Quantum Teleportation Mechanism between Retina and the Visual Cortex

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Abstract
The nature of the brain processes is a debatable problem, and there are many conclusions in this realm. Penrose and Hameroff believe that the nature of brain processes is quantum mechanical. However, Max Tegmark asserts that the processing in the nervous system is classical. The other physicist, Thaheld, concludes that because of the collapse of the coherent light (i.e. quantum mechanical information) in the Retina, there is no collapse of any state in the human brain. In this paper, we assert that none of them is wrong. We believe that each of them describes some aspect of the quantum teleportation mechanism. We present a model for visual consciousness which is based on the quantum teleportation mechanism.

1-Introduction

There are a wide range of specific theories and models that have been proposed, appealing to a variety of quantum phenomena to explain a diversity of features of brain processes in general and consciousness in particular.

Roger Penrose and *Stuart Hameroff* have presented a model to describe different properties of consciousness. Their model (i.e. Orch OR model)[1,2] is based on the structures called cytoskeletons. They assert that the main processing in the neurons of the brain is performed in the hollow cylinders (i.e. microtubules) in these structures and the nature of the processing is {mainly?} quantum mechanical. The processing unit in their model is *tubulin* which can be in a superposed state (fig.1). Tubulins act like qubits in quantum computers.

Max Tegmark [3] believes that the system of neuron in the brain can not be included in any quantum processing for the brain processes. In accordance to Tegmark conclusions, considering the central processes of neuron firing, one may study a superposition of a neuron in "firing" and "non-firing" state. These two states differ in the location of millions of Na^+ and K^+ ions separated by a membrane by a distance of several nanometers. Possible decoherence mechanism include collisions with other ions or water molecules and long-range coulomb interaction with distant ions. These mechanisms cause to collapse the superposition of ions very fast before that any brain process performs, so this behavior of neuron is completely classical.

Thaheld asserts that there's no any possibility to transfer quantum information from the retina to the visual cortex, since the retina is a rigid obstacle for coherent light and it does collapse the quantum information. [4,5,6]

Briefly, we can classify above conclusions as follows:

Orch OR model	*Collapse in the BRAIN* *quantum processing in the brain*
Tegmark conclusion	*There is no collapse* *classical processing in the brain*
Thaheld conclusion	*Collapse in the EYE* *classical processing in the brain*

The question is, ***" Who is right?"***

2- Teleportation mechanism between retina and the visual cortex

We, however, in our model which we would presented later in this paper, claim that this authors are neither *completely* right or *completely* wrong, but each present part of the truth, which through our model we could see how the whole processing, at least virtual consciousness, emerge naturally. In other hand, everyone describes some aspects of the quantum teleportation mechanism.

Table 1 Simulation of the transferring visual information from the eye to the brain to the Teleportation mechanism.

Human Brain	*Quantum Teleportation Mechanism*
Retina	Alice
Membrane of axons in neurons	Classical channel
Cytoskeletal structures	Entangled channel
Visual cortex	Bob
Light	Quantum information

Our simulation is based on Brassard teleportation circuit[7].

Cytoskeletons are found mostly among the retina and the visual cortex in the cells of optic nerve. There are many reasons that these structures can be entangled with each other:

1. Superradiance and self-induced transparency occurring in ordered water within the hollow core of cylindrical microtubules behaving as waveguides will result in coherent photons. This coherence, estimated to be capable of superposition of states among microtubules spatially distributed over hundreds of micrometers, which in turn are in superposition with other microtubules hundreds of micrometers away in other directions and so on, could account for a coupling of microtubule dynamics over wide areas[8].
2. Because mitosis (cell division) is organized by centrioles and requires precise, mirror like activities, quantum entanglement mediated by quantum optical effects between centrioles has been proposed by Stuart Hameroff[9].
3. In accordance to Frohlich oscillations, the single mode, which can exhibit long range correlations is thus akin to laser like coherent pumped phonons in the range of 10^9 to 10^{11} Hz[10,11,12]
4. While in superposition, tubulins communicate/compute with entangled tubulins in the same manner, and in microtubules in neighboring neurons, and through macroscopic regions of brain via tunneling through gap junctions and possibly tunneling nanotubes.[13]
5. The synaptic β-neurexin/neuroligin-1 adhesive protein complex is claimed to be not just the core of the excitatory gluta matergic CNS synapse, instead it is a device mediating entanglement between the cytoskeletons of the cortical neurons. Thus the macroscopic coherent quantum state can extend throughout large brain cortical areas and the subsequent collapse of the wave function could affect simultaneously the subneural events in millions of neurons.[14,15,16]

2-1. What happens?

