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“The Observer” in Physics and Neuroscience.

1. Introduction.

Neuroscience is an important component of the scientific attack on the problem of consciousness. However, most neuroscientists, viewing our discussions, see only conflict and discord, and no reason why quantum theory has any great relevance the dynamics of the conscious brain. It is therefore worthwhile, in this first plenary talk of the 2003 Tucson conference on “Quantum Approaches to the Understanding of Consciousness,” to focus on the central issue, which is the crucial role of “The Observer,” and specifically, “The Mind of The Observer” in contemporary physical theory. I shall therefore review here this radical departure of present-day basic physics from the principles of classical physics, and then spell out some of its ramifications for neuroscience.

My talk is divided into nine sections:

1. Introduction.
2. The problem of the interaction between mind and matter.
3. The *passive* role of “The Observer” in classical physics.
4. The *active* role of “The Observer” Copenhagen quantum theory.
5. Process I: A dynamical psycho-physical bridge.
6. The *active role of the mind* of the “The Observer” in von Neumann quantum theory.
7. The Quantum Zeno Effect and the causal efficacy mental effort.
8. Ramifications in psychology.
9. Ramification in neuroscience.

2. The problem of the interaction between mind and brain.

First, the meanings of the terms “mind” and “brain” must be distinguished.

Your *mind* is your stream of consciousness. It consists of your thoughts, ideas, and feelings, and is described in *psychological* or *mental* terms.

Your *brain* is an organ in your body consisting of nerve cells and other tissues, and is described in *physical* terms - in terms of *properties assigned to tiny space-time regions inside your skull.*

Your mind and your brain are obviously related. Your conscious intention can cause your arm to rise. What happens is this: Your thought causes nerve pulses to emanate from your brain, and these pulses cause muscles in your arm to contract, and those contractions cause your arm to rise.

But *how*, according to the basic principles of science, does your conscious thought initiate that chain of bodily events? How does a *mental* action cause *physical* events?

3. The passive *role of “The Observer” in classical physics.*

To get the answer given by science one might turn to *classical physics.* This is a theory of nature that originated with the work of Isaac Newton in the seventeenth and was advanced by the contributions of James Clerk Maxwell and Albert Einstein.

Newton based his theory on the work of the astronomer Johannes Kepler, who found that the planets appeared to move in accordance with simple mathematical laws, in a way determined wholly by their spatial relationships to other objects. Their motions were apparently *independent of our human observations of them*. Newton assumed that all physical objects were made of tiny miniaturized versions of the planets, which, like the planets, moved in accordance with simple mathematical laws, independently of whether we observed them of not.

According to classical physics, the physical world is built out of tiny bits of matter/energy, and the motion of each tiny part is completely determined by its contact interactions with neighboring parts. These interactions are such that the state of the physical world at any time is completely determined by the state at any earlier time. Consequently, according to classical theory, the complete history of the physical world *for all time* is mechanically fixed by contact interactions between its tiny component parts---along with the initial condition of the primordial universe.

But this means that, according to classical physics, *you are a mechanical automaton*: your every physical action was pre-determined before you were born solely by local interactions between tiny mindless entities.

That makes your mental side *causally redundant*: everything you do is completely determined by mechanical conditions alone, without reference to your thoughts, ideas, feelings, or intentions. Your intuitive feeling that your thoughts make a difference in what you do would be an illusion.

Many scientists, philosophers, writers, intellectuals, teachers, and policy makers claim to believe this mechanical conception of human beings, and base policies upon it. They believe that this is what science says, and hence that this is what you must believe.

But this is *not what science says*! It is what *classical physics* says! Classical physics is merely *an approximation* to a more accurate theory---called quantum mechanics---and quantum mechanics says just the opposite. *Quantum mechanics describes the effects of mental actions upon physical systems.* It *explains* how your mental effort can cause your arm to rise. Quantum theory thus converts science's picture of you from that of a mechanical automaton to that of a mindful person. And quantum theory shows explicitly how the *approximation* that gives classical physics also *completely eliminates* all the effects of mind upon matter.

