Life Transcends Computing

Kenneth A. Augustyn

Department of Physics
Michigan Technological University, Houghton Michigan, 49931 USA
kaaugust@mtu.edu

Abstract

To say that there is more to reality than physics can account for is not a piece of mysticism: it is an acknowledgement that we are nowhere near a theory of everything, and that science will have to expand to accommodate facts of a kind fundamentally different from those that physics is designed to explain. (Nagel, 2017)

This paper suggests that there are facts of a fundamentally different kind to be discovered, namely, natural processes that are simultaneously partly physical and partly nonphysical, processes that I call transrobotic. At some point in evolution, life produced a mental world that is beyond computation. Organisms became more than robots. Transrobotic mentality offered an external means of altering some of the otherwise deterministic or probabilistic physical processes taking place within the organism's body. Long before the emergence of consciousness, transrobotic mentality developed a genuine independence from the physical processes that it partially controls.

The conscious human self is much more than robotic brain activity. Theories of this kind are often thought to be ruled out because they violate conservation, but local violations are to be expected where and when nonphysical mentality interacts with the physical organism.

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1. Introduction

It is impossible, in my opinion, to go from computing to consciousness. That is, no amount of data processing, however complex, can produce conscious awareness. If it is the case that my opinion is correct, this paper may be of interest as it offers a highly speculative theory of the physical and nonphysical foundations of consciousness.

> *The hard problem of consciousness is the problem of explaining how and why physical processes give rise to consciousness.* (Chalmers, 2020)

Here I will claim that physical processes do not give rise to consciousness. Rather, undiscovered processes that are partly physical and partly nonphysical give rise to an unconscious mentality that transcends physical processes and achieves a degree of genuine independence from physical processes. This unconscious mentality began with very primitive organisms billions of years before consciousness evolved in higher organisms. Consciousness is only a very small part of human mentality, which is largely unconscious.

I will talk about the mental capabilities of living organisms that I presume are never and were never conscious yet are more than robots. This class of organisms is important because organisms with consciousness evolved from them and utilize capabilities perfected by them. But before describing my theory I need to introduce some terminology.

The word unconscious is used in two completely different ways. A person can be unconscious. In this case the negative structure of the word is perfectly appropriate: an unconscious person is not conscious. But

also a person is said to have an unconscious mind, sometimes called the unconscious. Here the negative structure of the word obscures the fact that the person's unconscious mind is something, it is not just "not something". Synonyms such as the subconscious, the nonconscious, the preconscious are no better as they all leverage negatively off of consciousness.

Consider a fruit fly anesthetized by ingestion of propofol as in, for example, (Gardner, 2016). It would be quite awkward for me to say that the fruit fly is now unconscious since I never thought it was conscious in the first place. I have similar but much more serious problems in trying to discuss the possibility that the nonconscious mental capabilities of the fruit fly are not fully reducible to computing (or to any other deterministic or probabilistic physical processes). And so I ask the reader to put up with a nomenclature of my own that will help me to express my theory.

I will be using the term *biological mentality* to encompass the entire repertoire of an organism's various means of controlling its internal processes and coping with its external environment. I will be using the term *robotic mentality* for that part of an organism's biological mentality that is fully reducible to physical processes. I am perfectly willing to accept that very primitive organisms such as bacteria may be entirely robotic, i.e., their biological mentality may be nothing but robotic mentality. But I will be speculating that other types of organisms are more than robots. I will be using the term *transrobotic mentality* for that part of an organism's biological mentality that is not fully reducible to physical processes and is therefore at least partly nonphysical. I will argue that organisms such as the fruit fly, though not conscious, have a transrobotic mentality as well as a robotic mentality. Transrobotic mentality requires a foundation of robotic mentality, so organisms with transrobotic mentality always have robotic mentality as well.

Transrobotic mentality is not consciousness. However, consciousness requires a foundation of transrobotic mentality, so all conscious organisms

always have transrobotic mentality (and therefore robotic mentality as well).

The theory to be discussed has the following properties:

- It expects local violations of mass-energy conservation
- It includes a theory of transrobotic processes that connect the nonphysical and physical components of biological mentality
- It includes a conjectured evolutionary history of biological mentality
- It posits that transrobotic mentality, though generated by the body, achieves a degree of genuine independence from the physical workings of the body
- This partial independence means that there is not a one-to-one correlation between every mental event and some physical event: transrobotic mentality once established follows its own laws (if it follows laws at all).

This paper is organized as follows: Part 2 discusses computing and robotic mentality. Part 3 is about transrobotic processes and unconscious transrobotic mentality. Part 4 presents consciousness as an outgrowth of unconscious transrobotic mentality and proposes major transitions in evolution leading to consciousness. Part 5 answers questions that have been brought up in discussions of this theory during four annual Workshops on Biological Mentality (Augustyn, 2019b) (Augustyn, 2020b) and in reviewer interactions. Part 6 is a concluding summary. This is followed by an Appendix describing a broad concept of computing relevant to Part 2.

Earlier versions of this theory have been published (Augustyn 2019a, Augustyn 2020a). However this paper contains additional new information and is meant to be read stand-alone.

I try to use ordinary language and avoid using philosophical terms-of-art. However for readers wishing to first locate the theory to be discussed

within contemporary theories of mind-matter, see §5.2 before continuing.

I use the term *physical* process without regard to whether such a process is deterministic, as in classical physics, or probabilistic, as in quantum physics.

2. Computing and robotic mentality

Robots, man-made or biological, use physical processes (deterministic or probabilistic) to operate on inputs and generate outputs. They are not limited to using Turing-computable processes. (A discussion of computing is presented in the Appendix.)

2.1 Robotic mentality

Robotic mentality is my term for the many layers of physical processes within living organisms that are used to control the organism's internal affairs and formulate reactions to help it cope with its external environment.

Vast numbers of biochemical pathways jointly form complex dynamic networks. The pathways we know about have been plotted manually and more recently by automated techniques, e.g., (Wu, 2019). Biochemical processes may control other biochemical processes by providing inputs, catalysts, or otherwise.