STEP 1:

According to a paper by Schlouschauer [17], the interaction of light and rhodopsin creates a superpositioned state of rhodopsin which is correlated to special states of neurons in the visual cortex. The first gate L, converts the state of rhodopsin $|\cdot\rangle$ to a superpositioned state: $\frac{1}{\sqrt{2}}(|0\rangle+|1\rangle)$ .After that, we can write three qubits as follows:

$$|\psi\rangle$$
$$\frac{1}{\sqrt{2}}(|0\rangle+|1\rangle)$$
$$|0\rangle$$

STEP 2:

Rhodopsin is a membrane structure, and microtubules interact with membrane structures mechanically by linking proteins, chemically by ions and second messenger signals, and electrically by voltage fields. This interaction entangles rhodopsin with cytoskeletal structures.

This step entangles the two bottom lines using the Controlled-NOT gate. Here, the control line is the state of rhodopsin and denoted c, and the data line is tubulin and denoted d.

With using CNOT gate, cytoskeletal structures and rhodopsin would be entangled with each other.

$$\oplus\frac{1}{\sqrt{2}}(|0\rangle_c+|1\rangle_c)|0\rangle_d=\frac{1}{\sqrt{2}}(\oplus|0\rangle_c|0\rangle_d+\oplus|1\rangle_c|0\rangle_d)$$

$$=\frac{1}{\sqrt{2}}(|0\rangle_c|0\rangle_d+|1\rangle_c|1\rangle_d)$$

The state of the circuit at this stage is:

$$|\psi\rangle$$
$$\frac{1}{\sqrt{2}}(|0\rangle|0\rangle+|1\rangle|1\rangle)$$

STEP 3:

The next operation entangles $|\psi\rangle$ with the middle qubit, which is already entangled with the bottom qubit. This means that three lines can be entangled with each other.

The light interaction with rhodopsin which was entangled with cytoskeletal structures before, causes to entangle three lines.

$$\oplus|\psi\rangle_c\frac{1}{\sqrt{2}}(|0\rangle_d|0\rangle+|1\rangle_d|1\rangle)$$
$$=\frac{1}{\sqrt{2}}\oplus(a|0\rangle_c+b|1\rangle_c)(|0\rangle_d|0\rangle+|1\rangle_d|1\rangle)$$
$$=\frac{1}{\sqrt{2}}(a(\oplus(|0\rangle_c|0\rangle_d)|0\rangle+\oplus(|0\rangle_c|1\rangle_d)|1\rangle)$$
$$+b(\oplus(|1\rangle_c|0\rangle_d)|0\rangle+\oplus(|1\rangle_c|1\rangle_d)|1\rangle))$$
$$=\frac{1}{\sqrt{2}}(a(|0\rangle_c|0\rangle_d|0\rangle+|0\rangle_c|1\rangle_d|1\rangle)+b(|1\rangle_c|1\rangle_d|0\rangle+|1\rangle_c|0\rangle_d|1\rangle)$$

In this time, light and rhodopsin and cytoskeletal structures are entangled with each other. The state of retina is no longer in a state that would let us isolate any of the lines.

