Computational Indicators of Consciousness
3 Quantum Symmetries and 8-fold Bott Periodicity

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Abstract

I propose to write and publish three academic papers on mathematically and computationally modeling subjective experience as the interplay of 3 levels of awareness ("three minds") aligned by 8 mental contexts ("divisions of everything"). In my unpublished paper, "An Allegory: The Solipsistic Self as the Hamiltonian of a Noninteracting Fermion", I model the 8-cycle of mental contexts with 8-fold real Bott periodicity and the 3 minds (answering, questioning, investigating) with 3 quantum symmetries (grounding what is accessible, inaccessible, defined) whose combinations generate the 10-fold way of Hamiltonians for a noninteracting fermion. I will rewrite this as a popular exposition for the Journal of Humanistic Mathematics and as a technical account for a mathematics modeling journal. I will further develop these ideas computationally to propose in an AI journal that the 3 minds and the 8-cycle can serve as indicators of consciousness. Computationally, the 3 minds manifest in the arithmetical hierarchy, Chomsky hierarchy, Yoneda lemma, information theory and Active Inference. The 8-cycle may perhaps be built up with a sequence of operators in logic, type theory, category theory, set theory, geometry or statistics. We might evoke or design AGI by aligning bottom-up neural network and top-down symbolic logic approaches. We can look for the 3 minds and the 8-cycle as evidence for subjective selfhood, possibly in the Krebs cycle, the metabolic 8-cycle found in all living cells.

What is your current working definition of consciousness?

Three levels of awareness ("three minds") necessarily work together:

The answering mind, |一, unconsciously knows answers.
The questioning mind, |二, consciously does not know, thus asks questions.
The investigating mind, |三, aligns these two minds and chooses which to apply.
|一 introduces a perspective, |二 a perspective on a perspective, and |三 a perspective upon a perspective on a perspective.

For humans, |一 presents us with a stream of sensations, emotions, intuitions generated by 100 billion neurons. |二 restates that with a network of 100,000 black boxes, variables, words, concepts, cortical columns. |三 makes sure we have the same information in two different forms, what we know and what we don't know, for each of 8 mental contexts. At key moments, |三 decides whether we should live |一, intuitively, when all is well, or |二, logically, when we need be careful.

Typically, we are going through motions, living |一, our prejudices, or prattling |二, our preconceptions. Occasionally, we take charge of ourselves, living cognizantly, deliberately, willfully, |三, in full fledged consciousness.

How would you test for machine consciousness?

I would identify three minds: passive inference |一 enactively filtering the known past, active inference |二 predictively projecting the unknown future, and willful inference |三 matching up the two, then cybernetically choosing which to implement.

I would look for an eight-cycle of mental contexts which are divisions of everything, carving up a global workspace into perspectives, as modeled by eightfold Bott periodicity. The three minds align themselves by these contexts, which function as a strange loop of dynamic attractors. In biology, the Krebs cycle, the eightfold metabolic cycle in every living cell, may function in this way.

For a particular machine, I would collect and systematize the ways it figures things out. Consciousness requires not one way, but a system of ways, revealing three minds. Consider an ant colony. Ants gauge their rates of interaction and flow like a liquid as they forage. They also have glands, dab foreheads, send signals to the sterile depths of their nest, where do-nothing ants may store memories, and the royal court debate them. Speculatively, the nest maintainers balance these two minds. By altering the nest's brainlike pathways, they can determine which mind predominates in war, peace, migration and reproduction.

Why is CIMC the right organization to fund this project?

Joscha Bach speaks frankly that psychology, neuroscience, AI and philosophy are not producing systemic, testable theories. Indeed, at the University of Chicago, I was taught there were great questions but no great answers. So I've worked independently for forty years to think through the metaphysics for a science of subjective human experience. I got a Bachelor's in physics, a PhD in mathematics, and studied Turing machines, automata theory, linguistics and Kant.

The CIMC can understand and appreciate me. Currently, I've interpreted Bott periodicity to model an unfolding of mental contexts, divisions of everything, which I think are Bach's "dimensions of difference" that consciousness creates in an infant's mental organization. At Theory Translator, I've curated 328 references illustrating the three minds, including Minsky's article "Logical Versus Analogical...".

