Mind in the Quantum Universe.

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Astronomy and the Phenomenal Aspects of Nature.

Astronomy has affected civilization in many ways, but none more profoundly than its impact on our idea of what we human beings actually are. We, in our innermost aspect, are our minds, and, strange as it may seem, our ideas about the nature of our minds are rooted in astronomy. It is not that our minds *themselves* are rooted in the stars, instead of in our brains. It is rather that *our ideas about our minds* are rooted in science, and that our basic science is rooted in astronomy.

The careful astronomical observation of Tycho led to Kepler's three laws of planetary motion. These laws, coupled to Galileo's association of gravity with *acceleration*, led directly to Newton's inverse square law of gravitational attraction. This led to the idea of *physical determinism*, the notion that a complete description of the values of all physically described variables at any one time completely determines the values of all physically described variables at any later time. By a *physically described* variable I mean a variable that is specified by assigning mathematical quantities to points in space-time. The space-time trajectories of particles and the strengths and rates of change of 'local fields' are the paradigmatic examples of physical variables.

The predictable motions of the planets in accordance with Newton's laws are the prime embodiment of the idea of *physical determinism*. Newton extended this idea, with tremendous success, first down to the scale of terrestrial motions, to the tides and falling apples etc., and he then conjectured a further extension down to level of the atoms. According to this conjecture, the entire physically described universe, from the largest objects to the smallest ones, would be bound by the precept of physical determinism: by the principle of "causal closure of the physical". This idea of *universal physical determinism* is a basic precept of what is now called "classical physics".

The Omission of the Phenomenal Aspects of Nature

The dynamical laws of classical physics are formulated wholly in terms of physically described variables: wholly in terms of what Newton's predecessor, René Descartes, called the elements of "res extensa". Descartes' complementary *psychologically described* things, the elements of his "res cogitans", were left completely out: there is, in the causal dynamics of classical physics, no hint of their existence. Thus there is not now, nor can there ever be, any *rational* way to explain on the basis of the dynamical precepts of classical physics, either the existence of, or any causal consequence of, the experientially described aspects of nature. Yet these experiential aspects are all that we directly know.

This troublesome point was abundantly clear already at the outset:

Newton: "…*to determine by what modes or actions light produceth in our minds the phantasm of colour is not so easie"*

Leibniz: *"Moreover, it must be confessed that perception and that which depends upon it are* ***inexplicable*** *on mechanical grounds, that is to say, by means of figures and motions."*

Classical physics, by omitting all reference to the mental realities, produces a logical disconnect between the physically described properties represented in that theory and the mental realities by which we come *to know* them.

The Apparent Causal Effects of the Phenomenal Realities

Our entire productive lives are built around the belief, drawn from its incessant empirical validation, that our conscious efforts can influence our physical actions. One conceivable resolution of this classically inexplicable seeming intrusion of mental processes into the closed dynamics of the physically described world, as it is conceived of in classical mechanics, is that each mental reality is, again inexplicably, the very same thing, at least causally, as an associated brain process. This is essentially the resolution proposed by the *physicalist* philosophers. An alternative resolution that is at least worth considering is that the precepts of classical mechanics *are not* 100% correct: that Newton's *speculation* about the extrapolation of his dynamical ideas from planets to atoms is not exactly valid.

At least one prominent scientist/philosopher dared to broach this unsettling idea during the nineteenth century, *before* the precepts of classical mechanics had been empirically invalidated. William James, speaking of the scientists who would one day resolve this mind-body problem, said: *"and never forget that the natural-science assumptions with which we started are provisional and revisable things"* (Psychology: The Briefer Course, last page). Strangely, his idea that precepts of classical physics might be wrong in ways pertinent to the mind-brain problem is, in effect, aggressively denied by most philosophers of mind *today*, more than eight decades *after* the downfall of that theory.

Philosophers are often called upon to defend highly counter-intuitive and apparently absurd positions. But to brand as an illusion, and accordingly discount, the supremely successful conceptual foundation of our lives---the idea that our conscious efforts can influence our physical actions---on the basis of its conflict with a known-to-be-false theory of nature that leaves out all that we really know, is a travesty against reason, particularly in view of the fact that the empirically valid replacement of that invalid classical theory is *specifically about* the details of the nontrivial connection between our consciously chosen intentional actions and the experiential feedbacks that these actions engender.

