### What Is Consciousness?

Artificial Intelligence, Real Intelligence, Quantum Mind, And Qualia

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#### **Abstract**

We approach the question "What is Consciousness?" in a new way, not as Descartes' "systematic doubt", but as how organisms find their way in their world. Finding one's way involves finding possible uses of features of the world that might be beneficial or avoiding those that might be harmful. "Possible uses of X to accomplish Y" are "Affordances". The number of uses of X is indefinite (or unknown), the different uses are unordered and are not deducible from one another. All biological adaptations are either affordances seized by heritable variation and selection or, far faster, by the organism acting in its world finding uses of X to accomplish Y. Based on this, we reach rather astonishing conclusions: (1) Artificial General Intelligence based on Universal Turing Machines (UTMs) is not possible, since UTMs cannot "find" novel affordances. (2) Brain-mind is not purely classical physics for no classical physics system can be an analogue computer whose dynamical behavior can be isomorphic to "possible uses". (3) Brain mind must be partly quantum—supported by increasing evidence at 6.0 sigma to 7.3 Sigma. (4) Based on Heisenberg's interpretation of the quantum state as "Potentia" converted to "Actuals" by Measurement, a natural hypothesis is that mind actualizes Potentia. This is supported at 5.2 Sigma. Then Mind's actualizations of entangled brain-mind-world states are experienced as qualia and allow "seeing" or "perceiving" of uses of X to accomplish Y. We can and do jury-rig. Computers cannot. (5) Beyond familiar quantum computers, we discuss the potentialities of Trans-Turing-Systems.

Keywords: Affordances, Universal Turing Machines, analog computers, classical physics, quantum mechanics, Artificial General Intelligence, Potentia, Actuals, classical neurodynamics, quantum computing, dynamical criticality, soft matter, Trans-Turing-Systems.

### I Introduction: The Issues

This short paper makes four major claims:

- i. Artificial General Intelligence is not possible.
- ii. Brain-mind is not purely classical.
- iii. Brain-Mind Must be Partly Quantum.
- iv. Qualia are experienced and arise with our collapse of the wave function.

These are quite astonishing claims. Even the first claim is major. Artificial Intelligence (AI) has made tremendous achievements since its first steps in the fifties of the last century, with Turing introducing the main concepts and questions regarding computing machines [Turing, 1950], and the enthusiastic research plan of the Dartmouth research summer project [McCarthy et al., 1955]. Amazed by today AI systems' capabilities, some await with fear replacement by intelligent robots. We hope to show that this is not possible for wonderful and fundamental reasons: The becoming of any world with an evolving biosphere of philosophic zombies, let alone conscious free will agents, is, remarkably, beyond any mathematics we know.

The pathway to this insight depends upon a prior distinction between the degrees of freedom in physics and in an evolving biosphere. In physics, the degrees of freedom include position and momentum, energy and time, the U(3)U(2)U(1) group structure of particle physics, the Schrödinger equation, General Relativity and Dreams of a Final Theory [Weinberg, 1994, Kaku, 2021].

Oddly, in the evolving biosphere, "affordances" are the degrees of freedom. An "Affordance" is "The possible use, by me, of X to accomplish Y." Gibson [Gibson, 1966], points out that a horizontal surface affords a place to sit. In evolution, an existing protein in a cell used to conduct electrons also affords a structure that can be used as a strut in the cytoskeleton or bind a ligand. Evolution proceeds by organisms "stumbling upon ever new affordances and 'seizing' them by heritable variation and natural selection". "Evolution tinkers together adaptive contraptions", as F. Jacob said [Jacob, 1977].

We humans do the same thing when we tinker and jury-rig. Given a leak in the ceiling, we cobble together a cork wrapped in a wax-soaked rag stuffed into the hole in the ceiling and held in place with duct tape [Kauffman, 2019].

Jury-rigging uses subsets of the causal features of each object that articulate together to solve the problem at hand. Any physical object has alternative uses of diverse causal features. An engine block can be used to drill holes to create cylinders and craft an engine, can be used as a chassis for a tractor, can be used as a paper weight, or its corners can be

used to crack open coconuts [Kauffman and Roli, 2021].

