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Whiteheadian Process and Quantum Theory of Mind *

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Abstract

There are deep similarities between Whitehead's idea of the process by which nature unfolds and the ideas of quantum theory. Whitehead says that the world is made of 'actual occasions', each of which arises from potentialities created by prior actual occasions. These actual occasions are 'happenings' modelled on experiential events, each of which comes into being and then perishes, only to be replaced by a successor. It is these experience-like 'happenings' that are the basic realities of nature, according to Whitehead, not the persisting physical particles that Newtonian physics took be the basic entities.

Similarly, Heisenberg says that what is really happening in a quantum process is the emergence of an 'actual' from potentialities created by prior actualities. In the orthodox Copenhagen interpretation of quantum theory the actual things to which the theory refer are increments in 'our knowledge'. These increments are experiential events. The particles of classical physics lose their fundamental status: they

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dissolve into diffuse clouds of possibilities. At each stage of the unfolding of nature the complete cloud of possibilities acts like the potentiality for the occurrence of a next increment in knowledge, whose occurrence can radically change the cloud of possibilities/potentialities for the still-later increments in knowledge.

The fundamental difference between these ideas about nature and the classical ideas that reigned from the time of Newton until this century concerns the status of the experiential aspects of nature. These are things such as thoughts, ideas, feelings, and sensations. They are distinguished from the physical aspects of nature, which are described in terms of quantities explicitly located in tiny regions of space and time. According to the ideas of classical physics the physical world is made up exclusively of things of this latter type, and the unfolding of the physical world is determined by causal connections involving only these things. Thus experiential-type things could be considered to influence the flow of physical events only insofar as they themselves were completely determined by physical things. In other words, experiential-type qualities. insofar as they could affect the flow of physical events, could—within the framework of classical physics—not be free: they must be completely determined by the physical aspects of nature that are, by themselves, sufficient to determine the flow of physical events.

The core idea of Whitehead's thought is, I believe, that the experiential aspects are primary: they control the physical, rather than the other way around.

It is therefore interesting to inquire about the direction of the flow of causal influences in the quantum picture of nature: Are the experiential qualities still slave to the physical quantities?

This question of which way the causal influences runs is probably the most basic question in both science and philosophy: Are the physical aspects of nature in complete charge, as they are in the classical picture of nature, or do the experiential aspects of nature have a degree of autonomy that can feed into, and effect in significant ways, the flow of physical events?

The issue here is whether the physical description is self-sufficient? Are the experiential aspects of nature merely consequences of the physical aspects, whose dynamical evolution is completely specified by laws of nature that involve only these physical aspects themselves—together with random elements that represent aspects of nature that are beyond the scope of human experience—or do experiential-type things, uncontrolled by the physical aspects, enter in an essential way into the dynamical connections that guide the evolution of physical aspects.

I shall argue here that the structure of quantum theory renders the physical description non self-sufficient. The experiential aspects of nature enter into the dynamical rules that determine the unfolding of physical reality by way of needed *choices* that are specified neither by the deterministic aspects of quantum laws, *nor by the random elements that enter into quantum theory.* Moreover, these 'free' choices can significantly affect the behaviour of an organism that is associated with a sequence of such free choices.

This result buttresses Whitehead's idea that subjective elements play a basic role in the process of the unfolding of nature.

Disclaimer

1. Introduction.

Quantum mechanics, regarded as a tool for making certain kinds of practical predictions, appears to be complete. But as a description of nature it is not. It is incomplete because the lawful process of the unfolding of nature that it describes has two missing links: the quantum laws do not yield definite conclusions unless *two* kinds of choices are made, and the theory leaves open the questions of how these choices are made, and what the outcomes of these choices will be.

In this connection, Bohr, describing the 1927 Solvay conference, noted that:

> an interesting discussion arose about how to speak of the appearance of phenomena for which only statistical predictions can be made. The question was whether, as to the occurrence of such individual events, we should adopt the terminology proposed by Dirac, that we were concerned with a choice on the part of "nature", or as suggested by Heisenberg, we should say we have to do with a choice on the part of the "observer" constructing the measuring instruments and reading their recording.

The point is that two very different kinds of choices enter into the determination of what happens.

(1) A particular question must be posed.

(2) Then nature gives an answer to that particular question.

