Justifying and Exploring Realistic Monism

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Abstract

The foundations of mathematics and physics no longer start with fundamental entities and their properties like spatial extension, points, lines or the billiard ball like particles of Newtonian physics. Mathematics has abolished these from its foundations in set theory by making all assumptions explicit and structural. Particle physics has become completely mathematical, connecting to physical reality only through experimental technique. Applying the principles guiding the foundations of mathematics and physics to philosophical analysis underscores that only conscious experience has an intrinsic nature. This leads to a version of realistic monism in which the essence and *totality* of the existence of physical structure is immediate experience in some form. Identifying physical structure with conscious experience allows the application of mathematics to the evolution of consciousness. Some of the implications from Gödel's Incompleteness Theorem are connected to creativity and ethics.

Introduction

I use the terms consciousness and immediate experience interchangeably. We project consciousness onto other people and often onto animals. How far this goes is a focus of this paper. The terms, as used here, are considered applicable to even the simplest possible experience such as a single isolated point in the visual field. It is such consciousness that even rocks may have or (closer to my position) be.

Over the last two centuries foundations research in mathematics and physics have moved from studying fundamental entities and their properties to studying abstract structures. In set theory, from which all widely accepted mathematics can be derived, the only fundamental entities are the empty set and the relationship of set membership. Mathematics no longer begins with points, lines or even numbers. There are no fundamental entities, not even the billiard ball like particles of Newtonian physics, in the Standard Model of particle physics. There are only a raft of 'fundamental' constants and mathematical equations. This paper applies the approaches to fundamental theories from those fields to the problem of consciousness.

In 'Realistic Monism'[26] and a follow up article[27] Galen Strawson argues that physicalism, the belief that everything that exists is physical, implies panpsychism. This paper argues that his conclusion is correct but can be made stronger: the *totality* of the existence of physical structure is immediate experience in some form. Stawson's approach

relies on 'self evident' philosophical assumptions which are inevitably contested [15]. This paper develops assumptions based on the principles that underlie the foundations of contemporary mathematics and physics. The resulting arguments are less dependent on intuition, which differs widely, and is circular when used in arguments about the ultimate nature of existence.

I start by describing the two principles that underlie foundations research in mathematics and physics. I explain how these principles lead to the removal of any intrinsic nature from a scientific or philosophical analysis. It exists only in conscious experience. From this and the two principles I argue for a strong form of panpsychism and develop some rules of consciousness. A brief detour to the foundations of mathematics describes the open ended nature of mathematical truth. This mathematics is used to derive boundary conditions for the ever expanding evolution of consciousness. These conditions are proposed as central to the development of an objective ethics based on the connection between physical structure and conscious experience.

Two Principles

Discussions of the relationship between physical structure and conscious experience are about the ultimate nature of existence. Metaphysical assumptions used in deciding such questions push the *ultimate* up another level. The assumptions must be justified. Claims that they are self evident will probably be contested. History teaches that, even when such claims are widely accepted, they are often eventually rejected.

The situation is similar to that in the foundations of mathematics and physics where there are no prior laws or axioms one can draw on. Over time, two principles have evolved as a basis for selecting the fundamental assumptions of mathematics and physics. The first is to make the simplest possible assumptions consistent with what we know to be true.[1] Physicists justify their fundamental laws based on their simplicity and the experimental record they accurately model. They may speculate about why some law is beautiful and must be true, but such claims are never sufficient to establishing new science.

The second principle, from mathematics, is to make all assumptions explicit.[2] This is taken to an extreme in contemporary set theory where the only fundamental entities are the empty set and the relationship of set membership. The only property of the empty set is that it contains no members. This is an explicit axiom. Properties are created in more complex sets by the axioms used in constructing them. The integers are a good example. Zero is the empty set. One is the set containing the empty set. Two is the set

[1] In mathematics one first searches for the most powerful and general consistent assumptions and then tries to simplify without weakening them. There has long been and still is a controversy about mathematical truth discussed in the section on mathematics.

[2] Physicists make their assumptions explicit by formulating them mathematically. One current exception is the measurement problem in quantum mechanics. This is the need for a philosophical interpretation to explain the actualization of probability densities into experimental observations. Physicists are notorious for being less rigorous than mathematicians because their first priority is explaining the experimental record. This translates to less concern with making assumptions explicit.

containing zero and one. Any positive integer N is the set containing all positive integers less than N including zero.

Mathematicians did this in part because they were embarrassed by a history of making self evident assumptions that proved to be false. The most notorious was the postulate that parallel lines never meet. It is true of Euclidean Geometry, but not of the geometry of the surface of a sphere like our planet.

Relying only on these two principles avoids the inherent circularity of self evident or intuitively obvious assumptions. What is self evident depends on evolutionary, cultural and personal history. These are, in part, a result of the fundamental principles being sought. An example of the difficulties this can lead to is Strawson's argument about extension in physical space.

> Suppose someone — I will call him pseudo-Boscovich, at the risk of offending historians of science — proposes that all ultimates, all real, concrete ultimates, are, in truth, wholly unextended entities: that this is the truth about their being; that there is *no* sense in which they themselves are extended; that they are real concrete entities, but are none the less true-mathematical point entities. And suppose pseudo-Boscovich goes on to say that when collections of these entities stand in certain (real, concrete, natural) relations, they give rise to or constitute truly, genuinely extended concrete entities; real, concrete extension being in this sense an *emergent property* of phenomena that are, although by hypothesis real and concrete, wholly unextended.
>
> Well, I think this suggestion should be rejected as absurd.[26, 15].