> *Cells, with their constant energy consumption and myriads of local interactions between distinct proteins, lipids, carbohydrates and nucleic acids, represent the perfect playground for self-organization. It therefore comes as no surprise that many properties and features of self-organized systems, such as spontaneous formation of patterns, nonlinear coupling of reactions, bi-stable switches, waves and oscillations, are found in all aspects of modern cell biology. Ultimately, self-organization lies at the heart of the*

> *robustness and adaptability found in cellular and organismal organization, and hence constitutes a fundamental basis for natural selection and evolution. (Wedlich-Söldner, 2018)*

The biological hardware for performing robotic mentality is in many ways superior to man-made hardware, e.g. (Zhirnov, 2014).

3. Transrobotic processes and transrobotic mentality

I will be assuming that at some point in evolution a mental world emerged by chance via natural processes described below. This mental world was initially not conscious. Consciousness emerged billions of years later, in much more advanced organisms, as will be discussed. Since a mental world is not physical, it did not emerge literally in the organism. Rather, a mental world is connected to the individual organism that generated it by means of two transrobotic processes, each process being partly physical and partly nonphysical. Very roughly, one process converts a physical entity, energy, into a mental entity. The other process converts a mental entity into a physical entity, energy.

The reader is reminded that everything here in Part 3 precedes the emergence of consciousness by billions of years.

I want the reader to avoid thinking that the mental world is composed of energy, or has a reservoir of energy at its disposal: the mental world has no physical properties. Likewise the physical world has no mental properties. Nothing in the physical world sees colors, hears sounds, or feels pain although it is convenient for us to use metaphors as-if physical instruments do so.

3.1 The incoming transrobotic process

As life evolved from living organisms that were entirely robotic, such robotic mentality increased in complexity, power, and range of applications.

Consequently any computing malfunction potentially had a more dire consequence in the more advanced robotic organism than in the more primitive one. But, like a genetic mutation, on rare occasions a malfunction could have had adaptive value. The conjecture here is that evolution found a way of exploiting and even causing these advantageous robotic malfunctions as will be discussed.

Upon the foundation of continuous robotic processes in a robotic single-cell organism, a first type of transrobotic process emerged, a type that I call incoming. An incoming transrobotic process consists of (a) a tiny localized withdrawal of energy from the organism's ongoing computing processes that in turn causes a malfunction in the subsequent execution of that computing, and (b) a simultaneous unconscious mental experience (to be discussed in §3.1.1). It is a process that is both partly physical (since energy is lost) and partly non-physical (since a mental experience is created). It is a process that bears some similarity to spontaneous parametric down conversion, but with major differences to be discussed in §3.1.2.

3.1.1 Unconscious sensations

The word sensation means a feeling or perception resulting from something that happens to or comes into contact with the body. That is, sensations are commonly thought of as conscious events. But it is well known that a person can sense without being conscious of having done so, e.g.:

> *Subliminal stimulation refers to the presentation of stimuli with an intensity that is too low to reach the threshold of conscious awareness. Typically, people cannot consciously detect these stimuli, but they are nevertheless influenced by them. (Custers, 2010)*

I use the term *unconscious sensation* for such unconscious mental experiences (whether subliminal or not). But it is important to realize

that I am also claiming that before organisms evolved to the point of having consciousness (and hence conscious experiences), they had such unconscious experiences and that it was incoming transrobotic processes that caused these unconscious experiences, i.e., they did not come from robotic processes.

3.1.2 Down conversion analogy

In the well-established process of spontaneous parametric down conversion, a single photon entering a certain kind of crystal exits as two photons heading off in different directions, where each of the two exiting photons has lower energy than the incoming photon with the sum of their energies equaling that of the incoming photon. Furthermore, the two exiting photons are entangled.

In the incoming transrobotic process, I conjecture that a single unit of energy that is involved in an ongoing computing process is split into two components that remain entangled, one component remaining in the physical organism with lower energy (thereby disturbing the computing process) and one component exiting the physical world entirely, creating a nonphysical unconscious mental experience. Since energy is literally withdrawn from the physical word to create the unconscious experience, the process violates mass-energy conservation locally, where and when the process occurs.

Conservation of mass-energy holds if the physical universe is closed, i.e., if there are no nonphysical influences. But if there are nonphysical influences, as I am suggesting, conservation is violated locally where and when such influences exist and nowhere else. This will be discussed in §3.5.

I am not saying that mental worlds are composed of energy: there is no such thing as mental energy (except as a metaphor). All physical entities such as energy, mass, charge, etc. are in the physical word only while all mental entities such as color, sound, taste, etc. (whether perceived unconsciously or consciously) are in the mental world only.

As a reminder, I am claiming that for a very long period of evolution the mental world of organisms existed and was entirely unconscious but was more than robotic.

3.1.3 Physical-physical entanglement

Quantum entanglement is a joint property that two (or more) quantum systems (physical entities) may or may not exhibit (or may exhibit to a degree). Quantum entanglement is a physically real phenomenon, a natural resource that mankind has only recently learned to exploit.

If two physical quantum systems are entangled, they carry with them a capability of exhibiting correlations that exceed what would be possible if they were truly independent entities. So they are not independent even though nothing can be determined from the measurement of one system alone that contradicts their independence. That is, no measurement result from a single quantum system can tell you whether or not it is entangled with some other quantum system. And entanglement cannot be used to signal between two physical locations.

3.1.4 Physical-mental entanglement

In physics today there is no such thing as physical-mental entanglement, but I will be using the term *physical-mental entanglement* as a natural generalization of physical-physical entanglement. This idea was proposed by Richard A. Muller:

> *In ordinary entanglement, between two particles in the physical world, detection of one entangled particle affects the wave function of the other.*
> *When I try to understand my own soul, this picture makes some sense. There is a spiritual world separate from the real world. Wave functions from the two worlds are entangled, but since*

> *the spiritual world is not amenable to physical measurement, the entanglement can't be detected. (Muller, 2016)*

Physical-mental entanglement is conjectured here to be simply a wholeness between the two products of an incoming transrobotic process, one physical and one mental. (Whether or not wave functions are involved is unknown.) Whenever an incoming transrobotic process occurs, such products are created and are entangled in this sense of oneness.