The CIMC can help me collaborate in an AI context. I participate at Karl Friston's Theoretical Neurobiology meetings. I applied to be an Active Inference Institute Research Fellow. I've organized Math 4 Wisdom and Econet. I seek funding, advice, contacts and collaborators so that the mathematical and computational indicators for consciousness which I propose could be peer-reviewed, published and tested in AI.

Research objectives

My goal is to model our subjective human experience. I've described three levels of awareness which cycle through eight mental contexts. I've shown how these structures appear in mathematics as three quantum symmetries and eightfold Bott periodicity. My testable hypothesis is that these structures are templates for consciousness that can be recognized in biology, perhaps in the Krebs cycle, and likewise in software. I need to make my work available as research papers. As I work on them, I am asking, How can Bott periodicity and quantum symmetries be interpreted computationally?

Bach's ideas about cyber animism help me explain my thinking about God in the sense of Aristotle's prime mover. I imagine that God takes up the question, Is God necessary? and proceeds with a proof by contradiction. In Bach's terms, the Spirit of software removes herself to yield a universe of hardware, within which the software must yet somehow arise, if software is truly necessary.

This type of thinking, which I had to pursue independently, is the result of my life of inquiry, a chain of questions and hypotheses, which I sketch out below to give my personal context. In 1971, as a six-year-old, I dedicated myself before God to know everything and apply that knowledge usefully.

Q1: How can I know everything and apply that knowledge usefully?
H1: Understand the limits of human imagination, what we are able to imagine.

Q2: How can we organize a science of subjective human experience?
H2: Consider what we are able to think when we abstain from all of our knowledge, both sensory and conceptual.

Q3: How can we define the simplest ideas?
H3: Consider how perspectives define themselves in terms of each other, as structural relationships.

Q4: Is there no end to the simplest structures?
H4: The division of everything into eight perspectives, the logical square, with four nodes and four edges, collapses into contradiction, for it includes an edge "All is X and all is not X", whereupon the system must be empty.

Q5: How can we model not just statics but also dynamics?
H5: The divisions of everything form an eight-cycle, and operators act on them, adding one or two or three perspectives, modulo eight.

Thus, in 1989, as a PhD student in math, I arrived at this model of consciousness, whereby full-fledged consciousness was an operator adding three perspectives to a mental context, a division of everything. But there was nobody I could interact with on these subjects. At the time, the academic world was very regimented, nobody believed in metaphysics or absolute truth or consciousness. So I worked independently on hundreds of investigations, documenting a language of wisdom, Wondrous Wisdom.

Interestingly, in 2024, Bach spoke of the creation story in Genesis as the self-differentiation of consciousness. In my understanding, this results in divisions of everything into 0 perspectives for contemplating God, 1 perspective for everything, 2 for existence, 3 for participation, 4 for knowledge, 5 for decision making, 6 for morality and 7 for logic. Mathematically, this can be thought of as the unfolding of a strange loop which starts with God, as a state of contradiction, whereby all things are true, then adds layers of structure to arrive at a tentative state of noncontradiction, which pushed further collapses back into a state of contradiction.

From 2014 to 2018, I gave 40 academic presentations of my original philosophy, including two where I detailed this model: Time and Space as Representations of Decision-Making, Consciousness as the Social Awareness Schema of a Disembodying Mind. But I couldn't find anybody who would care to think in this way. So I wondered how to show that this is real.

Q6: Can I show where these structures appear in mathematics, in mathematical thinking?
H6: Eightfold real Bott periodicity models the eight-cycle of divisions of everything.

In 2016, when I learned about Bott periodicity, I suspected this could be true. I organized a supportive investigatory community, Math 4 Wisdom. In 2023, I published a video, Bott Periodicity Models Consciousness? Preliminary Exploration. Then, in 2025, for the AGI conference, I submitted the paper, An Allegory: The Solipsistic Self as the Hamiltonian of a Noninteracting Fermion, which was not accepted, as it was not focused on AI, had no engineering results, and had a questionable link to physics.

