Essay

Explanation of the Passage of Time Shapes Our View of Life

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Abstract

We experience time in the accumulation of experiences and events that happen in an instant, and then are behind us. Since the school of Anaximander[1] at least, philosophers have tried to explain the nature of time and its origin or basis. In modern times, scientists must explore the domain of time, so now *they* attempt to explain its nature and basis – with varying degrees of success. This is complicated because explanations from Classical Physics or Relativity are different from and incompatible with answers from Quantum Mechanics, so many hope Quantum Gravity theories will help resolve this question. Advances in Mathematics hold promise for a unified basis explaining both the thermodynamic and quantum-mechanical time arrows in a way that consistently informs our Philosophy. However, we will likely need to explore beyond the island of familiar Maths to reconcile the divergent pictures of how and why time passes. This paper revises and expands on my Marcel Grossmann 16 contribution[2], to add more practical insights and include material not available a year ago.

Keywords: Origin of time, basis of time, passage of time, perception of time, physics of time, philosophy of time, philosophy of physics.

1. Introduction

We imagine time to be a single entity but the reality of time is more complex and far more interesting. At least as far back as Anaximander[3], philosophers have tried to make sense of that complexity, and the analogy of stepping into a moving river or stream from Heraclitus[4] comes very close to the reality we observe, since things keep moving and changing while events happen. Thus the simplest realities of life are governed by a rule that assures most decisions will be complex instead of simple. Coupling Plato's observation "time is the image of eternity[5]" with the insight that space is an image or projection of infinity can help us make sense of its deeper message by making space and time equivalent.

We can put time and space on an equal footing, or look at them in the same way. If we do, we see glimpses into quantum gravity from the ancient Greeks and other philosophers. Carlo Rovelli's book "Reality is Not What it Seems[6]" shows how insights from the ancient philosophers extend to topics including quantum gravity and the nature of time. While I agree we

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find the seeds of quantum gravity with the birth of atomism among those philosophers, especially the Greeks, he and I may differ on whether time is fundamental or primordial as a result. However we both have learned from some of the same teachers, so there is much common ground. The origin of space and time involves both cosmology and quantum gravity. But this paper explores how recent developments in pure Mathematics likely have deeper relevance than was previously appreciated and advance our understanding of time. So now, I will discuss the examples cited above in greater detail and offer unique insights from my own research[7,8].

Already in 1922, concluding a debate with Bergson, Einstein said “There is no such thing as the time of the philosopher.[9]” So for some it is a dead issue. But the debate goes on in the Physics community and among modern philosophers, over consequences of physical theory and our understanding of time. This debate centers on sharply differing views of time in Relativity and Quantum Mechanics. And there is strong evidence both views must be true. The traditional outlook that time is a single entity for all is broken or flawed in this case. But this paradox emphasizes the need to create new ways to conceptualize what we have learned in Physics, in recent years, and incorporate that into our Philosophy[10]. And yet, Heraclitus’ ancient view of time as a river or stream which flows even as you are stepping across it remains enlightening or informative in modern times.

There is hope for reconciling Physics with Philosophy, therefore, and knowledge that by developing quantum gravity theories and early universe cosmology, we gain a better philosophical understanding of time. The reverse also appears true; it is easier to choose or develop better approaches to quantum gravity or cosmology by understanding the Philosophy of Time and the Philosophy of Physics better. Prevailing QG theories share many features and predictions with considerable common ground to explore[11]. I examine ideas from Connes[12], Longo[13], Gisin[14], as well as Drossel and Ellis[15], on the emergence of time from quantum gravity, with some unique insights on wavefunction collapse from Dieter Zeh[16], and a brief discussion of how global asymmetry in Maths may influence whether time is primordial or fundamental[17].

2. What is there to Explain?

If we had a better understanding of the extreme micro- and macro-scale in Physics, time might not be an enigma at all. But for the most part, people are unaware that we live in the ‘Goldilocks zone’ on an island of comfortable norms. The domain of settled spaces is now familiar and well-understood. The realm of familiar Maths is perfectly sufficient for people exploring anything anywhere on this island, so who could want more? Theoretical Physics typically seeks the origins of events occurring in the observed surface-layer reality in deeper layers or causal elements further back in time.

