The Nature of Mind: mindless math = projections on reality

Abstract

Does purpose arise from 'mindless math'? Humans are self-aware and aware of their surroundings, thus conscious. The Darwinian Credo holds that consciousness *emerges* from increasing complexity. The alternative is an inherently conscious, purposeful universe. How does one decide this issue? The basis of physics is experience, so we analyze *mind* from this perspective.

Introduction

The topic of *mind*, once considered a career killer in physics, is starting to appear: *Physics Today* [1] just published a speculative article about consciousness emerging from physical building blocks and FQXi asks whether *mindless math* can give rise to *purpose*. But physics has no terms for *purpose* so teleological terminology is a problem. Thus I define [2] key terms as follows:

Consciousness = awareness and will	*– including self-awareness*
Mind = possessor of consciousness	*– including self-consciousness*
Intelligence = consciousness plus logic	*– including self-analysis*
Purpose = intelligence plus goal	*– including self-imposed goals*

Awareness and *will* are subjectively defined. *Logic* means physical structural instantiations of AND and NOT, from which all other logic can be built. If a *goal* is reachable, an approach based on *wandering to the goal* implies random travel in hopes of reaching the goal. This simple scheme depends on luck – wandering randomly until one reaches the goal. Since infinite trials do not fit into finite lifetimes, a better method is: observe the system and determine, in appropriate *measure*, the *distance to the goal*. *Guided wandering* may be implemented as a *hill-climbing* technique, with the target at the top of a topological hill, characterized as *height*, while other parameters represent *wandering around the hillside*. The rule is: after each random step, if you gained height, keep it; if you lost height, return to the last position.

Height thus yields meaningful information to ratchet the system ever closer to the goal in finite time. But FQXi did not ask "*how best to effect 'wandering to a goal'?*" They asked *how goals arise*.

In the *Darwinian Credo*, survival is the goal. Rovelli [3] considers a binary system (turn left or right) as the choice for a bacterium wandering toward its goal of acquiring fresh energy that should exceed the energy expended by the organism's search for food. Variables sensed by the bacterium are weighted by a system yielding a processed signal to guide fueling for survival. To address the terminology problem Rovelli builds *intentionality* into the definition of *meaningful information* – meaningful with regard to Darwinian evolution of function. But function is *structural*, and information, in a physical sense, occurs only when change occurs in a physical structure.[4] Yet Rovelli notes that "*the probability of acquiring meaningful information… opens the door to recursive growth of meaningful information and arbitrary increase of semantic complexity*." The *Darwinian Credo* belief is that ever-increasing complexity leads to consciousness. His *meaningful information* does *not* claim to be the full chain from physics to mental, but rather "*the crucial first link of the chain*". The essential belief: complexity grows until, presto-chango – dead matter becomes aware.

So physical mechanisms exhibit a *purpose*, i.e., *continued existence*, which, in case the physical mechanism *does* continue to exist, simply defines a sufficiently efficient survival mechanism. This is a long way from mental *purpose*, as typically understood. Mental implies mind, so we focus on *the nature of mind*.

Thus the question boils down to how one explains consciousness. If consciousness emerges from physical reality, one should explain how – give a narrative that lays down a starting point and unfolds an account of connected events. A physics theory, based on assumptions, often stated as either *principles* or *axioms*, has the goal of an account of connected events. *How many events?* The question implies *counting*, a process defined *primarily* by $n \leftarrow n+1$ and only *secondarily* by numbers, the (optional) output of the counter. Counters [5] are quite common in RNA, DNA, proteins, cells, neural nets, silicon circuits – and easy to implement, being self-implemented in almost all biological physics. A study [6] of *animal math*:

> *"No one seriously argues that animals other than people have some kind of symbolic numerical system, but nonhuman animals – a lot of them – can manage almost-math without numbers."*

The Transubstantiation of math: *Mindful purpose from mindless math?*

Once we have numbers, we have math – everything else follows (per Kroneckar). The distance between two numbers is the difference $dx = | x_1 - x_2 |$ denoting separation of one number from another. *Was there ever a number-less state?* Do numbers exist or have meaning without mind? That is the *mindless math* question posed by FQXi, due to the inseparable connection of mind to math for humans. If we ask about *minimal* mind, we start somewhere, say embryogenesis, the transformation of egg to organism. The embryo develops with self-awareness, independent of numbers. Numbers do not exist. But one fine day, feeling my oats, I *kick* and encounter a boundary or wall. Now there is self and not-self: 0 and 1. You know where it goes from there – separation and numbers: my hand, my feet, my birth, my mother, my blanket, and my cookies, all the way to my political identity.

