Title
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QUANTUM THEORY OF THE HUMAN PERSON.

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1. Introduction.

What is the future of quantum theory? Where will it go from here?

Quantum theory will go where it is most needed, which is into the effort to understand ourselves, and in particular the connection of our minds to our bodies.

Mind is the new frontier of science. The present century will be, for science, a century for advancing our understanding of the mind. Quantum theory is essential to progress here because classical physics leaves mind out: it relegates consciousness to the role of passive witness to a parade of physical events that are completely specified by local mechanical laws. Quantum theory, on the other hand, brings in the human participant in a subtle but essential way, and the quantum laws then suffice to explain the causal effects of our thoughts upon our actions.

The primary lesson taught by quantum theory is that the structure of empirically observed macroscopic phenomena cannot be understood within a conceptual framework in which the course of physical events is determined by local mechanical laws of the kind specified by the laws of classical physics. To deal with this in controvertible fact the creators of quantum theory found themselves compelled to bring our minds into basic physical theory in a way less trivial than that of passive witnesses. This shift, though subtle in character, is sufficient to allow quantum theory to provide a causal explanation of the kinds of action of mind on brain that are now being observed in a growing number of neuro-psychological experiments conducted at major laboratories and universities. (For references, and a discussion of these experiments see Schwartz (2002, 2004))

The nature of the causal connection between our minds and brains will, for many reasons, become increasingly a key focus of scientific research, The first reason is funding. Research goes primarily where the money is. The nature of the connection of our thoughts to our bodies is an important medical question. In an era of shrinking budgets major funding will probably be channeled increasingly to research fields that are perceived to be vital to human needs. Already one sixth of the US GNP goes to the health industry, as contrasted to 2.8% for education and research. Thus there is a big pot from which to fund research into the nature of the conscious human organism.

But perhaps even more important than the question of our mental and physical health are cultural ramifications. We live immersed in a sea of ideas, and the impact of these ideas is, today, at least as important to human destiny as our immediate physical conditions. This world of ideas is based directly upon our conception of what we ourselves are, and how we are connected to the forces that govern the universe.

The main contributors to the progress and development of these ideas are science, philosophy, and religion. The voice of science is strong in the construction of this intellectual milieu. But the message of science is blunted by the fact that it has hitherto been based mainly on classical physics, which proclaims us to be mechanical automata. That verdict conflicts with our deep intuitive idea of what we are, and leads to an impoverishment of values: value is reduced to the measure of mechanical well being. Also, moral philosophy is undermined by the self-contradictoriness of the idea of striving to improve a future that was already mechanically determined before the earth was born. These difficulties with the classical-physics-based idea of man in nature tend to mute the voice of reason based on valid applicable science, and the more-than-just-matter conception of man that it provides.

The quest for an understanding of the mind-brain connection is rapidly becoming recognized as the most important and interesting task of science, at least on the biological side. Antonio Damasio (2002) begins his lead article in the recent special issue of Scientific American devoted to the mind-brain problem with the words:

> "At the start of the new millennium, it is apparent that one question towers above all others in the life sciences: How does the set of processes we call mind emerge from the activity of the organ we call brain?

The article by Francis Crick and Christoph Koch (Crick, 2002) begins with the similar assessment:

> "The overwhelming question in neurobiology today is the relationship between the mind and the brain."

Some scientist (Crick, 2003:124) appear to believe that an adequate understanding the mind-brain connection can be based essentially on classical physics, even though that theory is known to be unable to explain the observed macroscopic properties (e.g., electrical and thermal conductance, elasticity, etc.) of systems that depend sensitively---as conscious brains certainly do---on the behaviors of their constituent atoms, molecules, electrons, and ions. This fatal failing of classical physical theory was remedied by the founders of quantum theory, who formulated their theory as a set of practical rules that specify how knowledge-seeking human agents should go about their tasks of first acquiring knowledge, and then representing that knowledge in a form that permits them to form expectations about the outcomes of their subsequent knowledge-seeking activities. The theory created by the founders is explicitly about connections between human experiences. It is a conceptual structure that allows us to organize and make practical use of the knowledge we acquire. This profound shift of perspective is proclaimed by statements of the founders such as:

> “The conception of the objective reality of the elementary particles has thus evaporated not into the cloud of some obscure new reality concept, but into the transparent clarity of a

mathematics that represents no longer the behavior of the particle but rather our knowledge of this behavior." (Heisenberg, 1958)