It may be absurd but it is true in both mathematics and conscious experience and may be true in physics. Mathematics builds all continuous structures as sets of discrete points, starting ultimately with the empty set. The human eye has discrete receptors creating an image composed of an array of dots. Each receptor produces a neural output centered at a spatial point reflecting the average brightness over the area of the receptor. Neural networks in the brain 'connect the dots' to create the illusion of continuous extended objects. Many leading physicists have come to suspect that time and space are ultimately composed of discrete points. These include Albert Einstein, 'I consider it quite possible that physics cannot be based on the field concept, i. e., on continuous structures.[20, 467]', Richard Feynman[14, 57] and the 1999 Nobel prize winner, Gerard 't Hooft[28]. This may or may not be true of physical reality but it is a possibility fully compatible with mathematics and science.

Our intuitive sense of spatial extension starts with the way our brain is wired to visualize the world. Such intuitions are generally valid in the context in which they evolved. The history of physics, especially quantum mechanics, ought to make it obvious how wrong applying such intuition to fundamental questions of physics, mathematics or philosophy can be.

Analysis

Applying the principles of empiricism, simplicity and making all assumptions explicit to philosophical questions challenges Platonic idealism that dominates many philosophical approaches.[3] It is particularly difficult to make all philosophical assumptions explicit. One needs to avoid fundamental intuitive concepts like extension in physical space. Purging these from metaphysics removes questions from philosophy. They either migrate to mathematics and physics or are no longer considered meaningful. The result is that the only undefined primitive concepts are conscious experience plus the two primitives of mathematics. Analyzing down to the level of the empty set underscores the ultimate emptiness of analysis.

There is no metaphysical significance to the empty set and set membership by design. They are one of many possible alternative bases for all analysis. Their advantage is their obvious lack of inherent properties or structure. Something similar happens whenever analysis can be fully applied. For example any computer can be analyzed down to the simplest of logical operations such as AND OR and NOT.[4] A common mistake in analysis is to see this is possible and draw conclusions about the ultimate nature of the thing being analyzed. A good example is Richard Dawkins' analysis where he pits gene selection against group selection in the *The Selfish Gene* as if they were diametrically opposed[6, 8]. A high level abstraction like group selection can only work if it is compatible with the lower level abstraction, gene selection. However, the high level abstraction is often the best way to understand what happens. For example group selection explains why the cells in our body cooperate to create who each of us is[29, 135]. There is little point in analyzing a Pentium computer into individual logic circuits because it contains hundreds of millions of them. Contemporary high end computers are designed and understood in terms of high level abstractions. The analysis needed to complete the design of a new computer into individual logic circuits is almost entirely automated.

Analysis can be done at many levels of abstraction. None are more correct or reveal the true nature of reality, although some are more detailed and complete perhaps at the expense of overwhelming complexity. Levels of abstraction are chosen for their convenience and practicality.

Intrinsic nature does not exist when analysis can be carried out in complete detail. Ultimately it exists only in conscious experience. Assuming there are fundamental entities with an intrinsic nature masks the implicit structure that underlies intuition about them. This can lead to endless pointless arguments between people with different and/or internally inconsistent intuition.

This apparent disconnect between physical structure and the intrinsic nature in conscious experience is an ancient issue in both Western and Eastern philosophy.

Though heavily contingent upon a physical base – including neural networks,

[3] The foundations of mathematics is facing a similar challenge to the Platonic philosophy that justifies the axioms of set theory. This is discussed in the section on mathematics.

[4] Computer design also involves clocking that controls when logic states change and memory that preserves states over time.

> brain cells and sensory faculties – the mental realm enjoys a status separate from the material world. From the Buddhist perspective, the mental realm cannot be reduced to the world of matter, though it may depend upon that world to function. With the exception of one materialist school in India, most ancient Indian and Tibetan philosophical schools agree on the impossibility of reducing the mental to a subset of the physical.[5, 126]

Historically 'reducing' meant explaining the structure *and essence* of a complex entity in terms of its constituent elements. In contemporary science, one phenomena is reducible to another if the second can completely explain all *measurable* aspects of the first. Many scientists believe that chemistry is in theory reducible to physics and biology is in theory reducible to chemistry and physics even though they are far from being able to carry out these reductions in many practical cases[30].

The fundamental entities of contemporary physics are the equations and constants of the Standard Model of quantum mechanics. This essence free abstract mathematics is connected to physical reality through experimental technique and not through the intrinsic nature of fundamental entities. Reductionism, in the scientific sense, has no functional need for the intrinsic nature in conscious experience sometimes labeled as qualia.

Qualia

Conscious experience has a structure that we can describe and model mathematically and an intrinsic nature beyond communication or analysis. For example the experience of the color green cannot be constructed from simpler or more basic experiences. However, whenever we experience green it has a shape (even if the shape is the entire visual field), a hue, a saturation and perhaps shading and texture all of which can be described and analyzed. The structural aspect of experience is inseparable from its intrinsic nature, but we can analyze the structure independently of the experience. For example we experience spatial relationships visually, audibly or through touch. A relationship like A is left of B can be the same in all cases, but the intrinsic nature of the experiences are remarkably different.

The term qualia is used to refer to the intrinsic nature of immediate experience sometimes divorced from its structural aspect. I use qualia to mean what it feels like to have an experience which includes its structural aspect. We can, in theory, analyze external reality down to the empty set so that all properties are explicit and structural. Conscious experience has both an analyzable structure and an intrinsic nature beyond analysis. Bertrand Russell may have been among the first to comment on this direction that philosophy and science were moving in pushing all sense of intrinsic nature into consciousness.