Theories of Reality

A theory is a model of reality based on *real* events, although occasionally imaginary events work their way into the picture. How does one distinguish real from imaginary? A primary distinction is sensory; the basis of general relativity: the observer *feels* the gravity field – *feeling* involves the observer's mind. The current narratives of physics are *observer-based* quantum mechanics and general relativity, expressed in terms of the *projection of mental structures onto physical reality*. I list examples of key structures of quantum mechanics, and then discuss how we decide 'what is real'– what is *territory* versus what is *map*. When maps become *too* complex and are unproven, they become *credos*, or belief systems.

FQXi asks whether *mindless math* can give rise to purpose. Lacking physics terms for purpose, physicists tend to subscribe to *Darwinian Credo* mixed with *Information Theory*. Shannon defined *information entropy* in terms of counting possible messages – the similarity to *thermodynamic entropy*, based on counting possible states, has led many to equate the two [7] but Jaynes [8] noted: "*failure to distinguish between these entirely different things [leads to] proving nonsense theorems*."

Maps from territory

Modeling reality means *creating maps from territory*. Literal maps, such as a *Texaco* roadmap through the Rocky Mountains, make it easy to recognize the truth of Korzybski's "*the map is not the territory*". Korzybski claimed sanity is the ability to distinguish real from abstract, for example, valuing real living people over an abstraction such as communism. As implied by the *Texaco* map, a *temporal* relation exists between maps and territory: territory exists in reality *and then* is modeled abstractly, not the other way around. The *symbol-to-territory* translation is physically impossible, lacking agency. This relates to the

belief that we can obtain physical reality from math symbolism. It doesn't work that way. Maps have become too complex when we can't distinguish them from reality; they become *belief systems* or *credos*. Maps from fundamental particles to self-aware humans are too complex for us to distinguish abstraction from physical reality.

Three belief systems currently dominate physics: the *Quantum* [9], the *Platonic* [10] and *Darwinian Credos*. The *Quantum Credo* holds that the classical world emerges from a quantum substrate, while a version of the *Platonic Credo* holds that the physical world emerges from mathematics, and finally, one recognizes *Darwinian Credo*, holding that consciousness emerges from the physical world. These beliefs have not been logically proven, or else they would not be called *credos*. As Feynman noted, "*no one understands quantum mechanics*" and Zurek's *Quantum Credo* program is as yet unsuccessful. And the ubiquitous contribution of our conscious minds to math makes *'mindless math'* an open question.

The classical physics of gravity and trajectories of objects were intimately *experienced* and *practically* understood. For centuries *symbolic* and *logical* relations applied to physics yielded predictions of reality that closely matched experience. Planck's discovery of a minimum action $\hbar$ removed the possibility of predicting point-based interactions, introduced uncertainty, and required probability, severing the more or less *direct mapping* of math onto physical reality and introduced an era of *projections onto reality*.

Structural projections onto reality

The first projection is the quantum constraint $\hbar$ limiting interaction between quantum systems, per *Bohr*. Analytical solutions, no matter how strenuously derived, do not necessarily provide realistic physical solutions but may require imposition of conditions to filter unrealistic solutions. This is well understood in terms of Maxwell's *fields-in-a-cavity*, or Schrödinger's *particle-in-a-box*, in which only solutions that satisfy initial and/or boundary conditions actually represent physical reality. Realistic solutions *projected onto reality* yield *models of reality*, or theories. The break with classical thought led to confusion and to *the invention of new structures*, which in turn were projected onto reality, giving rise to more confusion:

quantum:	$\hbar$	Planck
spinor:	$\vec{\sigma}$	Pauli, Goudsmit, Kasner $\hat{\sigma}_{\pm}\|\pm\rangle = \pm\|\pm\rangle$
isospin:	symmetry	Heisenberg $\rightarrow SU(3)\times SU(2)\times U(1)$
helicity:	$\alpha = \langle\vec{\sigma}^2\rangle$	Dirac
qubit:	$\|\uparrow\rangle$ or $\|\downarrow\rangle$	Pauli, Feynman, Bell, Aspect, Susskind, etc.
gauge:	$\vec{A} + \partial\chi$	Maxwell, Yang-Mills, etc
color:	invisibility	Greenberg, Wilczek
bit:	information	Shannon-to-Susskind '*measure of information*'

This list is not exhaustive, but *all* current quantum theories are built on these *artificial* constructs, mental constructs projected onto reality. Unphysical consequences associated with these structures are ignored. For instance, relativistic field theory texts only rarely mention that Dirac's equation implies particle speed of $\sqrt{3}c$, greater than the speed of light. Yet Dirac's equation is used to develop QED, QCD, and undergirds the Standard Model of Particle Physics, whose most notorious aspect is the need to put in over two dozen basic parameters 'by hand'. Similarly, [11]

> *…many successes of the Big Bang model "can be traced to the initial conditions postulated … and put in by hand, without justification, other than to retrofit the data."*

Standard Model and *General Relativity* parameters that must be put in 'by hand' form *links* in a *narrative chain*, linking basic principles to observed data. Rovelli [3] agrees that we *project structure onto reality*:

> *"We do not actually know the extent to which the structure is superimposed over the elementary texture of reality by ourselves."*

Finding itself smack dab in a *real* world, the *mind projects mathematical structure onto physical reality*. It apprehends the observed system in terms of constructs formed in the physical brain by the neural network, which recognizes patterns and produces signals. The number of potential math models of physical reality is unlimited, yet there's only *one* reality, bounded by the cosmic background, encompassing all scales with few constraints: $(G,\hbar,c)$. *One reality* is the dominant concept or cognition, regardless of how many diverse models are *projected onto it*. To believe that such projections *give rise to* physical reality, or to aspects of mind such as *purpose*, is to vastly overrate the enterprise. In fact, Weckbach [12] points out that from Godel we conclude that "*relatively simple mathematical systems, although they are consistent, must remain incomplete*" but the mathematical system cannot itself formalize this conclusion! This is a powerful argument against "*the complete formalizability of all that exists*." He concludes math speaks to us; the message is: "*there is more to existence than mathematical structures ever can deliver.*"

We derive mental structures using pattern recognition capabilities of neural networks, and mark places with coordinate numbers, based on the neural networks ability to implement counters [5]. Physicists are the world's experts in projecting complex mental structures (as math) onto physical reality. Yet either *one seamless reality* exists, or the universe is simply a sum of disjointed parts, which have no conceivable reason for "hanging together" in such elegant and enduring fashion. Rovelli: "… *evidence is strong that nature is unitary and coherent."* How do we decide which is the case?

How do we know?

One understands the world through *primary* means (*experience*) and *secondary* means (*abstractions*). Primary experience is physical, based on awareness of sensed data; secondary sources are abstract; both develop 'pathways' in the brain. Secondary sources can change every time we pick up a new book, but significant change of primary experience is normally *ever-so-slow*. Comparative effects are analogous to *reading* that "fire is hot" versus *sticking one's hand in the flame* – experience is far more realistic. For example, the recent US election shows that half of the people believe one narrative; the other half believes another narrative; yet all of the people are hesitant to stick their hand in the fire. The *Quantum, Platonic, and Darwinian Credos* are *narrative-based* abstractions far removed from direct physical experience, so we should hesitate to base our primary understanding of reality on such. Knowledge of *one* common physical reality is based not on *mindless math* but on *mindful awareness* of physically real experience.