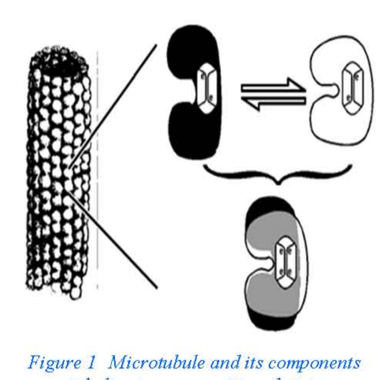

Figure 1 Microtubule and its components tubulins in superpositioned state

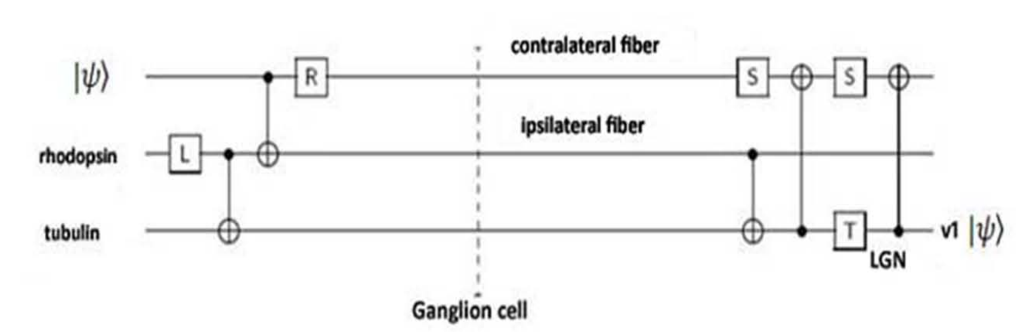

Figure 2 Simulation of the Brassard teleportation circuit with main visual pathway in the human brain