> As regards the world in general, both physical and mental, everything that we know of its intrinsic character is derived from the mental side, and almost

> everything that we know of its causal laws is derived from the physical side. But from the standpoint of philosophy the distinction between physical and mental is superficial and unreal[23, 402].

Daniel Dennet takes this disconnect between causal analysis and intrinsic nature as evidence that there is no need to assume the existence of anything but physical structure.

> Thus we arrive in mysteryland. If you *define* qualia as *intrinsic properties* of experiences considered in isolation from all their causes and effects, logically independent of all dispositional properties, then they are logically guaranteed to elude all broad functional analysis–but its an empty victory, since there is no reason to believe such properties exist[9].

I believe conscious experience has an aspect beyond analysis or scientific description because I experience it. Because qualia are inseparable from their causal structure, they do have causal force. We avoid pain and seek pleasure. Those experiences are what physical reality is. Our mathematical model of neural structure is not the reality of our existence. Sir Arthur Eddington put it colorfully.

> We have only one approach [to world-stuff], namely, through our direct knowledge of mind. The supposed approach though the physical world leads only into the cycle of physics, where we run round and round like a kitten chasing its tail and never reach the world-stuff at all[11, 280].

Claiming that there are nonstructural aspects of consciousness that cannot be communicated or explained may seem self contradictory. However, having experience is structural. If one were to design a machine capable of self reflection, communication and some form of sensation, it would understand the question: Does it feel like something to have a sensation? After all it can describe its sensation. That is what it feels like. If it had multiple sense organs and the capacity for subtle pattern recognition across its forms of sensation, it might use metaphors about light and color to describe what a symphony is like.

Claiming to have experience with an intrinsic nature is structural and a subject of science. It is a logically emergent property in a self reflective machine with sense receptors, memory and language that sufficiently mimics the structure of the human mind. Experiencing the intrinsic nature in qualia is internal, private and empirical[5] although recognizing this is structural. If physicalism is true, we will almost certainly be able to build such machines eventually. Of course we can force the machine to say whatever we want, but, to the degree we build it to resemble the structure of the human mind, we can expect it to react like humans do. I think such a machine, like everything that exists, would have immediate experience, but there is no way to tell unless you are that machine.

[5]Some may object that internal experience beyond communication cannot count as empirical evidence. The claim that it must, that it is the most certain of empirical facts, is at the core of realistic monism.

What Exists

When mundane elements combine to create a human brain, the rich experience of human consciousness comes into being. The matter the brain is constructed from is nothing special, but the structure of the brain is remarkable. Aspects of that structure are experienced directly in consciousness. Those aspects have direct connections to memory[6] and language. Nothing else seems to separate them from other similar structures in the brain.

Neural networks in the brain, with less direct connections to memory and language, may also embody immediate experience. We experience consciousness disconnected from memory and language when we perform some oft repeated task in autopilot mode. We daydream and pay no attention to the task. At the end we remember nothing about it. Yet at every moment we were, at some level, conscious of what we were doing. If something suddenly broke us out of our daydream, consciousness of the task would not suddenly come into being. It was there all the time, but not connected with memory and language. Paying attention reestablishes the connection.

One can assume everything that exists is structured immediate experience without contradicting our scientific understanding of the physical world. Aspects of the physical structure in our brain combine to create the rich stream of consciousness we experience. There can be other immediate experience embodied in our brain. The consciousness we experience only seems to exist at the level of a neural network, but immediate experience could exist at all levels of structure in the body and the molecules and atoms that the body is built from.

Once one recognizes that immediate experience can fully embody the abstract structure that science has revealed, there is no requirement to postulate the existence of anything but structured immediate experience. This leads to the Totality Axiom.

> The essence and *totality* of the existence of physical structure is immediate experience in some form. Structure is the only aspect of immediate experience that can be communicated.

The Totality Axiom implies panpsychism. It implies that there is nothing in conscious experience, beyond its physical structure, that can affect what a sentient being says or does. Causality is fully described by physical structure which is an aspect of immediate experience.

[6]By memory in this context I mean memory one can consciously recall. The brain is constantly building neural connections at different levels of its organization. Many of these are a form of memory. For example when we learn to ride a bike we build some conscious memories, but much of the work is in building memories of how to maintain balance which are outside of consciousness.

Consciousness and Structure

There are no absolute boundaries in our current understanding of physical reality. The fundamental particles of physics are as much or more diffuse fields[7] then point like entities. This is reflected in the nebulous nature of conscious experience. The simplest assumption is that the focus and intensity of consciousness is a reflection of the focus and intensity of physical structure. The mythologist, Joseph Campbell, said it well.

> It is part of the Cartesian mode to think of consciousness as being something peculiar to the head, that the head is the organ originating consciousness. It isn't. The head is an organ that inflects consciousness in a certain direction or to a certain set of purposes. But there is consciousness here in the body. The whole living world is informed by consciousness. [3, 18]

Consciousness can be focused or diffuse. It is focused when many structures in the brain act in a highly coordinated way. The depth and subtlety of this coordination is the depth and subtlety of immediate experience.

Human consciousness is like an intense beam of light in a faintly glowing background. The development of an embryo into a baby is a gradual build up in intensity and focus that continues as the child develops. The light returns to a dim background in death. With extreme trauma to the brain, there is a nearly instantaneous shift away from intense focus that continues to diffuse as the remaining intact neural connections cease to function. In death from Alzheimer's the dimming is gradual over many years.