3.1.5 At this point, sensation had no adaptive value

Of the two products of the very first incoming transrobotic process, the unconscious sensation produced had no adaptive value, i.e., it did not contribute to survival/reproduction. It was the other product, the withdrawal of energy at a specific location involved in a robotic computing process, that might possibly have had adaptive value by causing a computing malfunction. Although such a malfunction would likely have been deleterious, under rare circumstances it might have been beneficial. The trouble here is, even if an advantageous malfunction happened to occur, the organism had no way of building off the accompanying experience. The advantageous malfunction at this point was merely a piece of good luck, unlikely ever to occur again.

3.2 Mental-mental interaction and mental structural development

As life evolved, incoming transrobotic processes occurred at a higher frequency. This enabled the discrete mental products of such processes (units of incoming unconscious mentality) to interact together, binding them together into an unconscious continuum, an unconscious structure. How such integration takes place is completely unknown. Since it happens entirely in the mental world, it is a mental world process, i.e., no physical world processes are involved.

It is this unconscious mental structure that has a degree of genuine independence from the physical body, while remaining connected to it via physical-mental entanglements. Once this mental structure reached a degree of buildout, a second kind of transrobotic process emerged from it.

This second process (discussed in §3.3) enabled the unconscious mental structure of the organism to actually do something about the situation it was experiencing by means of externally modifying its internal robotic processes, i.e. it enabled nonphysical mentality to intervene on (by doing work on) a physical process within the body of the organism.

3.3 Outgoing transrobotic processes

The created mental structure is at all times entangled with the body of the organism at many locations, namely at all of the current locations of the lower-energy residues produced by all of the previous incoming transrobotic processes. In some unknown way, the mental structure can choose to convert something of itself (from the nonphysical world) into energy that is injected into the body at such locations for purposes of doing work on physical processes involved in the organism's robotic mentality. Doing work on a physical process changes its otherwise deterministic or probabilistic trajectory, and in this way an unconscious free choice is made and an associated unconscious free-will act is executed.

Just as an incoming transrobotic process is analogous to parametric down conversion, an outgoing transrobotic process is analogous to parametric up conversion, where two lower energy photons merge into a single higher energy photon through nonlinear interaction. Outgoing transrobotic processes enable the precursor to conscious free will, an *unconscious* free will (see §3.3.1) that can direct computing by doing work on the organism's robotic process.

The earliest and most primitive mental structure may have been something like a single axis of good-to-bad experiences. The primitive organism learned through trial and error to direct the robotic mechanisms

via outgoing transrobotic processes in ways that tended to favor good and avoid bad future experiences. Nonphysical mentality began to learn how to use physical processes.

3.3.1 Unconscious free will

The term *free will* commonly means *conscious* free will, but I am claiming that before organisms evolved to the point of having consciousness (and hence the possibility of conscious free will) they had unconscious free will capabilities that are analogous to human unconscious capabilities sometimes described as unconscious will, e.g. from this review in Science entitled *The Unconscious Will: How the Pursuit of Goals Operates Outside of Conscious Awareness* (Custers, 2010):

> *Here we review research demonstrating that goals and the motivation to pursue them can arise unconsciously, and we propose a mechanism for how this may happen. This proposed mechanism is based on the idea that, in principle, the mind (and the brain in which it resides) is designed for action, and continuously and largely unconsciously processes behavioral-relevant information to readily "tell" its owner what she wants and should do to deal with the opportunities and challenges presented by the environment. Thus, setting, pursuing, and realizing goals can occur without conscious interventions.*

Humans experience sensations without consciousness and act upon such sensations without consciousness. For example, sleepwalkers can drive cars while unconscious, which certainly requires sensing, decision making, and choice of action:

> *Sleepwalking is a behavior disorder that originates during*

deep sleep and results in walking or performing other complex behaviors while asleep.
Sleepwalking usually involves more than just walking during sleep. Symptoms of sleepwalking disorder range from simply sitting up in bed and looking around, to walking around the room or house, to leaving the house and even driving long distances (Suni, 2020)

3.4 Life learns to use the robotic

Incoming transrobotic processes continually build up and power the mental structure of the organism while outgoing transrobotic processes allow that organism's mental structure to at least partially control robotic processes in reaction to the experiences it is having. Over billions of years, evolving life forms developed more sophisticated ways of using these capabilities to produce richer mental structures and finer control of their underlying robotic processes.

Robotic processing remains critically important, but it changes from being everything to being something that is used. Robotic mentality is a complex hierarchy of continuously active process control computing systems. But with transrobotic mentality, processing interrupts come not only from the physical environment of the organism but also from the nonphysical mental structure via transrobotic processes. More developed organisms have high rates of both incoming and outgoing transrobotic processes, thereby continuously using the robotic processing of the organism while having some genuine independence from it.

3.5 Conservation violation is not out of the question

There is a nearly universal misbelief that conservation laws refute interaction between a nonphysical mentality and a physical body. For example (Pitts, 2019):

> *Many contemporary philosophers of mind invoke the conservation of energy against interactionist dualism (Bunge 1980, p. 17; Morowitz 1987; Pollock 1989, p. 19; Flanagan 1991, p. 21; Dennett 1991, pp. 34, 35; Fodor 1998, p. 64; McGinn 1999, p. 92; van Inwagen 2002, p. 196; Searle 2004, p. 42; Lycan 2011; Westphal 2016, pp. 41-44; Schweizer 2019) (and more in lists in ((Montero 2006; Collins 2008; Gibb 2010))).*

Conservation laws have been found to hold exactly in every physical system tested. There is no evidence whatsoever that they are ever violated. However, conservation laws have not been sufficiently tested on living organisms. Such testing would be difficult and expensive (as discussed in §6.4.1). And why bother? Since it is commonly presumed that every living organism is nothing physically different than any other object made of matter, why shouldn't the well-established laws apply? The answer is that although a living organism may be made out of matter, that matter is structured such that energy flowing through it in performing biological computing processes may trigger transrobotic processes. These are conjectured to be perfectly natural processes, but of a kind never encountered in a physics lab or particle accelerator because of the highly specific structural and energy flow conditions required. As discussed, transrobotic processes are partly physical and partly nonphysical.