However, by cutting ourselves off from the possibility those origins are higher-dimensional, we omit some probable realities that solve standing problems in Physics. This resolution is possible because evolutive properties arise unavoidably when the underlying or governing algebra is non-commutative or non-associative. Time's passage may thus be caught up in how universes in higher-order spaces are reduced in dimension through cosmological transitions to obtain a cosmos with familiar properties which match what we observe.

Evolution arises automatically if the dimensions are high enough, or as any system's degrees of freedom approach infinity, so it is almost certain a space or its underlying algebra will evolve, or is self-evolving, once certain initial conditions are met. This could involve a unit of minimum uncertainty or action and at least a modicum of energy, if we are talking about physical systems, but physicists know these conditions are handily met at the Planck scale according to nearly every model. One might question creating something from nothing, but we are uncertain that absolute nothing ever existed. Ergo there is no difficulty or little argument to find reasons for time's to inexorable forward movement, if we assume the universe started from variations or variability and then evolved toward conditions.

People ask "what can cause numbers to vary on their own or physical parameters to change of their own accord?" It seems more reasonable to accept that virtual particles can pop in and out of existence than to imagine that objects and spaces are inherently evolving processes. However to explain time, we may need to accept that everything evolves on its own unless it is otherwise constrained. To understand why time passes, I suggest we start with the assumption that objects and spaces are not necessarily static or fixed and could be inherently time-evolving instead. This is precisely what Alain Connes proposed when he emphatically wrote in 2000 "Noncommutative measure spaces evolve with time![18]" This result is based largely on the findings of Tomita[19] and Takesaki[20] which study modular Hilbert algebras, but Connes has generalized that work to create a new kind of differential geometry.

This time-evolving phenomenology is more nearly universal than people are aware of, however. Some of his ideas have not panned out, but Connes' line of reasoning is not falsified because intrinsic time evolution arises in higher-d Maths undeniably and is worthy of further investigation. This idea and its broader context provide a framework for a more realistic yet more flexible view of time. We see that time is, at its root, inherently or automatically progressing, originating from the dynamism of intrinsic evolution of forms and spaces in higher dimensions because the non-commutativity and/or non-associativity of their underlying algebra induces algebraic and geometric directionality and/or sequentiality.

This approach offers a unified basis for the quantum-mechanical and thermodynamic arrows of time that resolves some paradoxes or quandaries. If we see time arising in the tendency for objects and spaces to evolve automatically, once the degrees of freedom are sufficient, we have a way to unite the Math and the Physics of spacetime origins that resolves the paradox of differing time arrows from various models. This is perhaps a more major advancement than has been appreciated to this point. It restores seeing time as an accumulation of experiences or events that occur and are then behind us in a view of Quantum Mechanics where Heisenberg's uncertainty or 'unsharp measure' is due to spacetime being non-commuting. All interactions or observations accumulate because quantum-mechanical reality is like Heraclitus' stream, where every action affects future events.

If we assume evolution in the early cosmos was higher-dimensional too, we can extend intrinsic time to canonical time evolution in the initial origin at the Planck time through the inflationary period at least until baryogenesis and likely continuing to play a part until decoupling or recombination occurred, or at the 5-d → 4-d boundary[21,22] that is seen as a black hole → white hole transition[23,24] in some theories. Time evolves from higher-d spaces through cosmological transitions, to arrive at today's 4-d spacetime, in these scenarios. The Aikyon theory of Singh[25,26] employs Connes' intrinsic time and uses the octonions and trace dynamics to explain both cosmic origins and particle physics without requiring such transitions, but since it affirms other aspects of my present work this also validates my line of research. So we shall examine my proposed basis and a context for these varied ideas.

3. Explaining What We Observe

Great successes in Physics assume that what we observe is built from and can be explained from the bottom up, starting with the smallest components or the simplest applicable formulas, but there is another way to explain what we see, where nature employs top-down methods taking advantage of pre-existing higher-order and higher-dimensional mathematical forms, as well. If we allow a broader spectrum of possibilities at the cosmos' origin, by assuming that both bottom-up and top-down strategies are at work simultaneously, a picture emerges where dimensionality has an upper and lower limit at the outset of geometrogenesis, which later converges toward a single value[27]. In this scenario, higher-d projects onto lower-d reality.

