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The Problem with the Hard Problem: Thoughts on an Oscillatory Theory of Consciousness

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Abstract

In this essay we propose that "the hard problem" of consciousness - the difficulty to equate physical brain states with corresponding phenomenal experiences - is in part an illusion deriving from the language that some philosophers and scientists use to describe where and how consciousness occurs. The scientific premises underlying our hypothesis is that the brain is oscillatory and not linear and that comparisons between the brain and a linear computer are therefore misleading. We propose that, given the adequacy of this premise, consciousness in the human brain may be equated with cerebral oscillation. This position is in line with other oscillatory theories of consciousness, but goes further in depicting consciousness as a non-linear process that is chaotic (stochastic or deterministic), highly organized and self-organizing, unpredictable and difficult to measure. Against that background, we discuss implications of the theory, particularly, whether given the conditions we describe it is possible to create a "moral machine".

Keywords: *The-Hard-Problem; Consciousness; Synchronous-Oscillation; Moral-Cognition; Moral-Intuition; Neuroethics; Neuroscience; Cognitive-Science; Philosophy-of-Mind; Artificial-Intelligence*

Introduction: "The Hard Problem"

"The Hard Problem" is a term coined by philosopher and cognitive scientist David Chalmers to characterize the persistent inability of contemporary neuroscience to equate a physical state of the brain, which is observable, measurable and quantifiable, with a state of mind, which is not [1]. Consciousness is the experience of perceptual contents, and experience is subjective. Therefore, one cannot prove that consciousness happens in the physical brain because one cannot observe, measure or quantify experience. One cannot quantify "the feeling of what happens" [2].

Frank Jackson hardened "the hard problem" of understanding how consciousness happens with "the knowledge argument", which declares that no matter how much is known about the state of a person's brain, it can never objectively be known what it feels like for that person to experience any particular object, event or relationship [3]. In light of this, philosopher Colin McGinn declared that how consciousness happens will always be a mystery - a position in neurophilosophy referred to as "mysterianism" [4,5].

Opposed to the "anti-physicalist" views of Chalmers, Jackson and McGinn are those who ascribe to a "physicalist" orientation and declare that science can and will equate consciousness, experience and subjectivity with activity of the material brain[i]. The anti-physicalists reply, that this cannot be known, because even in the absence of brain activity, one cannot prove the absence of consciousness. Since consciousness cannot be directly measured, the absence of subjective reports of its presence does not necessarily prove its absence.

Advanced physicalist views on consciousness can be traced back from at least the 17th century and onwards, a time in which dualism came under serious attack as the natural sciences developed. The pioneer of French materialism, Jean Meslier (1664-1729), suggested that in order for matter to become conscious, its parts would have to be organized in a specific manner; an idea that was taken up strongly in the French Enlightenment. Following Meslier, in 1748, the French physician and surgeon Julien Offroy de la Mettrie published his influential work *L'homme machine* (trs. as *Man a Machine*, 1749) [6,7], the atheism and materialism of which outraged not only the pious and dualistic orthodoxy, but even the famously tolerant Dutch who had offered a haven to Spinoza. La Mettrie's "blasphemy" consisted precisely in rejecting classical dualism, suggesting that mental processes should be explained in physiological terms because consciousness is a bodily function. Voltaire coined the expression "thinking matter" in a letter of 1733, and Diderot in *Le Rêve de d'Alembert* (1769) discussed in quite modern terms the problem how matter need be organized in order for consciousness to develop [8]. These and other ideas that flourished during the French Enlightenment led to one of the most important events in human history: The weakening of the Catholic Church's political power and religious persecution of intellectuals and the academic freedom that was thereby enabled.

Despite this powerful historic background, the 20th century tensions between physicalists and anti-physicalists might have remained an arcane oddity of academic disputation were it not for the intersection of science, military tactics, art and popular culture. There came artificial intelligence (AI) and Watson - IBM's computational system that beat humans at the television quiz game *Jeopardy*, which convinced many that machines are capable of human-like behaviour. There are drones, and a desire to create autonomous machine systems that can effect decisions about human health, safety and life. In the midst is the growing discipline of neuroethics, which seeks to both investigate the theory and practice of moral cognition and behaviour, and evaluate the aptness and probity of neuroscientific research and its uses and meanings in social contexts [9-13][ii]. These contemporary events ask whether or not it is possible to replicate human consciousness in a machine, and is it wise to try?