A perusal of the writings of prominent contemporary physicalist philosophers of mind reveals starkly the cause of their impairment: they do not understand the details of the workings of quantum mechanics, and hence dismiss its relevance for illogical reasons. They uniformly, as far as I been able to discover from their writings, identify the basic change wrought by quantum mechanics as either the introduction of an element of "randomness", which, as they correctly point out, does not help at all with the promotion of rational control of physical action by conscious mind, or as the introduction of a general "indeterminism" which is likewise of no help: "randomness" and general "indeterminism" both act in the wrong direction. By thus conceiving the changes wrought by quantum mechanics in these simplistic, and extremely incorrect and misleading, ways these philosophers render themselves incapable of grasping of how our minds can achieve, *directly via the basic dynamical rules of quantum mechanics, in spite of the opposing quantum randomness, but by virtue of the failure of physical determinism,* a bona fide conscious influence over our physical actions.

Phenomenal Reality is Central to Copenhagen QM

Copenhagen quantum mechanics is the original version of QM, propounded in the late 1920s by the founders: Werner Heisenberg, Niels Bohr, and Wolfgang Pauli. It is the hugely successful set of computational rules, embedded in a linguistic structure pertaining to our intentional probing actions and their phenomenal consequences, that physics students are taught in our universities, and then use in actual practice. The phenomenal aspects of nature that were left out of classical mechanics (CM) re-emerge as the central focus of Copenhagen QM:

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 relations between the multifold aspects of our experience". (Atomic Theory and the Description of Nature: p.18)*

Heisenberg: *"The conception of the objective reality of the elementary particles has evaporated not into the cloud of some new reality concept, but into the transparent clarity of a mathematics that represents no longer the behaviour of the particles but our knowledge of this behavior."* (Daedalus, 1958: p. 95.)

Bohr: *"The freedom of experimentation…is fully retained and corresponds to the free choice of experimental arrangement for which the quantum mechanical formalism offers the appropriate latitude."(Atomic Physics and Human Knowledge: p.73)*

Copenhagen quantum theory is basically a set of pragmatic rules that allow scientists to form valid expectations pertaining to what an observer will experience under each of the various alternative possible courses of action between which he or she is free to choose. Thus Copenhagen quantum theory is basically about the structure of human knowledge! It constitutes a swing away from the *classical-physics extreme*, which excludes conscious experiences from the dynamics, to the opposite extreme of making the contents of our

streams of conscious experiences the central concern of the useful and testable science that it creates.

The Middle Way: Von Neumann's "Orthodox" Ontological QM

Von Neumann constructed an objective version of QM that, like CM, can be construed to be a description of reality itself. This reality is conceived to have, as Descartes proposed, both physical and phenomenal aspects. The relationships between these two parts are specified by the quantum dynamical laws that von Neumann spells out. These laws integrate the phenomenal/experiential realities into an evolving, objective, physically described universe.

Von Neumann's method of constructing this ontologically interpretable QM starts with the pragmatic Copenhagen QM, which eschews all talk of an objective (impersonal) physical reality. Von Neumann's construction removes from the Copenhagen version certain ambiguities, in order to arrive at an ontologically interpretable objective version. Von Neumann's version was dubbed the "orthodox" interpretation by Eugene Wigner to distinguish it from the pragmatic Copenhagen version.

Technically, the Copenhagen QM, from which von Neumann starts his analysis, rests on the idea of a "cut" that separates the world into an experientially described part (that includes the observer and his measuring devices) that lies "above" the cut and a quantum mechanically described part (the system being probed by the observer and his devices) that lies "below" the cut. The part lying above the cut is conceived to be actively "probing" the part lying below the cut, and *receiving* randomly selected answers to the 'Yes-or-No-type' questions that it is posing. The statistical weights of the alternative possible *answers* are determined by the theory, *but the contents of the probing questions are not specified by any yet-known rule or law*. *The probing actions can therefore, at least in principle, be determined in part by the experiential aspect of the probing system*

Ambiguity in Placement of the Copenhagen Cut

A device that lies above the Copenhagen cut is made up of particles and fields and it thus in principle could be shifted to below the cut. Such an ambiguity in cut placement might be unacceptable in an ontological theory, but it is perfectly OK in a pragmatic theory, provided that no prediction depends upon this placement.