It is essential that there is no deductive relation between these uses. And there is, therefore, no deductive theory of jury-rigging (ibid).

How many uses of a screwdriver alone or with other things exist? Is the number exactly 16? No. Is the number infinite? How would we know? How define? No, the number of uses of a screwdriver alone or with other things is *indefinite*.

Consider some uses of a screwdriver alone or with other things. Screw in a screw. Open a can of paint. Scratch your back. Wedge a door closed. Scrape putty off the window. Tie to a stick and spear a fish. Rent the spear and take 5% of the catch...

What is the relation between these different uses? There are four mathematical scales, nominal, partial order, interval, ratio. The different uses of a screwdriver are merely a *nominal* scale. There is *no ordering relation* between the different uses of a screwdriver [Kauffman, 2019, Kauffman and Roli, 2021]. This fact has profound and far-reaching consequences, as we show in the following.

## II We cannot use set theory with respect to affordances

The Axiom of Extensionality states that: "Two sets are identical if and only if they have the same members." But we cannot prove that the indefinite uses of a screwdriver are identical to the indefinite uses of an engine block. No Axiom of Extensionality.

We cannot get numbers. One definition of the number "0" is "The set of all sets that have no element." This would be the set of all objects that have exactly 0 uses. Well, No. We cannot get the integers this way. We cannot get the number 1, or the number 17.

The alternative definition of numbers is via the *Peano axioms*. Define a null set, and a successor relation, N and N+1. But we cannot have a null set. And the uses of objects are unordered. There is no successor relation. We cannot get numbers from Peano. No integers, no rational numbers, no equations 2+3=5. No equations with variables 3+x=5. No irrational numbers. No real line. No equations at all. No imaginary numbers and no complex plane. No manifolds. No differential equations. No topology. No combinatorics and no first order predicate logic. No Quaternions, no Octonions. No "Well Ordering" so no "Axiom of Choice" so no taking limits [Kauffman and Roli, 2021].

One implication affects computability: no Universal Turing Machine (UTM), which operates algorithmically, hence deductively [Kripke, 2013], can find new affordances not already

in its logical premises. In a computer program, we represent the objects that are relevant for our purposes, along with their properties and their relations by means of a formal language. The program can then reason on this ontology and produce plans to solve a given problem. While doing this, both objects and relations can be combined by following constraints and rules in the knowledge base of the program. Nevertheless, a computer program cannot deduce new properties nor new relations. That is to say, the program cannot provide new explanations of the data it manipulates, besides the ones that can be deduced. The central reason is that, in general, there is no deductive relation between the uses of an object. From the use of an engine block as a paperweight a computer program cannot deduce its use as a way to crack open coconuts. It can of course find the latter use if it can be deduced, i.e. if there are: (A) a list of properties including the fact that the engine block has rigid and sharp corners, (B) a rule stating that one can break objects in the class of "breakable things" by hitting them against objects characterized by rigid and sharp corners, and (C) a fact stating that coconuts are breakable.

The universe of possibilities in a computer program is like a LEGO<sup>®</sup> bricks world: components with predefined properties and compositional relations that generate a huge space of possible combinations, even unbounded if more bricks can always be added. Now, let's suppose to add scotch tape, with which we can assemble bricks without being constrained by their compositional mechanism, and a cutter, which makes it possible to cut the bricks into smaller pieces of any shape. Here rules and properties are not predefined and we have a universe of indefinite possibilities: we are no longer trapped inside the realm of algorithms.

Besides deduction, other forms of logical reasoning exist, namely induction and abduction. The former proceeds from evidence to hypothesis: from the observation of black ravens, the hypothesis that "all ravens are black" is formulated. But the relevant "thing" is already prestated. Induction is over already identified features of the world. Induction by itself does not identify new features of the world.