This shifting of focus and intensity is a physical process that we can measure, record and directly influence. Progress in neural science suggests that all structural aspects of consciousness will, in time, fall into the domain of science. Structural aspects are everything we can model mathematically, including shapes, relationships like larger, brighter or louder etc. Also included are relationships that are hard to understand analytically, but that artificial neural networks[8] can be trained to recognize.

Eventually we should be able to model all structural aspects of immediate experience as neural correlates of consciousness (NCC). By this I mean we will have discovered dynamic neural structures that are isomorphic to everything we experience. Direct manipulation of these structures will directly alter conscious experience in a predictable way. One example is research on phantom limbs[22, 1608]. We will have mapped all the structures that contribute to consciousness. This will go far to bridge the gap between mental state and external reality but a seemingly unbridgeable chasm will remain.

The secret to bridging this remaining gap is to understand that it is a matter of perspective. Structures in the brain directly connected to memory and languages are

[7] Fields can be discrete or continuous. In the former case field values are only defined at discrete points, the only locations that exist.

[8] Artificial neural networks are electronic circuits that emulate to some degree the structure of biological neurons. They are trained to perform tasks by strengthening connections that lead to better results and weakening those that do not. They are particularly useful in pattern recognition applications where it can be extremely difficult to develop an analytical solution.

indirectly affected by external reality through sense organs and complex neural processing that occurs prior to conscious experience. It is the indirectness of these external connections, and the way external information is manipulated by our nervous system before entering consciousness, that distinguishes our relationship to our internal stream of consciousness from our relationship to the external world.

The distinction between internal and external reality is not absolute. It exists on a continuum. Consider the difference between visual perception of color and spatial relationships. The experiences of red, green and blue have no structural correspondence to what is detected in the eye, i. e., light of specific frequencies. Rather the structure of those sensations, evolved because of the relevance of objects with those colors to our survival. For example red stands out probably in part because it is important to pay attention to blood. This contrasts with our perception of spatial relationships (left, right, above and below) where our conscious experience is isomorphic to a two dimensional projection of what exists physically in three dimensions. There is a close structural relationship between external spatial relationships and our visual experience of them. We experience spatial relationships more directly than we experience the frequency of light. Sound is an intermediate case. We hear the relationship between sound frequencies (higher and lower notes), but not as distinctly (at least for most of us) as we visually perceive spatial relationships.

Our sense of self is an evolved feature of the mind with enormous practical value but there is no absolute boundary between external and internal structure or between self and not self. There is only a single enormously complex evolving universe that we are an integral part of.

Rules of Consciousness

The Totality Axiom and the principles on which it is based identify physical structure with conscious experience. Additional implications from these assumptions are listed in the following rules of consciousness. All of them echo ideas that have long been present in this field.

Assumed Rules of Consciousness

1. Physical structure completely determines conscious experience.

   This is problematic. I claimed that there are nonstructural aspects of consciousness, for example, the experience of green. One might assume that these are independent to some degree (or completely) of structural constraints. The simplest assumptions is that they are not, that identical physical structures are the same conscious experience. Saying more about this easily leads to a never never land of metaphysics that investigates the 'structure' of nonstructural aspects of consciousness.

2. Identical structures are identical experiences. Your perfect clone, in an exact duplicate of your environment, would have the same experience you do.

This follows from the first rule.

3. Just as structural organization can exist at multiple levels (molecules, cells, neural networks, etc.) so can conscious experience.

   Our stream of consciousness seems to exist at a high structural level. Most of the hierarchy of structure within the brain is not part of our conscious awareness. The Totality Axiom implies conscious experience exists at all levels of physical structure.

4. Lower level structures affect higher level consciousness only to the degree they affect structure at the higher level.

   This is the simplest possible assumption and will become an empirical question when we are able to replace parts of the brain with nonbiological prosthetics that exactly duplicate the function of the part being replaced.[9]

5. Isomorphic structures have (are) the same experience at the level of the isomorphism. Perfect duplication of the *functioning* of your neural circuits, even with different technology such as electronics, combined with a perfect simulation of your environment, would duplicate your conscious experience.

   This follows from the previous rule and the second rule.

6. Changes in physical structure are isomorphic to changes in conscious experience.

   This follows from the assumption that the *totality* of physical structure is conscious experience.

7. The depth and richness of conscious experience associated with a physical structure is limited by the level of abstraction and self reflection in the structure.

   This is based on mathematics and empirical evidence. The ordinal numbers[10] definable within a mathematical system determine what structures can be defined within that system. The ordinal numbers form a hierarchy involving ever more complex abstraction and self reflection.[11] The human mind seems to be capable of rich and deep experience because, in part, of the high level of abstraction and self reflection that it is capable of. We will expand on this in subsequent sections.

These rules and the Totality Axiom clarify the connection between physical structure and conscious experience. They imply that mathematics, as the study of all possible structures, is the study of all possible conscious experience. Before exploring some implications we need a little mathematics.

[9] A change of consciousness will only be detectable if one can compare memories with current sensation. A change could affect not only current sensation, but also how we experience memory. The empirical evidence will always have this caveat.

[10] The ordinal numbers are a class of sets that generalize induction on the integers in an open ended way. Higher levels of induction in set theory are defined by defining more complex ordinal numbers.

[11] All ordinals beyond the integers are defined as infinite sets. However a fragment of them, called recursive ordinals, have a structure that can be output by a recursive process or ideal computer (see note 12) program. It is such ordinals that can characterize the level of abstraction and self reflection of a finite physical entity like the human mind.