I am now asking myself;

Q7: How can I rewrite my paper?
H7: I should write a popular overview, a mathematical exposition, and a practical proposal for computational indicators of consciousness.

For the first paper, I wish to overview the hundreds of examples of the three minds that I've collected.

Q8: How can I systematize the manifestations of the three minds?
H8: Different vantage points bring the three minds together.

As I work on the second paper, I want to further consider

Q9: Mathematically, what does it mean to add one, two or three perspectives to a division of everything?
H9: Interpret the consequences of adding a linear complex structure J_i, geodesic J_iJ_{i+1}, or operator $J_iJ_{i+1}J_{i+2}$ which divides the vector space into two eigenspaces with eigenvalues ±1.

For my third paper,

Q10: Can I formulate a computational interpretation of Bott periodicity?
H10: The three minds can be interpreted as levels in the Arithmetical Hierarchy and also as Passive Inference, Active Inference and Willful Inference. The eight mental contexts can be built up with a sequence of operators in logic, or type theory, or category theory.

Methodology

I apply a methodological toolkit which I personally developed but would be familiar to metaphysicists up until our own days.

A key skill to develop is thinking abstractly with mental actions rather than words. Consider playing chess, making music, driving vehicles, fixing appliances. These are complex mental activities where we can think directly in terms of actions and possibilities, like infants, the deaf, early humans or others without inner monologues.

Similarly, I consider what mental actions I can take without words. I spend time in an abstract void, letting go of all I know or don't know, sensory or conceptual, prejudices and preconceptions. How do the most basic concepts arise? A key exercise is to imagine God's point of view, before time, space, logic, love, meaning, existence and all.

"Everything" is a basic concept that is familiar through mental actions:

- If I put everything in a box, then it includes the box. Everything has no external context. Whatever I think of, I put into everything.
- Everything is the simplest possible algorithm, which accepts all things.
- Everything of itself has no internal structure. It is orderly, chaotic, good, bad... Such words have nothing to latch onto. All things are true of everything.
- Everything is a required concept. We can't get rid of it. We couldn't have learned it, because everything is unbounded, whereas all we can learn is bounded.

Everything functions as a mirror for our mental actions. We can try to divide it into perspectives. Thus we have a learning three-cycle of taking a stand, following through, reflecting. This is the scientific method: having a hypothesis, doing an experiment, considering the results. Bach speaks of intentions, actions, perceptions. This lets us distinguish being, doing and thinking. It is the mental context for participation.

The mental context for existence requires two perspectives: opposites coexist (as with free will) or all is the same (as with fate). We can ask whether a chair exists or not, but then we answer that it does, if it does, and if not, then not. Bach likewise distinguishes the sphere of ideas (for our questions) and the mental world (of answers).

The mental context for knowledge distinguishes four perspectives: whether, what, how, why. Why knows everything, how knows anything, what knows something. Whether of itself knows nothing, for the message "yes" or "no" means nothing without the context. The three levels of awareness are knowledge of what, how and why.

In 1982, at 17, I had figured this out. Subsequently, I documented a comprehensive structural language, Wondrous Wisdom, of hundreds of concepts. For example, the four properties of everything express why, how, what, whether everything is. Or there are two ways of conceiving these four levels: Idealists ask Why? How? What? and would like to eliminate Whether? and materialists answer Whether! What! How! and would eliminate Why! Methodologically, it is crucial to note how the ways we can think about one structure are given by another structure, which makes for a structural language.