If consciousness is *awareness plus volition* and intelligence is *consciousness plus logic* (i.e., *physical structural instantiations* of AND and NOT compatible with Darwinian *evolution of function via surviving structures*) then *logic, function, and physical structure* are *added* to consciousness; consciousness does not *emerge* therefrom. How does one know whether this is a true statement? By exploring consciousness as a physicist, i.e., *experimenting with consciousness*.

Is consciousness real?

I can *sense* it, so it meets that criterion. Is waking consciousness *more real* than dreaming consciousness? In that the dream is decoupled from the sensory equipment, this seems to be the case. Is there any state of consciousness other than waking or dreaming? From time immemorial such states of consciousness have been reported. James [13] described states of consciousness where "…*the outlines of confining self-hood melt down*." Maslow [14] referred to *Peak Experience* as

> *"… awareness of an "ultimate truth" and the unity of all things."*

If humans truly experience *awareness of 'the unity of all things'* this has consequences for the view that local awareness *emerges from specific things*.

The nature of mind

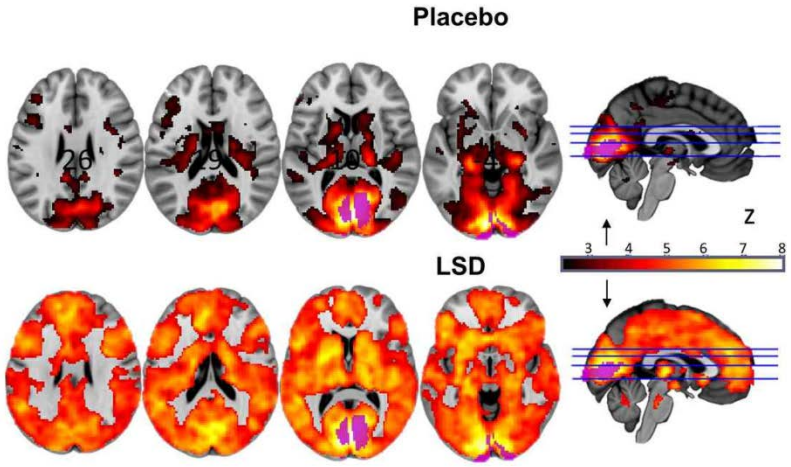
Despite the Darwinian assumption that consciousness arises from *mindless matter* —fortuitously arranged into Lego-like structures such as neural nets – there is absolutely *no factual proof of this*. So, ignoring all *beliefs*, we will focus on *experience*, which is as real as we can get. Weinberg's observer [15],

> *"will say that he feels the gravitational field."*

To *feel* is to *be aware of*, and the field is felt by a mind possessing *awareness plus volition*.

One view in *Physics Today* [16]: "*mind is fundamental to the universe; it cannot be derived from matter or reduced to anything more basic*." I make the same claim. [2] This perspective is relevant to recent articles on LSD, psilocybin, mescaline, [17][18][19][20] or other consciousness expanding substances, [21][22] and continuing legalization of marijuana.

If mind is as primordial as physical reality, then it is best conceived as a field – the *consciousness field* – which interacts with the physical world to *sense physical reality* and to *act on physical reality* purposely. If mind couples to the physical brain, it is not surprising that chemically induced states of consciousness will differ from normal consciousness: [19][29]



Experience of different consciousness may yield broader awareness of consciousness than inexperience, analogous to experience of color in normal vision compared to blindness. A blind person may understand a *theory* of color, with or without equations — a qualitatively different understanding than *experience* of a *colorful world*, from flowers to atomic spectral lines to sunsets.

In like manner, unitary *experience* of expanded consciousness is qualitatively different from a speculative *theory* of consciousness. *Experiment-based* practice is preferred to *speculation-based* theorizing, so some of our greatest scientists have performed this experiment, including Nobel laureates Richard Feynman, Francis Crick (claimed he perceived the double helix on LSD; later switched from physics to brain theory), and Kary Mullis [23], (invented *Polymerase Chain Reaction*) who describes LSD as mind-opening and "*more important than any course I took*.". Also, head of the *Stanford Physics Department*, Leonard Susskind [24], and the author. Bill Gates and Steve Jobs used LSD; Jobs: "*one of the most important things in my life*".

How is expanded consciousness relevant to an essay asking if "mindless math" can give rise to purpose?