4. The active *role "The Observer" in Copenhagen quantum theory.*

Quantum mechanics arose during the twentieth century. Scientists discovered, empirically, that the principles of classical physics were not correct. Moreover, they were wrong in ways that no minor tinkering could ever fix. The *basic principles* of classical physics were thus replaced by *new basic principles*, and these new basic principles appear to work perfectly.

This revision was profound. The whole *conception of what science is* was turned inside out. Classical physics is about the "world out there," with no explicit reference to "our thoughts in here." But quantum mechanics is about *our actions as knowledge-acquiring and knowledge-using agents*. Thus quantum theory is *fundamentally* about what is "in here," namely *our knowledge*.

A key feature of quantum theory is that, in the words of Niels Bohr: "in the great drama of existence we ourselves are both actors and spectators." (Bohr,1963:15 & 1958: 81) The emphasis is on "actors": in the earlier classical physics we were idle spectators.

The original formulation of quantum theory is called The Copenhagen Interpretation because it was created mainly at the Institute in Copenhagen run by Bohr.

Copenhagen quantum theory is about the relationships between human agents (called participants by Wheeler) and the systems that they act upon and observe. Each agent is a human person together with his (or her) measuring devices. This agent is described in the language that he uses to communicate to himself and to his colleagues what he doing - or wants them to do - and what he is experiencing. I call this language *mentalistic* or *psychological*. The "system" that the agents are acting upon is described in *physical* terms – that is, in terms of (un-experiencable) local properties assigned to very tiny space-time regions.

But why were the founder's of quantum theory driven to this idea of breaking nature into two parts, described in two very different languages.

Von Neumann, analyzing Copenhagen quantum theory, identified two very different processes that enter into the structure of the quantum description. He called them Process I and Process II.

Process II is the analog in quantum theory of the process in classical physics that takes the state of a system at one time to its state at a later time. However, Process II by itself is not sufficient: it generates mathematical structures that do not agree with human experience. For example, if only Process II were present then the state of, say, the moon would be a structure smeared out over large parts of the sky! And the state of the brain of each observer would be a continuously smeared out structure that would correspond to a blur of experiences of the kind we know.

To tie the mathematical theory to human experience another process is needed. It is called Process I. It is a *selection.* But that selection is *not determined* by the mechanical process II. From a practical standpoint, each needed selection is made by a human person: it is a *choice* about of how he or she will act.

<u>The agent's choices are "free choices."</u>

According to Bohr (1958: 73)

"The freedom of experimentation, presupposed in classical physics, is of course retained and corresponds to the free choice of experimental arrangement for which the mathematical structure of the quantum mechanical formalism offers appropriate latitude."

This "freedom of choice" follows, in the Copenhagen approach, from the fact that the agent is not part of the physical system that is described by the quantum mathematics: the agent stands outside the system that is governed by the known laws.

Thus this "freedom" means simply "not determined by the *known* laws!" There certainly could be other factors that could supplement the *known* laws of orthodox quantum theory and determine these "free choices."

Here is how the orthodox theory works.

If the letter S represents the state of the system being acted upon by the agent then Process I can be represented by the following equation:

$$S \rightarrow PSP + (1-P)S(1-P)$$

It exhibits the key fact that this Process I action changes the state S of the system being acted upon into a *sum of two parts*.

The first part, PSP, represents the possibility in which an intended experiential feedback called "Yes" appears, and the second part, (1-P)S(1-P), represents the possibility that this feedback does not appear.

The symbol P is important: it represents the fact that the Process I depends on *the intention of the action of the agent*: for example his intention to place the Geiger counter here, not elsewhere, or his intention to "attend to" whether this Geiger counter "fires" or not.

Notice that Process I produces the *sum* of the two alternative possible feedbacks, not just one or the other.

Since the feedback must either be "Yes" or "Not-Yes," one might think that Process I, which *keeps* both "Yes" and "Not Yes" (= "No"), would do nothing. But that is not correct! This point is made clear by considering the identity

$$S = PSP + (1-P)S(1-P) + PS(1-P) + (1-P)SP$$

This identity shows that the state

S is a sum of four parts, two of which are eliminated by Process I.

