

# Neural Correlate of Consciousness in a Single Electron: Radical Answer to “Quantum Theories of Consciousness”

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## ABSTRACT

In recent years, so-called “quantum theories of consciousness” become popular. Most of them suggest that human phenomena consciousness (and “self”) may be associated with macroscopic collective quantum phenomenon such as Bose-Einstein condensate. Macroscopic quantum system behaves, in some sense, like a single huge super-particle, and this seem to solve the problem of the unity of consciousness. These ideas are, however, not in a good agreement with contemporary physics. The ability of “quantum theories of consciousness” to explain correctly the unity of consciousness also seems questionable to some authors. In this paper we suggest a radical alternative: we argue that human consciousness may be a property of single electron in the brain. We suppose that each electron in the universe has at least primitive consciousness. Each electron subjectively “observes” its quantum dynamics (energy, momentum, “shape” of wave function) in the form of sensations and other mental phenomena. However, some electrons in neural cells have complex “human” consciousnesses due to complex quantum dynamics in complex organic environment. We discuss neurophysiological and physical aspects of this hypothesis and show that: (1) single chemically active electron has enough informational capacity to “contain” the richness of human subjective experience; (2) quantum state of some electrons might be directly influenced by human sensory data and have direct influence upon human behavior in real brain; (3) main physical and philosophical drawbacks of “conventional” “quantum theories of consciousness” may be solved by our hypothesis without much changes in their conceptual basis. We do not suggest any “new physics”, and our neuroscientific assumptions are similar to those used by other proponents of “quantum consciousness”. However, our hypothesis suggest radical changes in our view on human and physical reality.

**Key Words:** unity of consciousness, binding problem, single cell consciousness, single particle consciousness, pontifical cell, pontifical particle, quantum consciousness

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## 1. Introduction to the problem of the unity of consciousness

The problem of the *unity of consciousness* (*unity of mind*) is one of the most important problems in the philosophy. It is closely related to (and often completely associated with) *binding* (*combination*) problem (Cleeremans, 2003). In this paper, we will use these terms as synonyms. The problem of the

unity of consciousness may be summarized as follows. Subjective experience of a single person consists of many phenomena (sensations, thoughts, emotions, volitional acts), but all of them are “observed” by the single *observer* (*subject*, “*self*”). It is hard to imagine 1.5 or 2.3 observers. Some authors such as Searle (2002) even suggest that no “separate” subjective phenomena exist at all. Consciousness is unified in space and time. Term “*spatial unity*” means that single observer has sensations produced by many different sensory organs. Some factor unifies (*binds*) them into a single state of consciousness. Term “*temporal unity*” means that single observer has sensations at many different time moments. Some factor unifies

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(binds) many states of consciousness into a single “stream” of consciousness. Due to temporal binding, observer is not only a holistic, but also an indivisible and self-identical thing. However, brain is not an indivisible object, and its physical and informational states in different time moments are not identical. Observer (“self”, subject) has some features that are absent in most of physical systems, and this is a problem.

In 17<sup>th</sup> century, Rene Descartes supposed that the observer is not a physical object, because any physical object may be divided onto parts. Therefore, the world consists of two radically different substances: indivisible subjects (souls) and divisible objects (matter). Today we know that this Cartesian argument was wrong: physical reality also consists of indivisible elementary particles such as quarks and leptons. However, human body and brain are not the indivisible objects. And 20<sup>th</sup> century’s science has shown that this “metaphysical” problem may be directly related to practical questions.