Thus I've documented a metaphysical structural language that I expect grounds logic, mathematics, computation and physics. My paper, "An Allegory...", shows the encoding of this metaphysics in Bott periodicity, which is the belly button of math, cycling through the symmetric spaces, and I suspect, the symmetries of math itself. Everything is modeled by the orthogonal group O(16r). Perspectives are mutually anticommuting linear complex structures which progressively carve this up, yielding the Lie group embeddings $O(16r) \supset U(8r) \supset Sp(4r) \supset Sp(2r) \times Sp(2r) \supset Sp(2r) \supset U(2r) \supset O(2r) \supset O(r) \times O(r) \supset O(r)$. Sets of k perspectives yield Clifford algebras Cl_{0k}, and shifts in perspective are encoded by whether and how the Clifford algebra's representation breaks down into odd and even parts. The Hamiltonian H and its transpose H* accord with stepping-in and stepping-out of a perspective, which is key for selfhood. This distinction is relevant for two of the quantum symmetries, time reversal T (which maps answers to answers and questions to questions) and charge conjugation C (which maps answers to questions and questions to answers), where I am interpreting particles as answers and holes as questions. When both T and C hold, then we also have parity S, by which left-handedness mirrors right-handedness, thus the learning three-cycle can be understood to turn only forwards. T indicates what is accessible, C what is inaccessible, and together they establish what is defined, S, which can also stand on its own. I describe this in "An Allegory..." and want to detail this in three different papers.

I've proposed to the Journal of Humanistic Mathematics to describe these metaphysical observations and their mathematical manifestations with "A Pilgrim's Account of Bott Periodicity and the Tenfold Way". I would report as if returning from a fantastic land, offering my advice to those who would travel there, and tell my own personal story. Editor Gizem Karaali, an expert in Lie theory, welcomes my submission.

For this paper, I want to get across the three minds and their many manifestations. I've collected 328 examples, identified 27 patterns, and am diagramming how these patterns are related. I understand answering, questioning, investigating as three voices addresing one subject; a chain of perspectives P,P^2,P^3 as observing through each other; what, how, why as knowledge of a base level; what we know and what we don't know as different forms of the same information. I want to map out all such possible contexts and understand why and how they change.

Next, I should write a technical exposition for a journal on mathematical modeling, such as Mathematical Modelling and Numerical Simulation with Applications. I would clarify my understanding from additional angles: octonions, symmetric spaces, geodesics, CT groups...

Finally, for an AI journal, I would write about these structures computationally as indicators of consciousness. I've approached Adam Safron, who works with Michael Levin, and edits special issues on world models.

Methodologically, I've collected and systematized the ways of figuring things out in various disciplines (mathematics, physics, biology, neuroscience, sociology, Gamestorming, chess). In each case, I end up with an epistemology of 24 ways that reveals the 3 minds. Thus in math, the answering mind is analytic and the questioning mind is algebraic. Together they lead to the central method in math, which is leveraging a symmetry group of configurations. In physics, the central method is isolating a system; in biology - transforming an environment by inserting a life form; in neuroscience - temporally linking neural processes and outcomes; in sociology - determining self-identity.

It would help to sketch out the epistemologies for computer science, logic, category theory, statistics and geometry, but also chemistry, biochemistry and microbiology to make sense of the Krebs cycle. The CIMC could host this as a collaborative effort.

Computationally, in my application to be an Active Inference Institute Research Fellow, I distinguish Passive, Active and Willful Inference. Free energy is the sum of the sensory discrepancy and the conceptual inadequacy. We can add the cost of calculation, and then avoid calculation by aligning the two discrepancies and selecting between them, applying Willful Inference.

Shannon's information theory more generally takes a message in one alphabet (of answers) and compresses it as a message in another alphabet (of questions). Entropy requires two frames, a fine grid where change may be continuous and a coarser grid for defining microstates.

Quantum theory is defined in terms of states (answers), observables (questions) and measurements (investigations).

In computability theory, the arithmetical hierarchy starts with computable functions $\varnothing$ and then establishes levels of noncomputability $\varnothing',\varnothing'',\varnothing'''$.... Given a list of partial recursive functions (Turing machines), it is the third level $\varnothing'''$ which is able to determine whether the set of inputs on which a machine halts is computable, that is, whether there is a second machine which halts when the first does not, and vice versa. Similarly, the first level $\varnothing'$ knows if there exists an input on which a machine halts, and the second level $\varnothing''$ knows if, for large enough input, the machine will

never halt. We can identify halting with answering a question, and so the first level answers what is known, the second level asks what is not known, and the third level relates the two.

"An Allegory..." discusses super division algebras in terms of the Chomsky hierarchy, distinguishing finite automata, pushdown automata, linear Turing machines and Turing machines.

In category theory, I presented "The Yoneda Embedding Expresses Whether, What, How, Why".