This means that:

The Process I action, before any choice between "Yes" and "Not-Yes", already affects the state being acted upon. And this action

depends upon P, which is determined by the intention of the agent.

That is the *key point*:

Process I, specifies the effect upon a physical system of a *freely chosen intentional action* described in psychological terms.

5. Process I: A dynamical psycho-physical bridge.

Any scientific theory must specify connections between its theoretical concepts and other experiences of the scientists who use it. In classical physics this connection is part of a *metaphysical* superstructure: it is not part of the core dynamical description. But in quantum theory the Process I injects the effects of a psychologically described action directly into the physically described theory, thereby creating a *dynamical psycho-physical bridge.*

But the question arises: How can the effect of a psychologically described action be injected into the dynamics of a physically described system without upsetting causal structure of the latter.

The answer is this: Physicists have discovered an important and unexpected property of nature. It pertains to observable phenomena that depend upon microscopic properties that are *in principle inaccessible to observation.* In such a situation we are *in principle* unable, due to the lack of crucial micro-data, to give a complete causal description of the observable phenomena. However, our principled inability to give a complete causal account of the psychologically described phenomena, due to this inherent gap in the micro-data, can be partially offset by introducing into the theory, *instead of the inaccessible micro-data,* the *psychologically described selection of an action* made upon the system by an agent.

That is, a (statistical) causal account can be achieved by replacing the inaccessible micro-data by empirically available and controllable data about human selections of actions!

6. The active role of the mind of "The Observer" in Von Neumann quantum theory.

The Copenhagen procedure works very well in practice. However, the bodies and brains of the human agents, and their devices, are parts of the physical universe, and thus ought to be describable in physical terms.

The great mathematician and logician John von Neumann showed that the bodies and brains of the agents, along with their measuring devices, can be shifted into the physically described world, without disturbing significantly the successes of quantum theory, *provided the essential-to-the-theory mentalistically described free choices made by the human agents are ascribed to the minds of these agents*, and the mind of each agent is taken to act on the physically described brain of that agent.
(von Neumann, 1955: 421)

In von Neumann quantum theory the psychologically described agent is the mind of the participant, and what is acted upon is his or her physically described brain.

To summarize:

In Copenhagen quantum theory "The Observer" is taken to be the mind and body of the human agent plus his measuring devices. The *system being acted upon* is the system being probed by those devices. This has the unphysical feature of leaving the bodies and brains of the human participants, and their devices, out of the physically described universe.

Von Neumann shifts the devices, and the bodies and brains of the human agents, into the physically described universe, leaving only the *minds of the participant-observers* on the psychologically described side.

This shift does not eliminate the need to bring in the selections: these choices associated with Process I are still required in order

to bring the theoretical structure into practical accord with human experience.

Thus von Neumann quantum theory *shifts the psychologically described - and dynamically essential - selection process from the agent, considered to be the total human person plus his measuring devices, to the mind of the agent,* which acts on his brain.

But this means that von Neumann quantum theory is, precisely, a psycho-physical theory of the conscious brain.

It is this consequence of quantum theory that makes it profoundly relevant to neuroscience, and that drives this conference!

Von Neumann's work carries the concepts and the mathematics developed by quantum physicists to cope with the inaccessible-in-principle micro-processing that bears upon the experimental data available to atomic scientists over to the similar situation of neuroscientists endeavoring to account causally for empirical phenomena pertaining to mind-brain states involving inaccessible-in-principle micro-processing.

In regard to the inaccessibility of micro-data, and the availability and controllability of data about the choices made by active human agents, there is a close parallel between atomic physics and neuroscience: Atomic scientists and neuroscientists are in the same boat.

7. The Quantum Zeno Effect and the causal efficacy of mental effort.

The agent makes a choice that is intended to bring a certain experience into his stream of consciousness. For example, his intention may be to create the feedback of experiencing his arm rising, or experiencing a Geiger counter set in a certain particular place.