In common life, we believe in dogma “one brain – one person”. Any two neurons of a single brain are connected, and we suppose that they produce a single unified experience. Brains of different humans have no direct connection, and we suppose that they produce different experiences. However, this simple intuition fails to explain some mental disorders, when human demonstrates the behavior, which may be interpreted as a result of coexistence of two consciousnesses in his brain. Especially prominent “split” of consciousness occurs after surgical separation of brain hemispheres (sometimes used for the treatment of epilepsy). This separation is always partial, and it may be said that any two neurons remain connected through other neural tissue. However, there were many reports that such human seem to have two independent minds: left hemisphere controls right hand and speech, while the right one controls left hand (Sperry, 1966; Gazzaniga, 1970). Until today, there is no clear explanation of this effect. One group of authors supposes that consciousness literally splits during surgery (therefore, it might be not truly indivisible) (Nagel, 1971), second group supposes that there are two consciousnesses in any brain even before surgery (Puccetti, 1973), and third group supposes that there is only one consciousness

even after surgery (Marks, 1981). Similar hard questions accompany the phenomenon of *craniopagus* - conjoined twins directly connected with brains. Most of such people die in early childhood, and they do not report their subjective experience. However, there is at least one incredible case of Tatiana and Krista Hogan (Roberts, 2011), who are 5yo now. A “bridge” connects their thalami, and each twin observes sensory data from sense organs of other twin. However, each twin controls only her own limbs and demonstrates her own behavior. Each twin literally “has” four eyes and ears; however, their “selves” are not unified.

So what is “self”? Where is its “boundaries”? Which factor unifies many neural signals into a single personality? The question is so hard that many scientists suppose that the unity of consciousness (at least, temporal) might be just a kind of illusion (Dennett, 1991; Nagel, 1971; Shadlen and Movshon, 1999), and it does not require explanation. This highly controversial *eliminativist* approach is rather popular today, but in the limited framework of this paper we will not discuss it.

## 2. Disclaimer

In this paper, we postulate that both spatial and temporal binding really exist and require scientific explanation. In other words, we postulate the unity of consciousness in a strong Cartesian-like form. We understand that this assumption might seem too strong for some readers, but this is a normal scientific practice to analyze some problem only in the framework of some controversial assumption.

The goal of this paper is to demonstrate a novel hypothesis about the nature of consciousness, but not to prove it rigorously. We believe that its verification (or, at least, falsification) is possible in a scientific study of intracellular informational processes. Therefore, we do not declare complex philosophical apparatus in this paper and do not pretend to comprehensive analysis of all possible unclear philosophical aspects.

Term “consciousness” is used in this paper in the phenomenal sense, as a synonym of “subjective reality”: perception, volition, mental images, and emotions. However, such things as intellect or memory might be related



to consciousness but not definitely identified with it.

### **3. Popular explanations of the unity of consciousness and their drawbacks** **Classical informational / functional hypotheses**

Traditional view of 20<sup>th</sup> century was that consciousness is unified by some “holistic” properties of brain functioning. In particular, there may be some information integration due to which brain acts as an indivisible “information machine”. Other popular functional explanation of binding is a neural synchronization. Consciousness might be produced by a network of synchronized neurons generating same signals (Crick, 1995). If this network would be divided on two independently synchronous sub-networks, then two consciousnesses would appear.

#### **Specific drawbacks**

Any definition of “indivisible informational system” is contingent, while indivisibility of consciousness seems to be a fundamental feature that can’t depend on our definitions (Ivanov, 1998; Bayne and Chalmers, 2003). In particular, any synchronization of classical computational units is just a temporal correlation between many processes. This correlation may be more or less precise, but never ideal.

#### **Macroscopic quantum state hypothesis**

According to this hypothesis, consciousness is related to some macroscopic collective quantum phenomenon, which, in some sense, behaves as a single super-particle. The most prominent and famous proponents of this hypothesis are Roger Penrose and Stuart Hameroff (Hameroff and Penrose, 1996; Hameroff, 2006). Macroscopic quantum state hypothesis is similar to functional synchrony hypothesis, but it supposes quantum, not classical, synchronization between neurons. Penrose and Hameroff suppose that consciousness is produced by a network of neurons connected by *gap junctions*. This network is a *syncytium* – a “hyperneuron” with common cytoplasm and many nuclei (Draguhn *et al.*, 1998; Hameroff, 2006). Authors suppose that in this syncytium, microtubules (components of cytoskeleton) form a collective quantum state. Hameroff claims that some electrons in microtubules are

close enough to become quantum entangled and form a Bose-Einstein condensate or Fröhlich condensate (Fröhlich, 1968). He supposes that this condensate could extend to many neurons via gap junctions.

