

A thermodynamical theory of consciousness

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Abstract:

Humans have always thought of consciousness as property possessed by a living organism, without being able to properly define it in scientific terms. Many articles have been published to explain what consciousness is. In this article, consciousness has been defined as a quantity ('variable' would be a better word according to mathematics), which is linked with entropy of the system. The article explains consciousness, its role in the universe, not only in living systems, but also in non-living thermo-dynamical systems. Not only that, the article also explains its role with quantum biology, a newly emerging field of biology.

Keywords:

Evolution; quantum physics; quantum biology; statistics; mathematics; big bang

Introduction:

A lot of research has been done to understand consciousness by many scientists around the globe. Some of such articles have been provided in the references (1)-(10). However, it has never been thought to be measurable in terms of physical quantities, or to be a broader aspect than a property of living systems. In 2019, a paper was published (11) in which theory based on Expected Float Entropy (EFE) was further investigated. The theory and results were consistent with the proposition of there being a close connection between association learning processes and the emergence of consciousness. Experiments (12) were done which showed that entropy is linked to consciousness. The researchers think that entropy is the reason for consciousness. Some experiments (13) were done which showed that consciousness and mental states follow quantum mechanics. In 2014, a theory (14) was published to explain consciousness states, informed by neuro-imaging research. Many such recent researches (15)-(18) show that consciousness is linked to entropy. However, most of these researches are often misinterpreted by general media. For example, in some articles, consciousness is thought of to be same as entropy or to be a side-effect of entropy. However, this is misconception. In this article, we would start by defining consciousness in a simple derivative form and later extend the theory by derivation of various equations for many particular controlled environment using quantum mechanics and thermo-dynamics. Then, we would link it to biological concepts like evolution, biochemistry. In the end, we would discuss the conclusions of the theory and how this theory can be used in further study and development in science. For the sake of knowing the advances and earlier researches on the topic, you are recommended to read the paper published by John S. Torday and William B. Miller (19).

Basics:

Consciousness is the ability of a system to sense and respond to its surroundings. But the most important question is 'how the system shows/expresses this ability?' The answer to the question is 'by creating/forming information which forms a chain of forming information by the constituent particles of this system'. Basically, we could imagine it by thinking about the nervous system of human body. The brain forms the information, which starts a chain reaction, in the neurons, due to which the information transports itself from one place to another. Now, we know by the information theory that information is measured and expressed as entropy. So, basically consciousness is the ability to form entropy/information. Now, the most basic reason that entropy is not same as consciousness is that consciousness is an intrinsic property, while entropy is an extensive property. Therefore, we must firstly define it, and then derive formulas for particular situations.

Defining consciousness:

Since, consciousness is an intrinsic property; we have to define it for a particular physical property like mass, or energy. In this article, we intend to understand consciousness in the most fundamental form. Therefore we would define it for a particular amount of energy, as a simple mathematical ratio.

Through intuition from above paragraph, we can define consciousness as 'the change in entropy per unit energy of the given physical system, during a process'.

This can be shown mathematically as

$$C = \left| \frac{\Delta S}{E} \right| \text{ Or } dC = \left| \frac{dS}{E} \right|$$

Where C is consciousness; S is entropy of the system; E is the initial amount of total energy present in the system.

This shows that a body present at a relatively low energy level which has a high change in entropy, will be more conscious than a system with the opposite condition, and vice versa.

According to the above formula, the unit of consciousness is K^{-1} . [K is Kelvin (unit of temperature)]

However, consciousness shall not be confused to be the inverse of temperature.

Extending the theory

Statistical physics

Statistical physics is a relatively old, classical branch of physics which uses methods of probability theory and statistics, and particularly the mathematical tools for dealing with large populations and approximations, in solving physical problems.

We know the formula of Gibb's entropy (20) from classical statistical mechanics to be

$$S = -k_b \sum_i p_i \ln p_i$$

$$\text{And } dS = -k_b \sum_i dp_i \ln p_i$$

Therefore, equation of consciousness turns out to be

$$dC = \frac{-k_b \sum_i dp_i \ln p_i}{E}$$

Where, C is the consciousness of an isolated system, k_b is the Boltzmann constant, p_i is the probability of the system being in the microstate i , and E is the energy present in the system.