"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" (Bohr, 1934, p.18)

The subtle shift, alluded to above, in the role of the human agent is emphasized in statements such as:

"In the great drama of existence we ourselves are both actors and spectators." (Bohr, 1963, p. 15: 1958, p. 81)

"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 the appropriate latitude." (Bohr, 1958, p. 73}

"To my mind there is no other alternative than to admit in this field of experience, we are dealing with individual phenomena and that our possibilities of handling the measuring instruments allow us to make a choice between the different complementary types of phenomena that we want to study. (Bohr, 1958, p. 51)

2. Von Neumann's Processes 1 and 2.

Quantum theory was rigorously formulated by John von Neumann (1955, p. 418), who identified two distinct processes, Process I and Process II.

Process II is the quantum analog of the classical process of motion and, like it, is governed by laws that are both local and deterministic.

Process II is constructed from its classical counterpart by "quantization," which replaces 'numerical values' by 'actions.' The effect of this change is to smear out the numerical values: it turns the physical state into a smeared out collection of overlapping classically conceivable possibilities. (This feature is not undone by the much-studied environmental decoherence effect, which effectively wipes out certain off-diagonal interference terms of the density matrix but does not restrict the evolution of the important diagonal elements.)

Process II is, however, not the whole story. It generates a continuum of overlapping physical possibilities that extend over a range of experientially realizable possibilities. Thus, for example, if Process II were the only process operating since the big bang then the physical structure representing the (center point of the) moon would extend over a large portion of the sky, contrary to the empirical facts. Some other process is needed to bring the physical state S of an observed system into conformity with human experience.

To tie the physically described state S to human experience the founders of quantum theory brought human agents into basic physical theory in a fundamental way. This was a radical move because the successes of the earlier classical theory were due in large measure to the policy of keeping human agents out. But in orthodox Copenhagen quantum theory the conscious actions of agents become crucial elements. In von Neumann's rigorous formulation of the theory, each such action is called a Process I intervention. This act is a preparatory act that amounts to posing a specific question with a Yes or No answer. (More complex cases can be built up by further decomposing the No possibility, but the essential point can be explained by focusing on a question with just two possible answers, Yes or No.

A typical quantum question is: “Will a Geiger counter set in some particular place be observed to fire at a time later than some specified time T1 but earlier than some later specified time T2.” The preparatory action of putting this question to nature causes the state S to jump to a new state

$$S' = PSP + (1-P)S(1-P).$$

The first term corresponds to the possibility that the feedback from nature will be a human experience of seeing the Geiger Counter fire during the specified interval, and the second term corresponds to the failure of that specified experiential feedback to occur. These connections provide the critical correspondence between the mathematical/physical description and the psychological/experiential one.

3. The action of mind upon brain.

This Process I action by the agent involves a selection of a projection operator P from a continuum of alternative possibilities. This selection is, according to the orthodox rules of quantum theory, not specified by the physical state S of the system being examined or probed. This choice is taken to be a “free choice” on the part of the experimenter/agent, as indicated by the statements by Bohr quoted earlier.

The reason why, in the original “Copenhagen” version of quantum theory, the agent's choice must be regarded as "free," *in the specific sense that this choice is not determined by any *known* law of nature*, is that in the Copenhagen formulation the experimenter stands outside the system that is being probed, and his choice about how to conduct his probing action is considered to be up to him, not the system he is about to probe. In actual empirical practice, it is the prerogative of the observing agent, not the system being observed, to determine, from a continuum of possibilities, what *kind* of information or knowledge will be gathered by the agent during his act of observation. The system being observed does not make this choice.

Copenhagen quantum theory separates the dynamically unified physical world into two systems, the physical system S that is being examined, and the agent who is doing the examination. This latter system includes not only the stream of consciousness of the agent, and his body and brain, but also his measuring devices, which are regarded as extensions or parts of the agent. This extended agent is described in the sort of language that we use “to tell others what we have done and what we have learned”(Bohr, 1958, p.3). This conceptual arrangement works well in practice, but it means that the theory cannot be viewed as a possible description of nature: it must be viewed as merely a set of rules for calculating expectations pertaining to relationships between human experiences.

