Things, Laws, and the Human Mind

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ABSTRACT

The physical universe is made up of objects and events in space and time. We refer to them collectively as Things. How does the human mind convert things in the observed universe, into laws? What role does our consciousness play in this conversion process? We propose that the dynamic pathways connecting the neurons in our brains have a dual interpretation, as a thing-law. The pathways are things, by virtue of their material nature. However, our consciousness also accords a pathway the interpretation of a law, which could be a thought, an idea, an emotion, a number, a geometrical figure, a physical law, or a mathematical theorem. The mind's conversion of things into laws is what we call the horizontal fundamental. But are laws different from things? In the emergent complex universe, apparently yes. However, as we dig deeper and deeper into the reductionist layers of reality, a process we call the vertical fundamental, laws and things become more and more like each other, until deepest down, they become one and the same.

I. THINGS, LAWS, THE HUMAN MIND, AND THE WATCHER

I am sitting on a chair, in front of my laptop, thinking as to how to begin this essay. In so doing, I become aware of myself. I am defined by my consciousness, my self-awareness. The conscious I. The watcher, who watches over the body, and watches over the mind and its thoughts. Consciousness which cannot be defined tangibly, but which is felt powerfully and clearly and is in all likelihood a property of the stuff of which the body and the brain is made. Consciousness, which is an entity entirely distinct from the mind-brain, and which belongs to the organism as a whole [1].

I look out of my window at the starry night sky. The universe out there, the material world, is the universe of Things. The stars and planets, galaxies, dark matter, dark energy, elementary particles, atoms, fields, are all things. In an extended definition, space, time, motion, and events, are also things. Thus the motion of Mars around the sun is a thing. And of course, our bodies and brains, as all living organisms, are also things.

Then, somewhere, there is the world of Laws. Those abstract entities, rules, which are not Things. Rather, laws are elegant and beautiful bookkeeping devices which tell us how Things behave. We shall extend the definition of laws to include abstract concepts, such as force, mass, velocity, acceleration etc. Laws also include numbers, mathematical relations, and in fact all of mathematics. Newton's second law of motion tells us how the force on an

object relates to its mass and acceleration. The laws of quantum chromodynamics tell us how elementary particles such as quarks and gluons interact quantum mechanically, through the strong force. The law of Fermat's last theorem tell us that there are no positive integers a, b, c, n such that $a^n + b^n = c^n$ if $n \geq 3$. We shall further extend the definition of Laws to include abstract mental entities such as perceptions, thoughts, emotions and ideas.

In between the realm of Things, and the realm of Laws, is that vaguely defined but well-perceived entity known as the Human Mind. We physicists derive immense joy from using our mind to discover laws of the observed universe. But should we not ask how our brains do this? We shall define 'fundamental' as the process by which the human mind converts Things into Laws. The mind is an entity completely distinct and separate from the Conscious I - the latter we have called the Watcher, who watches over things, laws, and the mind, and watches over the mind converting things to laws. Understanding how consciousness emerges as a state of matter is unfortunately beyond the scope of the present essay, and we simply assume the watcher as a given.

This essay is about understanding the relationship between the watcher, things, laws, and the human mind. It is about the understanding of understanding.

II. THE THING-LAW

The human brain and its functioning is extraordinarily complex; it is the most complex object that we know of. Yet, the history of science tells us that the principles underlying even the most complex systems are simple, when understood. What might be the simplest and most rudimentary model that we can make for the brain-mind system? Neurons are points in a three-dimensional space, and the synapses connecting the billions of neurons in a human brain form the collection of pathways. A [chemically/electrically] activated pathway is a circuit. An activated pathway is a thing, obviously, because of its material nature: it is made up of atoms, ions, and electrons. [Let us leave aside that neural activity which concerns purely biological function or response to sensory inputs]. Enter consciousness, the watcher. We propose that the watcher gives the activated pathway a dual interpretation - the watcher associates an abstraction with the pathway. This abstraction could be a memory, a concept, a word, a thought, a feeling, the number five, a triangle, or the statement of Fermat's last theorem, or the statement of Einstein's equations in the general theory of relativity, or a new prediction for an experiment. Consciousness facilitates the transformation of a thing into a law. A stimulus from the external universe translates into an activated neural pathway, which the watcher then interprets as a law. An active neural pathway is a thing-law. We may define the mind as the collection of thing-laws, and laws as the interpretation given to thing-laws by the watcher. No watcher, no laws.