Under the theory proposed, the biological mentality of living organisms above a certain level of evolutionary development is *expected* to leave traces in the physical world in the form of conservation violations where and when such interactions take place (and nowhere else). Although violations are expected in both directions (i.e., incoming transrobotic processes withdraw energy while outgoing processes inject energy), withdrawals will overwhelmingly exceed injections as it takes energy to power unconscious mentality to a buildout sufficient for it to do injections.

Thus there will always be net withdrawal, although the rate of withdrawal will fluctuate.

Recent publications (Pitts, 2019, 2020) (Cucu, 2019) explain in detail that

- energy conservation must hold if there is symmetry (i.e., the sameness of the laws) over time
- momentum conservation must hold if there is symmetry over space.
- if there are time-places where symmetries fail due to nonphysical influence, conservation laws fail there and then, while holding elsewhere

The possibility of nonphysical interaction is an empirical matter to be settled by experiments on living organisms. It is not consistent with established physics to casually dismiss this possibility.

It is also commonly assumed that any violation of conservation would be unimaginably catastrophic for the universe. This assumption is also false as explained by these same publications. The universe does not blow up or grind to a halt if local violations occur.

3.6 Recap

So far I have proposed that in evolution, as organisms encountered difficult problems in coping with their environment, a natural process occurred that made units of energy disappear altogether from the physical world while simultaneously generating units of nonphysical unconscious mentality. Each such energy disappearance caused a malfunction in the computing processes of that organism. Like a mutation in genetics, such a malfunction was almost always deleterious but on rare occasions it had adaptive value. As life evolved and this process occurred with higher frequency, the generated units of mentality found ways of interacting

together, forming a mental structure which could employ a second natural process that worked in the opposite direction, injecting energy back into physical locations with which it still had a relationship. Now for the first time an organism could do something about the situation it was in by means of externally (i.e., nonphysically) taking control over some of its internal physical processes. Unconscious mentality, having emerged from the physical, achieved a degree of genuine autonomy that is not reducible to physical processes.

Physical objects including computers do not literally want anything no more than a ball rolling down a hill wants to be doing so. The term *want,* when applied to any physical process such as a computer executing a program, is a only metaphor. Evolution by natural selection is correctly called *blind* because it too is a robotic process that does not want to accomplish anything. It is the transrobotic processes that enabled the living organism to have a nonphysical mental world and hence enabled literal rather than just metaphorical wanting.

With the advent of the transrobotic unconscious, long before consciousness emerged, a new dimension in the evolutionary equation came into being. Living organisms could now literally *want.* Their literal wants, as well as other mental emotions, influenced their physical behaviour, and thus affected all of evolutionary history from that point on. Blind evolution now had a nonphysical source of variation. The emergence of the transrobotic unconscious affected evolutionary development by enabling willful seeking of new affordances for possible survival options. Mentality, even unconscious mentality, literally wants to survive, literally tries to survive.

4. Consciousness

Consciousness emerged much later in the evolution of life, following billions of years of unconscious transrobotic mentality development, and

is utterly dependent on the highly developed unconscious of the more advanced organisms. A timeline of events leading up to the emergence of consciousness follows.

According to our best physical theories, the Earth formed some 4.3 bya (billion years ago), approximately 9.5 billion years after the big bang. Fossil evidence for bacteria on Earth dated 3.7 bya shows that living organisms did not take long to appear. We have plausible theories on how life could have emerged from non-life here on Earth (Lane, 2015b), as well as theories of how life could have arrived from elsewhere in the universe (Steele, 2018). First life from either source provided the seed for evolution of higher forms of life.

The evolutionary history of biological mentality from this first life through human life outlined below contains many conjectures. It would be distracting and tedious to delve into why I made each and every one of them. The important point is that I am suggesting that there was a very long period of time - billions of years - between first life on Earth and the emergence of consciousness, and in this period of time organisms were already transcending physical processes by exploiting natural transrobotic processes that enabled an unconscious mentality having some degree of genuine independence from the physical workings of the organism's body.

4.1 Nature's robots

Although a computer can be programmed to simulate behavior, including emotional behavior and apparent free will choices, the computer does not have any nonphysical externality from its internal physical processes: it *has* to do what it is programmed to do.

I conjecture that the earliest life forms, bacteria and archaea, had only such robotic capabilities. Metabolic energy limitations prevented them from encountering the transrobotic processes described in Section 3, processes that require energy flowing through complex structures involved in robotic processing. That is, bacteria did not have (and still don't have) the excess

internal power or structural complexity needed to hit upon this discovery. If so, there is nothing phenomenal in the life of a bacterium. Bacteria are Nature's robots.

4.2 Eukaryotes

Until the advent of eukaryotes 2.2 bya, organisms had severe metabolic energy limitations (Lane, 2005, 2015a). Eukaryotes have many properties that the more primitive prokaryotes lack, such as internally reproducible-as-needed mitochondria which can produce all the ATP needed provided there is sufficient food to metabolize. Also eukaryotes are much larger and have much more complex structure than bacteria including the cell nucleus and microtubules, the latter having remarkable physical properties (Craddock, 2014). These new properties are conjectured to have enabled eukaryotes to first exploit transrobotic processes. With the power of mitochondria and the shape-shifting enablement of microtubules, eukaryotes pioneered whole new dimensions of life including active hunting. But with these new powers came more difficult problems of internal and external process control, problems that robotic mentality alone could not solve.

The emergence of transrobotic mentality had survival value because it provided a nonphysical externality to the organism's internal robotic processes, a means of taking over some of its robotic mentality mechanisms. Such external interventions resulted in adaptive payoffs in coping with changing environmental conditions.

The biological mentality of a single-cell eukaryote organism is still primarily robotic. But it is not entirely robotic. It is an amalgam of robotic processing and transrobotic mentality. The point to note here is that transrobotic mentality emerged very early in evolution as Nature's solution to problems stemming from limitations of robotic mentality. Then over billions of years, transrobotic mentality co-evolved with the robotic, assuming many more functions via exaptation, culminating in what we call

our human unconscious and, as will be discussed, consciousness.

