Bionoetics, vol. 1, no. 1, 2014

MIND, BRAIN, AND NEUROSCIENCE

Henry P. Stapp

Abstract: Quantum mechanics as conceived by Niels Bohr and formulated in rigorous terms by John von Neumann is expressed as quantum neuroscience: a description of the relationship between certain conscious experiences of an observer that are described in terms of the concepts of classical physics and neural processes that are described in terms of the concepts of quantum physics. The theory is applied to recent neuroscience data to determine the rapidity of the observer's probing actions that is needed to account for the capacity of a person's mental intentions to influence that person's bodily actions in the intended way.

Keywords: Quantum measurement, Quantum neuroscience, Physical Effects of Conscious Effort

INTRODUCTION

How are our conscious experiences connected to our physical brains?

Certain theories of this connection are based on classical physics, others on quantum physics.

My talk is about key differences between these two approaches, and some pertinent recent neuroscience data.

Theories of the mind-brain connection based on classical mechanics have two major drawbacks: The first is that they are rationally incoherent; and second is they are based on a physical theory that is known to be is fundamentally incorrect, and incorrect at precisely the crucial point of how consciousness enters into the dynamics.

The theories based on classical physics are not rationally coherent because the consciousness does not stem rationally from the underlying precepts of classical physics, but is simply pasted on "ad hoc", because we know it exists.

And those theories are based on a physical theory that is known to be fundamentally incorrect because classical physics is known to be fundamentally incorrect. And it has been replaced by quantum physics, which, instead of ignoring consciousness, is fundamentally about the structure of our conscious experiences. In the words of Niels Bohr:

> "In our description of nature the purpose is not to disclose the real essence of phenomena, but only to track down as far as possible the multifold aspects of our experience" [I. p. 18]

This stance changes the basic realities of the theory from *whatever lies behind our experiences* to *our experiences themselves.*

But the most astounding feature of this shift is that the concepts of classical physics do not drop out, or fade away, but are transferred from the reality that lies behind our experiences, to what had formerly been left out, our experiences themselves. In the words of Niels Bohr,

> "…it is important to recognize that in every account of physical experience one must describe both the experimental conditions and the observations by the same means of communication that is used in classical physics." (II p.88)

The effect of this condition is that, in practical measurement situations. one is supposed to divide the world by a cut, called the Heisenberg cut, such that big things observed by observers are placed above the cut, and are described in terms of the concepts of classical mechanics, while things lying below the cut are described in quantum mechanical terms.

This rule was imprecise and ambiguous and led to the so-called "measurement problem." John von Neumann, and the basis of a detailed mathematical examination, resolved this problem by moving the Heisenberg cut all the way up, until everything normally considered to be part of the material world built of atoms and molecules, and the electromagnetic and gravitational fields that they generate, were placed below the cut and were described in quantum mechanical terms, whereas our conscious experiences, including our perceptions, were described generally in psychological terms, *but with our perceptions expressed in the usual way associated with the concepts of classical physics.*

The theory thus becomes a genuine psychophysical theory with the boundary between our conscious experiences and the atom physical world lying at the mind-brain interface. The essential core of the theory thus becomes the description of what is happening at the mind-brain interface between the experientially described and abstractly described aspects of the psychophysical world.

CLASSICAL DESCRIPTION, OSCILLATIONS, AND THE QUANTUM MECHANICAL "COHERENT STATES" OF THE ELECTROMAGNETIC FIELD.

What we see, do, and intend to do is described at the mental level in classical terms, but at the brain level in quantum mechanical terms. This need to correlate the classical mental description to a naturally corresponding quantum counterpart at the mind-brain interface is met by taking this connection to be via the well-known "coherent states" of quantum electrodynamics. These are quantum states that exhibit a simple harmonic oscillator (SHO) motion that is essentially identical to a classical SHO motion, except that the location of a classical point particle is replaced by a minimum uncertainty Gaussian quantum wave packet whose center point follows the phase-space trajectory of classical oscillating point.

Diagram 1. A circle of radius R, and a rotating ray whose intersection with the circle represents the center of point of the rotating SHO gaussian wave function. The energy of the wave packet above that of the ground state is R^2, measured in units of omega hbar. This picture represents the energy and phase of the component of the EM Field in the computational unit of the motor cortex that is embedded in an environment that is generating this SHO behaviour.

Our interest is in the possible influence upon the radius R of a mental intention of the owner of the brain within the framework of von Neumann's dynamical theory of the mind-brain connection.