The second kind of choice is described by Dirac as a choice on the part of "nature" as to what the outcome of a given observation will be. For this kind of choice quantum theory does give at least a statistical prediction: it specifies, for each possible outcome of the observation, the probability for that outcome to appear. This is the famous statistical element in quantum theory. But that choice is out of human hands: it is not the focus of this study.

The first kind of choice is also essential. It is the choice by the observer of which aspect of nature he is going to observe. In the context of a scientist performing an experiment on some external physical system this choice by the experimenter of which experiment he will perform is decided by something going on in the experimenter's brain. That brain process is not usually the matter under investigation. But if, following von Neumann, we take the view that quantum theory ought to cover all physical systems, including human brains, then the freedom in the theory about which aspect of nature is going to be examined—about which question nature will be asked to answer—gets traced back to a corresponding freedom at the level of the brain.

This *freedom* pertaining to questions of the first kind, and the *need* for these choice to be made, does not disappear from the quantum process when the brain is included in the system. It just gets shifted to where it belongs: the dynamics *needs* a choice of which aspect of the brain is going to be observed by 'the observer', in order to allow the quantum rules to be applied, and this choice is *free*, in the sense that is is not specified by the "physical" aspects of nature, which are the aspects represented in the quantum state of the universe.

In psychological terms this freedom apparently translates into some degree of freedom, as far as the known laws of nature are concerned, of the observer to choose what he will attend to.

The question then arises: What effects can this freedom of choice have on behaviour of the observer's brain?

I shall argue that this freedom, given to the observer by quantum theory, can give a human observer great power to direct the activities of his brain, and thereby the activities of his body.

By "freedom" I mean here freedom in the sense of being unconstrained by the known laws of nature: a freedom to control physical action that is neither obliterated, wiped out, nor compromised by the statistical element in quantum theory, and that involves no baising or alteration of that statistical aspect of the world. It is a freedom to control bodily action that acts *via* the normal statistical rules, not via any biasing or alteration of those normal statistical rules.

2. Posing the Question.

The starting point of this study is the fact that contemporary quantum theory is ontologically incomplete. Two fundamental questions remain unanswered. The theory requires that questions with 'Yes or No' answers be put to nature, whereupon nature delivers an answer, The relative statistical weights of the two possible answers, 'Yes' or 'No', are then specified by quantum theory. What is not specified by the contemporary form of quantum theory is: (1), what determines which questions are put to nature, and (2) what determines whether the individual answer to a posed question is yes or no?

The objective here is to begin to answer these questions, adhering to the naturalistic principle that the actually occurring experiences be specified by (supervene on) the physical universe, specified by the evolving quantum state of the uviverse. However, the experiential aspect will enter as cause, not effect.

To make the argument clear to physicists I shall use the language and symbols of quantum theory. But I shall try to explain things in a way that others can understand, if they just regard the symbols as pictorial abbreviations of the ideas that I describe.

The (physical) state (of the universe) is represented by the (density operator) S.

A possible experience is labeled by the letter e.

The connection of this experience to the mathematical formalism is via the correspondence;

$$e \Longrightarrow P_e,$$

where P_e is the projection operator

$$P_e = \sum_{i \in \{e\}} |i >< i|.$$

Here the sum is over a set of basis states i each of which if actualized produces experience e.

The basic connection is this:

If S is the state before experience e occurs, then the state after this experience occurs is:

$$S' = P_e S P_e.$$

This change is called the "reduction of the wave packet" to the form that incorporates the restriction imposed by the new knowledge supplied by the experience e.

There is a basic difference in philosophy at this point between the Copenhagen view espoused by Bohr et. al. and the view proposed by von Neumann. Bohr assumed that the state involved in the quantum description was the state of some relatively small system that has been prepared by experimenters, and that the projection operator P_e acted in the space associated with that small system. The surrounding world was not represented except by way of the scientist's description of the experimental set up, and the whole quantum procedure was considered to be merely a way to make predictions about what would appear to observers under well defined observed conditions.

This radical restriction on the scope of science was rejected by Einstein.