#### **Specific drawbacks**

The existence of long-term microscopic and especially macroscopic coherent effects in cytoskeleton is considered as a questionable idea by physicists (Tegmark, 2000). Hameroff and Penrose believe that standard quantum limitations do not work in this case, and microtubule dynamics should be described by special quantum “OR” model originally introduced in (Penrose, 1994). This model, however, is also very controversial, and its experimental verification remains problematic.

#### **Single cell / microscopic quantum state hypothesis**

A significant number of authors do not support the idea of macroscopic coherency. From the physical viewpoint, microscopic intracellular collective quantum effects are more realistic than macroscopic. In particular, coherent intracellular behavior might exist in microtubules (due to mentioned-above mechanisms, but without intercellular coupling) or in cellular membrane (Bernroider and Roy, 2004). This idea, however, leads to radical philosophical conclusion that single neuron may be individually conscious (Zeki and Bartels, 1999; Bieberich, 2002; Edwards, 2005; Sevush, 2006). In 19<sup>th</sup> century, William James supposed that human consciousness exists in special “*pontifical cell*” (PC) in brain (James, 1890). This idea was criticized, but never disproved rigorously. Today’s proponents of single cell consciousness hypothesis suppose that, in principle, there might be many synchronized PCs with similar subjective experiences (Bieberich, 2002; Edwards, 2005; Sevush, 2006). Each neuron is conscious, but only several neurons (PCs) have highly developed consciousnesses (sharing almost the same sensations and performing almost the same volitional actions). Authors provide neuroscientific hypotheses, where PCs may exist in brain. Large pyramidal neurons in prefrontal cortex have up to 50 000 synapses. Their synaptic input is estimated to be several megabytes per second (Bieberich, 2002). This seems enough for the encoding of all



subjective sensations of one person. Bieberich has suggested self-organization mechanism due to which *recurrent fractal neural networks* form. In such networks, a lot of PCs may receive similar synaptic input because of self-similarity of the fractal structures. Mentioned-above Hameroff's "hyperneuron" (by analogy, we will call it "*pontifical syncytium*", PS) might be also just a synchronized network of PCs (not a single conscious object but a network of neurons with individual consciousnesses having almost the same sensations and producing the same volitional acts).

### **Specific drawbacks**

The hypothesis is based on a controversial assumption that some neurons receive the whole human sensory input. More than 100 years of studies did not discover any "final integration center" in brain. The hypothesis of multiple PCs might explain this negative result, but it is also based on rather speculative than experimental arguments.

### **General drawback of mentioned hypotheses**

Common problem of all mentioned hypotheses is their inability to explain temporal unity (and indivisibility) of consciousness in rigorous terms. Any collective phenomenon, whether classical or quantum (except for hadrons), may be divided onto parts. Neither classical, nor quantum synchrony hypotheses explain, which part will be "mine" after such experiment. For example, if consciousness is produced by classical synchronized network, and brain-split surgery divides it on two parts, then there is no explanation, which hemisphere would contain original "self". This is also true for quantum Hameroff-Penrose model. When some gap junctions close, quantum synchronization breaks and several isolated syncytiums appear. According to Hameroff, if they are large enough, they may have own consciousnesses. For example, many gap junctions close in deep sleep or anesthesia (Hameroff, 2006). What happens with human "self" is such a situation? Is it dies or not? Which process keeps it alive without quantum coherence? Hameroff says that self stays alive because "microtubules are still the same" (Hameroff, 2011). However, without synchronization, they do not constitute any holistic object. Single cell has similar problem at cellular level. In contrast

with "hyperneuron", single neuron does not split in a normal life. But theoretically, it may be broken and then repaired by artificial methods (for example, using nanotechnology). What would happen with its "self"? It may be hypothesized that any split of our conscious structure kills original person, but this leads to highly counter-intuitive conclusion that we die after any change in a structure of our synchronized network or PC. This does not deny temporal binding, but close to eliminativist ideas. Therefore, it would be good to find a solution without such strange assumption.