The Mathematics of Self Reflection

Mathematicians, in developing their fundamental axioms, search for the most powerful and inclusive assumptions. They then look to simplify these without limiting their power. The aim is to derive as much mathematics as possible from the simplest axioms. This led to the idea that every property should define a set of objects that satisfy the property. Gottlob Frege developed a formalization of mathematics in which one could, in effect, define the set of all sets that do not contain themselves. Assuming such a set exists leads to a contradiction. If the set contains itself it cannot contain itself and vice versa. Such self referencing or impredicative properties are both extremely useful in constructing powerful mathematical axioms and a potential source of inconsistency.

Defining powerful consistent self reflecting structures is an open ended problem with no finite solution. That follows from Gödel's Incompleteness Theorems. Gödel proved that any system powerful enough to embed a general purpose ideal computer[12] (or equivalently the primitive recursive functions) must be incomplete or inconsistent. He did this by first showing how such a system must contain, as a valid proposition, the question of its own consistency. He then proved that, if the system could prove this proposition was true, then the system must be inconsistent with a paradox similar to, but far more complex than, the one that plagued Frege's formalization of mathematics[12].

Gödel's results led to a hierarchy of mathematical truth involving ever more complex levels of abstraction and self reflection. No finite axiomization of mathematics can capture more than an infinitesimal fragment of this hierarchy.

Many mathematicians have embraced a Platonic philosophy of mathematical truth that contrasts with the open ended implications of Gödel's results. This philosophy postulates a hierarchy of infinite sets that embody absolute mathematical truth that cannot be decided by finite means. Today mathematicians think it unlikely that set theory is inconsistent, but many of them are having doubts about the objective validity of the hierarchy of infinities that seem to be far removed from anything that could conceivably exist in physical reality. It is a philosophy that has always been questioned by some mathematicians.

The intuition that justifies the set of all real numbers in contemporary set theory is, in some ways, similar to that used to justify the parallel postulate or the claim that spatial extension is fundamental and irreducible. These assumptions seem intuitively obvious to some as if human intuition is sometimes the ultimate arbiter of truth. Increasing skepticism about this philosophical approach is raising doubts about one of the most important open conjectures in mathematics, the Continuum Hypothesis.[13] One example comes from Solomon Feferman, the editor of Gödel's collected works.

> I am convinced that the Continuum Hypothesis is an inherently vague prob-

[12] An ideal computer can run forever error free and has access to unlimited storage.

[13] Cantor proved that one could not pair up every real number with a unique integer. He claimed that this implied there must be more reals than integers. This is an obviously correct argument for finite sets, but can be questioned for infinite ones. The Continuum Hypothesis is the conjecture that the reals are the smallest set larger than the integers. It has been shown that both the Continuum Hypothesis and its negation are consistent with the standard axioms of set theory[4].

> lem that *no* new axiom will settle in a convincingly definite way.[14] Moreover, I think the Platonic philosophy of mathematics that is currently claimed to justify set theory and mathematics more generally is thoroughly unsatisfactory and that some other philosophy grounded in inter-subjective human conceptions will have to be sought to explain the apparent objectivity of mathematics[13].[15]

Regardless of what we will ultimately conclude about infinite sets, the lessons about finite self referencing structures from Gödel's results and subsequent mathematics are clear. Formalizations of mathematics are finite rules for enumerating theorems. The combinatorial self referencing structure of these rules limit the power of the mathematical system they define. It is reasonable to assume that related self referencing combinatorial structures in the brain limit, to some degree, the depth and subtlety of human thought, perception and consciousness.

There are practical consequences of these limitations. No finite physical process, can solve the computer halting problem[16] for all computer programs. The halting problem is an example of asking whether some event will *eventually* occur. No finite physical system can, in general, solve this problem, even in a deterministic universe where initial conditions are known exactly. If the event does occur one can determine this eventually, but one needs an infinite amount of computation to determine that it will *never* occur.

There may seem to be a huge gap between predicting what an ideal computer (with unlimited memory) may do and practical problems of human survival. However more powerful mathematical systems can be used to solve more problems more efficiently than weaker systems because they allow work at higher levels of abstraction. The ability to solve more halting problems in the abstract translates to an ability to deal with practical problems with more depth and efficiency. The human brain does not work like a formal mathematical system, but it does have a structure capable of subtle self reflection and abstraction that made the human creation of mathematics possible. That capacity could only have evolved to solve practical problems of survival.

The human brain contain a great deal of biological machinery dedicated to making good decisions. This is especially important in a world inhabited by creatures with similarly complex brains. The message from mathematics about this arms race in mental capacity may not be what one first suspects.

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[14]'[Feferman's note] CH [Continuum Hypothesis] is just the most prominent example of many set-theoretical statements that I consider to be inherently vague. Of course, one may reason confidently *within* set theory (e. g., in ZFC [Zermelo Frankel axiomization of set theory plus the Axiom of Choice]) about such statements *as if* they had a definite meaning.'

[15] I have argued for a philosophy of mathematical truth that limits objectively meaningful mathematical questions to those relevant to ultimate destiny in a finite but potentially infinite universe. Such questions are logically determined by a list of events that an ideal computer program could enumerate[2].

[16] The problem is to determine if an ideal computer will run forever or eventually halt. The determination must be made by an algorithm that produces an answer for every possible computer program in a finite number of steps. The problem is solvable for some examples, but there is no general solution. The question of whether a finite formal mathematical system is consistent is equivalent to the halting problem for some computer program easily constructed from the axioms of the formal system.

Gödel's result was a shock to the mathematical community because it dashed forever the hope of coming up with a single formalization of all mathematical truth. Mathematics was seen by many as the one source of absolute truth in a mostly uncertain world. There is only one way around the limitations of Gödel's proof in a finite universe[17] and is not one widely embraced by the mathematical community but, in a sense, it has been embraced by biological evolution.