Von Neumann systematically studied the effects of shifting the placement of the Copenhagen cut between the physically and experientially described parts of the world. He considered a sequence of placements in which the boundary is shifted, step by step, from an initial placement used in the Copenhagen interpretation, further and further up to *and into* the brain of the observer, until at last the entire world that is describable in terms of atoms and molecules is on the physically described side, with only the observer's "abstract ego" lying on the side described in experiential terms. At that stage the boundary separates the observer's mind from his brain. The connection between the two sides of the cut then constitutes a mind-brain connection. Von Neumann's work shows

that the boundary can be moved up in this way without disrupting the predictions of the theory, which are always expressed ultimately in terms of relationships between experiences.

Von Neumann's Two Processes

The analysis outlined above is pursued by von Neumann within a mathematical formalism that is basically just a rigorous formalization of the rules implicit in Copenhagen QM.

Von Neumann's formulation is based on *two processes*: Process 1 and Process 2. Process 1 is a physically described action upon the physically described state. This action can be conceived of as posing a 'Yes-or No-type' question: it reduces the prior physical state to a sum of two parts, one corresponding to the 'Yes' answer to the question, and the other corresponding to the failure to receive a 'Yes' response. Multiple choice questions can be constructed by considering sequences of these 'Yes-No' questions.

The state is represented by a matrix, which has two sides. The 'Yes' term is really 'Yes-Yes' and the 'No' term is really 'No-No'. Consequently, the Process 1 action reduces the prior state to less than it was: it eliminates the 'Yes-No' and 'No-Yes' parts. Thus the Process-1 action picks out, from an infinitude of possible questions that could be put to nature, one particular 'Yes-or-No-type' question, which therefore *logically* precedes nature's randomly selected answer to it.

Process 2 is the process of physical evolution of the quantum state *between* the Process-1-initiated selections of outcomes. Process 2 is a physically deterministic process that is analogous to the physically deterministic causal-evolution process of classical mechanics. It is governed by the Schroedinger wave equation. Process 2 prevails only *between* the reduction events, which are essential features of the Copenhagen and Orthodox versions of quantum mechanics.

[A competing "many-worlds" approach denies the occurrence of such reduction events, but has yet to produce a rationally coherent way of relating the resulting theory to human experience in the practically successful way specified by the Copenhagen/Orthodox theory, without introducing a logical equivalent of Process 1. I add here, for technical clarity, that the fundamental quantum state is taken to be the state (i.e., density matrix) of the entire universe, which is assumed to be finite, and that the state of any *subsystem* is formed by taking the partial trace over the complementary set of variables.]

The key point is that von Neumann's Process 1 action *merely poses a probing question!* The system being probed, for example some pertinent part of a person's brain, has been interacting strongly with its environment, and its quantum state (density matrix) has therefore been reduced to nearly diagonal form in the pertinent coordinate basis. The continuity of the Schroedinger-equation-directed dynamics ensures that this state will be continuous in these variables. The "butterfly effect" in the highly nonlinear brain system,

with abundantly available free energy, probably operating at the boundary of chaos, entails that this state will probably extend over a multitude of possible patterns of brain activity of the kind that would correspond to a particular conscious experience, of say, intending to act in some particular way in response to some perceived situation in which the person finds himself or herself. The Process-1 action is *associated* with some particular possible bodily action. But the occurrence of the Process-1 action does not entail that this action will occur. All that it does is to specify some particular possible pattern of brain activity, and then *to put to nature* the question of whether this particular pattern of brain activity will or will not become actual. This Process-1 action does *not depend upon* the element of "quantum randomness": rather, it *sets the stage* for the entry of this element of randomness. Yet the future physical possibilities of the world have nevertheless been drastically curtailed by this choice of action, which is not *determined* by any yet-known law or rule, but that *seems,* in many cases, to stem, at least in part, from "reasons" and "sentiments". While the apparent contribution of mental causes *could be* a delusion, there is no reason within QM for this to be the case, for these choices are definitely not determined by the deterministic Schroedinger equation in any known or specified way. The Schroedinger-based physically deterministic evolution has generated, rather, a continuous plenum of possibilities that the Process-1 action must reduce to a discrete set of logically distinct alternatives *before* the element of quantum randomness can enter.