Into the fray stepped the renowned playwright Tom Stoppard, who offered his penultimate play, "The Hard Problem" [14]. Stoppard does not "solve" the hard problem. Rather he dramatizes the existential conclusion that it doesn't matter if our moral intuitions derive from "nature" (e.g. genetic, epigenetic, and/or neurophysiological sets of traits) or "nurture" (i.e.- products of learning), and no matter how morality happens in consciousness, in the end, what matters is how we use our moral intuitions - how moral intuitions and behavioural control make the "right" moral choice in spite of our appetites, emotions and biases that would lead to a "wrong" action. For Stoppard, the really hard problem is understanding how to behave properly.

Stoppard's play motivated this essay in which we seek to show that "the hard problem" may not be so hard after all, to the extent that by equating consciousness with cerebral activity (e.g. oscillation) the apparent inequality between a 'measurable', physical state of the brain and an 'immeasurable', subjective state of mind becomes in part an illusion: the subjective state of mind is a cerebral state, albeit one that requires subjective experience to be known "from within", i.e. from a first-person-perspective, and this ontological identity makes them equally (im)measurable: that specific inequality vanishes. The epistemological challenge remains: across individuals we cannot wholly know another's experience without merging with it. As developed by Evers and Sigman [20], our distinction as individuals necessarily introduces a filter, an interpretation that individuates our respective points of view. In other words, by virtue of our distinction we have a private room that cannot logically be violated. The presence of this logical limit says nothing about the extension of our privacy, except that it isn't null. It does not exclude that our unalienable privacy may be extremely small. Moreover, it does not entail that we need have privileged access to our own experiences: the fact that there is an essential incompleteness in any other person's knowledge or experience of you does not mean that there is no, or less, incompleteness in your own self-understanding. To the contrary, a brain decoder may access more information about the intention of a subject than that which may be simply accessed by introspection [21].

[i]Physicalists far outnumber anti-physicalists. We decline to cite any one or several among them. It's not that there aren't any worthy of citation, there are too many.

[ii]This too is not an esoteric scholarly pursuit; but instead fosters notions, if not ideals, of the 'basis' of morality [15-17]. Perhaps then, the larger question is what can – and should – studies of the structure and function of the brain offer and provide to an understanding and articulation of what it is to be moral? (see also: Giordano, Becker and Shook [18] and Salles and Evers [19])

The scientific position underlying our hypothetical philosophical view of consciousness is that the brain is oscillatory and not linear, and that that comparisons between the brain and a linear computer are therefore misleading. A linear, linguistic approach is intuitively accessible [22], particularly when studying the perceptual apparatus. However, as neuroscientists, ethicists and participants in the drama of the human condition, we are more concerned with moral decision making. Therefore, once one abandons a linear concept of how consciousness happens, several consciousness studies require review; and against the background of that discussion, we shall conclude by discussing implications of the oscillatory theory of the conscious brain for the possibility of creating a "moral machine".

Oscillatory Theories of Consciousness

Consciousness, variously referred to as: "the experience of perceptual contents", "the subjectivity of the human condition", "the feeling of what happens" [2] or "the remembered present" [23], can be defined as the synchronous oscillation of massively interconnected, widely distributed circuits, networks and systems of the global workspace of the body-brain [24]. What we know as awareness of first person experience (of what happens within and around us) is probably oscillation at the nodal and harmonic frequencies of about 40 hertz (Hz). An oscillatory theory of consciousness is neither new nor novel. Bernard Baars developed the concept of "the global workspace" more than a quarter of a century ago, proposing that consciousness does not happen in any one or set of places in the brain, but, rather, it happens throughout the brain [25,26].

That brain bioelectricity is oscillatory has been evident since the 19th century work of Berger and Beck [27], which showed that states of wakefulness and awareness are associated with various frequency bands of oscillation. Nonetheless, demonstrating the relationship between brain oscillation and consciousness has been much harder [28]. Instruments for measuring brain function leave a wide gulf between temporal and spatial observations [29,30]. Poor temporo-spatial concordance makes oscillatory behavior difficult to measure. Functional magnetic resonance imaging has relatively coarse temporal resolution, while the various forms of electroencephalography lack the breadth of spatial sampling necessary to observe oscillation in the "global workspace"[iii].