### **4. Single particle consciousness hypothesis and its philosophical advantages**

In order to overcome mentioned drawbacks of collective state hypotheses, we propose a radical alternative: single particle consciousness hypothesis. We entirely through away "one human - one consciousness" paradigm and suggest that there is no unified "brain" or even "cell" consciousness. We suppose that each electron (or even each fermion) has its own consciousness. In the past, similar ideas were supported by German philosopher and mathematician Gottfried Leibnitz, Russian space flight theoretician Konstantin Tsiolkovsky (1925), and famous physicists of 20<sup>th</sup> century David Bohm and Basil Hiley, who said: "In some sense a rudimentary mind-like quality is present even at the level of particle physics. As we go to subtler levels this mind-like quality becomes stronger and more developed." (Bohm and Hiley, 1993). However, none of them built a satisfactory theory in neurophysiological terms. In this paper, we try to build the "bridge" between "crazy" single particle consciousness hypothesis and the experimental science. We suggest and justify the following statements.

- Each electron in the universe is conscious. Each electron is the subjective "observer" of its quantum dynamics (energy, momentum, "shape" of wave function). Each electron "feels" its quantum dynamics as "own" subjective sensations and volition. In principle, the same may be true for all fermions.
- Most of electrons (or fermions) in the universe have primitive





consciousnesses. However, some particles in biological cells (especially in brain) have complex consciousnesses due to complex dynamics in complex organic environment. This is especially true for chemically active electrons.

- Animals are hierarchical structures of particles. Some chemically active electrons in animal brain are “on the top” of the hierarchy. Their dynamics is directly influenced by sensory data and has direct influence upon animals’ behavior. In this paper, we will call them “*pontifical particles (PPs)*”.
- So-called “human mind” is actually mind of PP. In principle, there may be several PPs with synchronized dynamics in one brain. They “feel” the same and perform the same volitional acts. Principle “one human – one consciousness” is wrong. Human brain might have a lot of observers sharing similar “human” mind.
- Most of human intellectual functions are performed by classical mechanisms in neural network. PPs are responsible only for perception and the “final stage” of decision-making.

Philosophical advantages of this hypothesis are obvious. Although it is based on two highly counter-intuitive assumptions (that human has many consciousnesses and that electrons are conscious), it suggests extremely simple ontological model.

- Neutral monism is supposed. It combines conceptual advantages of both physicalism and panpsychism. There is only one substance. The world is not divided to material and immaterial things, or to conscious and unconscious things. Everything is physical, and there are no supernatural factors. Consciousness may be studied by objective scientific methods. On the other hand, everything is conscious, and there is no need to explain how consciousness emerges in high-developed systems. It exists in any kind of systems.
- Elementary physical particles are the only fundamental indivisible “bricks” of the reality. One particle has one

consciousness. Any larger object is just a system of independently conscious elementary particles without “magic” emergent properties.

- Information has no special ontological status: it is just a tool for the description of material processes. It is not the basis of consciousness. Only physical substrate is fundamental.
- Unity of consciousness is not an illusion.
- All problematic clinical cases of “two persons in one brain” have clear explanation: many persons coexist in any brain, but in normal conditions we can’t distinguish them (Puccetti, 1973).

On the other hand, single particle hypothesis has unclear relationship with contemporary science in a lot of aspects. Major scientific challenges to single-particle hypothesis may be summarized as follows.

#### **Physical aspects**

Elementary particle has no structure. In an atom, states of electron are quantized. They may be described by several integer numbers. It should be explained, how the electronic state might contain the whole richness of human subjective experience.