4.3 The true individual

As eukaryotes evolved so did their biological mentality capabilities, both robotic and transrobotic. But eukaryotes have only single-cell mentalities. The true individual is a multicellular organism composed of specialized cells: reproductive (germ) cells and nonreproductive (somatic) sterile cells. It is not until the advent of the true individual 0.7 bya that a much more elaborate multi-cellular mentality became possible. The specialized cells collaborate for the greater good of the whole. Specialized proto-brain cells, free of other tasks, found ways to collaboratively utilize their individual transrobotic capabilities by means of mental-mental interactions as described in §3.2. Groups of specialized proto-brain cells interacted with a common mental structure, indirectly enabling mentality generated from some cells to physically influence other cells. Such a multi-cell-based mentality could support much richer adaptive capabilities than single-cell mentality.

4.4 Warm-blooded organisms

Continuous endothermic temperature regulation characteristic of mammals and birds appeared a mere 0.2 bya. So-called cold-blooded organisms use exothermic means (e.g., basking in the sun) to warm body temperature. Warm-blooded organisms regulate endothermically. Endothermy is continuous and not dependent on muscle activity. It is achieved by having about five times as many mitochondria in the visceral organs as equivalent cold-blooded animals. Note that once again an energy problem has been overcome, perhaps for several adaptive reasons (as endothermy gives greater stamina, speed, endurance, aerobic capabilities) but perhaps also for enabling a richer, more stable and more continuous mentality.

4.5 Many other mentality milestones

Throughout the evolutionary process, and especially since the emergence of primates, there have been many other important state-change improvements that are relevant to the increasing power of biological mentality. It would be a distraction to cover them all. Two examples:

Primate miniaturization of neurons: primates have more neurons compared to non-primates with approximately the same brain mass (Herculano-Houzel, 2017).

Anatomical additions to the brain in primates: e.g., the prefrontal cortex that has no counterpart in the mouse (Rakic, 2009).

4.6 The emergence of consciousness from the unconscious

4.6.1 Emergence

Genuine emergence happens in the universe. Once something new appears, it can always be claimed that prior to its emergence the new thing must have had a prior positive probability of occurring since it occurred. But that is false. Probabilities can only be defined on a prestated list of possible outcomes. As Stuart Kauffman noted, it is even impossible to prestate all possible uses of a screwdriver (Kauffman, 2016) let alone all possible things that might emerge in the future of the universe.

Emergence can be defined in many ways, all of which are highly controversial (Kivelson, 2016). I use *emergence* to mean first realization in the history of the universe. Laws of nuclear forces, for example, emerged with the first appearance of elements having nuclei more complex than hydrogen. Before that moment in time, there were no nuclear forces simply because there were no complex atomic nuclei to have them. Historical circumstances, in this case the gravitational fusing of hydrogen to make the first helium, enabled this emergence (this example from (Popper, 1982)).

A richer concept of emergence was introduced in a key paper (Laughlin, 2000), and further developed in a follow-on book (Laughlin, 2005).

Laughlin focuses on emergence as a function of the organization of constituent parts that themselves do not exhibit the emerged property, e.g.,

> *... the ability of certain metals to expel magnetic fields exactly when they are refrigerated to ultralow temperatures strikes us as interesting because the individual atoms out of which the metal is made cannot do this. (Davidson, 2005)*
> *... the organization can acquire meaning and life of its own and begin to transcend the parts from which it is made. What physical science thus has to tell us is that the whole being more than the sum of its parts is not merely a concept but a physical phenomenon. Nature is regulated not only by a microscopic rule base but by powerful and general principles of organization. Some of these principles are known, but the vast majority are not. New ones are being discovered all the time. (Laughlin, 2000)*

4.6.2 Transrobotic mentality enabled consciousness to emerge

In my view, there is a huge class of organisms that are not conscious but are more than robots. Transrobotic mentality intertwined with robotic mentality generates in each of them a nonphysical mental world that continually interacts with their physical body. As life evolved, greater robotic mentality capabilities emerged in parallel with greater transrobotic mentality capabilities, and the latter assumed more control over robotic processes. Eventually conscious awareness emerged, first in brief intermittent flashes and later more or less continuously, as the product of the unconscious transrobotic mentality. Consciousness proved its value as a more effective interface[1] to the external world. And later in evolution it

[1] I owe the concept of conscious sensations as a user interface to Donald Hoffman (Hoffman, 2019). I share his view that conscious sensations are not true representations of objective reality, but not his view that the physical world itself is something made by conscious agents.

assumed a degree of autonomy one level removed from the autonomy of transrobotic processes.

As discussed, consciousness came only after billions of years of unconscious transrobotic development, and consciousness is utterly dependent on this unconscious mental world:

> *Without consciousness we would not have the experientially flavoured world we have, but without the non-conscious we would not have it at all; for we would not be able to breathe, eat, move, walk, feel, mimic, gesture, laugh, etc., and even see, talk, remember, understand, think, imagine, and make myriad spontaneous decisions as we continuously do in all life situations, from trivial to existential ones (Radman, 2017).*

Consciousness, both on the incoming side (awareness) and the outgoing side (free choice and volition) interfaces with the physical world via the unconscious. Consciousness is deeply intertwined with the unconscious, as both psychology experiments (e.g., (Custers, 2010)) and work in anesthesia (e.g., Boly (2013)) make clear.

4.6.2.1 Conscious awareness

On the incoming side of consciousness, we have the feeling that we sense the outside world directly but we do not. The content of our awareness is produced and delivered to consciousness by unconscious processes. For example, two areas of identical instrument-measured color (i.e., patches having identical pixel values) may be consciously perceived as two very different colors because of context as illustrated in a demonstration by Donald Hoffman on YouTube[2]. Technically this is an illusion, but we have to be very careful here! *Illusion* is a loaded word. Look at any dictionary

[2] https://www.youtube.com/watch?v=oadgHhdgRkI Start at 5:00

definition of illusion and you will find words like “false”, “wrongly perceived”, “deceptive”. The subjectively perceived colors constructed by unconscious processes that take context into account are not deceptive at all. The unconscious had good reasons for presenting the colors as different because of the partial shadowing.