One of the properties of a conscious organism is its ability to associate a law interpretation

to its own active neural pathway. This can well be the definition of thinking, and of intelligent behaviour. Only a conscious [self-aware] organism can accomplish this. It is possible that an organism is self-aware if and only if it can associate laws to neural pathways, i.e. if and only if it can think. A human being is hence a self-aware computer. While a computer responds to external inputs, it does not by itself associate a law with the input; it has to be told to do so, by an external agent. The day computers become self-aware, they will become intelligent, and capable of thinking. By being self-aware, a human being is capable of acting on a microscopic subset of itself; the action being the act of associating a law with the microscopic material pathway. This action then influences macroscopic behaviour. For example, if I say "I turned left at the end of the road because I mistakenly thought the tennis court was on the left", the behaviour of turning left is influenced by the law 'mistakenly thought' associated with the pathway. This of course is a very non-computer thing to do, nor can lower life-forms, which are presumably not self-aware and cannot think, accomplish this. This capability to consciously influence a microscopic subset of oneself, and to behave in response to a feedback from the microscopic subset, is the essence of the fundamental process of converting things into laws. Life forms that are not self-aware (presumably pre-mammalian organisms) respond to inputs from environments, based on feedback from their nervous system [if they have one] but they do not associate laws with neural pathways. Their response is primitive and instinctive.

By bringing self-awareness on the scene, we get rid of the self-referential problem of brains having to understand brains. Brains do not have to understand brains; that job is left to self-awareness. Self-awareness is probably a property and a consequence of the collection of neural pathways all over the body, but the whole is more than the sum of its parts. It is also a unique situation where the whole influences the parts of which it is made. In an inanimate system, the whole does not influence its own parts; it is only influenced by them. To describe the macroscopic thermodynamic properties of a box of gas, we do not need to know that the gas is made of atoms. But to understand the behaviour of a self-aware being, we need to know its neural pathways, and the laws that the being associates with the pathways.

There is evidence from the world of neuroscience, to support the thing-law interpretation and its connection with the watcher. It is quite convincingly evident from ongoing studies of brain evolution that the human brain had very primitive beginnings in the earliest of organisms which did not even have a brain. [For a very lucid elementary account see [2].] And that the purpose of the early brain is to coordinate body functions in such a way that in response to the environment, chances of survival of an organism improve. Even single-celled organisms such as bacteria, which of course have no neurons, possess ion channels (large proteins) which control the flow of ions in and out of the bacterial cell. Ion channels affect bacterial functionality, and similar channels in the human brain are key for communication in neurons, and the very same genes which express for ion channels in the human brain are also

found in bacteria! The bacterial ion channels were inherited by successive generations for a few billion years, until a few hundred million years ago, when multicellular organisms [with no organs or neurons] evolved, and used proteins to communicate between cells. These same cell proteins are importantly involved in forming synapses which allow neurons in the human nervous system to communicate with each other! It is likely that neurons and synapses in nerves and brains of higher organisms resulted from an application of these pre-existing parts (ion channels and synaptic proteins), a process known as exaptation ("recommissioning an inherited trait for a new purpose" [2]). Some fifty million years after the first multicellulars appeared, marine life forms having neurons and nerve nets emerged. The evolution of the vertebrate nervous system was the next important step in the story, followed by the mammallian brain, the large primate brain, and eventually, the even larger hominid brain some two million years, and the human brain, about two hundred thousand years ago. The large size comes predominantly from the cerebral cortex (especially the frontal lobe), known to play a key role in higher functions such as memory, attention, perception, cognition, awareness, thought, language, and consciousness. Enter, the neo-cortex, the largest part of the cerebral cortex, the so called grey matter whose surface area increases greatly from rodents and other small mammals, to primates and humans.

In a non-mammalian brain such as that of a reptile, the neo-cortex is absent, and while there are sophisticated senses and complex behaviour, intelligent behavior [i.e. the thing-law association determined by the self-aware watcher] is absent. The neo-cortex is a key add-on to the reptilian brain, and thought to be responsible for memory and prediction, essential for intelligent behaviour [3].

