniqueness of the dynamics, non-repeatability of experience, and capacity to fold in the ambiguity, paradox, and uncertainty inherent in the clinical moment. All of these models and metaphors are folded into the reasoning and underlying empirical foundations of Bryon's paper.

Advantages to incorporating metaphors and models from physics

Metaphors can serve as a bridge between the concrete and abstract levels to tangibly express invisible, complex, and abstract psychological processes. They function as tools that connect while highlighting differences between the metaphorical system and the psychological reality it seeks to explain – exactly what Bryon accomplishes in her paper on reflection, representation, and diffraction.

The use of metaphors and models from physics within psychoanalysis allows for conceptual clarity and structure. They provide a systematic way to understand the dynamics of mind, and how change can emerge from the complex interweavings of relationships. Metaphors derived from contemporary nonlinear science are holistic. They embrace what is unique, spontaneous, and unpredictable. They are complexly situated, embodied, and situated in context. The most contemporary approaches help to grant the scientific legitimacy so desired by Freud at the inception of psychoanalysis but beyond reach by the limitations of the physics of the time.

By drawing parallels with well-established fields of nonlinear dynamics, including non-equilibrium thermodynamics, complexity theory, and quantum physics, psychoanalysis slowly gains credibility and the power to position psychoanalysis not just as a speculative or purely philosophical endeavor but as a discipline with a scientific basis. Metaphors and models derived from physics align psychoanalysis with the physical sciences. Common language and concepts allow ready adaptability to other disciplines, which enables psychoanalysis to remain relevant as new scientific paradigms emerge.

While metaphors and models from physics can provide insight, I wish to end on a note of caution, as differences between the physical system and the psychological reality need to be respected. Over-relying on any metaphor or pushing it too far can obscure important psychological nuances. The awareness of where the metaphor falls short parallels the analyst's sensitivity to where their own understanding may diverge from the patient's subjective world.

Disclosure statement

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Notes on contributor

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