Now, according to Boltzmann principle (21), in statistical physics,

$$S = k_b \ln \Omega$$

Where, S is the entropy of the system, k_b is the Boltzmann constant, Ω is the number of microstates consistent with the given macro-states.

Therefore, we can also use Boltzmann principle to obtain value of consciousness of the system. However, the above formula, obtained by Gibb's entropy is just the generalization of the principle. Therefore, we shall stick with it.

Thermodynamics

Using thermodynamics, hundreds of equations may be derived using above text for particular given states of the system and surrounding. However, in this current article, we shall not derive those equations for the sake of simplicity.

Quantum physics

Quantum physics is a highly advanced and complex branch of physics. The most basic and fundamental equation of quantum physics is the very famous Schrödinger's equation which holds for a single particle, i.e.

$$\hat{E}\Psi = -\frac{\hbar^2}{2m}\nabla^2\Psi + \hat{V}\Psi = i\hbar\frac{d\Psi}{dt}$$

E can be replaced by $\hat{E}\Psi$ in the first equation to make the theory consistent with quantum physics. By replacing E by $\hat{E}\Psi$, we are basically defining an operator of consciousness with a set of eigenvalues just like the Hamiltonian operator. The function may be called as the consciousness operator. The operator is mathematically defined as the following:

$$\hat{C}\Psi = \frac{\Delta S}{\hat{E}\Psi}$$

The operator can be further simplified as:

$$\hat{C}\Psi = \frac{2\Delta S m}{-\hbar^2\nabla^2\Psi + \hat{V}\Psi(2m)} \quad \text{Or} \quad \hat{C}\Psi = \frac{\Delta S}{i\hbar} \left(\frac{\partial\Psi}{\partial t}\right)^{-1}$$

Where \hat{C} is the consciousness operator just like \hat{E} is the energy (Hamiltonian) operator.

Just like thermodynamics, hundreds of equations may be derived using equations formed in earlier researches for particular scenarios like the harmonic oscillator, quantum tunneling, and many more. Again, in this current article, we shall not derive those equations for the sake of simplicity.

Relativity

Just like above, hundreds of equations may be derived using equations formed in earlier researches and papers on relativity. Again, in this current article, we shall not derive those equations for the sake of simplicity.

Main purpose of this sub-section

The sub-section 'extending the theory' is provided in the article to show that theory can be easily used in major branches of physics as well as phenomenon, whether it be on a macroscopic or microscopic range, by using previous researches and data.

Consciousness in evolution

Now, let us discuss the role of consciousness in evolution. First, let's just start from that lame definition of entropy, which says that 'entropy is the order of randomness of a thermo-dynamical system'. When we think of the reasons for evolution, the very first one that comes to our mind is 'variations'. We know that variations are the slow and small changes in the genetic material, which occur during the formation of gametes (in sexual reproduction), or during asexual reproduction. It is basically the mistakes done by the DNA replication enzymes, like DNA polymerase, Helicase, Ligase, Primase, Sliding clamp, Topoisomerase, SSB. These mistakes often happen, because the enzymes bind at a wrong position during replication, which causes the change in the sequence of the base pairs of the DNA, which shows the random nature. The variations are completely random and thus, are directly proportional to the entropy of the DNA, and so does to consciousness. This shows that the more the consciousness of the system, the faster it will evolve. Not only the living systems, each system in the universe does evolve, but because of having very little consciousness, it evolves, slowly. If we check the history of the universe, it is evolving itself to a higher conscious state and thus, more complex. This may be interpreted as 'the universe is self-conscious!' we know that there are usually more microstates in a living system than a nonliving system. This is why the universe is expanding, to increase the microstates and thus the entropy, at the same energy level.