Abductive reasoning aims at providing an explanation of an observation by asserting a precondition that is likely to have this observation as a consequence. For example: if the corridor light bulb does not switch on, we can suppose it is broken. Abduction is differential diagnosis from a prestated set of conditions and possibilities. When implemented in computer programs, these kinds of reasoning nonetheless cannot add new symbols to represent new possibilities and new meanings. Abductive reasoning can only work with explanations already in its knowledge base. In other words, new symbols—along with their grounding in real objects—are outside of the ontology of the system.

We can conclude that UTMs, at least those that are *not embodied*, cannot find new affordances. If finding new affordances outside of the ontology of the UTM is a necessary

<sup>&</sup>lt;sup>1</sup>We prefer the expression "computer program" over "algorithm" as it is more general and to emphasize the physical realization of a computational process.

condition for passing the Turing test, then UTMs will never pass the Turing test. Moreover, besides the capability of reasoning and learning, an Artificial General Intelligence (AGI) should also be capable of using common sense knowledge, dealing with ambiguity and ill-defined situations and creating new knowledge representations [Roitblat, 2020]. All these capabilities rely on the ability of finding affordances beyond the algorithmic predefined space, therefore AGI in non-embodied UTMs is ruled out.

As affordances characterize actions in the physical world, a fundamental question arises as to whether and how robots, which are *Embodied UTMs*, can find and exploit novel affordances. Robots interact with the physical world through their sensors and actuators, and they can be capable of learning, therefore they can possibly discover new sensory-motor patterns useful for their goals. Nevertheless, two unresolved issues come into play: first, the *symbol grounding problem* [Harnad, 1990], i.e. how to attach symbols to sensory-motor patterns. As stated by Harnad [Coradeschi, 2013], "sensory-motor transduction is not computation: it is physical dynamics". No algorithmic way of tackling this issue is therefore possible.

A second issue is the generalized version of the so-called *frame problem* [McCarthy and Hayes, 1969], i.e. the problem of specifying what is relevant for the robot's specific goal in this moment. Consider a case of a robot using an engine block as a paper weight and the solution to achieving its goal is to use the engine block to crack open coconuts. To do so, the robot must acquire information on the relevant causal features of the engine block to crack open coconuts. The robot can move and sense its world via its sensors: What must occur such that the robot can discover the use of the engine block to crack open coconuts? Achieving the final goal may require connecting several relevant coordinated causal features, none of which can be deduced from the others. Therefore, there is no way for the robot to know that it is improving over the incremental steps of its search. The robot cannot accumulate successes until it happens upon the final success. Even a first step is a search in an undefined space. Taking this first step and reaching the goal is blind luck with some time scale.

We conclude that even an embodied UTM can rarely find a concatenated set of novel affordances on some very long time scale compared to the time available to the robot to accomplish the task. Therefore, neither embodied UTMs can attain AGI.

Computers cannot jury-rig in novel ways. The evolving biosphere can and does jury rig in ever-creative ways by jury-rigged Darwinian Pre-adaptations such as the evolution of the swim bladder from the lungs of lungfish [Kauffman, 2019]. Cells do thermodynamic work to construct themselves. The evolution of the biosphere is a progressive jury-rigged construction not an entailed deduction [Kauffman, 2019, Kauffman and Roli, 2021]. The evolution of hominid technology for the past 2.6 million years is also one of unending non-deductive jury rigging, ten stones 2.6 million years ago exploding to billions of goods including the space station today [Koppl et al., 2021].

Life and mind are not algorithms. Robots will not replace us. We can just see or perceive affordances. We can see and laugh about using an engine block as a paper weight and also to crack open coconuts. Thus, we are not merely disembodied or embodied UTMs.

But we do perceive affordances? How can we possibly perceive or "see" affordances?