In the eighties, scientists succeeded in mapping all the seven thousand connections between the three hundred neurons of the worm *C. Elegans*, thus determining its 'connectome' - the entire set of neural connections in an organism's brain. The human connectome is far more complex, because the human brain has a hundred billion neurons, and a million billion connections. Does the connectome define an individual, and could it be that when the connectome in the brain of an animal crosses a critical threshold, consciousness emerges? Connectomes change over time, with neurons gaining and losing branches, and synapses getting created and destroyed. These changes can be genetic, or caused by neural activity, which in turn is the result of the brain's response to the environment, or to its own internal thinking process. The connectome in turn determines the pathways along which neural activity takes place [4].

Given that the rudimentary brain elements such as ion-channels and synaptic proteins were already present in primitive life forms which did not have a nervous system, it is evident that the brain evolved to help life-forms adapt and survive better. With the emergence of the neo-cortex in mammals, brains appear to cross a critical threshold and give rise to self-aware living forms, who are also able to associate a law interpretation to the thing (thing

being the active neural pathway). The crossing of the threshold is accompanied by enhanced size and complexity, and a vast increase in the number of connections in the connectome. Since the connectome determines the pathways of neural activity, which in turn shape the connectome, we may speculate that consciousness is an emergent property of a connectome, which allows the association of a law with an active neural pathway. The mammalian brain, possessed with the neo-cortex, does not necessarily need an external input for activation of a neural pathway. It is self-aware, and self-processing as well. Current computers are like pre-mammalian brains. Their thinking capacity could be illustrated by this amusing example of an e-mail I got in my Inbox a few days ago:

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Dear Kinjalk Lochan,
Greetings and good day.
I represent EnPress Publisher Editorial Office from USA. We have come across your recent article "Statistical Thermodynamics for a Non-commutative Special Relativity: Emergence of a Generalized Quantum Dynamics" published in Foundations of Physics. We feel that the topic of the article is very interesting. Therefore, we are delighted to invite you to publish your work in our journal, entitled Trends in Genetics and Evolution. We also hope that you can join our Editorial Board. Please reply to this email if you are interested to join the Editorial Board.
I look forward to hearing your positive response. Thank you for your kind consideration.
Best regards,
Aaliyah Lopez
Editorial Office
Trends in Genetics and Evolution

"

When the connectivity of an artificial neural network crosses a critical threshold in complexity and in number of networks, it perhaps become self-aware, and also an intelligent thinker. Thinking is the act of a connectome to bring changes unto itself, of its own volition, without any external input. That 'own volition' is self-awareness.

III. IS THE LAW A THING?

Material objects are easy to localize, as we may picture them as existing in space and time. This is equivalent to describing one thing (the object) in relation to other things (space and time). In particular, an activated neural pathway is a thing in space and time. But how about the law associated with this thing? Where does the law reside? Say, I imagine in my mind the color blue. Where does this imagination/law reside? We expect this to be the law interpretation that the watcher associates to the corresponding neural

pathway, and we would not be averse to accepting that the law is 'resident in' or in some way locally associated with the pathway. We would not want to say that the imagination of blue is somewhere out there in some surreal space, and that the activated neural pathway somehow discovers that imagination. The imagination is created/invented, not discovered. Similarly, a poem is invented, not discovered. Another example; say I recall that it rained yesterday. There is a neural pathway storing the law that 'it rained yesterday'. We would not want to assert that this memory lives in some outer abstract space, and we discover it; rather, the mind created the memory. Or the neural pathway that discovers the resident law of the concept of 'mass'. Next example, say the number five. It is an abstraction - a law - associated with the nerve path for the number five, and we are happy to accept that this law 'lives in' the path.

Now it gets more interesting. Let us think of relations between numbers. As one out of innumerably many examples of the magic of number theory, consider the infamous 3n+1 problem, which is stated as follows. Start with a natural number N. If it is even, divide it by 2. If it is odd, multiply it by 3 and add 1. Repeat the same algorithm with the resulting number. For every number that has been tested, the process always ends in the cycle 4, 2, 1, 4. But till today there is no proof for this for arbitrary N; and it has been labelled as one of the toughest problems in mathematics, for which mathematics is not yet ready [the Collatz conjecture]! [5]

More relevant for us here is the randomness apparent in the 3n+1 sequences of different numbers. Here are a few examples:

5, 16, 8, 4, 2, 1

7, 22, 11, 34, 17, 52, 26, 13, 40, 20, 10, 5, ...