I have emphasized that the orthodox theory gives no microcausal explanation of the origin of the free choice associated with

Process I. However, one does have the feeling that one can, by willful effort, put more or less consciousness onto one's mental processing. To capture this intuition I make the assumption that the rapidity at which the Process I actions occur can be increase by mental effort.

This assumption entails, by virtue of the quantum dynamical formulas, that a person can, in principle, by increasing his mental effort, hold an intention in place longer. This follows from the formula for the transition from the state PSP at time t=0 to the state (1-P)S(t)(1-P) at time t:

(1-P) exp –iHt PSP exp iHt (1-P) = Order t squared.

The point is that the terms of zeroth and first order in t are both zero due to the von Neumann condition P=PP on the projection operator P.

This result entails that by increasing sufficiently the rapidity of the Process I actions associated with a constant (or even slowly changing) operator P, an agent can keep the state S of his or her brain in the "Yes" subspace associated with states of the form PS(t)P.

This "holding-in-place" effect of rapidly repeated observation is known as the Quantum Zeno Effect (QZE). (Misra, 1977) It is a quantum effect, which is not diminished by the very strong interaction of the brain with its environment.

8. Ramifications in Psychology.

William James, in his chapter on Will, in the section entitled ``Volitional effort is effort of attention,'' writes:

> ``Thus we find that we reach the heart of our inquiry into volition when we ask by what process is it that the thought of any given action comes to prevail stably in the mind.'' (James, 1892: 417)

> ``The essential achievement of the will, in short, when it is most `voluntary,' is to attend to a difficult object and hold it fast before the mind. ... Effort of attention is thus the essential phenomenon of will." (James 1892: 417)
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> ``Everywhere, then, the function of effort is the same: to keep affirming and adopting the thought which, if left to itself, would slip away." (James 1892: 421)

Von Neumann quantum theory gives a dynamical explanation of how psychologically described mental effort can hold in place the brain state corresponding to an intentional action. *It explains, in terms of Process I and QZE, the causal efficacy of volition.*

Much has happened in psychology since the time of William James. I have described in Stapp (2001) the non-trivial concordance of the quantum predictions with the findings described by Harold Pashler (1998) in his book *The psychology of attention.*

9. Ramifications in Neuroscience.

The situations in neuroscience and atomic science are essentially the same. Due to the Heisenberg Uncertainty Principle, micro-properties such as the velocities of the ions emerging from narrow ion channels, are in principle unknowable. Thus the computation of the causal behavior of a conscious brain is in principle impossible. Thus just as in atomic physics, and indeed as a direct consequence of the basic principle of atomic physics, there is both room for, and , at least at the practical level, a rational need for, the input of psychologically described data that can according to quantum theory be rationally treated as replacements of the accessible-in-principle micro-properties. According to orthodox quantum theory, the micro-properties postulated by classical physical theory simply do not exist, or at least play no practically useful role in science, but this dynamical gap can be partially filled by accepting the psychologically describable and partially controllable data pertaining to conscious human choices about

how to act as primary data describing pragmatically independent realities.

The breakdown in principle of the possibility a complete bottom-up micro-local causal description opens the door to the quantum psycho-physical description, which consistently combines the bottom-up micro-local Process II with the top-down mentally controlled Process I.

Francis Crick and Christoff Koch have published recently in Nature *neuroscience* a Commentary entitled "A framework for consciousness." (Crick, 2003), They explain that their framework will "not have rigid laws as physics does." But they put forth a ten-fold "point of view for an attack on" the scientific problem of consciousness. Much of their proposal focuses on neuro-anatomical details. But the general features of their framework are in very good agreement with the quantum psycho-physical framework described in Stapp (1993).

C&K explain that they are, in this initial phase of their program, restricting themselves to "attempting to find the neural correlates of consciousness (NCN), in the hope that when we can explain the NCC in causal terms, this will make the problem of qualia clearer." But what does a causal account dealing only with the neural correlates of consciousness say about the causal properties of the conscious realities themselves?

