# Proposed Experiment to Determine if there are EPR Nonlocal Correlations between two Neuron Transistors

Fred H. Thaheld*

Studies have shown that there are nonlocal Einstein-Podolsky-Rosen (EPR) correlations between human brains and, that the brain has a macroscopic quantum component. Recent experiments with neuron transistors reveal that it is possible to record both spontaneous and stimulated electrical activity of a single neuron by the source-drain current in a field-effect transistor. To test the possibility that individual neurons may also possess this quantum component at the microscopic level, a proposal is made to utilize two neuron transistors, physically separated in their own individual Faraday chambers and with no electromagnetic, sonic or electrolytic connection between them. Only one will be stimulated electrically to achieve an action potential or, is allowed to generate one spontaneously. It is then determined if the 2nd nonstimulated neuron, spatially separated, generates a *transferred action potential* on its own, simultaneously and without any classical physical intervention. If such a *transferred action potential* is achieved, it would be evidence for quantum mechanical nonlocal correlation at the individual neuronal level.

Keywords: EPR nonlocal correlations, neuron transistors, neurochips, action potential, transferred action potential, spontaneous and stimulated electrical activity.

Experiments have been performed in which neurons and transistors have been connected directly on the level of the electrical voltage [1-5]. This was based on the fact that both brains and computers rely upon electrical signals as the basis for signal processing. The electrical activity of single neurons from leech ganglia and rat brain (fetal rat hippocampus), was recorded by the source-drain current in a field-effect transistor (FET).

It has also been demonstrated that the brain may possess a macroscopic quantum component and, that there appears to be an EPR nonlocal correlation between two human brains under certain conditions [6,7]. An experiment is proposed herein to determine if this nonlocal effect can also be observed at the individual neuronal level, by utilizing two neuron transistors, which are not connected to each other in any classical fashion, and determining if an action potential elicited from one neuron transistor can result simultaneously in a transferred action potential in the other non-stimulated neuron transistor.

It should be mentioned here that there are several other methods available which could also be used to accomplish the same purpose being sought in this proposed experiment. These include intracellular recording [8,9], flat-metal extracellular electrode arrays [10-14] and, a most recent development of a modified flat-metal electrode array known as a neurochip [15,16]. Any of the proposed experiments can therefore be performed

* 2400 Natoma Station Dr. #76, Folsom, Calif. 95630; fthaheld@directcon.net

eventually utilizing the neurochip which is much more flexible and simpler to use than the neuron FET. A landmark paper by Einstein-Podolsky-Rosen was published in 1935 criticizing quantum mechanics [17]. The authors claimed that if quantum mechanics were a complete model of reality then non-local interactions between particles had to exist. Since they felt that this was impossible, they opined that quantum mechanics was wrong or incomplete. Their viewpoint later became known as the EPR paradox.

The EPR paradox was not experimentally tested until 1982, when it was verified that once these particles have interacted that nonlocal influences between particles do indeed exist [18]. And, as per Feynman, since this nonlocality cannot be duplicated by a classical system, this enables it to be used to test the quantum nature of systems [19].

Several studies have since revealed that there may be EPR nonlocal correlations between human brains [6,7]. In these studies, it was observed that an evoked potential in a stimulated subject is transferred to another subject once the two subjects have interacted through meditation. An evoked potential is an electrophysiological brain response produced by a sensory stimulus [20]. In this specific instance the sensory stimulus was produced by a series of random flashes from a Grass photostimulator on maximum power. Relatively large potential changes accompany the arrival of impulses from the illuminated retina via the optic radiation at the cortex and, these large potential changes possess a very distinct morphology which can be readily discerned from the normal brain waves of the electroencephalogram (EEG) [21].

Suggestions have also been made that for intelligence to operate, the firing of one neuron must be accompanied by the firing of many correlated neurons at macroscopic distances, as much as 10cm, which is the width of the cortical tissue [22,23]. It is then theorized that for this to happen, we would need EPR-style nonlocal correlations existing at the molecular level in the brain at the synapses [23]. Ordinary thinking may thus depend upon the quantum nature of events in the brain.

It should be noted here that the experiments previously mentioned between two unrelated human subjects [6,7], who displayed phase coherence in their brain waves (which is a well known signature of quantum nonlocality) were conducted with dual EEG equipment. These types of experiments ie; relying upon meditation to achieve brain wave phase coherence, may cast this paper in an unfavorable light, because of the controversial area they were performed in. If such is the case, one can proceed to a much firmer basis by relying upon studies revolving around the EEGs of identical (monozygotic) twins who come from a common fertilized egg. Most of the papers over the last 6 decades consistently reveal that the brain waves from these twins are either identical or almost indistinguishable from one another [24-28].