Models based on the evolution of 'mind' from 'math' must have a realistic concept of mind.

When LSD appeared on the scene in the 1950s one read statements such as "*I was one-with-everything*" or *"I experienced the connectedness of it all.*" A recent study reported in *Time* [25] concurs: "*you don't recognize yourself as a separate being from the universe*". But consider a group of inherently blind people, a few of whom are given color sight for 12 hours (the duration of the typical LSD trip). As they return to the normal state of blindness and attempt to describe the experience of color vision to their blind cohorts, *what would they say?* Or, compress the 12 hour LSD experience into 15 minutes of *Salvia Divinorum*, and then ask the same question.

> Inability to describe the experience using the vocabulary of the blind does *not* invalidate the experience of color; but it certainly does make communication difficult. In such cases *only analogies are possible,* i.e., correspondence between models.

The brain as neural networks coupled to a consciousness field

The brain is a neural network with trainable interconnections. That is, synaptic connections between neurons and axons can be weighted, and an unlimited number of such connections can exist. Trained connections establish pattern recognition circuits — *pathways* in the brain analogous to pathways through woods. A path is a *path of least resistance* implying some type of barrier or *increased resistance* if one leaves the path. Established ideas follow proven paths but these paths also *limit* ideas. By analogy, if a field of tall grass with established paths is mowed, it becomes easier to leave the path and perhaps to discover new things – maybe a flower not seen before, or an anthill. In a psycho-dynamic model of reality, psychedelic substances may lower established barriers between paths, enabling cross-talk between circuits that normally do not communicate. In the context of physics, this may yield ideas not previously thought. These are not necessarily *good* ideas; they may be *bad* ideas or erroneous connections. But the new connections might yield a *very good* new idea. Any good new idea that survives is a positive result, generally attributed to 'thinking outside the box', where established pathways 'box in' normal thinking. Hence the *Time* article [25] titled *LSD Might Make You More Creative.*

With this connection-based model of expanded consciousness let us ask how the 'one-with-everything' experience that is almost universally reported might come about.

Established truth

Compatible with our model of trained connections/pathways, Lenin claimed:

"A lie repeated often enough becomes the truth",

which can be rephrased in more neutral manner:

'An error repeated often enough becomes the truth."

Thus *any errors* in general relativity and quantum theory that have been *repeated* for 100 years *are now viewed as truth*. Hence the *Quantum Credo* is generally treated as religious truth, not subject to argument. Yet, as noted, these narratives are actually based on *projection* of complex math structures onto reality. But an even more basic truth is derived from *neural pathways* established in infancy. Infants in the womb establish boundaries by moving within walls, but, after birth, the infant learns to focus on separate things. As horizons grow we impose a *metric* on the universe. Because the apple on the tree appears the same size as the moon, it is valuable to formulate ideas of *distance* so that I do not waste energy trying to pick the moon out of the sky, but easily eat the apple. Finally, we reach the point all readers of this essay have reached, that of *experiencing the universe as separate objects at various distances,* implicitly believing in

the universe as metrically mapped. It's almost impossible to realize that this concept of 'separate' is a utilitarian *idea* that was established by the neural nets before we learned to walk or tie our shoelaces.

> "*…regions once segregated began to speak to one another, as if reversing restricted thinking that develops between infancy and adulthood*; *other brain regions that usually form a network became more separated in a change that accompanied users' feelings of oneness with the world.*" [20]

If we bio-chemically suppress the feeling of separation, our consciousness may revert to an embryonic-like *awareness of oneness*, while retaining language, math, and other ideas of everyday adult experience. Awareness of *oneness-with-the-universe* is real, but awareness of *boundaries* and *distance* is so necessary for survival that it dominates the normal consciousness of adults, which *always* returns, since *separation-and-boundaries* are practical, not fundamental. Jill Bolte Taylor, a neuro-anatomy teacher at Harvard, describing her stroke: [26]

> *"I could not determine how my body was positioned, where it began, where it ended. Without the traditional* [learned] *sense of my physical boundaries, I felt that I was at one with the vastness of the universe. Finer than the finest pleasures we can experience as physical beings, this absence of physical boundaries was one of glorious bliss* [and] *it wasn't that I could not think anymore, I just didn't think in the same way."*