This forces emergent forms to be shaped by higher-d figures like the Monster Group and E_8, during the earliest phases of cosmological evolution, even while they are being built from lower-d components. From this radically top-down outlook, even using causal structure theories of quantum gravity, the conventional view using bottom-up reasoning is seen to be inside-out, which means we need a view where we see the universe from the outside-in, to fully understand it. The disparity or shortfall is partly due to the way most people have learned Maths, where the simplest elements are taught first and advanced ideas are derived from the simplicities. However, there are emergent patterns in hyper-complex mathematical structures from which simple rules can be derived or facets to explore can be chosen.

This dichotomy is called additive vs. formant synthesis. In the one case, you add bits of clay to make a sculpture or individual harmonic tones to create the desired waveform, while in the other you chip bits away from the outside or remove some overtones from a more complex waveform, to obtain the desired shape. Here I propose that nature always utilizes both methods to shape the cosmos. It builds larger and more complex forms using smaller pieces, but it also pares physical reality down from a rich palette of possible or existing forms, and borrows structure from more complex forms to create simpler ones.

In this way, nature can employ the full range of Mathematics and exploit the true organizing power of forms residing in higher dimensions. But the outside-in view necessary to see this is obscured when working from the island of common Maths where mathematical structures are built from the bottom-up, rather than inherited from orderly patterns in higher-level structure. To gain *that* view we need to look beyond the familiar island where features like commutativity and associativity can be taken for granted, and explore the unfamiliar expanse of non-commutative and non-associative algebras and geometry. Luckily mathematicians have already charted a lot of the content that exists in higher-d spaces, and we are learning how some of it works to shape the laws of Physics. A clear example of what I have discussed is found in the normed division algebras, and in the reduction by constraints of the octonions to the quaternions, the complex numbers, and the reals.

$$\mathbb{O} \supset \mathbb{H} \supset \mathbb{C} \supset \mathbb{R}$$

The octonions are the most general number type, 8-dimensional with one real and seven imaginary parts, but they are non-associative, the quaternions are 4-d with three imaginary parts but are non-commutative, the complex numbers have one real and one imaginary part and they are well-behaved, yet only the reals are stable or encode a constant value. Imaginary numbers encode variation or the freedom to vary by a specified amount in a certain direction or orientation. So let us start from the top down, beginning with the octonions. Though they are the granddaddy of the familiar types, the octonions are thought to be weird and difficult[28], but this might be because they are misunderstood[29]. Viewing the imaginary dimensions as rotations, the octonions reduce to the quaternions if 4 of their 7 axes are fixed, they reduce to the complex numbers if 2 of the remaining 3 are fixed, and if the last rotation is halted as that axis is fixed, only the real-numbered value remains.

The octonion algebra itself is a reduction process because 480 possible multiplication tables before choosing a starting place and direction reduce to 16, 8 left- and 8 right-handed algebras[30]. However, once any table is chosen we must employ only that one table thereafter. Each step in any octonion calculation thus proceeds from optiony toward specificity.

$$Smooth \supseteq Top \supseteq Meas$$

$$Gas \supseteq Liquid \supseteq Solid$$

In the relations above, we see the pattern of moving from variability or variations to definite conditions as a more general bridge between the fields of Math and Physics that needs to be explored further. Moving from left to right, we see that acquiring a surface or boundary makes a space or object topological, or indicates a phase change from a gas to a liquid state. Then having a fixed metric makes objects or spaces measurable, or indicates the transition or a phase change to the solid state. This reflects the sensibility of the earlier expression where applying successive constraints to the octonions eventually gets us to the real numbers. We observe that evolutive properties arising from directionality in higher-d Maths project onto or influence what comes after, such that things tend to evolve from highly variable states toward specific conditions and discrete possibilities.

One might question the applicability of this line of reasoning to real-world Physics or everyday life. It certainly has a place in early universe Cosmology, in Quantum Gravity, and in the underpinnings or fundamentals of Quantum Mechanics. But the actual footprint of non-commutative and non-associative algebra and/or geometry on reality is not entirely known. That is why it is important for today's Physics researchers to look into evolutive properties arising in these Maths, as a possible source or root cause for the evolution of time.