### III Perhaps we are classical analogue computers

These classical analogue computers can be embodied as robots. Analog computers compute by being isomorphic to that that which is modeled. But we cannot be classical analog computers. The reason is unexpected: Affordances are "possible uses of X to do Y". But these Possibles are ontologically real. Before the evolution of the swim bladder from the lungs of lungfish was it possible that such a preadaptation would occur? Of course, the swim bladder really did come to exist. But what is the ontological status of this Possible? The possibility is ontologically real, as demonstrated by the subsequent fact that the swim bladder did come to exist, but it might not have come to exist. To "exist or not exist" is surely ontological! Five hundred thousand years prior to the evolution of the swim bladder there was "no fact of the matter" concerning whether it might or might not emerge. C.S. Pierce pointed out that Actuals obey Aristotle's law of non-contradiction. "X is simultaneously true and not true", is a contradiction. All of classical physics obeys the law of non-contradiction. "X is simultaneously possibly true and possibly false" is not a contradiction [Kauffman, 2019].

In evolution, affordances are about ontologically real "possible uses of X to do Y". This is also true in our seeing affordances in our immediate world. It is really true that it is possible to use the corners of an engine block to crack open coconuts. In technological evolution it is really true 5000 years ago that the cross bow might or might not come to exist. Five thousand years ago there was "no fact of the matter" concerning whether or not the cross bow might come to exist.

Astonishingly, this implies that no classical system can be an analogue computer for affordances. Affordances do not obey the law of non-contradiction, but all classical systems do obey that law. Thus, no classical system can be isomorphic to, hence model, affordances.

The claim that no classical system can be an analogue model isomorphic to affordances seems to be new and must survive severe critique.

### IV Brain-Mind is Quantum

This hypothesis is widely discussed [Penrose, 1989]. We wish to pursue a different set of data. There are, at present, two lines of evidence that brain-mind is partly quantum.

First, there is growing and powerful evidence gathered independently over decades that mind is quantum, seen in aberrant behavior of quantum random number generators, telepathy, and precognition. The data with respect to quantum random number generators are this: Given a massive public event such as the death of Nelson Mandela, will quantum random number generators around the world behave non-randomly? The data are objective. These publicly available data are confirmed at 7.3 sigma [Radin and Kauffman, 2021]. The results are hard to ignore. At CERN a 5.0 sigma event is considered a discovery. The data for telepathy and precognition [Radin and Kauffman, 2021] are confirmed above 6 sigma [Radin and Kauffman, 2021]. Are these physically possible? Yes, if mind is quantum, spatial nonlocality [Aspect et al., 1982] allows telepathy and psychokinesis. Temporal nonlocality [Filk, 2013], less well established, allows precognition (ibid). The phenomena are physically allowed if mind is quantum. It is time to take these data seriously.

Second, a particular interpretation of quantum mechanics was offered by Heisenberg [1958]. The quantum states are potentia hovering ghost like between an idea and a reality [Heisenberg, 1958]. We here adopt Heisenberg's view. Reality consists in ontologically real Possibles, Res potentia, and ontologically real Actuals Res extensa, linked by measurement. This interpretation explains at least 5 mysteries of quantum mechanics, including nonlocality, which way information, null measurement, and "no facts of the matter between measurements" [Kauffman, 2016, Kastner et al., 2018] so may rightly be considered seriously. It is of fundamental importance that Heisenberg's interpretation of quantum mechanics is not a substance dualism so does not inherit the mind body problem arising due to a substance dualism [Kauffman, 2016, Kastner et al., 2018]. Thus, the hypothesis that brain mind is partly quantum allows a new prediction: It suggests a natural role for mind [Radin and Kauffman, 2021]. Mind collapses the wave function, as von Neumann, Wigner and Shimony, hoped [von Neumann, 1955, Wigner and Margenau, 1967, Shimony, 1997].

Remarkably, this testable hypothesis stands quite well confirmed. Radin and others have shown at 5.2 sigma across 28 independent experiments that a human can try to alter the outcome of the two slit experiment and succeed. 5.2 sigma is one in 50,000,000 [Radin and Kauffman, 2021]. These results, if more fully confirmed, have at least three stunning implications. First, If strongly confirmed, the results alter the foundations of quantum mechanics [Radin and Kauffman 2021, von Neumann, 1955, Wigner and Margenau, 1967, Shimony, 1997]. Mind can play a role in the becoming of the universe. Since Newton, such role has been lost. Second, for the first time since Newton, a Responsible Free Will is not ruled out. In the deterministic world of Newton, Free Will is impossible. Given quantum mechanics, the

result of an actualization or measurement outcome is ontologically indeterminate, but fully

random. I have Free Will but no Responsible Free Will. If I can *try* to alter the quantum outcome and succeed, responsible free will is not ruled out. This, if true, is transformative. We are beyond Compatibilism [McKenna and Coates, 2019].

