

Could a Fractal Theory of Consciousness provide the long sought mechanism for consciousness.

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A *fractal theory of consciousness* is proposed where consciousness occurs at or below the Planck scale on the holographic foundation or boundary of space-time. Consciousness communicates with perfect fidelity up to the level of living minds, that are orders of magnitude larger, using fractals that exist only when minds are at a *critical point*. Consciousness and memory storage operate external to the human mind, analogous to the resilience and redundancy benefits seen in modern information technology *cloud computing*.

Renormalization as a link between consciousness and fundamental physics

Recent research has hinted at relationships between the tool used by physicists known as *renormalization* that is a mathematical technique which raises analysis “up a level” to ignore infinities that prevent finding a quantitative solution [1]. Scientists have noticed that similarities exist between human perception and renormalization that support the theory of brains operating at a *critical point* - where every neuron has influence on the network as a whole [2]. Research in renormalization, as well as *deep learning* and biological learning, all point to a common theme of compression of information i.e., optimization of data processing [1]. Experiments by many scientists have created a description of the brain as balanced precariously at a critical point between periods of calm and avalanches of activity [3].

Science writer Natalie Wolchover described the work of Pankaj Mehta and David Schwab on artificial intelligence deep learning:

“renormalization, which allows physicists to accurately describe systems without knowing the exact state of all their component parts, also enables the artificial neural networks to categorize data as, say, “a cat” regardless of its color, size or posture in a given video. Renormalization is a systematic way of going from a microscopic to a macroscopic picture of a physical system, latching onto the elements that affect its large-scale behavior and averaging over the rest... a suite of sophisticated approximation schemes is required to slide up the distance scales, dilating the relevant details and blurring out irrelevant ones along the way” [1, 4].

Notice how renormalization, as an approximation and methodology, is similar to Isaac Newton’s use of the *limit* in Calculus as well as techniques created by Benoit Mandelbrot with fractal math. Benoit Mandelbrot's famous paper *How long is the coast of Britain?* shows how fractal mathematical techniques are similar to the renormalization concept of “rising up a level” (e.g., an observer viewing a fractal) thus averaging out the coarse items to find higher order relationships for optimization of speed (reduction of calculation time) or to get a holistic “view,” and ultimately a solution, for what seemed to be a problem hidden in infinities - as seen in the example for the approximate answer to the length of the coast line of Britain [5].

Thus, perhaps the similarities between the techniques used to solve fractals and renormalization hint at a deeper connection in nature. Could it be that the nature of the smallest units of space-time, let us say a theoretical Planck-length space-time “pixel,” as opposed to a fundamental particle like an electron, is actually not a square or circle, in terms of its shape or dimension, but is, rather, a fractal shape? Could a space-time pixel that is fractal in nature possibly provide a sink-like surface area where gravity dilutes and is, thus, so comparatively weak, compared to the other three fundamental forces in the Standard Model, as it diffuses into the “cracks” of the fractal pixels of space-time?

Consciousness via fractals

Fractals are scale-invariant. [6]. When a system’s properties remain unchanged when viewed at different scales, we say it is *scale invariant*. This is the key attribute of fractals where the same patterns repeat themselves at smaller and smaller sizes. This feature of scale invariance or *self-similarity* is comparable to zooming in with a magnifying glass on an image to uncover finer, previously not visible, new

structure or details. However, when done on fractals, no new detail appears and the image does not change. Instead, we see the same pattern repeating over and over [7, 8].

Extensive study of phase transitions have shown how scale invariant phenomena such as fractals and power laws emerged at the *critical point* between phases [9-17]. Woodrow L. Shew et al., noted in their research that “findings suggest that in the cortex, balanced excitation and inhibition establishes criticality, which maximizes the range of inputs that can be processed, and spontaneous activity and input processing are unified in the context of critical phenomena” [18]. John M. Beggs, in his book *The Cortex and the Critical Point*, notes:

“One of the main consequences of being near a critical point is scale-free property. These are hypothesized to lead to optimal information transmission and also thought to optimize dynamic range, sensitivity to inputs, information storage, and computational power. Just being near the critical point will produce optimality over the scale of the brain” [19].

Brains are optimized at the critical point and consciousness fades as the brain drifts away from it, for example when a person is under anesthesia. Adam J. Eisen and his team:

“found that propofol-induced unconsciousness is associated with destabilized neural dynamics. ... Propofol disrupts the balance between cortical excitation and inhibition. This balance is known to be critical for maintaining the stability of cortical dynamics. Combined with our findings, this paints a picture in which propofol tampers with this balance, causing widespread cortical instabilities and thereby disrupting the brain’s capacity for information processing. Overall, our analysis suggests a mechanism for anesthesia that involves destabilizing brain activity to the point where the brain loses the ability to maintain conscious awareness” [20].