Von Neumann took the point of view that one should try to assume that quantum theory was universally true, and that, since measuring devices and human bodies were made up of atoms, the laws of quantum theory should work for these physical systems. By following through the logic he showed that one could suppose that the laws of quantum theory applied to the whole physical universe, and that the projection operator P_e could then be supposed to act on the aspect of the state of the universe that corresponds to the brain of the observer: this action of P_e on S selects out from S, and retains, only those states of the brain that correspond to the occurrence of the experience e. This gives an 'explanation' of the pragmatic Copenhagen rules, which did not bring in the brain of the observer, in terms of a connection of external events to brain events to experiential events. It yields a picture of the universe that is in general accord with the classical idea that there is a causal chain that links an event in the external world to the brain of the observer of that external event, and that this connection leads—under appropriate conditions of alertness and attention, etc.—to a corresponding brain event, which will produce the experiential event e upon which the Copenhagen interpretation is based.

The only "reductions of wave packets" that are needed in the von Neumann picture, in order to reproduce the predictions of the pragmatic Copenhagen interpretation, are reductions associated with human experiences that give increments in "our knowledge". Of course, it would be unacceptably anthropocentric to single out our particular species in an ontological approach. So I assume that this process in human brains is just a special case of a process of wide scope. But I focus here on that special case.

Von Neumann builds into his formulation the requirement that a specific question be posed by invoking his famous "Process I";

For comparison note that, for any P, the following identity follows from simple algebra:

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

"Posing of the question" is represented by the von Neumann reduction (i.e., by the von Neumann Process I):

For some possible experience e,

$$S \Longrightarrow P_e S P_e + (1 - P_e)S(1 - P_e).$$

The first term (after the arrow) is the part of the state S that corresponds to the definite outcome "Yes: Experience e occurs"; the second term corresponds to the definite outcome "No: Experience e does not occur (at least at this try)". The other two terms are stripped away by the VN Process I.

This action on S defines which question is put to Nature.

Nature will then give the answer 'Yes' with probability

$$TraceP_eS/TraceS = \sum_{i\in\{e\}} < i|S|i > / \sum_i < i|S|i > .$$

Quantum theory makes this definite statistical prediction about what the outcome will be, once the question is posed. But it does not specify what the question will be, beyond the requirement that the 'Yes' answer must correspond to some particular experience. Which question is posed is in the hands of the observer.

This freedom places in the hands of the observer great power to control the course of physical events in his brain without in any way conflicting with the constraints imposed by the known laws of nature. The argument for this follows.

3. Light as foundation of being.

There are many theoretical reasons for believing that our experiences are correlated mainly to the electromagnetic properties of our brains.

Our experiences have a classical character, and the closest connection of quantum mechanics to classical mechanics is probably via the so-called 'coherent states' of the EM field. [J.Klauder and E.C.G. Sudarshan(1968), R. Glauber(1970), H. Stapp(1983), T. Kawai and H.P. Stapp(1995)]

These coherent states integrate a vast amount information about the motions of individual ions that cannot be expected individually to affect thoughts.

These coherent states are pobably the most robust feature of brain dynamics, with respect to perturbations caused by thermal and other noise. [O. Kuebler and H.D. Zeh(1973), H.P. Stapp(1993), W.L. Zurek(1993)]

I do not need to go in more detail, other than to say that the EM field in the brain can be decomposed into modes each of which would, in the free-photon idealization, behave like a simple harmonic oscillator of well defined frequency.

The coherent state description is in terms of this collection of simple harmonic oscillators. For each such oscillator the ground state is a certain gaussian state in both of its internal variables p and q:

$$exp - q^2/2 \text{ or } exp - p^2/2,$$

This gaussian "cloud of possibilities" is centered at the origin $q = 0$ and $p = 0$ in both q and p.

If one shifts this state so that it is centered at some other point (Q, P). then this center point will, for the free-photon case, move around a circle of fixed radius with constant velocity, which is just the motion in these variables that a classical particle would follow for the simple harmonic oscillator case.

I shall assume that the mind-brain connection is via these coherent states of the EM field, and will examine the effects on the brain of mental action by considering the effects of mental action on these coherent states of the EM field in the brain.

4. Effects of Mental Action on Brain Behavior

I first show that, within the framework of quantum theory, the mere choice of which question is asked, can influence the behavior of a system, even when an average is made over the possible answers to the question.

This demonstration is intended for physicists; then it is quite short. Other readers can perhaps get the jist.

The issue is simply:

Can $X \equiv Tr[QPSP + Q(1 - P)S(1 - P)]$ depend on P ?

Take $Q = \sigma_z$, $S = (1 + \sigma_z)$ [Pauli sigma matrices]

If $P = S/2$ then $X = 2$. If $P = (1 + \sigma_y)/2$ then $X = 0$.