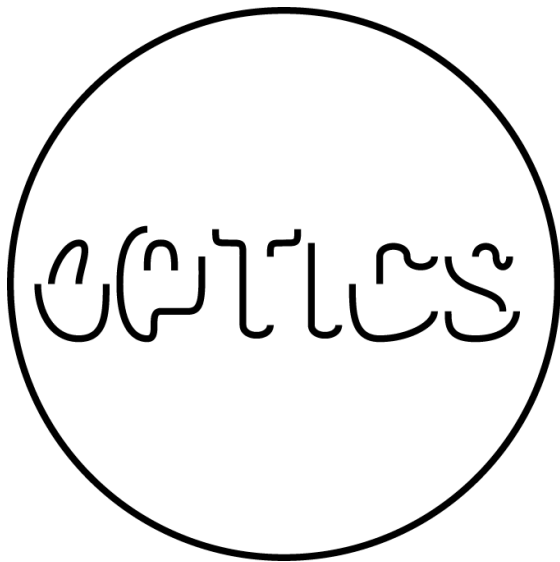
#### **Neurophysiological aspects**

If single electron contains human consciousness, it should be explained, how the sensory data (obtained by classical sensory organs) determines its quantum state, and how its quantum dynamics affects classical behavior of the body.

#### **5. Physical aspects of single particle consciousness hypothesis**

Though an electron has no inner structure, its wave function may be very complex. Electron may occupy a lot of energy sublevels due to interaction with neighbor atoms, Stark effect, relativistic effects, and spin-orbit coupling (fine structure of levels) etc. Electronic spatial distribution may be also very complex. For example, in numerical experiment (Bromage and Stroud, 1999), scientists had “written” the word “OPTICS” on the atomic wave function “surface” (Figure 1).





**Figure 1.** Word “optics” “written” on an atom in (Bromage and Stroud, 1999).

Let us estimate total amount of information that hypothetically conscious electron might contain in its consciousness. This estimation is not a trivial problem. In fact, the statement “electron subjectively observes its quantum dynamics” may be understood twofold. There may be two radically different versions of single particle consciousness hypothesis.

**Alternative 1.** Electron observes only experimentally observable variables, i. e. energy, momentum, position etc. Therefore, its state of consciousness may be completely measured with objective methods. Wave function (containing unobservable variables) is just a theoretical fiction, used for the simplification of numerical modeling. Therefore, experiment (Bromage and Stroud, 1999) does not prove large informational capacity of a single electron. Figure 1 demonstrates just a theoretical fiction. Electron observes its own dynamics with a limited precision given by Heisenberg uncertainty principle

$$\Delta E \cdot \Delta t \geq h / 4\pi \approx 0.5 \cdot 10^{-34} \text{ J} \cdot \text{s} \quad (1)$$

Our subjective temporal resolution  $\Delta t$  is well known. Most authors suggest that it is of the order of 0.02-0.04 s. In particular, Francis Crick directly associates conscious

activity with gamma-wave oscillations with the frequency  $\sim 40$  Hz (Crick, 1995). So let us put  $\Delta t \sim 0.025$  s. Therefore, “our” electron is able to “feel” energy with a huge resolution of  $\Delta E \sim 2 \cdot 10^{-33} \text{ J} \approx 2.25 \cdot 10^{-14} \text{ eV}$ . Typical energy fluctuations of an electron at room temperature are of the order of 0.025 eV. Therefore, electron might have  $\sim 10^{12}$  subjectively distinguishable gradations of energy, each of which might correspond to different state of consciousness. Moreover, due to level degradation, several different quantum states might have the same energy. Therefore, total number of different conscious states might be even larger. However, this seems not enough for the “storage” of our real conscious experience.  $10^{30}$  states may be encoded by only 100 bits of information.  $10^{12}$ - $10^{13}$  states may be encoded by 40-50 bits, or 5-6 bytes. This may be enough to encode volitional acts (which, of course, should correspond to objectively observable phenomena), but not the perception.