VON NEUMANN'S DYNAMICAL THEORY OF THE MIND-BRAIN CONNECTION.

The central problem in quantum mechanics is that the basic dynamical equation, the Schroedinger equation, generates not the evolving physical reality itself but only a smear of potentialities for the future.

But then how does what actually occurs get picked out. It is not picked out by nature acting alone. According to quantum mechanics, some subject/observer/agent must pose a question: "Is my immediately to appear experience Experience X?" Yes or No?. Nature immediately answers, and in the "Yes" case delivers Experience X. In either case it changes the entire physical world by eliminating all feature that are incompatible with the answer it has just chosen.

That choice on the part of some observer will single out some classically describable possibility. But the quantum mathematics does not specify what question will be asked. The choice is, according to quantum ideas, "a free choice on the part of the observer", where "free' emphasizes that it the choice not determined by the known laws of physics. The fact that what is asked is classically describable also indicates that it comes via the mental realm.

THE PERTINENT NUMBERS.

The measured general numbers for the Cortex are:

Size of computational unit: Sz = (1/20 x 1/20 x 2.4) x 10 ^-9 m^3
= 6 x 10^-12
[Ref. Brain 125(5), 935-951, Buxheoven & Casanova.]

Strength of the magnetic field: H = ½ picotesla

SHO frequency: 20 Hz

R= Radius of SHO orbit in the usual Modified Phase Space in which the coordinate variable is

y = [sq.root (hbar/m omega)] times coordinate variable X ,
(X meters) (m= 1 kg) (mks units) (angular velocity omega in radians per second) [20Hz => omega = 20x2pi]
[Ref. Wikipedia: Quantum harmonic oscillator]

Energy = 2 x (½ H^2/mu0) x Sz = omega x hbar x R^2

mu0 = 4pi x 10^-7 hbar = 10^(-34) in mks units

Energy = ¼ 10^(-12))^2 x (1/4pi) x 10^(7) x 6 x 10^-12
= ¼ (6/4pi) x 10^(-29)
= ¼ (60/4pi) x 10^(-30)
= 15/4pi x 10^(-30)
~ = 10 x 10(-31)

Energy = omega x hbar x R^2
= 20 x 2pi x (10^-34) x R^2
= (1/8) x (10^-31) x R^2

R^2 ~= 80 R ~= 9

This indicate that the process is at the quantum scale, and that a small change ΔR in R can give a significant change in the pertinent energy R^2.

THE QUANTUM ZENO MECHANISM FOR MENTAL CONTROL OVER BODILY ACTION: EMPIRICAL EVIDENCE FROM NEUROSCIENCE.

Let Psi(R) be the quantum SHO state whose center is located at radius R on the rotating ray that represents the 20 Hz oscillation in the computational unit.

If the current state is Psi(R), and one asks the question "Is the state Psi(R+Δ)?", then the probability that the answer is "Yes" is |<Psi(R)|Psi(R+Δ)>|^2, which for small Δ is (1- Δ^2).

If Δ is small, then the number N of probing questions that one can ask such that with 90% probability the answers will all be "Yes", so that the intended increase in R will occur with probability at least 90%, is therefore the N such that N Δ^2 =1/10, or

N= (1/(10 Δ^2). Hence the agent can achieve an intended objective ΔR = N Δ with 90% certainty if ΔR=1/(10 Δ) for small Δ.

A key question is: What rates of probing actions are needed in order to account, via this QZE mechanism, for the correlations found in neuroscience between intended actions and brain activity? Do we need extremely rapid rates?

Reference 1 describes statistically significant correlations between instructed manual motions of monkeys (which I am considering to be governed by QZE) and electromagnetic activity in the motor cortex. Figure 1c at 20 Hz and near 100 ms shows significant structure occurring over a 10 ms interval.

Ref.1. Nature neuroscience, Propagating waves mediate information transfer in the motor cortex, Doug Rubino, Kay Robbins, & Nicholas Hatsopoulos. (Full text available on Wikipedia.)

If one wishes to achieve a certain increase ΔR over a ten millisecond interval with a uniform set of increases Δ this Δ = 1/(10 ΔR), and the number of steps needed is

N=(1/10) Δ^(-2) =(1/10) (10 ΔR)^2 = 10 x (ΔR)^2

To achieve a unit change ΔR in R this number is 10, and the probing actions need occur only once each millisecond. These are normal time scales for neuroscience.

Lawrence Berkeley Laboratory
University of California
Berkeley, California, 94720