Any single path approach to expanding mathematics is bound to run up against a Gödelian limit. Within such a limit, progress can be made forever, but the entire sequence of results obtained over an infinite time can be fully captured in a finite axiom which will never be discovered. It is only a divergent process that follows an ever increasing number of paths that can avoid a Gödelian limit. There are two boundary conditions essential for exploring all mathematical truth. The first is ever expanding diversity and the second is ever more resources devoted to each viable path.[18] The immense diversity of evolution on this planet and the enormous concentration of resources in the human brain and nervous system are examples.

The dialectic between diversity and concentration of resources is a universal theme in creative processes. Carl Jung, in defining the modern usage of the psychological terms, intravert and extravert, observed that it applies to these psychological dispositions and to the fundamental strategies for reproductive success.

> There are in nature two fundamentally different modes of adaptation which ensure the continued existence of the living organism. The one consists of a high rate of fertility, with low powers of defense and short duration of life for the single individual; the other consists in equipping the individual with numerous means of self-preservation plus a low fertility rate. This biological difference, it seems to me, is not merely analogous to, but the actual foundation of, our two psychological modes of adaptation [intraversion and extraversion][16, ¶559]

Jared Diamond in *Guns, Germs and Steel[10]* observed a similar creative dialectic between diversity and concentration of resources in cultural evolution. He investigated why certain cultures came to dominate the planet while others remained relatively stagnant. One needed an appropriate balance between diversity and concentration of resources for modern civilization to arise. A culture dominated by a single ruling elite, like China, inevitably failed to pursue possibilities essential to future development. In contrast, a region, like Africa, with so many small communities, could never marshal the resources needed for certain kinds of progress. Europe presented the ideal combination of diversity and concentration of resources.

[17]Roger Penrose has argued that quantum effects in the brain allow mathematicians to transcend the limitation of Gödel's proof[21]. This is not necessary to explain the mathematically capable human mind. All that requires is the enormous diversity of biological evolution as discussed below. There is no significant evidence to support Penrose's idea.

[18]The proof is trivial. If unlimited resources are available and there is no need to select which approach is correct, all possibilities can be explored, each with ever expanding resources. As a practical matter, the possibilities will be restricted, but all alternatives that cannot definitely be excluded must be allowed.

There are many reasons why a good tradeoff between diversity and concentration of resources may be advantageous. Mathematics proves expansion of both is a fundamental *logical* requirement for unrestricted creativity. The Totality Axiom and the rules of consciousness suggest that the same tradeoff applies to the evolution of consciousness not just historically but into an indefinite future.

Ethics and Consciousness

Reproducing molecules have evolved to create the depth and richness of human consciousness. This is the most remarkable of scientific facts. Physical reality can evolve and transform to create exquisite ecstatic conscious experience with intrinsic meaning and value. The Totality Axiom and rules of consciousness establish a connection between mathematical structure and the meaning and value inherent in conscious experience. If these assumptions are correct, moving up the hierarchy of possible mathematical structures is to move up the hierarchy of possible conscious experience. This requires ever more complex levels of abstraction and self reflection and has the potential for ever deeper richer and more ecstatic experience. There is no finite limit to the depth and subtlety of possible conscious experience beyond that imposed by resource limits to diversity and concentration of resources. The universe may be potentially infinite.[19] If so, whatever ecstatic wondrous experience any being ever experiences, is the merest hint of a shadow of what can be and that will always be the case.

There is nothing to suggest that evolution has reached the limit of possible consciousness, but it has reached a unique turning point. Evolution has created a mind that is coming to understand evolution and is developing the tools that could control it. That same mind has the capacity to change the world and destroy humanity. We are facing challenges, dangers and opportunities without precedent.

At the root of many of our most dangerous challenges, is a disconnect between the exponential expansion of the power of science and technology and the haphazard development of ethics and morality. The latter largely determines how we use the enormous capabilities technology is providing. Experiments and mathematics provide the objective guidance that allows science to make consistent progress which accumulates exponentially. This is in sharp contrast to the lack of an objective arbiter of morality and ethics. The Totality Axiom and the rules of consciousness, by connecting the meaning and value inherent in conscious experience to physical structure, may hold one key to creating an objective ethics with the capability to expand commensurate with the power of technology.

Attempts at building ethics based on the conscious experience of sentient beings are ancient. Buddhism is the most notable example. However, it muddies the waters with its concepts of karma, reincarnation and enlightenment. These echo the other wordily concepts of sin, heaven and hell in the Abrahamic traditions of Judaism, Christianity

[19]Previous boundaries on the size of the universe have all been greatly expanded. Cosmology is of necessity a speculative science that is continually changing. For example, it has recently been discovered that 'dark energy' accelerates the expansion of the universe.[24]

and Islam. Buddhism adds more ambiguity with its concept of not-self. This ambiguity may be appropriate for the level of scientific understanding that existed at the time Buddhism was emerging.[20] It contrasts favorably with the literalism that is all too easy and frequent in the religions of the Abrahamic traditions and that often has destructive, dehumanizing consequences.

A recent example of ethics based on the conscious experience of sentient beings is the work of Peter Singer[25]. Singer's analytical utilitarian approach pays little attention to the transcendence that is central to many ethical systems.[21]

Applying mathematics to consciousness opens the possibility of refining and developing our understanding of meaning and value inherent in the evolving consciousness of sentient beings. Teilhard de Chardin, a Jesuit priest, scientist, philosopher and panpsychist[22] saw the evolution of complexity and the evolution of consciousness as ongoing and incomplete. De Chardin's concept of the 'Noosphere or thinking envelope of the earth'[7, 210] is central to his vision.