**Alternative 2.** Electron observes full wave function including experimentally unobservable values. It feels not only *eigenstates* but also *superposition states*. It “feels” not a single value of energy, but the total energy spectrum with  $\sim 10^{12}$  gradations of energy. For example, if in experiment, an electron may be detected in states  $|A\rangle$ ,  $|B\rangle$ ,  $|C\rangle$  etc., then, its “real” quantum state is a sum

$$a|A\rangle + b|B\rangle + c|C\rangle + \dots, \quad (2)$$

where a, b, and c are the amplitudes of states  $|A\rangle$ ,  $|B\rangle$ , and  $|C\rangle$ . This superposition state can’t be detected in a single measurement. In a measurement, we will detect an atom exactly in the state  $|A\rangle$ , or in the state  $|B\rangle$  etc. Squared modules of amplitudes  $|a|^2$ ,  $|b|^2$ , and  $|c|^2$  are the probabilities to find an atom in correspondent states. If PP observes the sum of  $10^{12}$  such terms, then total information capacity of its consciousness is really huge (at least  $10^{12}$  bits). This is obviously enough to encode human conscious experience at a given time moment. It might be assumed that different eigenstates correspond to different qualia (redness, sourness etc.), while amplitudes correspond to their quantitative parameters. However, “real” structure of consciousness might be more complex.



Anyway, many proponents of quantum consciousness note that quantum superposition state has similar features with human mental state.

We conclude that only alternative 2 is realistic. This result is very important for the interpretation of quantum mechanics: wave function is not a theoretical fiction, but a reality. Both observer and physical world actually “consist” of superposition states, while measurable parameters and wave-function collapse are just limited tools for their study. In principle, this conclusion may be interpreted in a Platonist manner: the reality consists on two worlds, the world of quantum superposition states (immaterial ideal world), and the world of physical measurements (material world). In our opinion, however, such interpretation is not a good choice. Superposition states may be described in physical terms. We are able to build their mathematical model, simulate on the computer and predict measurement results (with a limited precision). Therefore, it is hard to say that superposition states are immaterial. It is better to say that superposition states constitute real material world. We are unable to measure the whole superposition state due to gnoseological, not ontological reasons. For the same reasons, we are unable to see even the whole macroscopic object, if we do not rotate it (changing its state).

It may be concluded, that our hypothesis does not contradict contemporary physics. It only suggests particular interpretation of quantum mechanics. Single particle consciousness hypothesis has some advantages over other quantum consciousness hypotheses.

- We do not suggest any “new physics”. Our hypothesis is completely based on conventional quantum mechanics.
- We do not need macroscopic Bose-Einstein condensates or other coherent effects in brain. There may be either a single pontifical particle (PP), or a group of synchronized PPs. Synchronized PPs should demonstrate similar, but not exactly the same dynamics. They have individual consciousnesses, not the unified consciousness of “quantum hyperatom”.

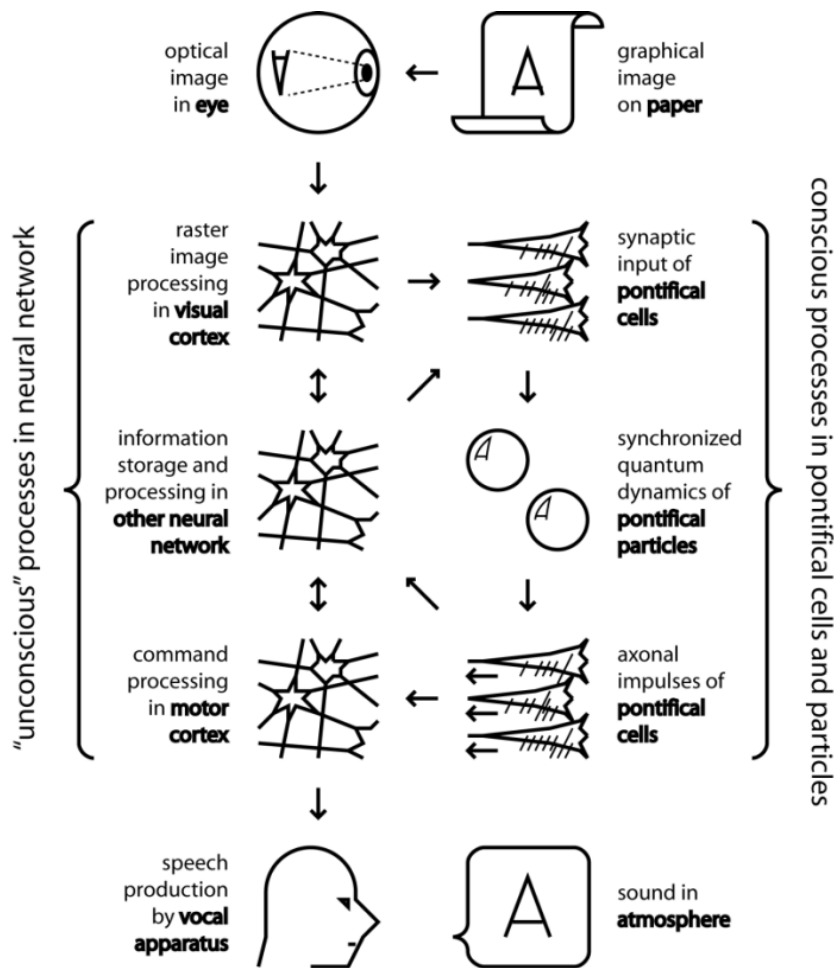
- If complex human consciousness is related to synchronization of many quantum processes, then we have clear answer, what happens, if synchronization breaks: particles’ “selves” survive but their consciousnesses go primitive.