The idea that spaces with certain properties have a built-in time evolution is neither well-known nor well-understood, except among a handful of ardent researchers in this arena. When Tomita[31] opened that door, by discovering intrinsic evolution in modular Hilbert algebras, Connes and others were quick to apply that notion to a broader class of objects and spaces. To walk through that door, we must go beyond the island of familiar Maths and embrace the idea that non-commutativity and non-associativity are more of a blessing than a curse to Physics[32], because they assure directed evolution.

To understand the advantage this confers, we must accept that if or because reality is quantum-mechanical, non-commutative ordering arises automatically since Heisenberg uncertainty makes the space we live in non-commuting. Notably, this issue arises even in Relativity[33] where factor-ordering problems require finesse sometimes, when applying the equivalence principle. However, it happens fairly often in Physics, and seems to be a fact of life. Cycles of action or calculations must be undertaken in a specific sequence both when doing octonion algebra and with common tasks like painting or baking[34], where a process of ratcheting accumulation of results happens in all cases. Therefore the demands of additional rules of order and sequence one must learn to use non-commutative and non-associative algebras are not unnatural or onerous, and in fact are the same laws of directional evolution all natural processes must follow.

$$\delta : \mathbb{R} \rightarrow Out(M)$$

Connes[35] uses the above expression, where $Out(M) = Aut(M)/Int(M)$ the quotient group of automorphisms of an algebra M by its normal subgroup of inner automorphisms, to show how modular or Tomita flow gives rise to intrinsic time evolution in this context. He emphatically states that non-commutative spaces evolve with time and this notion is echoed and greatly expanded in recent work by Longo[36], which shows *why* non-commutative spaces must evolve, and explains the basis for time's emergence in detail. Non-commutativity is demonstrably enough to assure time's evolution, and we undeniably live in a space that is non-commutative. The background state of physical reality is not what Classical Physics imagines a vacuum to be, a static space devoid of contents. It is dynamic instead. We can point to quantum uncertainty or use virtual particles as an explanation for this, but time's undeniable directionality is seen to result equally well from our residing in a higher-d non-commutative spacetime instead of the apparent 3-d space plus time.

In his work on emergent time, Longo extends Connes' arguments to a more robust connection between quantum mechanics and thermodynamics using the language of operator algebras, and shows how time emerges thereby. But he sees this as resulting from wavefunction collapse, and I do not think emergent time is dependent upon that feature. Since I imagine the two considerations are independent, I remind the reader of an outside-in view offered by Dieter Zeh[37] suggesting that the global wavefunction is more real or fundamental than particles or quantum transitions, and it persists while we measure, while the appearance of collapse is a matter of our perspective or locality. Work by Peter Morgan[38] using the Koopman-von Neumann formalism suggests we can also choose between collapse and no-collapse models depending on the context, so long as we talk about subsequent measurements rather than states.

Things automatically go from possibility toward actuality in the work presented. However, this dynamism does not depend on properties arising in higher-d spaces and hyper-complex algebras or from infinities, as in the above examples, so higher-d attributes are not essential for top-down mechanisms to work. Gisin[39] points out that even real numbers, which are commonly viewed as fixed quantities, are fixed only by a process of determination. From an intuitionist view, the exact or precise value of a quantity is not known before it is determined in a process. If there is a specific real number with a large number of digits, we may not find out what those later digits are for a long time, and information on what is beyond a certain point is no better than random data. This is like a stochastic background in the realm of the indeterminate, which influences our view of time by making the edges of what we can measure now fuzzy.

But we perceive time as something real. Gisin[40] speaks to this issue and related matters and how that inspires novel ideas about wavefunction collapse[41]. His work informs the Contextual Collapse model of Drossel and Ellis[42], a largely top-down approach which treats the quantum measurement problem in detail, where measurement is by nature a multi-stage process. Their work addresses shortcomings in decoherence theory and other models, which they handle individually, concluding that a robust description includes both Quantum and Classical elements because any physical measurement unavoidably includes a mix of both, depending on its context. They further extend the conversation to how quantum measurements are a special case, projections of the wavefunction for what they call events – a larger class of interactions which are ubiquitous in nature.