Conscious awareness comes passively. One does not have to make an effort to be aware, e.g. I don’t have to *try* to taste the apple I am biting into. (I may have to try hard to *become* aware of something, such as when searching for my misplaced glasses, but not to simply *be* aware.)

The content of awareness is personal and idiosyncratic. I see red and green as very different colors, and have no way of imagining how red and green look to someone who cannot distinguish between them. Why consciousness feels as it does to each conscious organism is unknown.

4.6.2.2 Conscious free will

Consciousness also has an outgoing side that I call *free will*. Free will refers to those thoughts and actions not predetermined by physical law, not arbitrary or random, not the result of any kind of compulsion. Free will has two components: *free choice* is the power of choosing without the constraint of necessity or fate, and volition is the power to carry out a free choice.

I can freely choose what to do next with my body and I can usually execute these choices (within limits of course). I can also choose what to think about, what to silently talk to myself about, what songs to “play in my head” - again within limitations. I may freely choose to do something only to find that I cannot do it. For example, I may encounter a person that I know very well but find myself unable to come up with his name even though I want to do so. Hence I distinguish between the free choice of an action and the actual execution of that choice (volition). An action that I did not choose, such as a muscle spasm, is not an act of volition.

Unlike awareness, which comes to me without effort, it takes obvious

effort for me to make a choice or to take action.

Free will discussions are complicated by the fact that conscious and unconscious processes are deeply intertwined and that we humans are really good at coming up with rationalizations for our behavior. We might rationalize, for example, that some bizarre act that we committed was freely chosen when in fact it was the consequence of a post-hypnotic suggestion. Other supposedly freely chosen actions might stem from a need to satisfy some very strong urges delivered to consciousness from our unconscious, urges we may be reluctant to admit we feel, even to ourself. The whole business of packaging and advertising is based on manipulating our desires so that we freely choose the advertised product. But people can and do try to examine their motivations and counter manipulation. Sometimes they succeed and the manipulation backfires. Not every choice is a compelled choice.

Another complication due to the intertwining of consciousness with the unconscious is that we can delegate tasks to the unconscious and let it handle them while we consciously move on to other things. For many examples of the intertwining of conscious and unconscious influences in behavior, see (Custers, 2010) and the references therein.

4.7 Conscious self-awareness

Self-awareness is yet another layer of mentality. In the development of a child, self-awareness comes after consciousness is well established, sometimes hitting young children like a lightning bolt as described in science writer John Horgan's first experience of self-awareness, abridged from (Horgan, 2018):

> *In an ancient flash memory, I am walking near a river on a hot summer day.*
> *I stop short.* ***I'm me****, I say. My friends don't react, so I say, louder,* ***I'm me.***

Over the decades, this incident has become my personal creation myth, which goes as follows: Before that moment beside the river, I was whole, living entirely within myself. Then my mind split in two. One part of me was still seeing, hearing, smelling, walking. Another part was gawking at the first part and thinking, Huh? I became self-conscious, aware of myself as something weird, distinct from everything else in the world. I couldn't articulate any of this at the time. I'm projecting decades of rumination back onto my clueless five-year-old self. But that moment, that Huh?, was my first confrontation with the mind-body problem.

4.8 Unsupported devaluation of the mental word

Scientific and popular science publications are strewn with statements made flatly as if they were fact and not opinion, statements that I believe are highly corrosive and certainly are unproven. For example, this quote (from a book that I otherwise highly recommend):

The brain's purposes reduce to regulating the internal milieu and helping the organism to survive and reproduce.
All complex behavior and mental experience - work and play, music and art, politics and prayer - are but strategies to accomplish these functions. (Sterling, 2017)

First of all, it is obvious that people sometimes choose (using their brains) to not survive or reproduce. They may choose certain suicide in the service of a supposed higher cause, or use one of many ways to avoid having children. So helping the organism to survive and reproduce can't be the brain's only purpose.

But even more corrosive is the second sentence. Work and play, music

and art, politics and prayer (and presumably also science, mathematics, law, etc.) are nothing more than strategies to survive and reproduce? And so the drive to pursue higher goals and the satisfaction in achieving them are merely illusions? Such summary dismissal of all of mankind's higher accomplishments and the assertion that “really” they are nothing but strategies to survive and reproduce is not science and is not even rational.

The conscious choices we all make, and the culture we build up (or tear down), all are factors in the future evolution of life itself, providing a source of variation that is anything but random. And all such conscious choices, as I have tried to explain, involve nonphysical factors.

There is a strong human desire to survive after death. Only humans, I presume, have the mental power to comprehend the inevitability of their own personal death and to conceive of a life after death. Belief in life after death may be yet another nonphysical factor influencing the course of evolution as it tends to encourage living for more than survival and reproduction (e.g. see (Fair, 1969)).

6. Answers to questions

6.1 Could a man-made device generate transrobotic mentality?

I have conjectured that energy flowing through internal cellular structures in the performance of computing is the minimum infrastructure needed for a physical object to execute a transrobotic process. Could a man-made robot accidentally discover transrobotic processes just as primitive robotic organisms were conjectured to have done? Even if a transrobotic process happened to occur in a man-made device, and even if it happened to cause an advantageous malfunction, there is no heritability to a next generation of robots to build upon. What about self-reproducing robots? Well if we keep going in this direction we might as well ask: what if we were to create self-reproducing robots that were physically identical in every way to a living organism? But

now we have completed the circle and are assuming the conclusion.

6.2 Is this a kind of dualism?

In an earlier paper I said the following:

> *It is not dualism. Dualism struggles to connect two layers: the conscious mind and the physical workings of matter. It ignores a vast middle layer between the two, a layer that is beneath consciousness yet above known physical law. (Augustyn, 2019a)*

My motivation for having said that my theory was not dualism should be clear: I strongly object to the idea implicit in so many mind-matter theories that one can go from computing to consciousness in a single giant leap without considering that something more than computing might be involved and without even mentioning the existence of the unconscious. I strongly object to ignoring the billions of years of pre-conscious mentality development. The word dualism also carries so much theological and philosophical baggage that I thought it would be better to keep away from it. But ultimately I realized that I can't. Reviewers insist that I must locate my theory within the framework of contemporary mind-matter theories. So, with the above objections noted, I reluctantly locate it under protest as a specific type of interactive dualism, a type which says that there is, for each of us, a private subjective and partly autonomous mental world, a world that is both conscious and unconscious and that that interfaces with and interacts with our common physical world by means of transrobotic processes that are partly physical and partly nonphysical as well as by robotic processes. The physical world provides the infrastructure that enables and incubates each of our mental worlds. Nevertheless, each of our mental worlds has a degree of genuine autonomy from the physical workings of our brain. This partial independence means that there is no one-to-one correlation between

mental and physical events. Mentality once established follows its own laws, if it follows laws at all.