> Structurally and notwithstanding any impression or appearance to the contrary, man is at present engaged in a process within which (by the very use of his liberty—that is to say in order to survive and transcend) he is compelled (*at least* statistically) to an ever increasing biological self-unification. Therefore, right in front of us in time, a *peak* of hominization[23] must necessarily exist—a peak which, to judge by the enormous *quantity of unarranged humanity* still all around us, must certainly lie *very far above* us in consciousness, if not so far from us in time as we might at first be tempted to suppose[7, 246].

De Chardin's intuition is taking shape through globalization and the Internet which can be thought of as the precursor of a global neural network that integrates human consciousness just as the human nervous system integrates the consciousness of cells.

[20] Although Buddhism has a rich intellectual tradition its primary focus for personal transformation is 'the refinement and utilization of first-person, introspective methods in Buddhist contemplation'[5, 142]. We may have much to learn from Buddhist introspective empiricism.

[21] Singer says 'The ethical point of view does, as we have seen, require us to go beyond a personal point of view to the standpoint of an impartial spectator. Thus looking at things ethically is a way of transcending our inward-looking concerns and identifying ourselves with the most objective point of view possible – with, as Sidgwick put it, "the point of view of the universe"[25, 334].' This suggests that, from an ethical point of view, one should care about the future evolution of consciousness, but that is not a focus of his work.

[22] 'Every element [of matter] contains, at least to an infinitesimal degree, some germ of inwardness and spontaneity, that is to say of consciousness.'[8, 225]

[23] '[De Chardin's note] A maximum—to be followed or not by a redescent? This question can only be decided by reference to a subsequent paragraph devoted to the "activation" of the human evolutionary force.'

De Chardin sees hominization as a process where 'it [humanity] is provided with special linking organs which not only assure rapid communication between the elements but little by little transform their aggregate into a sort of organism which it would be wrong to consider as simply metaphorical'[8, 59].

The futurist and artificial intelligence researcher Ray Kurzweil, another panpsychist[24], argues that the *Singularity is Near: When Humans Transcend Biology* in a book with this title[17]. Both men see the expanding evolution of consciousness as a physical process and a spiritual journey that connects with existing spiritual traditions[25] and both focus on the concentration of resources necessary for the expansion of consciousness.

Kurzweil pursues his vision from a largely technological perspective. He sees direct neural connections to the Internet and a time (∼2029) when 'The majority of communication involving a human is between a human and a machine.'[17, 222] He expects much of the mass of the universe to be gradually converted to computation, intelligence and high level conscious awareness.

> The Singularity, as we have discussed it in this book, does not achieve infinite levels of computation, memory or any other measurable attribute. But it certainly achieves vast levels of all of these qualities, including intelligence. With the reverse engineering of the human brain we will be able to apply the parallel, self-organizing, chaotic algorithms of human intelligence to enormously powerful computational substrates. This intelligence will then be in a position to improve its own design, both hardware and software, in a rapidly accelerating iterative process.
>
> But there still appears to be a limit. The capacity of the universe to support intelligence appears to be only about 10^{90} calculations per second, as I discussed in chapter 6.[19, 485-6]

Using human mental capacity[26] (sped up by large factors through technology[27]) to improve itself will no doubt produce levels of self reflection, mental capacity and consciousness vastly exceeding unaided[28] human capacity. However, unless this is done with ever expanding diversity, it will lead to a Gödelian limit infinitely far from what is possible.

De Chardin and Kurzweil both see a transcendent future implicit in physical reality. They are empiricists and intuitive visionaries. They focus on the expansion of consciousness through the concentration of resources. We need unity on a finite planet to preserve the environment and to establish and maintain the peaceful, productive and equitable societies essential for human progress. Within a global unity, ever expanding diversity is possible for a long time even on this finite planet.[29] I suspect that we will be unable

[24] 'So we could say that the universe —"all that is"— is indeed personal, is "conscious" in some way that we cannot fully comprehend. This is no more unreasonable an assumption or belief than believing that another person is conscious. Personally, I do feel this to be the case. But this does not require me to go beyond the "mere" "material" world and its transcendent patterns. The world that is, is profound enough.'[18, 215]

[25] Kurzweil's previous book on artificial intelligence was *The Age of Spiritual Machines*[17].

[26] I use 'mental capacity' because I think 'intelligence' is too narrow in this context.

[27] Biological neural circuits are much slower than electronic equivalents.

[28] Kurzweil foresees a merging of human and machine capabilities and consciousness by using nano technology to create massive direct electronic neural interfaces to the human brain.

[29] Eventually we may develop the technology to send robotic space ships to distant solar system with all our knowledge and the technology to reproduce our civilization.

to achieve the necessary global unity in the absence of creating institutions to support the necessary diversity. The creative instincts are too deeply imbued in our genes and psyche to tolerate anything less.

Realistic monism, the Totality Axiom and the rules of consciousness, combined with our mathematical understanding, could be one starting point for an objective ethics that recognizes the inherent meaning and value in conscious experience today and facilitates the transcendent conscious reality we can become.

Conclusions

Intuition is an essential guide to scientific and philosophical progress, but it is circular when dealing with the fundamental concepts of these disciplines. When intuition and intellect progress far enough in their development of a fundamental discipline, it is time to cut the cord by making all assumptions explicit and looking for the simplest possibility that explains what we know, even if that means disregarding what seems self evident. This has proved remarkably successful in the foundation of physics and mathematics, although the process is complete in neither discipline. Neural science and artificial intelligence have progressed to the point where the same approach may be usefully applied to the problem of consciousness. This leads to the Totality Axiom and the rules of consciousness that postulate an identity relationship between physical structure and conscious experience. Those two terms describe external and internal views of a single physical conscious reality.