25, 76, 38, 19, 58, 29, 88, 44, 22, 11, ...

26, 13, ...

28, 14, 7, ...

These are all small modestly sized sequences. But now look at the sequence for 27:
27, 82, 41, 124, 62, 31, 94, 47, 142, 71, 214, 107, 322, 161, 484, 242, 121, 364, 182, 91, 274, 137, 412, 206, 103, 310, 155, 466, 233, 700, 350, 175, 526, 263, 790, 395, 1186, 593, 1780, 890, 445, 1336, 668, 334, 167, 502, 251, 754, 377, 1132, 566, 283, 850, 425, 1276, 638, 319, 958, 479, 1438, 719, 2158, 1079, 3238, 1619, 4858, 2429, 7288, 3644, 1822, 911, 2734, 1367, 4102, 2051, 6154, 3077, 9232, 4616, 2308, 1154, 577, 1732, 866, 433, 1300, 650, 325, 976, 488, 244, 122, 61, 184, 92, 46, 23, 70, 35, 106, 53, 160, 80, 40, 20, 10, 5, 16, 8, 4, 2, 1

This sequence has 111 steps! What on earth suddenly happened between 26 and 28? We do not understand this, in fact. Now, there of course must have been a neural pathway established in the brain when we worked out the above sequence; and a similar pathway in the computer, if we used a program. But this sequence is so objective and universal in nature, and agreed upon by everyone, that it is impossible to believe that the neural

pathway created/invented this sequence, and that what we see above is the subjective law interpretation of the thing. The sequence very much seems to have a life of its own, showing no sign of any human involvement, but rather belonging to the world of numbers, which exists somewhere out there, and the neural pathway only discovers it, and then stores it. This same Platonic feature is of course true of all numbers, and of all mathematics.

Now we are in trouble. Because there seems to be no evidence from neuroscience to suggest that the connections which represent thought, the color blue, the rain yesterday, or the number five, are of a fundamentally different nature in construction, as compared to the connections which represent a sequence such as that for 27. Yet we very much believe that a thought is a subjective law which is resident in the thing (the neural pathway), but the number sequence is an objective law not resident in the thing, but only represented by the thing, and resident in a Platonic world.

Considering the diversity and subjectivity in the connectomes of different people, how are we to resolve this apparent conflict between the subjectivity of such thing-laws as thoughts and feelings, and the objectivity of thing-laws such as mathematics? Is there a world of mathematics somewhere, which the neural pathways discover, when we think mathematics? No. Because that belief in the Platonic 'somewhere' of mathematics is nothing short of supernatural. To believe that mathematics has a world of its own is a bit like believing in ghosts. Nobody has seen ghosts, yet some people are sure they exist. Rather, to resolve the aforementioned conflict, we make the bold proposal that a law is also a thing; it is the same as the thing which it represents. The difference between an abstract law and the thing which codes for it is an illusory difference. This is true as much in the neural pathways in the brain, as in the material world outside. Mathematics resides in the things of the outside world, and the same thing-law association is represented in neural pathways. Thus in the material world, we may view the 3n+1 sequence of 27 as follows: get a huge pile of a very large number of bricks. Pick say 27 of them. Then add 55 more to this lot to make a total of 82. Then halve the lot to 41. Then triple this lot and add another. And so on. And after 111 steps we will be left with just one brick. If mathematicians one day discover the proof of the 3n+1 conjecture, then where is the thing aspect of this proof? In the mind, the thing is the neural pathway that corresponds to this law. How are we to see the proof of the 3n+1 conjecture in the pile of bricks, without having to physically test it again and again with N bricks, for different N? We believe the proof is 'in the bricks', but in a complex emergent universe such as ours, this is not apparent. But if we investigate into deeper and deeper reductionist layers of physical reality [the vertical fundamental], laws come 'closer and closer' to things, until there comes the lowermost layer, where laws are not distinguishable from things at all. We try to justify this next. We will argue that we do not see the proof in material things because these material things are treated as being distinct from space and time.