Von Neumann's approach is to treat the entire physical world, including our own bodies and brains as belonging to the world described by the quantum laws. This tack circumvents the need to separate the dynamically unified physical world into two differently described subsystems. But it transfers those functions that the Copenhagen interpretation ascribes to the agent to what von Neumann calls the “abstract ego” (von Neumann, 1955, p.421). This “abstract ego” is what is left of the agent after his devices, body, and brain have been transferred to the physically described universe. This remainder, or residue, is the agent’s stream of conscious experiences.

In von Neumann’s formulation the stream of consciousness of the agent acts upon the brain of the agent. Thus in the Process 1 action

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

.

the operator P acts non-trivially only on the brain of the agent. The choice of the operator P is ascribed to the abstract ego of the agent, namely his stream of consciousness. This provides, in principle, an *opening* within quantum dynamics for a *possible* action of a conscious mind upon the associated physically described brain.

4. Ideo-motor action.

According to William James's ideo-motor theory of the connection between Volition and Action (James, 1890), willful action is associated with a prolongation of attention to the idea of the intended action. Accordingly, let it be assumed that each possible course of action that is conceivable to---and executable by---an agent is represented in the brain of that agent by an associated pattern of brain activity that if held in place for a sufficiently long period of time will tend to cause that action to occur. I call this pattern a “template for action.” It is the “neural correlate” of the idea of that action. This pattern of brain activity is specified by a projection operator P that singles out from the morass of possible states of the brain of the agent those in which the associated template for action is activated. This projection operator P defines a possible Process 1 action. But the choices of which Process 1 interventions will occur are, according to quantum theory, “free choices” made by the agents.

The key question then becomes: Can an agent’s freedom to choose which Process I interventions occur have any effect on his bodily action?

The answer in von Neumann quantum theory is Yes! The agent’s choices of Process 1 interventions can exert a huge effect on the physical activity of his brain, and this can have in turn a large effect on his bodily behavior. The simplest way to achieve such a result is via the Quantum Zeno Effect.

5. The Quantum Zeno Effect.

Suppose S describes some slowly changing degrees of freedom of the brain. Suppose a sequence of "freely chosen" Process I events consist of a rapid repetition of events with the same P. Then the laws of quantum theory entail that S will be trapped in the subspace of states of the form PSP if the original state has this form. Transitions to the other outcome (I-P)S(I-P) of the Process 1 interventions are suppressed by virtue of the quadratic dependence upon the short time interval t between interventions of

(I-P)exp-iHt(PSP)expiHt(I-P)=O(t squared)

That is, suppose a Process 1 event, followed by Nature’s choice of an outcome, lands you in the Yes state PSP. And suppose, your mental effort, within the range of "free choices" options available to you, can activate a rapid repetition of Process I events all associated with the same P. If the repetition rate is sufficiently fast then, due to the quadratic dependence on the time interval t between successive Process 1 events, there will be almost no transitions to the "No" states of the form (I-P)S(I-P) over a long peiod of time, even if strong forces would tend to quickly move one out of the space specified by PSP in the absence of the rapid sequence of process 1 interventions.

One verifies the quadratic dependence on t by observing that a replacement of *either one* of the two exponentials by the zeroth order term "unity" gives a null contribution to the transition probability, due to the constraint

$P(1-P)=(1-P)P=0,$

which is imposed by von Neumann’s rules on the operators P

The lowest order term is therefore of second order in t. This entails that if by means of his “free choices” an agent can increase the rapidity of the Process 1 interventions to the point of activating the quantum zeno effect, thereby holding in place some template for action, then the agent can, by exercising his “free choice,” influence his bodily actions.

This scenario is precisely in line with James’s description of the effect of will:

> "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.” (James, 1890:)

> "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, 1890:)

This explanation of the effect of mind on brain is strictly quantum mechanical. The classical-physics approximation eliminates the latitude provided by the uncertainty principle within which the play of free choice operates. Thus it closes the door opened by quantum theory to the possibility of a genuine causal influence of our thoughts, ideas, and feelings upon our physical actions.

William James clearly recognized the difficulty within classical physics of allowing mental effort to make a physical difference. He apparently understood what could then hardly be uttered by a man of science, namely that classical physics must be wrong. The prescient final words of his book "Psychology: The Briefer Course" are:

"...understand how great is the darkness in which we grope, and never forget that the natural-science assumptions with which we started are provisional and revisable things." (James, 1892)

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