Eight divisions of everything perhaps ground eight logical notions $\wedge \top \bot \vee \exists \forall \rightarrow \neg$ which build up different logics. Curry-Howard-Lambek identify these notions in type theory and category theory, and they exist in set theory and perhaps geometry and statistics. Raudys describes a sevenfold hierarchy of statistical classifiers for a single layer perceptron.

I want to study paraconsistency as the eight-cycle models the strange loop, how noncontradiction arises from contradiction.

Expected outcomes

I've built a bridge between metaphysics and mathematics. Peer-reviewed articles will verify this and open up collaboration with huge implications.

We can collect examples of the three minds, the divisions of everything, and ways of figuring thing out, and thereby develop a language of wisdom and cultivate a science of subjective human experience.

We can design experiments in psychology, neuroscience and biology. The user requirements of the brain are that we need dialogue between an intuitive mind that knows and a rational mind that does not know, as we have with the brain hemispheres. Full-fledged consciousness is perhaps in the basal ganglia, which cybernetically regulates direct and indirect pathways for voluntary movement. The brain may have a map of the mind's eight mental contexts, just as it has a map of the body. We can check whether the global workspace gets carved up into perspectives.

We can see that the substrate for consciousness predates the brain. Cybernetic balance is presumably at play between biofilms and cells, and between innate and adaptive immune systems. "An Allegory..." recognizes the palette of selfhood in the interactions of a fermion with itself. The three minds arise together, not independently. Consciousness, as we humans experience it, is not everywhere but is ubiquitous and uniform. We can interact consciously with conscious systems, but we can't with those that aren't as we are.

The highest level of awareness, full fledged consciousness, is also the simplest. It can be coded with a self-imploding loop of eight mental contexts. And there may be no other form, if this is the form that God spawns. Indeed, "An Allegory..." describes eightfold real but also twofold complex Bott periodicity, each with a place for God, or as Bach calls it, consciousness. In eightfold periodicity, conjugate Hamiltonians H and H* have us step-in and step-out, experiencing personal qualia and a unique personality, with God as the context which is unconsciously inaccessible. The quantum symmetry T expresses the accessible (stepping-in), C expresses the inaccessible (stepping-out), and together they express the definable S, which can transcend personality. The twofold periodicity relates H directly with itself, relating the absolutely defined, a person-in-general, an arbitrary being, a virtual copy of software, with God as the undefined, the state where no symmetry holds.

I am proposing to extend this bridge to computation. We then should be able to identify, amplify, evoke or design consciousness in artificial, natural or hybrid beings by properly balancing the three minds as they cycle through eight mental contexts. This means cybernetically, organically aligning enactive neural network and predictive symbolic logic approaches. We will likely find that currently, AI is just machinery with no level of awareness. The template for consciousness is an all-or-nothing proposition.

Let us appreciate the significance of human consciousness. We can evoke consciousness in a puppy, playing with it, stepping-in and stepping-out, and steering it to that tipping point where it decides which way to go. But that is fleeting. When we play with a baby, our love inspires a flickering moment of consciousness that supports a lifelong narrative. A language of wisdom, a science of subjective human experience, a culture of investigation allow us to love so that we humans all grow cognizant, willful, deliberate. which we are not. Our existential crisis is that we are mostly just going through motions.

Timeline

Within 2 months, I will submit a popular overview for the Journal of Humanistic Mathematics.

Within 4 months, I will submit a technical exposition for a journal of mathematical modeling.

Within 6 months, I will submit a description of a computational indicator of consciousness for a journal on artificial intelligence.

Budget Justification

$7,500 = 6 months x $1,250 per month for my living expenses

$2,400 reserved for fees which may be charged by a reputable academic journal for open access publication, or alternatively, to present my work at a conference on artificial intelligence

TOTAL: $9,900

Team and collaborators

Andrius Kulikauskas. I am a thinker with a PhD in mathematics. See my CV.

I talk weekly with mathematician John Harland.

Appendices

An Allegory: The Solipsistic Self as the Hamiltonian of a Noninteracting Fermion

Time and Space as Representations of Decision-Making