IV. THE VERTICAL FUNDAMENTAL

There is the classical world; beneath that is the quantum world; and perhaps, beneath that is the quantum gravitational world. This is the vertical fundamental. Consider the following three statements; the first about a ball in the classical world, the second about an electron in the quantum world, and the third about 'whatever it is', in the quantum gravitational world.

- The position of a ball in space is the same thing as the ball itself.
- The wave function of the electron is the same thing as the electron itself.
- The 'whatever it is' in the quantum gravitational world is indistinguishable from the 'quantum space-time' in which it is supposed to dwell.

Let us consider these assertions one by one. The first of these is clearly false. The ball as a material object lives in space, and it is not the space itself. By the time we get to the second statement, we are already beginning to think how intimately the wave function is related to the electron. It is not quite the electron, because it lives in the Hilbert space, whereas the electron is in physical space. The wave function is complex, whereas the electron is a real material object, and the squared modulus of the wave function gives the probability of finding the electron at this or that position in space. Already we are in troubled waters! To explain the outcome of the double slit interference experiment, we must accept that the electron behaves like a wave, but we cannot add the so-called probability waves. At every space-time point we must add the two complex wave functions corresponding to the passage of the electron from the two slits. And then take the square of the sum, to explain interference. So, is the electron the same thing as the wave function or not?! It seems real, it seems complex. Mystery! How can a complex wave travel through space-time? It makes no sense. Imaginary entities are mathematical abstractions; matter fields in space-time are real.

When we examine quantum theory more closely, we realise there are other problematic issues with the theory, and when we resolve those issues, it helps us also resolve the above mystery. The first is that classical time is alien to quantum theory, and there ought to exist an equivalent reformulation of quantum theory which does not refer to classical time [6–8]. The search for such a reformulation points us to an underlying space-time which is non-commutative [9]. The second issue is that quantum EPR correlations suggest a violation of locality and some kind of influence outside the light cone, which to some people suggests the need for a radical rethink of the space-time structure in special relativity [10]. We have argued that the non-commutative space-time which we were led to, is the one in which the electron and its associated wave function live, and in this scenario there is no longer the discomforting acausal quantum influence during an EPR measurement [11], nor trouble in understanding double slit interference. And what use there is then, any longer,

to distinguish the electron from its wave function? So, with some conviction, we revise the second statement above, as follows

• The wave function of the electron is the same thing as the electron itself, when viewed from the non-commutative space-time in which the electron lives.

Classical space-time is only an approximation to the underlying non-commutative space-time, emerging from a coarse-graining. All material objects dwell in this non-commutative space-time, but in such a space-time, there is no concept of classical position, nor of classical time, nor of classical events. Everything is everywhere all the time! [12] What is the use then, of distinguishing space-time from material objects? They must be one and the same thing. We have been led this far, by trying to resolve the puzzles and mysteries of quantum theory, starting from the weirdness of the double slit experiment with electrons.

And if there is no distinction between space-time and matter, could we even talk of substance, or of the ultimate constituents of matter? To talk of constituents, we must have the space-time in which the constituents live. And that we no longer have. All that we will have is a set of beautiful equations. No atoms, no electrons, no people, no here nor there, Whatever there ever was, has now become same as the mathematics which describes it. The law has become the thing; the thing has become the law. We do not have to any longer ask where does mathematics live, because the where has become mathematics. Platonism meets Nominalism. If we read in a bottom up manner the three assertions stated at the beginning of this section, we see how laws apparently become distinct from things, as we emerge into the classical world.

V. THE WATCHER REVISITED

We have come to the end of our journey. In trying to understand how the human mind converts things into laws, we are led to conclude that the mathematical world and the physical world are one and the same. The search for this union is what we would like to call fundamental. Everything springs from this union.

I am sitting on a chair, in front of my laptop, thinking how to end this essay. In so doing, I become aware of myself. I am defined by my consciousness. Could it be that consciousness itself is the law aspect of a thing-law? The thing being the physical connectome, or the body of the entire organism, and the law being consciousness? After all, consciousness is intangible, it is not material. It is felt, but cannot be defined. It is timeless - I am the same I at all ages; the I is timeless. Only the mind knows time; consciousness does not know time. And although consciousness seems confined to the spatially localised body, we have all felt at some time or the other that itchy desire to escape the body, to let the consciousness wander. Could it be that when we will have understood consciousness, its mathematical description will become one and the same as its physical description?

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