

Already Whitehead, James, and Quantum Theory

Whitehead's Process Ontology as a Framework for a Heisenberg/James/von Neumann Conception of Nature and of Human Nature

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"Nature and Nature's Laws lay hid at night, God said 'Let there be Newton', and all was light!" Alexander Pope

"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." Niels Bohr

INTRODUCTION

What is the proper task of science? Is it to illuminate the nature of reality itself, as Alexander Pope proclaimed was achieved by already Isaac Newton? Or should the purpose of science be curtailed in the way recommended by Niels Bohr?

Bohr asserted that "...the formalism does not allow pictorial representation along accustomed lines, but aims directly at establishing relations between observations obtained under well-defined conditions." (Bohr 1958, p.71) However, the impossibility of representing reality along *accustomed* lines does not automatically preclude every kind of conceptualization. Perhaps an *uncustomary* idea will work. Even Newton's mechanical conception was not customary when he proposed it. Hence if advances in science reveal an incompatibility of the empirical evidence with customary pictorial representations then perhaps the construction of a new vision of reality is needed, rather than the immediate donning of blinders.

To operate most effectively in the physical world we need an adequate conception of ourselves operating within that world and upon it. Optimal functioning is impaired if we come armed only with blind computational rules, severed from any rationally coherent conception of ourselves applying these rules..

There is, of course, no guarantee that our species can come up with an adequate conceptualization of our conscious selves acting in and upon the world. And even if such an idea were discovered, there is no assurance that it is unique. However, neither the fear of failure nor the specter of non-uniqueness constitutes a sufficient reason to refrain from at least trying to find some satisfactory understanding of our mindful selves imbedded in a reality that sustains and surrounds us.

Due undoubtedly, at least in part, to the impact of Bohr's philosophy, most quantum physicists have been reluctant even to try to construct an ontology compatible with the validity of the massively validated pragmatic quantum rules. However, because of this reticence we are faced today with the spectacle of our society being built increasingly upon a mechanistic Newtonian-physics-based conception of reality that is *known to be fundamentally false*. Specifically, *the quintessential role of our conscious choices in contemporary physical theory and practice*, is being systematically ignored and even denied. Influential philosophers, pretending to speak for science, claim, on the basis of a fundamentally false scientific theory, that the (empirically manifest) *influence of our conscious efforts upon our bodily actions*, which constitutes both the rational and the intuitive basis of our functioning in this world, is an illusion. As a consequence of this widely disseminated misinformation the "well informed" officials, administrators, legislators, judges, and educators who actually guide the course of societal development tend to alter the structure of our lives in ways predicated on an outdated notion of "nature and nature's laws".

Bohr's pragmatic quantum philosophy emphasizes the *active* role that we human beings play in the development of our scientific knowledge. But this orientation tends to lead to an anthropocentric conception of reality. An escape from that parochialism is provided by the ideas of the eminent philosopher, physicist, and logician Alfred North Whitehead. He created a conception of natural process that captures the essential innovations wrought by quantum theory in a way that allows our human involvement, as explicitly specified by quantum theory, to be understood within a non-anthropocentric conception of nature.

Whitehead, acting as both physicist and philosopher, struggled to reconcile the disclosures of early twentieth century physics with the insights and arguments of the giants of Western philosophy, including, most prominently, Plato, Aristotle, Descartes, Leibniz, Locke, Hume, Kant, and William James.

I shall describe here a conception of reality that expresses, primarily, the ontological ideas of Werner Heisenberg, the principal founder of quantum theory, expressed within of the ontologically construed Tomonaga-Schwinger formulation of relativistic quantum field theory. This ontology is in total accord with *certain of the key ideas* of Whitehead.

It will enhance the clarity of this quantum ontology to quote Whitehead's clear enunciations of those key ideas. On the other hand, I make no claim to encompass *all* of the pronouncements of Whitehead, who wrote long before the work of Tomonaga and Schwinger. Indeed, I shall always take the quantum theoretical findings as preeminent, and will use only those assertions of Whitehead that mesh neatly with the ontologically construed quantum formalism, as it was carefully described by John von Neumann, and was later brought into accord with the precepts of the special theory of relativity by the work of Tomonaga (1946) and Schwinger (1962)

The core issue for both Whiteheadian Process and Quantum Process is the emergence of the *discrete* from the *continuous*. This problem is illustrated by the decay of a radioactive isotope located at the center of a spherical array of a finite set of detectors, arranged so

that they cover the entire spherical surface. The quantum state of the positron emitted from the radioactive decay will be a continuous spherical wave, which will spread out continuously from the center and eventually reach the spherical array of detectors. But only one of these detectors will fire. The total space of possibilities has been partitioned into a discrete set of subsets, and the prior continuum is suddenly reduced to some particular one of the elements of the chosen partition.