Prominent thinkers have followed different paths to other forms of panpsychism. Some have speculated that the future evolution of complexity and consciousness may create experience vastly richer than what exists today.

Mathematics proves that following a limited number of paths, or limiting the absolute resources for a single path, of future development leads to a Gödelian limit infinitely far from what is possible. This mathematics seems to be reflected throughout biological and cultural evolution as two competing instincts for diversity and concentration of resources. Understanding the necessity of this conflict in its widespread manifestations is one of the keys to moving it away from dangerously destructive outlets.

Our ethics needs objective guidance to grow commensurate with the challenges of an exponentially expanding technology. Understanding the relationship between physical structure and conscious experience may be one key to finding this guidance.[30]

References

[1] Paul Budnik. *What is and what will be: Integrating spirituality and science.* Mountain Math Software, Los Gatos, CA, 2006. 17

[30]The ideas in this paper are more fully developed in *What is and what will be: Integrating spirituality and science*[1]. There is a related video, 'Mathematical Infinity and Human Destiny', on Google Video.

[2] Paul Budnik. What is Mathematics About? *Philosophy of Mathematics Education*, 22, 2007. 12

[3] Joseph. Campbell. *The Power of Myth*. Anchor Books, New York, 1991. 8

[4] Paul J. Cohen. *Set Theory and the Continuum Hypothesis*. W. A. Benjamin Inc., New York, Amsterdam, 1966. 11

[5] Dali Lama. *The Universe in a Single Atom*. Morgan Road Books, New York, 2005. 5, 15

[6] Richard Dawkins. *The Selfish Gene*. Oxford University Press, New York, 1978. 4

[7] Teilhard de Chardin. *The Appearance of Man*. Harper and Row, New York, 1965. 15

[8] Teilhard de Chardin. *The Vision of the Past*. Harper and Row, New York, 1966. 15

[9] Daniel C. Dennett. Consciousness: How much is that in real Money? In R. Gregory, editor, *The Oxford Companion to the Mind*. Oxford University Press, New York, 2002. 6

[10] Jared Diamond. *Guns, Germs, and Steel : The Fates of Human Societies*. W.W. Norton & Company, New York, 1999. 13

[11] A Eddington. *The Nature of The PhysicalWorld*. Macmillan, New York, 1928. 6

[12] Solmon Feferman, John W. Dawson Jr., Stephen C. Kleene, Gregory H. Moore, Robert M. Solovay, and Jean van Heijenoort, editors. *Publications 1929-1936*, volume 1 of *Kurt Gödel Collected Works*. Oxford University Press, New York, 1986. 11

[13] Solomon Feferman. Does mathematics need new axioms? *American Mathematical Monthly*, 106:99–111, 1999. 12

[14] Richard Ferynman. *The Character of Physical Law*. MIT Press, Cambridge Massachusetts, 1967. 3

[15] Anthony Freeman, editor. *Consciousness and its place in nature: does physicalism entail pansychism?* Imprint Academic, Exeter, UK, 2006. 2

[16] Carl Gustav Jung. *Psychological Types*, volume 6 of *The Collected Works of C. G. Jung*. Princeton University Press, Princeton, New Jersey, 1971. 13

[17] Ray Kurzweil. *The Age of Spiritual Machines*. Viking, New York, 1999. 16

[18] Ray Kurzweil. The Material World: "Is That All Their Is?" Response to George Gilder and Jay Richards. In Jay W. Richards, editor, *Are We Spiritual Machines? : Ray Kurzweil vs. the Critics of Strong A.I.* Discovery Institute Press, Seattle, 2002. 16

[19] Ray Kurzweil. *The Singularity Is Near: When Humans Transcend Biology*. Viking, New York, 2005. 16

[20] Abraham Pais. *Subtle is the Lord*. Oxford University Press, New York, 1982. 3

[21] Roger Penrose. *The Emperor's New Mind : Concerning Computers, Minds, and the Laws of Physics*. Penguin, New York, 1991. 13

[22] V. S. Ramachandran and William Hirstein. The perception of phantom limbs. *Brain*, 121:1603–1630, 1998. 8

[23] Bertrand Russell. *The Analysis of Matter*. Paul Kegan, London, 1927. 6

[24] Charles Seife. Illuminating the Dark Universe. *Science*, December:2038–39, 2003. 14

[25] Peter Singer. *Practical Ethics*. Cambridge University Press, New York, second edition, 1993. 15

[26] Galen Strawson. Realistic Monism. In Anthony Freeman, editor, *Consciousness and its place in nature: does physicalism entail pansychism?*, pages 3–31. Imprint Academic, Exeter, UK, 2006. 1, 3

[27] Galen Strawson. Panpsychism? : Reply to commentators with a celebration of descartes. In Anthony Freeman, editor, *Consciousness and its place in nature: does physicalism entail pansychism?*, pages 184–280. Imprint Academic, Exeter, UK, 2006. 1

[28] Gerard 't Hooft. Can Quantum Mechanics Be Reconciled with Cellular Automata? *International Journal of Theoretical Physics*, 42(2):349–354, 2002. 3

[29] David Sloan Wilson. *Evolution for Everyone*. Delacorte Press, New York, 2007. 4

[30] Edward O. Wilson. *Consilience: The Unity of Knowledge*. Knopf, New York, 1998. 5

Formatted: November 18, 2007