Is consciousness basically cloud computing

Some of the principles that drove the creation of modern information technology *cloud computing* include its resiliency and redundancy. These traits are also common to life, or gene pools, focused on long-term survival. Thus, we might extend the cloud computing analogy to brain criticality.

At the critical point, brain signaling is *scale invariant* (a fractal pattern going down to the smallest scale). Thus, might it be the case that life has found a “location” or mechanism for optimal information processing?

Might it be the case that human consciousness does not actually lie inside our physical brain but, rather, lies in the space-time boundary as described in the Holographic Principle? According to the Holographic Principle, information encoding everything taking place in our three-dimensional world is encoded on the boundary of that region as a kind of hologram [21-29]. Perhaps the reason for brain criticality is that, by reaching a state of scale invariance, actual thought and intelligence, occurring at the microscopic boundary, is thus able to be communicated up (and sensory inputs down) a “fractal ladder” to the scale of neurons in our macro world.

The brain, at its critical point, where self-similar fractals occur and each smaller fractal scale or level is exactly in-sync (has the perfectly identical pattern) with the top level (by definition), thus becomes a “vertical” human data network channel. Life as experienced in the living minds of organisms, in order to *read* and *write* data with perfect fidelity on a space-time substrate, utilizes fractals in minds at a critical point. Only a fractal pattern can maintain perfect fidelity up and down such a scaling distance. It is this idea that explains why consciousness occurs at a critical point which is the only state where fractal self-similar and scale invariant structure can occur.

The brain at its critical point, where all scales are identical fractals (i.e., synchronized), becomes synonymous with the definition of a “vertical” human data network telecommunications channel. According to the formal definition of a telecom channel, when a continuous stream of fixed-length frames are sent, a synchronized receiver can in principle identify frame boundaries forever, and receivers can usually maintain synchronization despite transmission errors [30, 31].

If all particles and forces that create our reality can, in theory, be encoded in a boundary, then why not consciousness as well? Colloquially this might imply that every consciousness is part of a single

consciousness (the singular boundary of our universe) and perhaps even add some merit to metaphysics as one's conscious *self* may already, and inherently, exist external to our physical world.

Consciousness as a tool for life

We may consider life less as an "inventor," and more of an entity that commandeers, almost always, out of necessity. We can envision life, with an ecosystem on planet earth that becomes increasingly large, diverse, complex, and intelligent, using whatever "tools" it can find for any competitive advantage e.g., neurons, memory, categorization and labelling, planning, learning, language, etc. Then we can imagine life seeking improvements on each of these including long-term memory, modeling, written language, and possibly even fractal messaging and holographic memory as fast, resilient, and perhaps abundant critical information processing resources.

We can speculate that it is the fractal structure that allows life to utilize yet another advanced data processing mechanism and to access a microscopic space-time substrate. We can imagine life using fractal structures for not only optimal memory storage but, perhaps, also to access an ultimate memory or ultimate "library of libraries," akin to Carl Jung's *collective unconscious* [32-35]. There is an obvious analogy here between the self-similar and infinite regression of a fractal, and the recursive nature of consciousness where a mind can ask or ponder i.e., why it asks why it asks why.

But is there any evidence that the Universe is fractal at a fundamental microscopic scale? Modern theoretical research does support this claim [36-43]. Oliver Lauscher et al., note that:

"spacetime is a fractal in general, with a fractal dimension of 2 on sub-Planckian length scales. ... The scale-free relation suggests that at distances below the Planck length... is a special kind of fractal with a self-similar structure. ...This phenomenon is familiar from fractal geometry"[36].

Mary Alexandria Kelly et al., who proposed the idea of human brains using holographic reduced representations (HRRs) or associative memory, note that:

"The mathematics of holography has long been suggested as the principle underlying the neural basis of memory... holographic associative memories have also been used to model how humans understand analogies and the meaning of words, how humans encode strings of characters, and to model how humans perform simple memory and problem-solving tasks" [42].

Another example of research that supports the idea of a deeper reality with the capability of memory involves theoretical work in the field of fundamental physics regarding *quasiparticles*. Institute of Theoretical Physics professor Leon Balents states that "unlike other particles we know of, these quasiparticles (Abelian anyons) can, in effect, remember how they have been manipulated... your electrons, photons, and quarks - may themselves emerge from something deeper" [43].

Conclusion

If consciousness is fractal and exists with memories on a holographic boundary, then many questions still remain. Has a microscopic consciousness, or even a collective subconscious, always existed? What is the exact process or protocol by which memories are stored and fractal messages sent? What is the minimum size in bits of a fractal message or duration in time? Can we observe, prove, or even change fractal messages or memories in a brain or in the holographic boundary? If we understand the mechanisms deeper, can a machine be built that has consciousness? Does this model imply that a consciousness could exist after the death of a physical body or brain? Is there a maximum limit to the amount of memory in the holographic boundary of a universe? Could an increase in the amount of memory stored in a holographic boundary be in any way part of the observed Dark Energy driven expansion of the size of our Universe?

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