In addition, analysis of the EEG of fraternal (dizygotic) twins, who come from two different eggs, showed that for a sufficiently representative sample, the within-pair similarity is significantly above the inter-individual similarity between unrelated persons [29]. Furthermore, it has been demonstrated that there is a recognizable but, not significant similarity of EEG tracings between related persons such as mother/son, father/daughter, *etc*. [30].

One might be justified in saying that not only the identical twins but, the fraternal twins and various related persons possess varying degrees of natural phase coherence of their brain waves and can be considered to be entangled, as the meaning for the term is used in quantum mechanics.

The question which must now be raised is: Can we attempt to achieve this same non-local correlation between two individual neurons attached to two separate transistors since, in the case of the brain, there is a tremendous advantage, in that there are some $10^{10}$–$10^{11}$ neurons, an untold number of which may be involved in the above process?

It appears that this may now be a distinct possibility based upon work performed over the last several years where individual nerve cells from leech ganglia (Retzius cells) were attached to the open gate of an FET, which is a metal-free device [1-3]. This resulted in a neuron-silicon junction or neuron transistor.

In one instance the neuron was stimulated by Gaussian voltage pulses and by ac voltages through a patch pipette which had been inserted through the membrane of the neuron [2]. The membrane voltage was recorded by an impaled microelectrode.

The researchers were able to elicit action potentials from the neuron by these current injections, which action potentials modulated directly the source-drain current in silicon. In addition to applying voltage transients to the neuron via current injection to achieve an action potential, they were able to record spontaneous action potentials of a single neuron by the source-drain current in the FET. The shape of this response resembled the signals obtained by current stimulation.

In their most recent experiments they impaled a neuron on a transistor with a microelectrode only and elicited action potentials by current injection [3]. In this instance they found that a minute mechanical deformation of the neuron triggered a bistable switching on the attached membrane between states of high and low conductance. The shape of the response was indistinguishable from the action potential itself. It should be mentioned here that utilization of the neurochip will not entail impaling the neuron nor subjecting it to any stress as in this technique.

In all the samples they prepared they only studied one at a time. In one experiment they compared the response of a transistor without an attached neuron at a distance of 300 microns from a transistor with an attached neuron [2]. In no case did they observe any significant signal in the distant transistor.

In the experiment being proposed herein, we will be utilizing and building upon these recent developments. We will have two neurons from the same leech or fetal rat hippocampus (which should have interacted), attached to two separate transistors. They will be in two separate Faraday cages, with neither the neurons nor the transistors physically connected to each other in any fashion.

By placing them in individual Faraday cages, one then rules out any influence from electromagnetic, sonic or electrolytic (tissue culture medium) sources. We will stimulate just one of the neurons to elicit an action potential, and see if the other neuron receives or picks up a transferred action potential. Alternately, we can rely upon one or the other of these neurons to generate a spontaneous action potential and see if the nonstimulated neuron receives a transferred action potential of the same shape and amplitude at the same instant. The term nonstimulated, as it is applied to the neuron in this experiment, is meant strictly in the classical sense. If a transferred action potential is seen, it should be evidence of nonlocal quantum mechanical correlations.

Since spontaneous action potentials can be generated at any time by both neurons on a random basis, this has to be taken into account when the results of this experiment are tabulated. Only those events which are simultaneous over a period of time would meet the criteria for success. Both the action potential and the transferred action potential would have to be not only simultaneous but, the morphology of the wave form should be the same as the original action potential.

In addition, we could also determine if the bistable reversible switching of the attached membrane between states of high and low conductance, resulting from a minute mechanical deformation of the membrane, is likewise conveyed to or picked up by the nonstimulated neuron. We could also utilize neurons from a multitude of other sources in order to determine if this is a generic phenomenon. And, proceeding from the present one dimensional arrangement with the neuron transistor to 2 and 3 dimensions with neurochips, where there would be up to 16 neurons on each neurochip, we might be able to ascertain accurately the extent of the spread and collapse of the wave-function.

Finally, it may also lend some credibility to those theories of consciousness wherein quantum mechanics is said to play a major role.

This paper is to be considered an extension of a previous paper of mine which dealt with the utilization of identical twins, who already appear to possess phase coherence and entanglement of their brain waves [31]. This was an attempt to achieve EPR-style non-local correlations, where one of the twins would be acting as a quantum observer.

This built upon certain experiments previously cited [6,7]. Later this year it is anticipated that a series of experiments will be commenced at the University of Washington, testing the hypothesis posed within this paper regarding not only identical twins but, various related and unrelated human subjects, concerning the possibility of biological quantum nonlocality.


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