In view of this detailed way in which the quantum dynamics works to produce its empirically validated predictions, one sees that the identification of the switch from CM to QM with merely the entry of "randomness" or "general (as opposed to physical) indeterminism" is an entirely unwarranted oversimplification, in the context of understanding the possible contribution, via quantum mechanisms, of mental processes to the course of bodily physical events. The contribution of the human mental input comes *before* the entry of quantum randomness, and *exploits* the failure of *physical* determinism. There is no need in QM for any breakdown of a possible pervasive underlying principle that every actually occurring event must have, in the totality of nature, a sufficient reason to be what it is: there is no suggestion in quantum mechanics of any need for a *general* indeterminism: no rational need for a breakdown of the principle of sufficient reason!

This quantum mechanical conception of nature, like science in general, is a work in progress. It is not yet complete because it does not specify the genesis of the Process 1 actions. But it does provide the general architecture of a rationally coherent interactive dualism that is a viable alternative to physicalism, to which it is greatly superior: first, because of its greater explanatory power; second, because it is not based on the precepts of a fundamentally invalid physical theory. It is completely compatible, without inexplicable dodges, with the incessantly empirically validated conclusion that our conscious efforts can influence our bodily actions in the way that they appear to us to do. I now turn to a description of how a person's thoughts can, in a completely natural and understandable way, influence his brain, and hence his body.

The Physical Effectiveness of Conscious Intentional Effort.

Our lives are built upon the capacity of our conscious intentional efforts to produce the intended bodily physical actions. But how does this important effect of conscious mind upon physical body come about?

A "template for action" is a pattern of brain activity which, if sustained for a sufficiently long period, will cause the specified action to occur. That such templates for action exist is plausible. If an action such as writing the letter "S" on the blackboard is to occur, then a particular sequence in neural firings that activate an appropriate sequence of muscle contractions must occur. It is plausible that some sustained pattern of brain activity would contain the synchronization information needed to produce the intended action.

Quantum mechanics allows Process-1 actions to be influenced by conscious effort. Given this logical opening we need merely assume that conscious effort can increase the *rate* at which an appropriate probing Process-1 action is repeated. If the brain correlate of an intentional effort is the *template for action* for the intended action, then conscious intentional effort can, by virtue of the *quantum Zeno effect*, cause the pattern of brain activity that constitutes the template for action to be held in place for an extended period of time. [Schwartz, et.al. Phil. Trans. R.. Soc. B, doi:10.1098/rstb.2004.1598]. This will tend to cause the associated physical action occur. Thus within orthodox quantum theory the physical effectiveness of 'conscious will', *per se*, need not be an illusion. It can be, instead, a direct causal consequence of the dynamical rules of orthodox quantum mechanics. The most problematic logical consequence of the classical-physics-based physicalist conception of nature is thereby evaded, namely the conclusion that human beings are causally equivalent to mindless mechanical automata.

Non-Human Minds

Von Neumann's formulation lends itself to an ontological interpretation, and I have interpreted it in that way, as providing a description of an objectively existing and evolving mind-matter reality. Von Neumann's ideas fit naturally with the ontological ideas of Heisenberg, and in particular with Heisenberg's embrace of the Aristotelian ideas of "potentia" and "the actual". The quantum mechanical state is considered to have the ontological character of a "potentia": it embodies not only information about what has occurred in the past, but also *objective tendencies* for the occurrence of the next "actual event".

According to this ontological interpretation, there is an objectively existing reality that is built out of a sequence of psycho-physical "actual events". Certain of these events are associated with human experiences. Each such event has a mental aspect that is an 'increment of knowledge' of some person, and also an associated physical aspect that is a reduction or collapse of the quantum state of the brain of that person to the part of its

prior state that is compatible with this increased knowledge. Each such collapse event is an objective physically described happening that occurs "primarily" in the brain of the experiencing observer. The quantum state acts both as a carrier of historical information about past events, and as an embodiment of statistically weighted potentialities for the next event. The causal effectiveness of the mental effort allows appropriate linkages between the intentional thought and intended physical action to become enhanced by natural selection.

The occurrence of observation-related events in the brains of human observers does not preclude the occurrence of actual events corresponding directly, for example, to the firing of a Geiger counter, or the formation of a bubble in a bubble chamber. If such a device-related-actual-event occurs, and is witnessed by someone, then there would be *both* the actual event located at the position of the device, and *also* a physical brain event directly associated with the human perception of the event at the device: the occurrence of a mind-brain event associated with an increment in human knowledge in no way precludes the occurrence of a related actual event outside the brain of an observing witness.