4. What Philosophy is best for Physics?

Is there a single best Philosophy of Physics? While some argue that learning Philosophy is a side trip for those learning Physics, that in itself is a Philosophy of how Science is done. So it is unavoidable that the two become interwoven. This is aptly illustrated by Rovelli[43] in his paper arguing that Philosophy and Physics need each other, which contrasts the schools of Isocrates and Plato. While Isocrates taught that practical skills and their application should be cultivated, Plato advocated the quest for knowledge of how or why things work, and how they came to be as they are. While Plato was among the first to be called a philosopher, we put both individuals in that category in modern times, and their teachings are seen as two competing schools of Philosophy. I think people need to blend the two ideologies or philosophies to survive in the real world and Aristotle argued that general theory supports practice, so one can claim that both approaches are needed to make progress in some endeavors.

But the debate about which philosophy is best for everyone still goes on today, writ large on the face of Politics. It also changed the face of Education. This influences funding for all areas of Science, depending on the philosophical bent of the prevailing political party. This ideological split is seen to be connected to our perception of time, in that liberals have a more forward-facing view focused on creating a better future, while conservatives tend to focus on preserving the legacy and traditions of our past, which is more rearward-facing. But regardless their motivation, people fiercely debate which philosophy is correct, or benefits us most, rather than seeing that both viewpoints are needed to make the world and our lives better.

If asked what Philosophy is best for Physics, I would advise people to seek an inclusive or encompassing view of reality, but also assume there is always more to learn or discover. We need to be explorers, unafraid to look beyond the boundaries, if we want important discoveries or developments. We must be wary of islands of knowledge and information silos that present a self-consistent but wrong-headed view of the world. The misleading usage of the word recombination persists in astrophysics, for example, to describe what happens at the horizon of last scattering during decoupling, even though early-universe cosmology tells us nuclei and electrons were never combined into atoms before that time.

This illustrates how scholars often work on islands of familiar and comfortable norms, with fierce pressure to work within established territory for their area of specialization, though this inhibits discovery. The self-consistent view within the silo is often reinforced by walls that are polished mirror smooth. An outsider and generalist like me gets a different view from others when attending quantum gravity lectures, for example, because the common ground stands out as starkly as the differences between approaches, and I have no need for a clear winner. All of the current lines of research inform us in useful ways I think are not necessarily mutually-exclusive. Ergo we should not stop exploring or seeking other options to explore, just because we have several viable explanations for gravity on the table.

The ideal Philosophy for Physics always leaves the door open to learning more about what we think we know, discovering something new or even totally unexpected, and so on. We reside within a construction that is the cosmos and our view is further limited because we can see only what is within the Hubble radius. We live on an isolated island world in a kind of 'Goldilocks zone,' here on planet Earth. We are forever on the inside looking out at the larger cosmos, which beckons. This is why I advocate seeking an outside-in view of Math and Physics, as a radical extension of the top-down view, and as a possible cure for the view that a bottom-up approach can not only create all form but aptly explains all we see. A basic fact about explorers is needing somewhere new to explore. Like the Disney character "Moana"[44] we need to resist the fierce pressure to stay on the island of comfortable norms, and be intrepid adventurers instead.

Perhaps some of us need to actually get off-planet to obtain the perspective we all require of the outside-in view beyond our limitations. Or maybe we need only the mountaintop perspective or overview from higher ground philosophically. To see a circle in its entirety, one must be off the page, in the 3rd dimension. Likewise, to draw that circle, one must reside in a dimension one higher than the surface on which you are drawing. If this as a general pattern, there is always a need for and a way to discern what the structure we are living in looks like from one dimension higher. Unfortunately, the block universe view of spacetime seen from the outside, that is used in General Relativity, incorporates a severe limitation. So we need to frame other constructs that give us better scaffolding for our ideas of how where we are 'here and now' looks from 'out there.' Therefore that is the main thrust of this paper, to inspire others who might help to create that next generation outlook.