This just confirms, as a matter of principle, that it matters which question is posed, and answered, even if one averages over the possible answers. Thus the gross behavior of a system can depend upon which questions the system is asking, internally, even if the gross behaviour is obtained by averaging over the answers that nature gives to these questions.

I give two example of how one's behavior could be influenced in this way by focussing one's attention, if focussing attention corresponds to specifing which question is posed.

The first is an application of the Quantum Zeno Effect, which is certainly theoretically well understood, and has, at least in a certain sense, been confirmed experimentally [Itano (1990)]. The point is that according to quantum theory a very rapid sequence of observations on a system keeps it from evolving in the way that the Schroedinger equation demands.

This could be connected to the psychological experience that intense concentration on an idea tends to hold it in place. If the general ideas being discussed here are correct, this holding of an idea in place by focus of attention could overwhelm the effects of a physical force that ought to move the center point of the state.

For example, if one is holding up some heavy object then intense mental focus of attention on some possible experience e, could produce a very rapid sequence of experiences e, each resulting in a collapse of the wave function associated with the brain to a state compatible with this experience e, that would hold this aspect of the brain state in place, in spite of physical forces that would tend to make this aspect of the brain state change.

A second example is this. Suppose we are representing the brain, insofar as its interface with consciousness is concerned, by coherent states of the EM field. This state is a Gaussian state represented by $N \exp -[(q-Q)^2/2]$, where N is a normalization constant.

Suppose I ask the question: Will I find the state to be $N \exp -[(q - Q')^2/2]$. The probability that the answer is 'Yes' is the square of:

$$N^2 \int dq \exp -[(q-Q)^2/2] \exp -[(q-Q')^2/2] = \exp -[(Q-Q')^2/2].$$

For small Q the probability is $\approx (1-(Q-Q')^2)$.

Suppose one has a large distance L in Q space, but breaks the distance into n small intervals, for which the above approximation is adequate, and asks the succession of questions: Is the state the Gaussian centered at the end of each of the succession of intervals.

Then the probability, at the end of this process, of finding the state to be the Gaussian centered at L is $\approx (1 - (L/n)^2)^n$. In the limit of large n this is unity: the mental effort of focusing attention in this way will have, with high probability, according to the statistical rules of quantum theory, changed the state of the brain to this other state in spite of the absence of any force arising from the physical connections represented in the Schroedinger equation.

These effects may seem strange. But the point is that there is a loose connection in quantum theory: the physical principles do not specifiy which question is posed. If that freedom can be exploited then there would be in nature, and perhaps available to us, an effective force associated with mind that is not controlled by the physical aspects of nature, but that can control some physical aspects of nature, namely the way a classically describable feature of the brain that is directly related to experience deviates, *in a way controlled by the observer's focus of attention,* from its normal evolution under the influence of the physical forces alone.

5. What Determines Which Question is Posed?

What sort of rule might one imagine for filling this logical gap left open by contemporary quantum theory?

A simple mechanical-type rule would be this:

Pick the e with the maximum value of of TrP_eS, subject to some other fixed rules about timings and durations, and such things, but without any reference the "quality" of experience e.

This would extend to mind the general sort of rule that works in the physical realm: experiences would still be epiphenomenal aspects of nature completely controlled by the physical aspect.

An alternative might involve a Value Function V(e) that assigns a "value" to experiences: then the rule might be to pick the e that maximizes $V(e)TrP_eS$.

Perhaps there could be a rule that an increment is added to $V(x)$ for $x = e$ each time e occurs. This would probably help get the universe going because the e's that tend to reproduce themselves would make $V(x)$ large for $x = e$.

This sort of rule would still make no reference to the quality of experience e.

However, there does not seem to be anything that would exclude the possibility that what enters into the fixing of V(e) is the "quality" of the experience e. The quality of an experience is as real as anything else, and it might be much more real than what has traditionally been regarded as real. Since the experience e is associated with a projection operator P_e that acts as a unit on the whole brain, the dependences on 'qualities' of experiences might bring into the dynamics qualities of nature that are quite different from the micro-structures that control classical dynamics.

The ideas of Whitehead certainly suggest that subjective/experiential aspects of nature do enter into the choice of which question is posed, in the process of the development of an organism. His ideas may give some guidance about how this subjective aspect might enter.

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