Our premise, that consciousness is oscillation of the global workspace, follows the theories of several writers who described mechanisms of consciousness in non-directional, oscillatory terms. Francis Crick and Christof Koch [31] began this line of thought over 25 years ago. Rodolfo Llinas [32], Henry Markram [33] and Wolf Singer [34], among others, expanded and refined the concepts of Crick and Koch to support the premise that spontaneous and induced oscillation "binds" perceptual contents of disparate functional regions into states of consciousness that enter awareness [35].

To describe how oscillatory consciousness occurs, philosophers and scientists use words like "recursive", "reentrant", "reverberating", "binding" and "resonating" to express the dynamic and synchronous bioelectrical activity of neural circuits, networks and systems throughout the global workspace. Somewhat colloquially, one might imagine the brain not so much to "snap, crackle or pop" with chains of isolated electrical discharges, but instead to "hum" [36]. At the risk of oversimplification, the "pitch" of the humming is the state of wakefulness and of awareness. The pattern of functional regions of the brain that hum together is the "intentionality" of experience [37], that is: what consciousness is about - the stimulus and its context of which we are aware[iv]. The result is the familiar first person experience of whatever perceptual content is the spatio-temporal epicenter of the oscillation. This theoretical mechanism applies to the neural process of "conceptual content" just as it explains the experience of "perceptual content".

[iii]The term "micro-array" hints at spatial sufficiency, but we propose that it is not yet "micro" enough.

[iv]What enters consciousness, as we define it, does not necessarily enter awareness. In fact, the vast preponderance of the perceptual contents that evokes oscillatory activity in the brain never enters awareness, yet is often capable of affecting behaviour and of affecting how other stimuli enter consciousness and awareness and how perceptual contents can be stored and enter awareness when the stimulus is remote.

The notion that consciousness, the experience of perceptual contents in or out of awareness, is no more nor less than specific types and sorts of synchronous oscillation meets with considerable resistance. Neuroscientists like Stanislas Dehaene are somewhat hesitant to take the conceptual leap. *In Consciousness and the Brain* [38] he declares that Crick and Koch's theory is "too strong". Although Dehaene's purpose is to describe the "signatures" of consciousness, not the thing itself, he almost entirely avoids the concept of synchronous oscillation in favor of linear descriptors of "access consciousness". In our view this linear approach derives from the concept of the "Global Neuronal Workspace" as originally developed by Jean Pierre Changeux and Dehaene (Global Neuronal Workspace Theory or GNWT). While praising Bernard Baars for the concept of a "global workspace", Dehaene has declared that the addition of the word "neuronal" is a significant conceptual advance, and that it permits enhanced research opportunities as though Baars meant something other than "neuronal" (although we believe that "neural" might be a better term, in that it is not implicitly exclusory of the putative role of glia in cerebral functions).

Neurons transform generated bio-electrical voltage gradients into pulses that propagate non-linearly in arrays, circuits, networks and systems whose function is mediated and modulated by glial immunochemistry. According to the oscillatory theory, when an oscillatory "front" increasingly incorporates functional regions and evokes awareness, that front would electroencephalographically appear to advance, or "sweep" from the sensory/perceptual apparatus to the evaluative and interpretive apparatus. This apparent linear progression is only the front of the oscillation of awareness and reportablility. Thus, awareness requires the oscillation of the interpretive apparatus, but does not "happen" in any one or combination of regions of the interpretive apparatus, or any other circuit, network structure or system of the global workspace.

Consciousness as Oscillatory Self-organizing Chaos

The word consciousness has many denotations. It is used symbolically to represent different things, e.g. an object, a state, an event or a relationship, has been the subject of speculation and theory through the ages. Colloquially, consciousness is for some a state of wakefulness, for others it is the capacity to report experience, and for yet others it is variously "the remembered present" [23], "the feeling of what happens", "the experience of perceptual contents" or "the subjectivity of the human condition". These latter four descriptions are, essentially, synonymous; yet each adds a nuance to something that seems like so much more than a bioelectrical event, namely the unique, first person experience of the world that is subjective, and can in considerable measure be like no one else's experience.

The literature of consciousness studies is littered with the assumption that consciousness is the contents of perceptual experience, as opposed to the experience of perceptual contents. The word order might seem trivial, but we suggest that it is not. Consciousness has no contents. It does, however, have "intentionality" [37], that is, it is about something. Intuitively one might imagine that since the brain is a physical, material thing, something like consciousness that happens within it must, therefore, be composed of bits of "stuff", the granularity of qualities (referred to as qualia [39]) that are its contents. One would thus be mistaken. There is no "granularity" of consciousness.