It appears that *diminishment* or *destruction* of local portions of her brain affected signals to neurons of other parts of the brain altering *local learned pathways*. Undamaged parts of the brain work, but in a *new mode*. This correlates well with a model of LSD inducing changed thresholds across the brain, since such disparate events as a *major stroke*, requiring years to recover lost modes, *LSD*, requiring hours to recover lost modes, and *Salvia Divinorum*, requiring minutes to recover lost modes, <u>all</u> *override local awareness of time and space boundaries.*

Minds operating along predominantly verbal pathways may resist this argument, but contrast the word "prick" with the prick of a needle in your skin. The word is a symbol; the act is an experience. All physics is based on *awareness of sensory data* and on how these may be interrelated. Weinberg, describing the *Equivalence Principle*, speaks of the observer *feeling* gravity, not *imagining* or *thinking* gravity. Mullis, discussing the senses through which we acquire data about the world, speaks of a sense of *weightlessness*. One might even feel *one-with-the-field*, consistent with the feeling *connected-with-all*. The physical world is understood differently once experienced as *limitless mind connected to everything*.

The Selfish Neural Network

Such experience reinforces a *continuum–based classical* world, possibly denigrating the *Quantum Credo* of structures projected onto reality. Yet many individual neural networks, trained on errors repeated for almost a century (and therefore *true*) strongly *believe* the credo, ignoring Feynman's "*no one understands quantum mechanics*" and thinking that they <u>do</u> understand the quantum universe. This is natural; by the time a specific neural net invests enough time and effort to even *pretend* to understand quantum mechanics, the *understanding* has become a major part of its self-organization and self-image. To claim this is based on misinterpreted *mental-projections-on-reality* is to attack the neural net's worth, its career, even its self-identity as *one-neural-net-that-understands-quantum-mechanics*.

Quantum mechanics is *useful* and *correct* yet some key *interpretations of* quantum mechanics are in error, based largely on the *projections-on-reality* we discussed. But repeatedly walking *well known* quantum pathways trains the brain to allowable models and inculcates an absolute faith in the *Quantum Credo*. [27]

The same applies to the *Platonic Credo* – faith in a *Mathematical Universe* that exists separately from the physical universe. One does *not* wake up one morning having suddenly become a Platonist. Instead, one traverses math pathways many times, over years, beating these paths into one's brain.

That bio-chemically-induced experiences can open the mind is a great wonder. This essay does not deal with social problems that accompany any widespread use of mind-altering substances. It is solely focused on *the nature of the mind* that is being referenced when FQXi asks about 'mindless math' and *purpose*.

Summary

Mind finds itself in a physical universe, experiencing *varying connectivity* over this physical universe. Intellect occurs locally when the consciousness field interacts with neural networks that combine material physical flows with logical operations. Decades are spent building pathways in the brain: 1,2,3… A, B, C, continuing through study of math and physics, memorizing facts, multiplication tables and equations, etc. Everyone reading this essay is quite good at this kind of path-building, but it is easily forgotten just how effective this is. After you've said 1,2,3,4,5… your brain does not wonder what comes next, it's programmed and programmed hard. After learning hundreds of times the various quantum narratives, inconsistent and conflicting as they may be, the mind accepts the quantum narratives, *errors and all*. Darwinian processes stabilize useful patterns of thinking so that they are ingrained as *fixed pathways* or *operational beliefs*. Survival-wise, it's too expensive to question every new data point when one already 'knows' the 'truth'.

Darwinian evolution of function *leading to consciousness* and *purpose* is compatible with this model of *neural architecture as learning network*, but differs in the interpretation of the *universal* state as the primordial state of consciousness, independent of the local structure of specific learned pathways. This finally boils down to *experience* versus *narrative*. Is the consciousness field primordial, or does consciousness arise locally from complex Lego blocks? Narrative cannot prove either case, it must *assume* one or other. The experience carries its own authority.