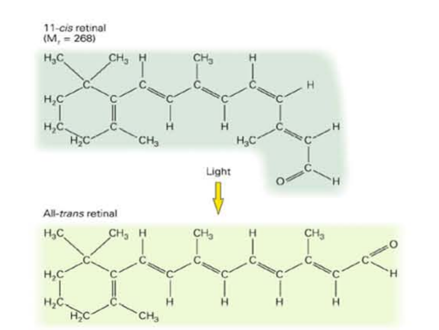

Figure3 Rhodopsin molecule in two states: cis and trans

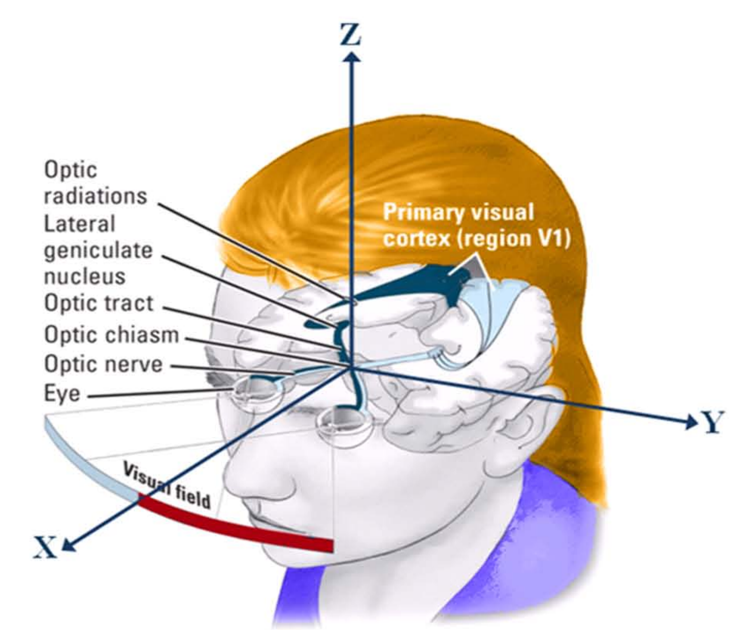

Figure 4 Ipsilateral fibers and contralateral fibers rotate around the z axis

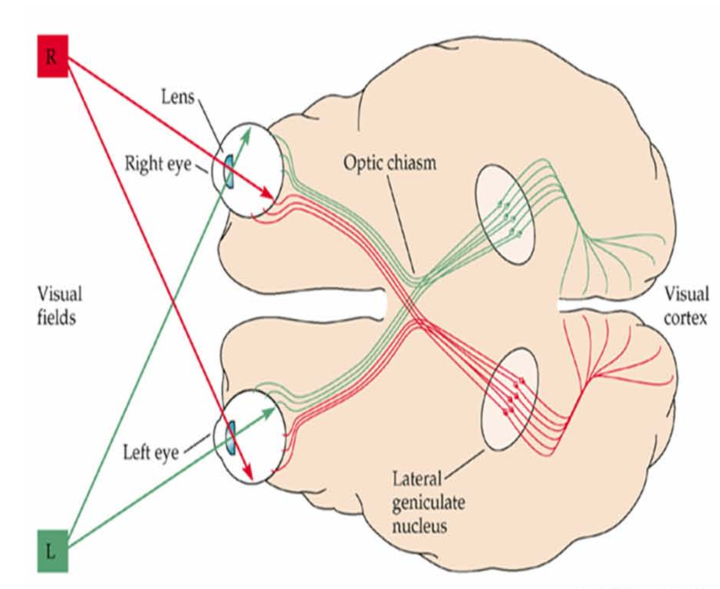

Figure 5 The main visual pathways in the human brain

STEP 4:

After collision of light with rhodopsin, rhodopsin naturally decoheres . For this case, operator R operates on this state which means that the branch connected carbon-11 of rhodopsin rotates 90 degrees to right:

$$R=\frac{1}{\sqrt{2}}\begin{pmatrix}1&1\\-1&1\end{pmatrix}$$

$$R\frac{1}{\sqrt{2}}(a(|0\rangle_R|0\rangle|0\rangle+|0\rangle_R|1\rangle|1\rangle)$$
$$+b(|1\rangle_R|1\rangle|0\rangle+|1\rangle_R|0\rangle|1\rangle))$$
$$=\frac{1}{\sqrt{2}}(a(R|0\rangle_R|0\rangle|0\rangle+R|0\rangle_R|1\rangle|1\rangle)$$
$$+b(R|1\rangle_R|1\rangle|0\rangle+R|1\rangle_R|0\rangle|1\rangle))$$
$$=\frac{1}{\sqrt{2}}(a(\frac{1}{\sqrt{2}}(|0\rangle_R-|1\rangle_R)|0\rangle|0\rangle+\frac{1}{\sqrt{2}}(|0\rangle_R$$
$$-|1\rangle_R)|1\rangle|1\rangle)$$
$$+b(\frac{1}{\sqrt{2}}(|0\rangle_R+|1\rangle_R)|1\rangle|0\rangle+\frac{1}{\sqrt{2}}(|0\rangle_R+|1\rangle_R)|0\rangle|1\rangle))$$
$$=\frac{1}{2}(a|0\rangle_R|0\rangle|0\rangle-|1\rangle_R|0\rangle|0\rangle+|0\rangle_R|1\rangle|1\rangle-|1\rangle_R|1\rangle|1\rangle)$$
$$+b(|0\rangle_R|1\rangle|0\rangle+|1\rangle_R|1\rangle|0\rangle+|0\rangle_R|0\rangle|1\rangle+|1\rangle_R|0\rangle|1\rangle))$$

At this stage we reach the measurement point. At this point, light and rhodopsin decohere naturally. This is equivalent to collapse of the quantum information $|\psi\rangle$ in the retina.

This operation causes to collapse the state to one of four states. $|00\rangle, |01\rangle, |10\rangle, |11\rangle$

This process forces the bottom qubit (tubulin) into a state that is commensurate with whatever the upper qubits become and with the original quantum state of all three qubits.

We assume that it collapses to $|01\rangle$, or in other hand to : $a|011\rangle+b|010\rangle$

Information from receptors is transferred both radially across and trans-retinally through the retina. The transretinal organization passes through the bipolar cells. In addition to convergence along the transretinal pathway the horizontal and amacrine cells provide the mechanism for the lateral spread of information radially across the retina. Except for the ganglion cells, none of the retinal cells display action potentials (digital forms i.e. classical states).

Suppose the upper two lines decohere to $|0\rangle|1\rangle$. This filters the state of the system into a state proportional to

$$a|0\rangle|1\rangle|1\rangle+b|0\rangle|1\rangle|0\rangle$$

No possible measurement outcome results in information loss about either a or b.