# V The *Third* potential implication may be the most important: We try to and do collapse the wave function to a single state. We experience that state as a qualia

The evidence for quantum aspects of mind and our capacity to play a role in "collapsing" or actualizing the wave function invite a new hypothesis for how we see affordances that we cannot see as classical systems including classical Universal Turing Machines. Our Brain-Mind entangles with the world in a vast superposition. We try to and do collapse the wave function to a single state. We experience that state as a qualia. Qualia! –Why not?

At least three further lines of evidence support the hypothesis just above that qualia are associated with collapse of the wave function.

First, as D. Chalmers points out [Chalmers, 1996], qualia are never superpositions. Chalmers suggests from this that consciousness plays some role in the collapse of the wave function. We agree.

Second, finding novel affordances is not deductive. Collapse of the wave function is also not deductive. Our experienced qualia are not deductions. Neither need ideas that pop into mind when the Muse calls be deductions. Sudden insight gained upon grasping the point of a metaphor is also not a deduction. Insight in doing mathematics is not deductive [Byers, 2010]. Creativity is not deductive, it is insight [Koestler, 1964].

Third, our analysis of the incapacity of UTMs and any classical system to see affordances has a further implication. The evolution of the biosphere with zombie organisms can only find new affordances by accidentally stumbling upon them and seizing them by heritable variation and natural selection. It works but is slow.

In stark contrast, if some living organisms are in fact sentient, such organisms can literally perceive, "search and see" [Gibson, 1966] affordances, are responsible and free-willed, and with preference and emotion choose to act to use them. Watch a cat and mouse near a low chest of drawers. The chest affords the mouse a hiding place. The chest threatens the cat with mouse escape. We do this all the time. So did T. rex.

The resulting selective advantage of mind rapidly seeing affordances via experienced qualia due to mind actualizing quantum potentia and free will choosing and acting is enormous. Mind can have and did evolve with diversifying life and played a large role the evolution of life that was far more rapid than were organisms philosophic zombies. Niche construction is just one major area in evolutionary biology in which purposive behavior plays a major role [Odling Smee et al., 2003, Noble, 2006]. Purposive, insightful behaviors as in Caledonian crows [Taylor et al., 2010] and proto-ethical behaviors in primates [De Waal, 1996] can have and did evolve. The hominid lineage can have and did evolve, with evolving culture and technology [Koppl et al., 2021]. Experimental physicists really do line up and adjust their equipment with detailed planning and inventiveness. We really did decide to go to the moon and Mars, innovated and constructed the rockets, left our spacecraft on those planets and altered the orbital dynamics of the solar system. We really are responsible.

### VI Relation to Established Neurodynamics

The classical brain is dynamically critical [Beggs, 2008].<sup>2</sup> Genetic regulatory networks are critical [Kauffman, 1993, Daniels et al., 2018, Villani et al., 2018]. Criticality is magical classically with small stable attractors, maximum entropy transfer, monotonic increase in basin entropy with the number of variables N and graceful evolution under change of connections and logic [Bornholdt and Kauffman, 2019, Krawitz and Shmulevich, 2007, Aldana et al., 2007]. Life is co-evolving self-constructing Kantian Wholes dynamically on the Edge of Chaos [Kauffman, 2020, Roli and Kauffman, 2020]. Co-evolving organisms may co-evolve to mutual criticality to maximize diversity of coordinated activities [Hidalgo et al., 2014].