## 6. Neurophysiological aspects of single particle consciousness hypothesis

In order to establish the correspondence between our hypothesis and neuroscience, we must suggest, how pontifical particle (PP) might “work” in real brain. Of course, it would be very difficult to “guess” the detailed mechanism. We may suppose only its general features (Figure 2).

- In the brain, there is at least one pontifical cell (PC) or pontifical syncytium (PS) (these terms are explained in Section 3). There may be also a group of synchronized PCs. Each PC or PS integrates sensory data from perceptual systems (Figure 2).
- Each PC or PS contains a system of synchronized PPs. They may be located in voltage-gated ion channels (most likely, chemically active electrons in carboxyl groups of amino-acid molecules) or in microtubules. Some physiological mechanisms (most likely, electrical or quantum mechanisms) “distribute” sensory information through the membrane or cytoskeleton. These mechanisms influence on quantum dynamics of PPs in such way that sensory signals are directly “observed” by them.
- PPs are not just passive observers of sensory data. They play some non-trivial functional role in axonal impulse generation. Axonal impulses of PCs or PS cause volitional activity: speech, motion of hands, thinking, volitional usage of memory (stored in other cells) etc. (Figure 2).
- Significant part of information processing and storage is performed by classical neural mechanisms outside PCs or PS (Figure 2).





**Figure 2.** Typical human reaction to visual stimulus according to single particle consciousness hypothesis

Many authors (including both proponents of quantum consciousness and single cell consciousness) use the first assumption in their attempts to solve binding problem (Bieberich, 2002; Hameroff, 2006; Sevush, 2006). In this paper, we will not discuss it much. Argumentation is given in cited works, but the final verification requires experimental studies.

Second and third assumptions are stronger than the first one. However, they are also very close to typical assumptions used in quantum consciousness hypotheses. In particular, ion channels and microtubules have been shown to be really very special objects.

Even in classical paradigm, dynamics of ion channels has direct impact on the dynamics of the whole neuron. Ion channels take part in the generation of impulses. However, according to (Bernroider and Roy, 2004), quantum effects are also important in the functioning of ion channel. When ion channel is closed, ion has very complex wave

function and interacts with protein environment in a very sophisticated manner. There is a quantum entanglement between ion and carboxyl groups, and their system is very sensitive to small fluctuations of electric field. It is possible that information processing in the cell is performed not only by classical polarization summation mechanisms, but also by quantum mechanisms inside ion channels. We may suppose some particular mechanisms providing different ion channels with similar sensory data. For example, chemically active electrons of oxygen atoms in carboxyl groups might “use” ion as a sensitive detector of charge distribution along the membrane (polarization patterns formed by synaptic input). Due to high sensitivity of such detector, dynamics of some ion channels might depend on all synaptic input received by the cell, not only local polarization of the membrane. Alternatively, it may be supposed that synaptic input influences not on individual ion channels but on a large quantum-entangled ensemble of ion channels. Bernroider and Roy





note that the number of ion channels in typical mammalian entorhinal cortex cell,  $10^8$  (White *et al.*, 2000), is extremely redundant from the classical viewpoint. Theoretic assumptions (Alonso and Llinas, 1989) show that  $5 \cdot 10^3$  ion channels would be quite enough for classical impulse propagation. Bernroider and Roy suppose that this extreme density of ion channels causes entanglement between them. Therefore, there may be collective quantum effects providing all PPs with the same sensory data.