> *"… under LSD the separateness of these networks breaks down and instead you see a more integrated or unified brain."* [19]

The background or *universal* state of mind is constant and ever-present. Since it represents no 'surprise' it thus disappears from awareness until physical changes in the brain cause it to temporarily be observed.

There is a truly vast literature on the state of consciousness discussed in this essay, both a religious literature and a psychedelic literature. As most who experienced such consciousness were proficient in neither quantum mechanics nor general relativity, they did not address these subjects and their reports have, for the most part, neither dealt with physics nor entered the physics literature. Nevertheless, if physicists now wish to ask whether 'mindless math' can give rise to purpose, it is time that physicists pay a little more attention to the *nature of mind*. Many thousands of reports of expanded consciousness describe the "unity of it all" in one way or another. This experience argues for a universal field, hinted at by John Archibald Wheeler and others in the guise of 'a purposeful universe', but never investigated as if it were real. It is.

Thus pathways in the brain, learned from interfacing to the physical world, 'map' the territory, and the mind, represented here by the consciousness field, reads the dynamic local map. The 'mindless math' at issue is based on physical counters, logic circuits and algorithmic structures instantiated in the brain (as briefly described in the endnotes) and, due to the dynamic nature, is sensed and comprehended by mind. The math is a formal byproduct, having nothing to do with *giving rise to* awareness, volition, or purpose.

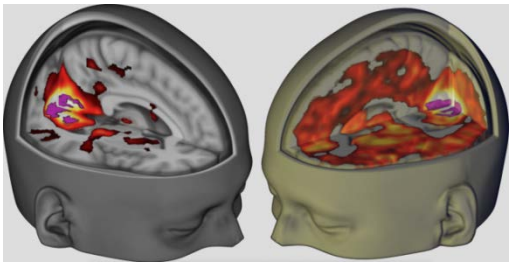
Endnotes

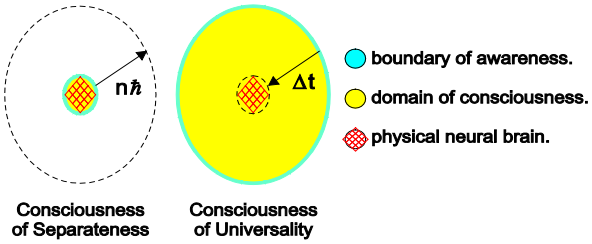
A Quantum Mind Model — qubit states of consciousness

In current physics [28]

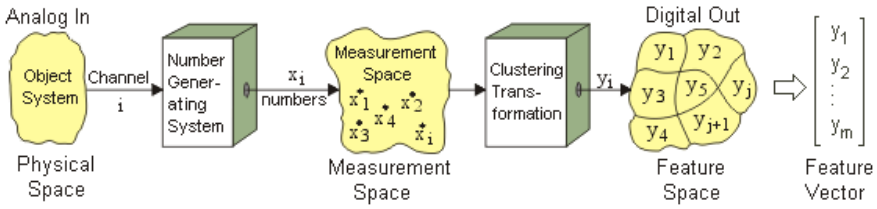
> *"The two-level model represents the most fundamental quantum system and is used to describe a wide variety of physical systems."*

Such *two-state projections onto reality* are at the root of much of quantum mechanics, thus a simplistic 'quantum' description of the mind would ask whether it's possible and reasonable to consider that the mind can exist (or operate) in two 'disjoint' states, and we have argued that this is indeed the case. A recent breakthrough in imaging LSD states[19,20] of consciousness is shown at left, a qubit model of mind at right:



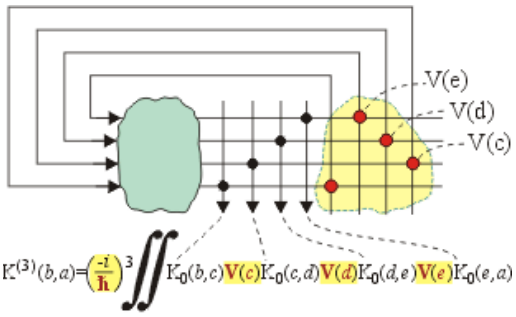


The construct is most useful if a *stimulus* $n\hbar$ *excites* the system from the normal state of local *separated* perception to the excited state of universal *connected* perception, and after a time delay, Δt, the excited system *decays* to the normal state. As in quantum mechanics, this is *descriptive*, not *explanatory*. This qubit structure is *projected* onto many different physical systems and found useful for many. The rest of quantum theory consists of *N*-state systems, $N > 2$, where the transformations of real world signals into mentally constructed state vectors is accomplished as follows:



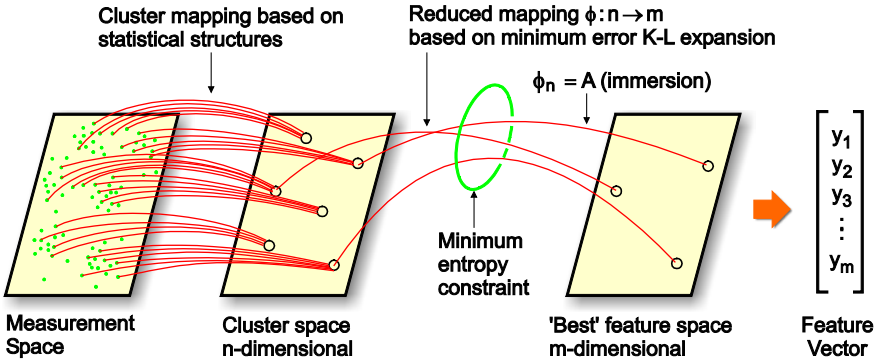
Physical space holds phenomena of interest, typically represented by analog signals that are measured in a number generating system, producing a measurement space. The raw numbers are processed by pattern recognition circuits that perform clustering transformations to identify 'features', the results of which, in list form, yield feature vectors. Math operations on *feature vectors* are the basis of physics.

I state: [5] "*All axiomatized theories of physics can be formally mapped into automatic machine representation.*" Counters are easily represented in this automata-based representation, but the scheme goes far beyond counters. A typical 3rd order Feynman diagram quantum field theory kernel $K^{(3)}(b,a)$, shown in canonical form, maps the automata's '*Next State-address*' into *local potential* in physics. All automata have, implicitly or explicitly, a *next-state-address* function, so the equivalent of local potential is built-in to the formalism.



This equivalence has not been noticed in other treatments of computational physics.

While the essence of math is awareness of relations and patterns, physical machines can be structured to perform mathematical operations; the fundamental operation being *counting*. The count can represent a magnitude that characterizes the phenomena or event, or it can represent time, position, or simply a sequence, such as the *next-state-address* for the automaton that effects the algorithm or behavioral rule appropriate to the physical model. When a counter produces a number, another machine can add this number to a different number yielding a new number. If the new number is zero, an identity of some kind is established; identity implies zero 'distance' from an entity. *Distance, as difference, is a key concept* leading to pattern recognition machines that measure distances between points in a set of measurements and perform inter-set and intra-set operations to partition and group sets into subsets, as diagrammed below. I have shown [5] neural network correlates of the general canonical automata; so every aspect of this formalism is reproducible by the physical brain, hence representable via mathematical structure.



Extracting features from measurements allows us to partition a physical continuum into a feature-based world, in which math operations on *features* form the basis of physics. The diagram shows the transformation of measurement data into *best* feature vectors, and the dynamical processes that produce eigenvalues, generally *taken as representative of the object system*. Feature extraction based on *distances* obtained from numbers is constructed from physical structures that can function as gates, implementing logic operations, which can be combined to *count* to produce integers and to *add* to produce *distance* maps and then compare distance maps to get *difference* maps (gradients) from measurements. The nature of the process of making math maps is thus rooted in the physical universe. Thus pathways in the brain, learned from interfacing to the physical world, 'map' the territory, and the mind, represented here by the consciousness field, reads the dynamic local map.

Math maps projected on the physical territory form the substance of physics.

I have awareness of only *one* physical universe, but I have *many* maps of the universe, and I use experience of the physical universe to qualify the maps.

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Note: All URL's verified on 3 Feb 2017

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