The first operation on the right hand side applies $\oplus$ to the second and third line. We continue with our convention of making control and data qubits with c and d.

$$a|0\rangle\oplus(|1\rangle_c|1\rangle_d)+b|0\rangle\oplus(|1\rangle_c|0\rangle_d)=a|0\rangle|1\rangle_c|0\rangle_d+b|0\rangle|1\rangle_c|1\rangle_d$$

STEP 5:

Axons leaving the temporal half of the retina traverse the optic nerve to the optic chiasm, where they join the optic tract and project to *ipsilateral* structures. Axons leaving the nasal half of the retina cross the midline at the chiasm and terminate in *contralateral* structures. This arrangement means that all the axons in the optic tract carry information about the contralateral visual field. Axons of the optic tract terminate in 3 areas of the central nervous system, the lateral geniculate nucleus (LGN), the superior colliculus and the pretectal area.

The contralateral fibers rotates in the middle of path, but toward this point ipsilateral fibers approximately are straight.

Now the upper line is equivalent to contralateral fibers and is passed through S gate.

Gates S and T represent a combination of rotations about the z axis with a multiplication by a fixed global phase-shift:

$$S=\begin{pmatrix}i&0\\0&1\end{pmatrix}=e^{i\pi/4}\begin{pmatrix}e^{\frac{i\pi}{4}}&0\\0&e^{\frac{-i\pi}{4}}\end{pmatrix}$$
$$T=\begin{pmatrix}-1&0\\0&-i\end{pmatrix}=e^{\frac{i\pi}{4}}\begin{pmatrix}e^{\frac{i3\pi}{4}}&0\\0&e^{\frac{-i3\pi}{4}}\end{pmatrix}$$

Now, the contralateral fiber is passed through the S gate, which in this case simply multiplies $|0\rangle$ by i, so that the state of the fiber becomes:

$$ia|0\rangle|1\rangle|0\rangle+ib|0\rangle|1\rangle|1\rangle$$

STEP 6:

The trajectory through the LGN is the largest most direct, and clinically most important pathway by which visual information reaches the cerebral cortex. About %80 of the optic tract axons synapse in the LGN. The LGN is a laminated structure, having 6 layers. contralateral fibers and ipsilateral fibers couple in the LGN. The *ipsilateral* fibers of the optic nerve terminate in laminae 2, 3 and 5 of LGN, while the *contralateral* fibers terminate in laminae 1, 4 and 6 of LGN.

For the circuit, the next operation couples the contralateral fiber and the cytoskeletons. At this time, tubulins control the gate. Again our subscript convention help:

$$\oplus(ia|0\rangle_d|1\rangle|0\rangle_c+ib|0\rangle_d|1\rangle|1\rangle_c)$$
$$=ia|0\rangle_d|1\rangle|1\rangle_c+ib|1\rangle_d|1\rangle|1\rangle_c$$

Now we apply S gate to contralateral fiber and T gate to ipsilateral fiber:

$$ia\hat{S}|0\rangle_s|1\rangle\hat{T}|0\rangle_T+ib\hat{S}|1\rangle_s|1\rangle\hat{T}|1\rangle_T$$
$$=a|0\rangle|1\rangle|0\rangle+b|1\rangle|1\rangle|1\rangle$$

And finally after applying inverse Controlled-NOT gate:

$$\oplus(a|0\rangle_d|1\rangle|0\rangle_c+b|1\rangle_d|1\rangle|1\rangle_c)$$
$$=a|0\rangle_d|1\rangle|0\rangle_c+b|0\rangle_d|1\rangle|1\rangle_c$$
$$=|0\rangle|1\rangle\begin{pmatrix}a\\b\end{pmatrix}=\Psi$$

There are about 10^6 neurons in each LGN, all of which project to the ipsilateral occipital cortex (area 17) as the optic radiations. The portion of the cerebral cortex that receives LGN axons is called the striate cortex and is usually labled V1 to designate it as the primary visual cortical area.

Most of the remaining axons of the optic tract terminate in the superior colliculus receives both retinal and cortical visual information, the latter descending from V1.

Virtually all information in the visual system is recognized as being processed by V1 first, and then passed out to higher order systems[18].

We see that according to Brassard teleportation circuit, the initial information of light can emerge in the primary visual cortex and can be processed to transfer to another areas of the brain to emerge consciousness.

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