When entertaining questions about Philosophy and Physics, one must remember that Mathematics inevitably makes its way onto the scene. Plato suggested a mathematical ideal or archetype which is projected onto physical reality. We now have a much more sophisticated notion of how that works, but the same idea persists to this day. I think we all need to be hyper-dimensional Platonists, and to actively entertain that view with a guide to the Atlas of Lie Groups[45] in every College library where they teach higher-level Math and Physics subjects. Likewise we need to facilitate exploring the Mandelbrot Set in Public schools and libraries. In this way, we will speed up the process of discovery fueled by the value of what only a select few know today. We need to introduce some advanced ideas to our youth at an earlier age, for tomorrow's young people to have the benefit of what some adults already know. This is what David Blair[46] seeks to do with the "Einstein First" program, which teaches advanced concepts to young people based on our modern views of gravity, and then works that back into the structure of what students have already learned in school.

This allows younger students to benefit from the understanding of their elders, in a context that is not intimidating for teachers with a limited knowledge of Relativity. We should attempt to do the same with other areas of Mathematics and Physics so the next generation will have the benefit of what we collectively have learned. This might not be possible if we teach things solely from the bottom-up view. What if young people were building Zome models[47] of E_8 instead? If not, at least we should give kids a chance to see what these figures (3-d models of higher-d objects) look like at Science Centers and Math Museums.

The nexus of Philosophy and Physics must be strong, for either topic to provide useful information. This means it is incumbent on the organizers of events and publications to provide a context for insightful contributions that forge a stronger connection between what appear to be separated views, or to push the envelope of developments on the outskirts. The 16th Marcel Grossmann conference was exemplary on both of these fronts, in its spirit of cooperation, openness, and inclusivity. The organizers deliberately included minority views and off-limits topics in both the choice of plenary speakers and in various breakout sessions. People were therefore encouraged to look outside of their silos somewhat, and to explore what is beyond the island of comfortable mainstream views.

During MG16, a Philosophy of Physics approaching the ideal was observed. But in the world at large, there is a lot of progress to be made forging connections which support a higher ideal. What we see now is a world that largely ignores the advice of both philosophers and physicists, in favor of following popular icons. There is much work ahead, if we want the ideas that enlighten physicists to be meaningful for everyone, but things that are discovered in Physics will have a meaning which unavoidably affects all equally. Physics informs both philosophers and everyone else about the true nature of reality. Therefore our Philosophy must include the notion that what we are learning from Physics remains relevant to all.

We owe much of our current scientific understanding to the philosophers of ancient Greece, not least the notion of atomism with indivisibly small bits or increments in the cosmos or how it is constructed, as was explained in Rovelli's book[48]. Leucippus likely brought the seed of this idea to Democritus from Anaximander's school. But we can see that applying atomism to Plato's comment that time is the projected image of eternity results in every atom in the stream or river of Heraclitus having a finite duration or persistence in time. This is observed as a half-life, when exploring the same phenomenon in nuclear or sub-atomic Physics, due in part to the relativistic effects of time dilation.

However parcels of space needed first to have persistence in time for particles to exist at all! That is why it is important to continue our exploration of quantum gravity theories and try to understand the cosmological context for these theories in a broader way. Physicists should see it as a responsibility to build bridges between the philosophically disconnected islands of thought, like String theory and Loop quantum gravity, by applying a Philosophy of Physics that supports our common endeavor to learn the secrets of the cosmos. Encouraging students as well as researchers to explore beyond what is known to be important and having a willingness to question our own boundaries is an important first step. We must be ready to leave the world of our comfortable norms behind, when examining cosmic origins, to fully understand how things got to be as they are now.

5. How Does a Philosophy of Time Affect Everyday Life?

It is not obvious that the ultimate origin of space and time is relevant to our everyday lives, and how we approach life. We do not realize just how deeply our lives depend on the same questions of cosmic origins that are at the leading edge of Physics and Philosophy. People fight over the relative value of "knowledge is power" and "time is money" not realizing that it recreates the ancient debate between Plato and Isocrates, nor knowing there is a deep connection of these ideals with questions of spacetime's origin. Adam Becker's recent article in Scientific American[49] emphasized that scientists have long debated which is more fundamental, space or time, but now the scientific community is coming to see *both* as emergent attributes of something yet more fundamental or primordial.