Now, let us think of this at the molecular level... we know that nearly every element is present in a so-called 'living body'. But, we know that the main constituents are organic molecules, made up of mostly carbon, nitrogen, and oxygen. If we compare the consciousness of any process performed by two different systems, one of which is 'living' and the other is 'nonliving', at the same energy, we would find out that the living system shows much more entropy change than a non-living in the same process, because of having more available microstates in any living system. This is because of the elements, mentioned above... they are the only elements which can make it possible for such a system. This explains why carbon is the most fertile molecule in this universe.

There are many other published articles which explain how evolution is predicted by quantum mechanics. One of them is (22)

We can explain this phenomenon in terms of coordination between particles. By general knowledge, we know that particles in a 'living system' are more coordinated than a so-called nonliving one or a less conscious living system. For example, brain shows way more coordination than any other body parts. So, we can also define coordination as a quantity in terms of relation between consciousness and its time taken to change the level of consciousness.

Therefore, the definition of coordination between two particles/systems can be written as

“The rate of change of consciousness with respect to time”

The above definition can be mathematically written as

$$dC_d = \frac{dC}{dt} \text{ Or } C_d = \frac{\Delta C}{\Delta t}$$

Where, C_d is the coordination of the system, C is the consciousness of the system and t is the time taken.

So, basically according to this theory, every system shows consciousness and is “living”, the only difference is the internal coordination of the systems.

Consciousness and dimensions (explaining big bang):

Consider the microstate before the big bang with zero-point energy (perfect quantum vacuum) (23). But when we go deeper and deeper, we would observe that this zero-point energy can be divided into two parts which have positive and negative energy. There is only one assumption in the theory, that those parts were conscious (they could create information). Now since the parts were conscious, quantum fluctuations will start as explained in (24), (25), and (26). The virtual particles started to increase. Now, since those particles were increasing, they first would travel in only one dimension, and then to second as the consciousness of the parts increases. This, in a simple way, can be explained that an increase in consciousness was the reason that the particles start travelling in a higher dimension. As mentioned above, it can be divided into two equal parts with opposite signs, $\frac{+x}{2}$ and $\frac{-x}{2}$. Now, since consciousness is intrinsic, the two parts must have equal and non-zero consciousness. However, the consciousness of the complete vacuum is infinite, as it is zero energy.

Let $\hat{C}\Psi_+$ be the consciousness of the positive part and $\hat{C}\Psi_-$ be the consciousness of the positive part.

$$\text{We get, } \hat{C}\Psi_+ = \left| \frac{2\Delta S}{x} \right| = \hat{C}\Psi_- \text{ (consciousness cannot be negative)}$$

The above discussion explains the big bang as a formation of information towards a negative and a positive part, such that its entity as a whole is zero. According to this, the zero-energy present at any point (zero dimension) in a complete quantum vacuum, divided into two parts, a positive and a negative, which initially traveled in one dimension and then to the second and then third, and so on. Let's mathematically explain this through mathematical equations. The negative energy can be dark matter/energy as explained in (27)

By solving for x (energy of the state) at 0 potential (the microstate before the big bang was a complete quantum vacuum with zero potential) by Schrödinger's equation, we get the equation for consciousness at big bang as follows.

$$\hat{C}\Psi = \frac{i\Delta S\sqrt{2}}{\hbar c\sqrt{V^2\Psi}}$$

For the above equation to be consistent, $\Delta^2\Psi < 0$ (negative), as consciousness, can't be imaginary.

This also shows that $\Delta S(\nabla^2\Psi)^{-1} \propto \hat{C}\Psi$.

So, as consciousness increases, the number of dimensions containing energy increases.

This means that consciousness is responsible for energy to travel towards higher dimensions.

This shows that an infinite number of dimensions are possible for our universe and each dimension has its consciousness level, after attaining which the energy will be present in that given dimension.

Let's take a classic example to understand this. Consider a particle in a box. As you increase its energy, its quantum field starts to increase the number of dimensions it is embedded in. Our universe also behaves the same way. There is no else possibility for our universe to exist.

However, in the present universe, the energy of every single particle is present in infinite dimensions but it decreases, as we move towards higher dimensions (just like the behavior of an electron in its orbital of the atom).