1. *The (unconscious?) homunculus*. C&K speak of the "overwhelming illusion" of the existence of a consciousness homunculus, and suggest that this illusion may "reflect in some way the general organization of the brain." But how do they conclude that the overwhelming intuition that our thoughts can influence our actions is an illusion? The only basis for that allegation is the known-to-be-false classical physical theory. What is the rational basis for denying the validity of this overwhelming intuition, rather than denying the validity of that provably false theory, and accepting, instead, the relevance of the validated physical theory that validates this overwhelming intuition?

2. *Zombie modes and consciousness*. C&K say "Consciousness deals more slowly with … and takes time to decide on appropriate thoughts and actions." But how can conscious, or conscious decisions, *deal* with anything if only their neural correlates are considered. *Some* property beyond mere correlation is needed for consciousness to be able to deal with anything, or to decide on actions. The quantum psycho-physical theory justifies this causal language.

3. *Coalitions of neurons.* C&K say that the winning coalition "embodies what we are conscious of" and "produces consciousness." But how does a coalition "produce" consciousness, within the framework of classical physics? All that can ever be derived or deduced from the principles of classical physics are combinations of simple mathematical properties imbedded in space-time, and functional properties deducible from them. The concept of "producing consciousness" is not part of classical physics. If one wants to argue that this "production of consciousness" property is an ontological aspect of the classical world that is not captured by the classical principles, there is the difficulty that there can be no ontological reality that is even *compatible* with the classical principles, and that ties into experience in a natural way. Is it, therefore, not more rational to accept the theory that quantum theorists have already discovered, and extensively studied and verified, which, in its orthodox formulation, brings consciousness into the theory in a rationally coherent and practically useful manner?

4. (7)Snapshots. C&K say, "We propose that conscious awareness (for vision) is a series of static snapshots, with 'motion' painted onto them." "Perception occurs in discrete epochs." This refers to "awareness" and "perception", but presumably it must be the NCC that has these discrete epochs. But dynamical discreteness is incompatible with classical physics. However, a

series of discrete conscious events is exactly what quantum theory gives. (Stapp, 1993: 158)

5. *(8)Attention and binding.* C&K say "Attention can usefully be divided into two forms: either rapid, saliency driven and bottom-up or slower volitionally controlled and top-down." The quantum approach *explains* the occurrence of these two kinds of attention, and also binding, as a consequence of the basic laws of physics. The micro-causal Process II is high-speed, saliency-driven, and parallel, whereas the nonlocal, integrative, and effortfully deliberative Process I consists of a *series* of similar actions held in place by the Quantum Zeno Effect. The extensive body of work in the book by Pashler (1998) that focuses on these questions has been examined (Stapp, 2001), and shown to be in good accord with quantum theory.

The quantum psycho-physical theory of the conscious brain is, like quantum theory in general, a *pragmatic* theory. It is set within the framework of communicable descriptions of our intentional actions, and the experiential feedbacks that result from these actions. It justifies *dynamically* our intuition that our psychologically described mental efforts are able to influence our mental and physical behavior in the way that we feel they do. Thus science becomes intelligible: our physical communications are allowed to convey the real knowledge, information, instructions, and meanings that they do in fact carry. They do the job of communicating physically efficacious ideas, rather than being physical vibrations that encode instructions passing between complex biological computers that mysteriously produce, in some presently (and surely eternally) incomprehensible mechanical way, the *illusion* that our thoughts themselves are doing what we think they are doing.

But why should neuroscience bind itself to this essentially seventeenth century approach based on logically inadequate principles and known-to-be-non-existent entities when contemporary physical theory provides a rationally coherent alternative that accords with all the new and old physics data, and that brings consciousness into the theory at the foundational level,

in close mathematically controlled coordination with the physically described brain.

Shifting to the quantum psycho-physical approach to the mind-brain problem means switching to a new research posture. The objective is no longer to explain how a classically conceived brain can "produce" or "be" psychologically experienced consciousness. It is rather to elucidate the respective roles of the physically described brain and psychologically described mind in the determination of the content and timings of the stream of conscious Process I actions.

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