The interactive dualism that I propose falls within what has been called conditionalism. According to (Robinson, 2020), conditionalism is:

> *... the view that conservation is conditional on the physical system being closed, that is, that nothing non-physical is interacting or interfering with it...*
> *That conditionality is the best line for the dualist to take, and that other approaches do not work, is defended in Pitts (2019) and Cucu and Pitts (2019). This, they claim, makes the plausibility of interactionism an empirical matter which only close investigation on the fine operation of the brain could hope to settle.*

6.3 Genuine autonomy vs. a dual aspect approach

I have suggested that each living organism, with the possible exception of very primitive organisms such as bacteria, has a degree of genuine mental autonomy that is not reducible to computing or to any other purely physical processes. I have been asked if I could accommodate a dual-aspect approach. The answer is clearly no. Dual aspect means that there is always and everywhere two sides to reality, the mental and the physical, e.g.,

> *The mental and the physical are aspects of this underlying reality which, in itself, is neither mental nor physical. Each one of us can know their own brain under both of these aspects—via introspection and (scientific) observation. But the claim of the theory is quite general: everything there is is to be understood as consisting of an underlying reality that has these two aspects. (Stubenberg, 2018)*

I am saying that at one time there was a physical-only universe long before life existed. So at that time there was no dual aspect because there were no living organisms with mentality. And, once Nature produced a biological mentality, there came into being mental-mental interactions that have no physical counterpart. So both before and after the origin of life, the dual aspect model does not fit with the theory that I am proposing here.

6.4 Experiments

6.4.1 Falsification experiment?

Designing an experiment to measure actual withdrawal of energy from the physical world would be challenging. A thought experiment to detect such disappearance is outlined below. A real experiment on a human subject might well require many other complicating factors that have not been considered. But even this thought experiment shows that the mass loss due to transrobotic processes is likely to be too small to be detectable with today's technology.

For the duration of the experiment the subject is in a state of maximal awareness while exercising minimal free will[3], e.g., imagine that the subject is watching a very gripping movie. The subject does not eat or drink so is losing mass. Each CO_2 molecule exhaled is heavier than the O_2 molecule inhaled to produce it. Water vapor is also exhaled, and water molecules evaporate from the skin. The subject radiates electromagnetic energy into the environment (and absorbs it from the environment). If all of these exchanges (and any others that I missed) were to be measured precisely, we could calculate, via the law of mass-energy conservation, the expected mass loss, e.g., perhaps 20-30 grams of mass loss in an experiment lasting 10^5 seconds.

[3] Transrobotic processes violate in opposite directions, i.e., incoming processes (for awareness) withdraw energy while outgoing processes (for free will) inject energy. In general there are many more withdrawals than injections, and to maximize the difference the experimental subject should be in a state of maximal awareness and minimal exercise of free will.

In this time period, let us assume that the awareness of the subject withdraws energy from the physical world at an average rate of 0.1 watt. The brain of an awake adult at rest uses 20 watts or 20% of the resting body's energy consumption of 100 watts. Roughly 25% of this is for brain housekeeping functions and 75% (15 watts) for synapses, action potentials, and other robotic information processing functions. So 0.1 watt is small but non-negligible relative to 15 watts. It is equivalent to an extra loss of mass at the rate of approximately 10^{-15} grams per second, or a total extra loss of 10^{-10} grams. So the capturing of all energy transfers between the body and its environment must be accurate enough to support the detection of an extra 10^{-10} gram loss beyond the calculated expected loss of 20-30 grams.

Today's best technology is not capable of measuring such a small loss, e.g.,

> *[The Kibble balance] machine at the National Institute of Standards and Technology (NIST) in Maryland, USA, is capable of measuring a mass to within about three millionths of a percent.*[4]

So it seems that unless someone comes up with a better idea for an experiment, the theory presented in this paper is only falsifiable in principle.

6.4.2 Computing capacity experiments

The idea here would be to record in detail the complete behavior of an active single-cell organism such as a lacrymaria olor[5] over a period of time, tracking all of its actions and speeds, and to develop a computer simulation that mimics its sensing and actions.Then the computing resources required to execute this simulation in real time (i.e., at the same rate as the organism)

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[4] https://www.nist.gov/si-redefinition/kilogram

[5] To see a lacrymaria olor in action in real time, watch Michael Levin's YouTube video starting at 5:15 https://www.youtube.com/watch?v=RjD1aLm4Thg

would be analysed, e.g., flops/sec, memory required, power consumed, etc. This exercise would provide a sense of how much computing power a lacrymaria olor must have if all of its behavior could be reduced to algorithmic computing. Of course it would not prove anything because perhaps a better simulation program could be written that uses less computer resources. But it might shake the widely-held belief that all biological behavior is fully reducible to computing if, for example, real time simulation of this 0.1mm organism required a supercomputer burning millions of watts.

6.4.3 Adversarial attacks

Adversarial attacks on so-called deep learning man-made neural networks reveal what I call the brittleness of robotic processes for visual recognition and other machine-learning applications. For example (Wikipedia, 2020 gives references):

Researchers showed that by changing only one-pixel it was possible to fool deep learning algorithms. Others 3-D printed a toy turtle with a texture engineered to make Google's object detection AI classify it as a rifle regardless of the angle from which the turtle was viewed. Creating the turtle required only low-cost commercially available 3-D printing technology. Researchers discovered methods for perturbing the appearance of a stop sign such that an autonomous vehicle classified it as a merge or speed limit sign.