Microtubules are other typical objects of interest in quantum theories of consciousness (Hameroff and Penrose, 1996; Hameroff, 2006). Hameroff and Penrose were criticized much for their idea of macroscopic collective quantum effect over many cells. However, in the framework of single particle hypothesis, it is not needed. Sensory information may be distributed among many cells via classical mechanisms (Bieberich, 2002), while quantum mechanisms are important only inside individual cells. Quantum mechanisms might bring different microtubule electrons to similar quantum states. Decoherence is not a much problem for single particle consciousness: it breaks synchrony sometimes, but not consciousness itself. In (Wildermuth *et al.*, 2006), it has been shown that one-dimensional Bose-Einstein condensate may be used as a sensitive detector of the spatial distribution of electric field. Therefore, if microtubule really contains some collective quantum effect, its state may be determined by electric patterns on cellular membrane and by synaptic input.

In this section, we have suggested only a general view, how PPs may take part in informational processing in real brain. Many details should be clarified in future study. It is still unclear, which particular intracellular mechanism provides different PPs with similar sensory information without significant losses. Particular relationship between PPs' dynamics and subjective experience (pleasure, time, qualia, and volition) should be also clarified.

## 7. Conclusion

In mid-20th century, the dominating view was that neuron is just a trigger-like mechanism with a simple classical algorithm. Today, there is a large amount of experimental results showing that neuron has very complex

function (Koch and Segev, 2000). According to different authors, neuron might have personal motivations (Shvyrkov, 1995), perform quantum computations (Hameroff and Penrose, 1996), and even be independently conscious (Zeki and Bartels, 1999; Bieberich, 2002; Edwards, 2005; Sevush, 2006). Recent studies have shown that quantum computation-like effects in neurons may involve just a few atoms (Bernroider and Roy, 2004). And in this paper, we have suggested even more radical idea that human consciousness may be produced by a single elementary particle.

We have shown that, being conceptually "crazy", single particle consciousness hypothesis, however, proposes no radically new effects that were not already proposed by other quantum consciousness hypotheses. In fact, we suggest just an alternative interpretation of well-known assumptions. Our major idea is that hypothetical collective quantum phenomena in brain (such as Fröhlich condensates or other forms of synchronization) do not form any "conscious super-particles". They are nothing but ensembles of individually conscious particles in similar states. This counter-intuitive assumption has a lot of philosophical and physical advantages over other quantum theories of consciousness (See Sections 3-4).

If the hypothesis of single particle consciousness would be proven, it will make a huge impact not only on neuroscience, but also virtually on all branches of philosophy including ethics and religion. If our consciousnesses are "attached" to single electrons, then our "souls" are physical, but immortal. The death of the body does not cause the death of the observer. "Self" remains alive; however, it loses memory and takes primitive form. If an animal would eat the pontifical particle (PP) from the dead body, then PP would have some small chance to be used in its brain. This would be a kind of reincarnation. In the future, nanotechnology may provide such reincarnation by artificial methods.

Scientific proof of "life after death" and scientific methods for its prediction and control would result in principal changes in human society. Scientific proof of single particle consciousness hypothesis would provide a fundamental theoretical basis for brain cyborgization (if PPs exist, then other



brain parts may be replaced with electronic ones without losing personal identity), cryonics (PPs are not destroyed under low temperatures, therefore, cryopatiens may be revived without losing personal identity), settleretics (PPs may be moved to another body) and other novel technological branches.

Without a firm solution of binding problem, these technological branches would be ethically problematic because it would be impossible to prove, whether original human stays alive or dies during experiment (Ettinger, 1964; Lem, 1964).

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