In our proposed theory, the oscillatory process of consciousness is chaotic [40]. As a chaotic system, these processes can assume and reflect both stochastic [41,42] as well as more deterministic [24] characteristics. They are highly organized and self-organizing. Defining chaos as disorganized is as archaic and pre-scientific as defining consciousness as a state of wakefulness. By virtue of being chaotic, brain oscillations are unpredictable - this being the essential feature of chaos [43].

The foregoing observations draw us back to a corollary proposition: that consciousness (as a non-linear oscillatory process) is difficult to measure - at least at present. In contrast, the state of a linear system is observable, measurable and quantifiable when one's instruments are up to the task. The brain as a linear system is the focus of Changeux's and Dehaene's creative and ground-breaking, though ultimately limited research. They rightly honour subjects' reports of experience, but there can be no measurement of the experience itself, only the "signature", or neurobiological "shadow"[v] of it. As explicitly written by Changeux, the aim of GNWT is not to solve the general problem of consciousness, but to model the independent processing of several and different signals passing through distinct parallel pathways and their integration in a unified field or a common workspace [44].

[v]Plato in The Republic (in what is commonly called "the allegory of the cave") got it right 2500 years ago.

We suggest that an apt analogy is the characterization of an electron. One cannot quantify the location and the momentum of an electron at the same time. The particle has measurable qualities, like mass and velocity, and it oscillates among discrete energy states. The oscillation is neither continuous nor random. Patterns of oscillation and signatures of energy states are observable. An instantaneous characterization of its state is not. We propose that the instantaneous observation of a dynamical, iterative, chaotic, oscillatory brain state and its experience, in or out of awareness, are similarly not observable[vi].

Oscillatory Consciousness - Intuitively Troublesome?

We offer the analogy that understanding consciousness is like trying "to conceive of a hypercube" [46]. A hypercube, also known as a tesseract, is a four dimensional structure developed through intersecting planes from a point to a line (1 dimension) to a square (2 dimensions) to a cube (3 dimensions) to a hypercube (4 dimensions). It is difficult, if not impossible to apprehend a hypercube in a three dimensional world. Conceiving of how consciousness happens is much the same. The leap is conceptual, not mathematical, for if consciousness is approached mathematically or statistically, its oscillatory nature is lost to our intuitions[vii].

The idea that the brain is oscillatory and not linear in its organization and function may appear counterintuitive for a number of reasons. First, neurons and neural systems have historically been viewed as linear schematics of on-off switches, wires and connectors, although contemporary perspectives appreciate that they actually function both individually and in networks as non-linear transform systems[viii]. Second, the peripheral nervous system (PNS) is almost entirely linear in its operations[ix]. Sense organs transduce stimuli to bioelectrical activity, which is transmitted to the spinal cord. Linear connectivity of reflex arcs and spinothalamic and thalamo-cortical circuits relay the neural representation of the stimulus to the brain. Mapping the interconnectivity of neurons and connecting them to input and output devices (sense organs and end organs) would complete the characterization of a fully determined body-brain that obeys the thermodynamic laws of Newtonian physics.

One may be forgiven for envisioning the process as continuing with linear distribution of neuronal activity to that hypothetical place or combination of places in the brain where consciousness and awareness of the stimuli happen.

And indeed, Dehaene describes the process in linear terms. In *Consciousness and the Brain* he describes the emergence of access consciousness as an "explosion", an "avalanche", the "progressive activation" of neuronal activity as the P3 "wave" evolves from the occiput to the frontal lobes. But even an explosion is a uni-directional event (i.e.: outward). While Dehaene describes the activation as sweeping back again to the hindbrain, the description makes it difficult to imagine the oscillation of a global workspace. The global sharing of information that Dehaene conceives seems to be a set of arrows, admittedly a lot of them, but all headed in one direction or another, and going from one functional region to another, rather than oscillating among them.

[vi]Notions about quantum fields contained in this analogy have prompted conceptions of consciousness as the literal perturbation of quantum fields in membranes of neuronal microtubules [45]. This remains suspect, if not controversial.

[vii]The mathematics of chaotic, oscillatory systems is beginning to represent the functions of the neural mechanisms of mind. A notable theorist is J Scott Kelso [47].

[viii]The Connectome Project that seeks to create such a "schematic" may have its uses for the understanding of health and illness, but we do not believe that it will explain how consciousness happens.