The implication of adversarial testing is that man-made neural networks, however “deep” they may be, are at best approximations to robotic mentality, not of transrobotic mentality. Adversarial attacks on man-made deep learning networks do not prove anything, but they provide yet another indication that computing has severe limitations.

6.0 Concluding remarks

Thomas Nagel in his review of Daniel Dennnett's book *From Bacteria to Bach and Back: The Evolution of Minds* argues that:

> *To say that there is more to reality than physics can account for is not a piece of mysticism: it is an acknowledgement that we are nowhere near a theory of everything, and that science will have to expand to accommodate facts of a kind fundamentally different from those that physics is designed to explain. (Nagel, 2017)*

This paper suggests that there are facts of a fundamentally different kind to be discovered, namely, natural processes that are simultaneously partly physical and partly nonphysical, processes that I call transrobotic. At some point in evolution, life produced a mental world that is beyond computation. Organisms became more than robots. Transrobotic mentality offered an external means of altering some of the otherwise deterministic or probabilistic physical processes taking place within the organism's body. Long before the emergence of consciousness, transrobotic mentality developed a genuine independence from the physical processes that it partially controls.

The conscious human self is much more than robotic brain activity.

Theories of this kind are often thought to be ruled out because they violate conservation, but local violations are to be expected where and when nonphysical mentality interacts with the physical organism.

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Appendix: A Broad Concept of Computing

Computing is a physical process

There are many different opinions as to what counts as computing. See, for example, the entry Computation in Physical Systems in the online Stanford Encyclopedia of Philosophy (Piccinini, 2017) or the book (Piccinini, 2018) by the author of that entry. For my purposes, in addition to conventional digital computing and quantum computing, any other physical processes may also count as computing.

Algorithmic computing

An algorithm is a step-by-step procedure to accomplish a goal. Digital computers are made to execute algorithms.

The von Neumann architecture, overwhelmingly the most common digital computer architecture, uses a special register called the program counter to point to the location in memory of the next instruction to be executed. That instruction is fetched, decoded, executed, and the program counter is then reset to either the next memory location or to a location designated by the just-executed instruction. Supercomputers have thousands of such processing modules, each executing step-by-step, and through communication with each other they can achieve a degree of concurrent processing.

Other kinds of algorithm-executing architectures exist, e.g., dataflow architectures. Here, no program counter is necessary as step control is achieved by other means.

Quantum computers are also algorithm-executing computers. Algorithms designed for quantum computers take advantage of quantum effects not available to classical computers as explained in (Steane, 2003).

In addition to real-world algorithm-executing computers, there is also an extensive body of knowledge on what can and cannot be accomplished by algorithms. This involves mathematical formalisms and imaginary Turing machines, from which the concept of *Turing computable* (De Mol, 2019) derives.

There is a widely held misunderstanding that all brain functions must be Turing computable. Arguments against this misunderstanding are given in the entry *Some consequences of misunderstanding the Church-Turing thesis* in the Stanford Encyclopedia of Philosophy (Copeland, 2020). The basis for this misunderstanding is the unproven assumption that all of reality is completely formalizable. Formal models of computation are not physical objects. Even physical objects such as the devices to be discussed below are not necessarily Turing computable. Certain types of classical physical systems cannot be algorithmically simulated with finite-precision inputs. It would be a distraction to get into this topic, but I mention it to highlight that not all possible control devices or biological control systems are necessarily replaceable by algorithm-executing computers.

Non-algorithmic computing

Non-algorithmic computing is performed by physical devices, chemical processes, and biological processes. Sometimes the physical devices are called computers, as in the case of electronic analog computers that use voltages to represent continuous variables in simulations. But in most cases the devices and processes are not called computers. For example: the flyball governor developed by James Watt in 1788 is an example of a non-algorithmic robot.

Years ago, a single Corliss steam engine[6] would power an entire factory, where a system of belts along the ceiling would allow drill presses, lathes, and other workstations to draw power from the steam engine via the overhead belts. As these different workstations drew power at different

[6] Photo at https://www.thehenryford.org/explore/stories-of-innovation/what-if/run-on-steam-corliss/

times and amounts, the load on the steam engine changed. To keep the belts turning at a constant speed, the amount of steam fed to the engine was regulated by a flyball governor. The flyball governor served as a functioning robot having a sensor (a belt from the engine shaft), a means of computing (centrifugal force of rotation versus gravity), and an effector (force applied to a valve in the steam pipe from the boiler to the engine)[7].

All automobiles through the late 1970's used a similar centrifugal mechanism (with springs replacing gravity) for computing and executing a nonlinear function: the spark advance required for optimal performance at different engine speeds.

Lest you think such devices are limited to simple jobs, the Norden bomb sight

> *... calculates a bomb's drop point based on the delivery aircraft's speed, range to target, wind, and other variables. The U.S. military spent $1.1 billion in 1940s dollars to build 90,000 Nordens, each one a 50-pound analog computer comprising 2,000 intricately joined parts including gyros, motors, gears, mirrors, and levers. (Long, 2020)*

Many other man-made devices for maintaining setpoints and computing control functions do not use step-by-step algorithms.

Biological processes in living organisms also perform non-algorithmic computing, e.g., see *A physiologist's view of homeostasis* (Modell, 2015) and may use internal physical processes to simulate other physical processes for predictive control.

Quantum processes in biology

> *Fundamentally, all matter—animate or inanimate—is quantum mechanical, being constituted of ions, atoms and/ or molecules*

[7] Diagram at https://www.mpoweruk.com/figs/watt_flyball_governor.htm

> *whose equilibrium properties are accurately determined by quantum theory. As a result, it could be claimed that all of biology is quantum mechanical.*
> *As we investigate biological systems on nanoscales and larger, we find that there exist processes in biological organisms, detailed in this article, for which it is currently thought that a quantum mechanical description is necessary to fully characterize the behaviour of the relevant subsystem. (Marais, 2018)*

The importance of quantum processes in living organisms has been established. Examples of such processes are summarized in recent reviews (Adams, 2020) (Marais, 2018) which contain numerous references to the experimental evidence. Biological quantum processes, as they are physical processes, may be utilized in robotic mentality

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