This might be the evolutive property I spoke about earlier. Its defining aspect, in simple terms, is that variation ensues automatically (unless otherwise limited) and structure emerges later as a product of those variations whenever variability is sufficient either physically or mathematically, in combination with pre-existing constraints. So in this scenario, there is no need to create something from nothing, for the cosmos or reality to arise, because the precursor of both space and time is automatic evolution or motivity in the absence of constraints. Knowing this changes the landscape of Philosophy, however.

The knowledge that space and time emerge together from a common source beyond and before them is profoundly liberating. It helps resolve some of the differences between competing ideologies or philosophies and allows a dialectical synthesis to emerge from what we thought were strictly (or appear to be) opposing and mutually-exclusive views. The whole idea of opposing ideologies carries a fair amount of baggage, but it is pervasive in politics where everyone is expected to choose a side. Scientists are expected to be more impartial. Yet even in a subject like theoretical Physics we see blatant competition where different groups of people hope the evidence will show theirs is the one correct theory and others do not require further exploration. However studying spacetime origins shows us instead that multiple approaches to quantum gravity and early universe cosmology all yield valuable insights, and various theories point us toward a common truth and a deeper reality.

So we need to stop fighting and expand our knowledge of that territory which reveals the unity behind the dichotomies. We are only now coming to understand that algebraic Mathematics has an intrinsic flow[50], as we already have seen with Geometry, because quadratic and higher degree polynomials have core entropy. This is news for many mathematicians. But philosophers all over the world have been contemplating this sort of thing for a long time.

The ancient Greeks got a lot of things right, regarding the nature of reality, given they did not have the sophisticated measuring or computing tools that we do today. Those individuals schooled by Anaximander and his students seem particularly impactful, and the impact of Democritus[51] is notable in sowing the seeds of atomic theory and quantum gravity, but Plato is probably the most widely known or heavily cited. His comment that time is the projected image of eternity can be understood as moments of time having the attribute of duration in a specific measure, while eternity is that which endures without end or forever.

Similarly, one can understand a parcel of space or measurable length to be a representation of an infinite expanse or extent. So in this way, both time and space partake of a property which can be called endlessness, and are in fact a limited projection thereof. And the origin of time and space proceeds in a way that is well-described by Heraclitus statements that “change is the only constant” and “one cannot step in the same river twice.” He notes that both we and the stream are different the second time. And this nicely echoes the tone of the work by Connes and by Longo cited earlier. But philosophers in other lands also thought about this.

Taoist scholars refer to the primal essence as Wuji[52, 53] existing beyond and before the first distinction. It is neither light nor dark, neither hot nor cold, and neither great nor small. In this aspect we again see a simile of Wuji with non-commutative geometry, where the familiar concepts of size and distance are altered and spaces are seen to have evolutive properties. The unified state of Wuji inexorably gives rise to duality or Taiji as the yin or receptive and the yang or projective attributes, once things are set in motion. Yin is seen as space-like while yang is time-like, in this context.

So, in this tale from ancient Chinese philosophers, we see again an analogy with the space and time origin story from modern Physics, where Taoist teachings assert there is a unity or natural balance in the dichotomy or opposition of yin and yang. This doctrine also affirms Aristotle’s words suggesting people should find value in both abstract knowledge and practical skills rather than choosing one or the other. That is why Education must ground students in abstract thinking skills and provide insights into how things work, as well as giving them facts to memorize. We all need practical skills to make a living but we should also value learning for its own sake. Advancing technology makes skills obsolete in just a few years, while abstract knowledge endures – lasting a lifetime. Some mathematical abstractions are effectively eternal.

If a working or free society needs educated people with a balance of abstract knowledge and practical skills, most of us fall short. However, the profundity of what humans have learned will not just go away. What is 'always so' (as Buddhists like to call it) includes the whole of Mathematics as we know it, plus a lot more we have not yet discovered. We are children playing on the shore with pebbles and shells while a vast ocean lies undiscovered just beyond. But we need to introduce today's children to some of the really fun Maths early in life, to catch their attention. Too often, Math is taught in a way that is mechanical and boring, which tends to introduce the basics by memorization.