[ix]There are notable exceptions, such as the local field effects of neuronal networks in the peripheral nerves and spinal cord, but the preponderance of bioelectrical activity in the PNS is linear.

Yet a third reason that consciousness-as-oscillation may seem counterintuitive is that humankind is prejudiced by the nature of language and how we use it [48]. Discussions of consciousness have been more the province of philosophy than of science [49-51]. This is unfortunate; the medium of philosophical discourse, and almost any discourse, is language[x]. It is symbolic representation, not the experience of the thing itself. The experience of objects, events and relationships is reported and expressed with symbols [52]. The symbols may be words, pigmented oil on canvas, sculpture, models of buildings, or numbers that quantify our observations. All symbols are linear, they exist in a Cartesian, Newtonian, three dimensional world. We manipulate them with linear processes of language, writing, painting, modeling and computation. Linear skill and logic establish the foundation for creativity, but new ideas emerge from non-linear intuition and imagination, not from logic. The gulf between the work of Newton and Einstein was largely conceptual, not mathematical.

Assumptions of linearity prejudice, if not predetermine answers to questions about the nature of consciousness. This is demonstrated in Carlos Blanco-Gomez's declaration that a stimulus "...is always translated into an electromagnetic signal. This code is the universal language of the brain... [consisting of] a general alphabet for all mental function....Consciousness is language speaking with itself" [22]. Natural language is a poor medium for conceiving of consciousness because of the linear bias intrinsic to language[xi]. Nonetheless, in observation and problem solving, intuition comes first; logic comes after [53]. Understanding intuition itself (experience or "the feeling of what happens") will not yield to discourse, talk as we might. No wonder the Mysterians are mystified.

We suggest that a more intuitively accessible illustration of the advantage of an oscillatory brain is face recognition. For this paragraph, we entreat the reader to leave epistemology for an exercise in intuition: Computers are capable of face recognition, but until recently, when iterative, multidimensional modeling routines became available, it took a very long time for a computer to identify a face. On the other hand, when you walk into a room where, say, 150 people are gathered, even if you had no anticipation of knowing any one of them, within a fraction of a second of your sight falling on the face of your uncle George, you recognize him. Of course, the interval depends on the amount of information contained in the image: faster for a frontal view and much slower for a rear or three-quarter rear view. A computer takes much longer to perform the same task. But, now consider how long it takes you to calculate the solution to a long quadratic equation. You take minutes, if not hours to solve the equation, even if you did well in calculus class. A hand-held calculator that you can buy in the corner drugstore for less than 20 dollars performs the linear calculation in milliseconds; yet, a supercomputer takes several (or many) seconds to recognize Uncle George's face, even though the computer is transmitting information close to one million times faster than your brain[xii]. The example represents an intuitively accessible difference between linear computation and oscillatory experience.

If one retains the bias that the brain operates with linear, deterministic cause and effect, one might characterize consciousness as *emerging from* oscillatory bioelectrical activity, or as being *caused by* the oscillation, or as being *associated with* a specific type or sort of oscillation. But, we contend that these would be false characterizations; instead we suggest that - based on the validity of the afore-mentioned oscillation theories about the brain - consciousness may *be* oscillation. Thus, conceiving of consciousness requires an intuitive leap away from thinking of the brain as some type or sort of computational machine. We are fully aware of the hypothetical nature of our view of oscillation as a putative mechanism of consciousness, and acknowledge that it exists among other well-developed, but equally not demonstrated theses and theories of consciousness. Each has its merit, and weaknesses: we simply do not yet have a definitive method by which to harness extant tools or make new tools to test these theses/theories. Pro Popper, their lack of testability to the extent necessary to 'prove' or 'disprove' them renders them all possible contenders. However, such lack of tools need not - and should not - diminish commitment to the quest.

[x]Mathematicians, logicians and scientists may discourse in numerical, alphabetic or other symbols rather than linguistic ones. The exceptions inform the significance of the rule.

[xi]We use language and numbers to describe non-linear objects, events and relationships, but the descriptions generally rely on simile and metaphor, several orders removed from the thing itself. Mathematical constructs include imaginary numbers, which, for the layperson, are exceedingly counterintuitive.

[xii]Neurons transmit at 100 meters per second, electrons transmit at close to the speed of light.