The contemporary empirical data is compatible with the possibility that there are no actual physical collapse events occurring outside human brains. The data is compatible also with the possibility that there is (also) an actual event occurring in conjunction with the detecting action of each large measuring device. That is, even though the entire physical world lies below von Neumann's final placement of the "cut", the openness of the theory with respect to the causal origins of the Process-1 actions, leaves open the possibility that Process-1 events can occur (also) in association with large detection systems besides human brains.

To escape anthropocentrism, we certainly want to include the "nervous systems" of various other living entities as allowed sites of actual events. The methods of von Neumann then show that, for all practical purposes (John Bell's FAPP), allowing other *macroscopic* detection systems to act on the physical world in ways similar to the ways that we ourselves do will produce no noticeable effects in the realm of human experience. This lack of sufficiently incisive data opens the door to metaphysical speculation as to which **macro-systems** besides human brains may host actual events. This openness is directly attributable to the afore-mentioned causal gap pertaining to what determines the Process-1 actions.

The psychological aspect of any actual event is presumed to be a particular feeling that exists in nature and is specific to an associated physical activity occurring at the associated physical site. The "feeling" of a relatively simple event in a "device" would presumably bear very little resemblance to the highly articulated feeling of perception associated with the extremely complex brain activity associated with a human perception of that device-based actual event.

Because the experiential aspect can itself be causally effective in the physical world, yet not fully determined by the prior state of the physically described world, it can become an

integral part of the process of the natural selection that has led to the evolutionary co-development of the brains and conscious minds of contemporary human beings.

If we trace this presumed evolutionary development backward in time we must allow the mental aspect to become ever more dissimilar to the human consciousness that we know. In this backward tracing it would seem unreasonable for a feature of nature as profound as these actual events to suddenly start occurring in association with the first lowly life form. It is more reasonable to expect the Process-1 events of that we know to be imbedded in a much more general set of actual events that encompass far more than our paltry contributions, and whose mental aspects, if indeed we should even call them "mental", have very little similarity to the highly specialized and developed occurrences that constitute the conscious human experiences that I have primarily been discussing.

Conclusion

Philosophers who try to address the problem of the logical and causal connections between mind and brain, and the related problem of conscious free will, from a basically physicalist perspective must deal with the fact that the physical theory that they have primarily relied upon, namely 19th century classical physics, is now known to be fundamentally incorrect: it was replaced during the 20th century, at the fundamental level, by quantum mechanics, which denies the basic precept of "physical determinism", or "causal closure of the physical", upon which their philosophical positions ultimately rest. Thus they must discount the relevance of quantum mechanics, in this context, of the influence of mind upon brain, and in the related context of "free will". This they all do by first claiming that the essential change wrought by quantum mechanics is the introduction of "randomness" or "indeterminism" into the dynamics, and by then pointing out, entirely correctly, that the introduction of "randomness", or of general "indeterminism", does not help to rescue the concept of meaningful "free choice" that is at issue. But those arguments completely miss the crucial point, in this context, of the switch from classical to quantum mechanics, namely the logically needed introduction of what von Neumann calls "Process 1". This process is not controlled by "quantum randomness". It is, instead, the *necessary logical predecessor* to the entry of the element of quantum randomness. It specifies *the otherwise-ill-defined set of discrete possibilities between which the logically subsequent random choice will be made.* The entry of this physically undetermined but causally efficacious Process 1 into brain dynamics constitutes a failure within quantum mechanics of the classical precept of ***physical*** determinism; and a failure that is *logically prior* to the entry of quantum randomness. There is no apparent reason in quantum theory to deny the precept of **general** determinism: the principle that every event must, from some deep place, have a sufficient cause.

By thus failing even to notice the absolutely crucial point, within this mind-brain context, of the entry into the quantum dynamics of the physically indeterminate but causally efficacious Process 1, the physicalist philosophers disqualify themselves as knowledgeable commentators on the subject of the relevance of quantum mechanics to the mind-brain issues upon which they propound. This failure to grasp the essential

nature of the radical dynamical changes wrought by quantum mechanics keeps these philosophers mired in the rationally irresolvable difficulties that flowed from the failed seventeenth century speculation that the causal ideas that worked so well for the planets of the solar system would work equally well for the atomic particles from which our brains are made.