I was privileged to get a glimpse into abstract Maths back in the 5th grade from my teacher Richard Lahey and a small volume that taught me via programmed instruction the elements of geometry and topology, then introduced set theory, and finally basic logic. This intro to abstract Maths helped me to excel in several subjects later in my schooling. He also led the class on an exercise where we learned about surveying and triangulation by doing it ourselves. But a lot of children never get the abstract view so they never learn how fun Math can be, once you get past the boring parts. The same is true in Physics, one must live through several boring lectures before the really boring ones suddenly become fascinating. Once some essential terminology is learned, off we can go on a journey of discovery.

We should introduce young people to the wonders of Math and Science as early as possible, to spark an interest and get them thinking. Part of the problem is that teachers find it hard to learn enough about various advanced topics themselves, to adequately present the material. However the rewards are great for those willing to chart the frontiers in a subject like Physics or Math. It gets fun to talk about what's happening, when you present a summary of the latest discoveries or advances. This is true even though progress in Physics is accompanied by advances in Math that require considerable study. The terminology barrier is often intimidating, as well, because mathematicians and physicists talk about many of the same things differently. This forces serious researchers to be conversant in the language of both Math and Physics – which is a daunting task.

However, if we could communicate the excitement and fun of exploring Math and Science frontiers to young people more effectively, they might find topics that really fascinate them and provide an incentive to learn. This could transform Education as we know it. Alison Gopnik[54] and her colleagues see very young children as 'little scientists' but we must nurture that spark to see it come to life in young adults. In an earlier paper[55], I suggest we should celebrate the value of play as a way to foster discovery or advancement in scientific endeavors, and there I highlight how dimensional estimation and triangulation may be gateway skills to allow symbolic reasoning. We learn the deeper lessons only once we acquire a sense of perspective, it would seem.

Here I note that while starting on the outside looking or working inward and starting on the inside and looking or working outward seem very different, they are the same action but with the opposite directionality and/or time sense! It is the same process or procedure either way. An example is taking a watch or engine apart and putting it together. I posit[56] that this time duality is what drives lateralization and hemispheric specialization in the brain, and that how we perceive the passage of time derives from contrasting the inside-out and outside-in viewpoints. Curiously, while Math appears to suffer from an inside-out bias, in terms of the way it is taught, Cognitive Science has suffered from over-emphasis of an outside-in view, where the inside-out approach[57] is only now gaining acceptance.

Both outlooks offer useful insights, in my opinion, and they contribute complementary pieces of the puzzle which allow a more complete theory to be constructed. We must take in what is out there *and* make our own way in the world. How the brain processes the passage of time appears to be a key element of cognition, therefore. We should expect cultural differences because various traditions including Indigenous peoples' have an entirely different view of the nature and flow of time[58] from Westerners. They are mindful of the natural flow of events instead of the time on the clock. This profoundly affects their cognitive processes and view of the world, which shows us that everyone could broaden their views about time and benefit from or enjoy time's passage, rather than being enslaved by it.

We need to get off our islands of limiting beliefs to see lasting change from new knowledge. However, the journey will be interesting and it could be a lot of fun! Astronauts describe the 'overview effect' which is the humbling yet awe-inspiring experience of seeing the whole planet beneath you. Man-made boundaries blur and the unifying global elements stand out more clearly. A similar outlook comes from contemplating the origins of space and time. Einstein's 'gedanken' experiments are a clear example of this. The view from outside space and time reveals that neither can exist without the other because they emerge together. Unfortunately not many will get to see the big picture by going to outer space or by studying advanced Math and Physics so they can peer beyond space and before time.

But by looking for a unity behind the apparent opposites, we might all get to the same place eventually. Aristotle's Doctrine of the Mean[59, 60] states that virtue is found in the balance between a deficiency and an excess of some attribute, where courage balances timidity and foolhardiness for example, though the two qualities falsely appear to be opposites. People get fooled by these false dichotomies, where an either/or choice will not yield the correct answer but there still is one, a third choice. Studying the origins of space and time will inform both Philosophy and Physics, but it may also yield profound insights into a unified reality which makes everyday life more meaningful and some arguments unnecessary.

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