Mechanism of Universal Quantum Computation in the Brain
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Abstract
In this paper the authors extend [1] and provide more details of how the brain may act like a quantum computer. In particular, positing the difference between voltages on two axons as the environment for ions undergoing spatial superposition, we argue that evolution in the presence of metric perturbations will differ from that in the absence of these waves. This differential state evolution will then encode the information being processed by the tract due to the interaction of the quantum state of the ions at the nodes with the ‘controlling’ potential. Upon decoherence, which is equal to a measurement, the final spatial state of the ions is decided and it also gets reset by the next impulse initiation time. Under synchronization, several tracts undergo such processes in synchrony and therefore the picture of a quantum computing circuit is complete. Under this model, based on the number of axons in the corpus callosum alone [2], we estimate that upwards of 15 million quantum states might be prepared and evolved every millisecond in this white matter tract, far greater processing than any present quantum computer can accomplish.

1 Introduction: a Gedanken Experiment
As per Tegmark [3], the smallest neuron imaginable, with only a single ion traversing the cell, would have a decoherence time of $10^{-14}$ seconds. As per [4], gravitational waves with strains of the order of $h = 10^{-16}$ will have an impact on axon tract information processing at the time order of $10^{-14}$ seconds to $10^{-18}$ seconds. Multiply each of the above three time periods by $10^{17}$ to get $10^0$ seconds, $1000$ seconds and $1$ second. Thus, if I start my clock now and a neuron can stay coherent for $1000$ seconds, then in parallel I can consider the other two numbers. That is, I will send along (in the past) a gravitational wave in the direction of my neuron tract. Say at $t = 0$ it interacts with the axon tract. As a result, if in its absence there was $0$ time difference between action potential initiation times on the two axons, in its presence this increases to say $100$ seconds. As information is time coded in the brain, the organism can sense the fact that there is some timing differential in progress. But can it do something with this information? Well, suppose the wave is switched on
and off 3 times, then about 300 seconds of time differential is accumulated by the tract input-output. But each of the neurons in the tract was in a quantum state during this time. This implies that the tract itself was in a joint quantum state. Now in the absence of these 3 switches, the quantum state would be preserved, but due to the 3 switches, it would get perturbed to a different state. This transformation can then be measured quantum mechanically, in order to detect the passage of 3 switches of a gravitational wave. If no measurement is performed, then because the coherence time is an additional 700 seconds, the perturbed quantum state would in principle be held for another 700 seconds. In contrast if the coherence time was say 0.1 second, then there would be no initial quantum state which could be perturbed 3 times gently to another quantum state and we would strictly be in the classical domain.

The perturbed quantum state is held for 700 seconds. This quantum information can, if it is part of a larger tract quantum state, be considered as a new state of the larger tract. In other words, the gravity wave induced a "quantum operation" on part of the brain. Several such different gravity waves can impinge sequentially or in parallel in different brain regions, carrying out a quantum computation in the brain. The moment the computation is over, say, the coherence time elapses and a decohering mechanism such as a measurement is carried out on the brain. This measurement thus reads out the result of this quantum computation. In other words, the brain can act like a quantum computer [1].

Our paper is structured as follows. In Section 2 we provide a review of Tegmark's paper and its implications and differences as compared to the present work. In Section 3 we look in detail at the action potential level, going further down to the quantum level. Finally, we conclude in Section 4.

2 Review of Prof. Max Tegmark’s Results

Tegmark's paper contains decoherence computations. He divides the problem into ion-ion, ion-water and other decoherence mechanisms. For each such mechanism, he considers a superposition of ions between the inside and the outside of the cell. Within say the ion-ion collision mediated decoherence section, he computes how long the spatial superposition state will stay quantum mechanical. His estimates yield the conclusion that decoherence precludes a significant role for quantum features because the characteristic time of a neuron is the action potential duration of 2 ms, according to him. He also considers microtubules and the associated decoherence times.

This absence of quantum effects can be used to argue that the brain and conscious processes can be entirely explained in terms of classical physics. In the present paper however, we show that the entire universe in a sense has a say in the quantum computation being performed in each part of the brain and the action potential is a very 'summed up' or 'gross' indication of what is happening at the deeper physical layers of the brain[1].

As opposed to the data layer [5].
3 Mechanism of Quantum Computation

Consider two slightly temporally displaced action potentials, as shown in Figure 1.

Figure 1: Two slightly displaced (in time) action potentials, $V_1$ representing axon 1 (top) and $V_2$ representing axon 2 (bottom). The temporal gap $a$ is indicated at an arbitrary temporal location.

Due to the gravitational wave, the temporal gap between the two action potentials, $a$, takes the value $a_1$ seconds during its presence and $a_2$ seconds during its absence. Suppose that $V_2 - V_1$ induces the quantum environment of an ion in the node of Ranvier (please see Figure 2).

Figure 2: Environment in the presence (left) and absence (right) of the gravitational wave.

Thus the potential $V(x)$ that enters into the Schrodinger evolution equation will be different during the presence and the absence of the gravitational wave. That is, the evolution will be different in the two cases. Again, if a different
gravitational wave-tract interaction takes place, the evolution will be yet of another type. Post evolution and subsequent decoherence, and following further classical evolution (see Figure 3), the action potential initiation process of the cell starts up again and this re-prepares a quantum state of the tract.

Figure 3: Quantum trajectory concatenated with a longer classical trajectory of the state of the tract with and without the presence of gravitational radiation.

Suppose there are a few tracts, each with synchronized impulses, where the synchronization has taken place using a combination of electric fields (between tracts) and currents (intratract) \( [6] \). At a particular instant say \( t_a \), all the axons are synchronized, and a joint quantum state is prepared on each of the axons. If there is a way for us to show that this joint state is actually entangled, then it results in more interesting processes taking place in the tract. But regardless, the joint quantum state of the ions will evolve under the influence of slightly different gravitational impact on each axon. And because there is this parallel evolution, we have the process of a quantum circuit evolution taking place. This is illustrated in Figure 4.
Figure 4: Quantum computation in synchronized axon tracts. The square blocks are where there is interaction with gravitational radiation, resulting in quantum operations. The triangular blocks at the end represent the points where the quantum computation comes to an end due to ensuing decoherence.

4 Limitations and Future Work

In this paper, we could have set up a mathematical framework for the entire process of quantum computation, but did not do so. We felt that there are adequate presentations of quantum computation in the literature. Our main goal was to present the novel aspect, namely that these computations can take place in the coherence window and the external ‘control’ or ‘direction’ is provided by impinging metric perturbations. In future work we need to investigate and demonstrate a mechanism for entanglement between the various tracts.

To conclude, this paper has pushed forward our understanding of how man and his universe are integrated as one inseparable whole, even at the level that at least some aspects of what man thinks and does are enabled and directed by fundamental phenomena in the universe.

References

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