Let the infinite dimensions possible be $x_1, x_2, x_3...$

We also obtained above that the wave function must be negative.

From the above results, if we think about the wave function, which could describe such a process in such a system, we get that wave function of big bang must be given by

$$\Psi_{BB} = -(c_{\infty}x_{\infty}^3 + c_{\infty-1}x_{\infty-1}^3 \dots + c_3x_3^3 + c_2x_2^3 + c_1x_1^3)$$

Where x_1, x_2, \dots, x_n are the displacements of energy in the respective dimension.

Such that $c_{\infty}, c_{\infty-1}, \dots, c_3, c_2, c_1$ are constants with units metre^{-3} (wave functions have no dimensions) and as we know from the string theory, that higher dimensions are present but at very small scale, with very high entropy change rate, $c_{\infty} < c_{\infty-1} < \dots < c_3 < c_2 < c_1$.

The above equation also predicts that the higher dimensions exist at all microstates, but they are not significant enough, to be experienced by any human or any technological program, or system. That is why; experiencing the effects of these higher dimensions and their curvature would only be possible at very small microstates, similar to as explained by the string theory (28).

Now, if we think more about the above wave function and imagine it, we will find out that it is like a big bang at every coordinate of this universe. We may explain it as the reason for the formation of the higher dimensions. The vibration of the virtual particles makes more virtual particles, which, being formed at a higher energy level microstate would travel at a much higher dimension. This is why; entropy of the universe always increases and never decreases.

We know, usually, in particle physics, scientists bombard different sub-atomic particles on each other. Some think that the so much energy produced, will make them travel in higher dimension, which could be used as a proof of higher dimension, but they are wrong, they don't need to create a high energy state system, but they need a system where the entropy change is very high and the energy state is very low.

Discussion:

Artificial intelligence

Information theory(29) given by Dr. Shannon had a huge role in invention and development of computers. In the theory, as described above, information transfer in computers and other devices was measured in terms of entropy. This theory of consciousness can similarly contribute to huge developments in the field of computers and especially artificial intelligence by increasing the consciousness of the devices, as artificial intelligence is basically intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans and animals.

Predictions by quantum mechanics

Since the theory can be applied at the quantum world too, it can increase the sensitivity of quantum mechanics, and may even explain Heisenberg's uncertainty principle as a result of consciousness of the observer and system.

Medications in the neurological field

We can improve the medications in the neurological field by checking which compounds substantially increase the consciousness of neurons, individually and as a whole in the brain.

Increase the Control and perception of the environment

One of the reasons that 'living' organisms are known to be 'special' is that they can sense/perceive and try to control their environment/surroundings by different methods. Unicellular organisms as well as advanced organisms show this ability. By increasing the consciousness in 'non-living' systems, we can expect similar results.

Law of attraction

In the New Thought philosophy, the law of attraction is the belief that positive or negative thoughts bring positive or negative experiences into a person's life. However, the law is not yet scientifically backed, but if true, can be explained using this theory. The theory explains consciousness in terms of entropy formed by the system/person. Every person/system while thinking always increases entropy and thus, interacts with other systems of the surrounding which forms consciousness and thoughts alter the reality.

Evolution

Evolution is usually perceived as mistakes. However, according to the theory every organism/system moves towards higher conscious state, which causes evolution. Thus, according to the theory evolution is not a mistake, but a reasonable work by nature to increase the entropy of the universe faster, by increasing the consciousness through generations/time.

Biotechnology

We can use the theory in understanding the concepts of biotechnology, biophysics and biomechanics.

Working of the brain

Brain is one of the most conscious parts of the body. With this theory, we can explain the working of the brain better. For example, a large amount of neurons causes the brain to form

information/entropy faster as the more number of neurons result to more microstates, and thus more consciousness.

Expected reaction time

More conscious organism will have a higher reaction time, as compared to less conscious organism. Using this, we can compare the reaction time without experimentation on the organism.

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Consent for publication

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Availability of data and materials

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The authors declare that they have no competing interests

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