Implications of an Oscillatory Theory: Machines and Moral Intuition

There are important, practical applications of studying if and when consciousness is present [54]. Understanding how consciousness happens also informs our understanding of moral decision making and the boundaries of strategy and conscience. On August 21, 2017, 116 prominent entrepreneurs, scientists and chief executives of the artificial intelligence community released an open letter entreating the United Nations to ban "lethal autonomous weapons" [55]. One of the signatories, Toby Walsh, Scientia Professor of Artificial Intelligence at the University of New South Wales declared:

In the short term, I worry more about stupid AI than smart AI. ... In the longer term, I am worried we will industrialize war, introducing machines that we cannot defend ourselves against...

The advent and iterative development of artificial intelligence (AI) and autonomous drones motivates engineers and neuroscientists to study how to manufacture ethical or moral computational systems and robots. Given the strongly competitive and global nature of the field, such pursuits become escalated: if "we" don't create ever more capable AI and drones, others surely will. There are some who view the rise of AI as a threat to the sustainability of human cognition - if not humanity at-large. While this remains debatable, the iterative interest in, and use of AI and drones in military applications is growing. Thus, it is likely that such systems will be used to effect influence, pose some threat, and the ethical rules or moral constructs of such systems may come into question [56].

Developing machines that "behave properly" requires that they have some sort of moral scruples. We propose that imbuing a machine with an "ethical program" is insufficient. Moral conflicts like "the trolley problem"[xiii] are challenging if not disabling for machines. But the ecological validity, if not reality of the trolley problem (and its variants), and certain inferences about the neuro-cognitive bases of its inherent decisions and actions, remain questionable [57].

One might intuit that the machine must have emotions to resolve a moral dilemma. We consider this doubtful. One might also believe that emotions are the same as feelings; in common usage they are often, but mistakenly, equated. However, emotions and feelings are quite different, and this difference informs the probability of creating a "moral machine". Emotions happen in the body, as Walt Whitman told us long ago. In contrast, a feeling is a state of mind - a subjective state of consciousness, such as the redness of a red, ripe tomato, the suffering of illness or the ecstasy of either spiritual experience or physical intimacy.

Since emotions are bodily functions and are objectively measurable, with sufficient sense organs and end organs, a linear electronic machine could have, display and reveal emotions, per se. Even without veritable emotions machines can easily be programmed to *simulate* emotions, and we are readily seduced by them to think that they "feel" what they display and express. The human capacity for sympathy, identification, fellow-feeling and empathy would project the experience of an emotion onto the machine, as in: "if it displays behaviour that I display when I experience sadness, then it must feel sad". Does the machine have feelings?[xiv] One cannot know, but we propose, in line with the arguments herein, that the probability of a linear system developing consciousness approaches zero as closely as anything can in a chaotic universe, and that a machine (such as the types currently being created) can mimic a signature of consciousness, but cannot replicate consciousness itself so long as it remains linear.

[xiii]A trolley is hurtling down hill toward a switch that you control. If you do nothing the trolley is headed straight toward 5 persons in its path who cannot get out of the way, but if you pull the switch and divert the trolley there is a single person on the side track who will be killed. Do you pull the switch or not? While widely cited and used, the trolley problem has been increasingly criticized as being somewhat contrived, and may not realistically engage the cognitive processes that are involved in "real-world" decisions and actions that are construed to be moral in content and/or implications.

[xiv]The analogy between the brain and a linear computer suggests, mistakenly in our view, that there could exist a "moral Turing test".

Finally: should we really want to put our trust in a machine that can be taught linear ethical rules but which cannot possess oscillatory processes necessary for consciousness and moral intuition? Consciousness may be noisy and our moral intuitions are often messy and troubling, but they are, arguably, essential to our humanity (for better or worse). We urge caution when considering current machine systems to develop, influence or make decisions affecting humans and the human condition [58,59]. Indeed, one should be very observant of a machine that can develop rational strategy, which requires only linear computation, but does so without the synchronous oscillation of activity within neural networks in the global workspace of a living body-brain that we recognize as consciousness.

On the other hand, the question can be reversed: do we really want to put our trust in an organism, human or otherwise, that possesses oscillatory processes enabling moral intuition - but uses it to develop nuclear weapons, commit genocide, and happily destroys future possibilities of life? Revisiting Stoppard: perhaps the mechanism by which "moral intuitions" and "consciousness" happen are not what counts when we assess the benefits vs risks of either machines' or humans' complex behaviour, but simply how they behave, whether or not they oscillate.

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