Years of superb work in neuroscience models suggests an astonishing diversity of brain dynamics perceptual behaviors with a variety of non-linear mathematical models [Grossberg, 2021]. These models are entirely classical physics. If the claim that no classical system can constitute an analog model for novel affordances is correct, as we claim, then a new pathway to investigate is the possibility of extending classical dynamical models to Hilbert space and seek homologous quantum behaviors.

Such homologous behavior may be possible: For example: can Brain mind be partly quantum and dynamically critical? Maybe with more specific hypotheses, e.g. Quantum scars [Turner et al., 2018]: The wave function remains in the vicinity of the classical attractor. Does the wave function of a quantum/classical critical brain remain in the vicinity of classical critical attractors that are usually taken to store alternative content addressable "memories"? In this quantum case, repeated actualizations could create highly similar qualia. In short, can such quantum systems inherit the magic of classical critical systems? Perhaps. Very recently a formalism to study quantum Boolean networks has been published [Franco et al., 2021]. More generally, can we seek a mapping from well-studied

<sup>&</sup>lt;sup>2</sup>A system in a dynamically critical regime is at the edge of chaos [Roli et al., 2018].

classical neuro-dynamics to quantum models with homologous behaviors? It should be possible to study quantum analogs of quantum criticality and chaos without and with decoherence [Kauffman et al., 2012, Vattay et al., 2015].

### VII Possible Soft Matter Systems to Examine and Trans-Turing Systems

At present enormous effort is focused on quantum computers that must maintain quantum coherence until decoherence or measurement achieves a solution, often the minimum of a complex classical potential, representing the solution, then computation stops [Das and Chakrabarti, 2008]. Cells do not stop. There is abundant evidence for quantum biology [Ritz et al., 2003, Kauffman et al., 2012, Pauls et al., 2013, Brookes, 2017]. Work in the past half decade has explored a Poised Realm hovering reversibly between quantum and classical behavior [Kauffman et al., 2012, Vattay et al., 2015]. Small molecules, peptides and proteins at room temperature can be quantum ordered, critical or chaotic. Quantum criticality lies at the metal insulator transition. Such systems have delocalized wave functions, conduct electrons very well, and have power law slow decoherence that may underlie quantum effects in biology [Kauffman et al., 2012, Vattay et al., 2015]. The Schrödinger equation does not propagate unitarily in the presence of decoherence [Kauffman et al., 2012, Vattay et al., 2015]. The dynamical and physical behaviors of such soft matter systems will be new.

Intracellular and intercellular protein—protein complexes may constitute such a new class of soft matter and can be studied with molecular dynamics and Lattice Boltzmann methods for quantum and classical behaviors [Succi, 2018]. More such soft matter systems might constitute "Trans-Turing-Systems" with their own new internal dynamical behaviors and receiving and outputting quantum, classical and poised realm variables [Kauffman et al., 2012, Vattay et al., 2015]. Trans-Turing Systems will be a new class of non-deterministic dynamical systems of largely unknown behaviors. Such systems should be constructable now. Trans-Turing Systems (ibid) are beyond UTMs whose fundamental limitations as purely deductive syntactic systems we have explored here. New realms may open up conceptually and technologically. Living cells may be Trans-Turing Systems. We may not be too far off from creating soft matter systems including evolvable protocells that could constitute Trans Turing Systems.

### VIII Conclusion

The hypothesis that qualia are the experience of the actualized wave function, even if sensible, raises major issues: Are all actualizations of quantum superpositions associated with qualia in some form of panpsychism? Does the Strong Free Will Theorem bear on this issue [Conway and Kochen, 2006]? When a human is in a coma or dreamless sleep, are there qualia? What is unconscious mind from whence the muse? How could we possibly

test the hypothesis?

Moral: Artificial Intelligence is wonderful, but syntactic and algorithmic. We are not merely syntactic and algorithmic. Mind is almost certainly quantum, and it is a plausible hypothesis that we collapse the wave function, and thereby perceive affordances as qualia and seize them by preferring, choosing and acting to do so. We, with our minds, play an active role in evolution. The complexity of mind can have evolved with and furthered the complexity of life. At last, since Descartes' lost his Res Cogitans, Mind can act in the world.

Free at last.

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