But what fixes, or determines, the partitioning of the continuous whole into the discrete set of subsets?

The orthodox answer is this: it is an *intentional action of an experimenter* that determines the partitioning!

Yet if the experimenter himself is made wholly out of physical particles and fields then his quantum representation by a wave function must also be a continuous function. But how can a smeared out continuum of classically conceivable possibilities be partitioned into a set of discrete components by an agent who is himself a continuous smear of possibilities. How can the definite fixed boundaries between the discrete elements of the partition emerge from a continuous quantum smear.

The founders of quantum theory could not figure out how such a discrete partitioning of the world could come out of the quantum physical laws---nor has anyone since. Accordingly, Von Neumann (1934), in his rigorization of the mathematics of quantum theory, calls this partitioning action an “intervention”: it is an *intervention* into the continuous deterministic Schroedinger-equation-controlled evolution of the physically described aspects of the universe. Every quantum mystery is packed into the structure of this intervention.

This “discreteness” problem is resolved in orthodox quantum theory, *and in actual scientific practice*, by what Heisenberg and Bohr call “a choice on the part of the experimenter”. Von Neumann calls *the manifestation in the physical world* of this conscious choice by the name “Process 1”. I shall call by the name “Process Zero, the conscious correlate of the physically described Process 1. [In some earlier works I have called this conscious correlate of the Process 1 physical action by the name Process 4, but Process Zero is the more appropriate name.]

The plan of Part I of this work is to:

1. Specify by using Whitehead’s own words *what I take* to be his key ideas.
2. Put them coherently together to form a space-time picture of Whiteheadian process.
3. Describe the basic structure of ontologically conceived Tomonaga-Schwinger relativistic quantum field.
4. Put these elements coherently together to form a space-time picture of quantum process.
5. Note the identity of these two space-time pictures.

6. Note some further identities, and propose a unified non-anthropocentric Whitehead/Quantum ontology.

This ontology is not completely specified. Yet it is far more structured than a general pan-psychism. It specifies distinctive conditions pertaining to space, time, causation, the notion of the “now”, the physically and psychologically described aspects of nature, and the role of conscious agents. The ontology imbeds the empirically validated anthropocentric concepts of contemporary orthodox pragmatic quantum theory in a non-anthropocentric conception of reality.

In the second part of this work I shall explain how quantum theory can account in a natural way for the influences of conscious volitional effort upon brain---hence bodily---activity.

PART I: A Non-Anthropocentric Whitehead/Quantum Ontology

Key Elements of Whitehead’s Process Ontology

I shall now state what I take to be Whitehead’s key principles, as expressed in Whitehead’s own words [1934]

Whitehead’s first principle is that the world is built out of actual entities/occasions!

“ ‘Actual entities’---also termed ‘actual occasions’, are the final real things of which the world is made.” (PR, p.18)

“The final facts are, all alike, actual entities, and these actual entities are drops of experience, complex and interdependent.” (PR, p.18)

Whitehead accepts James’s claim about the droplike (atomic/indivisible) character of experience.

“Either your experience is of no content, of no change, or it is of a perceptible amount of content or change. Your acquaintance with reality grows literally by buds or drops of perception. Intellectually and on reflection you can divide them into components, but as immediately given they come totally or not at all.” (James, 1890, Vol 1, p. 68)

Whitehead builds also upon James’s claim that “The thought is itself the thinker”

“If the passing thought be the directly verifiable existent, which no school has hitherto doubted it to be, then that thought is itself the thinker, and psychology need not look beyond.” (ibid, p.401)

Thus the “actual entities” are the “drops of experience” themselves, not the conscious thinkers that know them. Your *awareness* of your “self” must be an aspect of your

thoughts, and there is *no need for*, additionally, a persisting conscious “self” standing behind your thoughts. Your stream of consciousness consists of “ideas clinging together” and James poses the central question: “*whence do they get their fantastic laws of clinging?*” (ibid, p.3)

Whitehead draws a basic distinction between the two kinds of realities upon which his ontology is based: “Continuous Potentialities” versus “Atomic Actualities”:

“Continuity concerns what is potential, whereas actuality is incurably discrete.”
(PR, p. 61)

Another Whiteheadian precept is that actual entities decide things!

“Actual entities ... make real what was antecedently merely potential.” (PR, p.72)

“every decision is referred to one or more actual entities...Actuality is decision amid potentiality.” (PR. p. 43).

“Actual entities are the only reasons.” (PR, p.24)

One of Whitehead’s key ideas is that each (Temporal) actual entity is associated with a region of space.

“every actual entity in the temporal world is to be credited with a spatial volume for its perspective standpoint...” (PR, p.68)

A closely associated idea is that these regions “atomize” space-time

“The actual entities atomize the extensive continuum. This [space-time] continuum is in itself merely potentiality for division.” (PR, p.67)

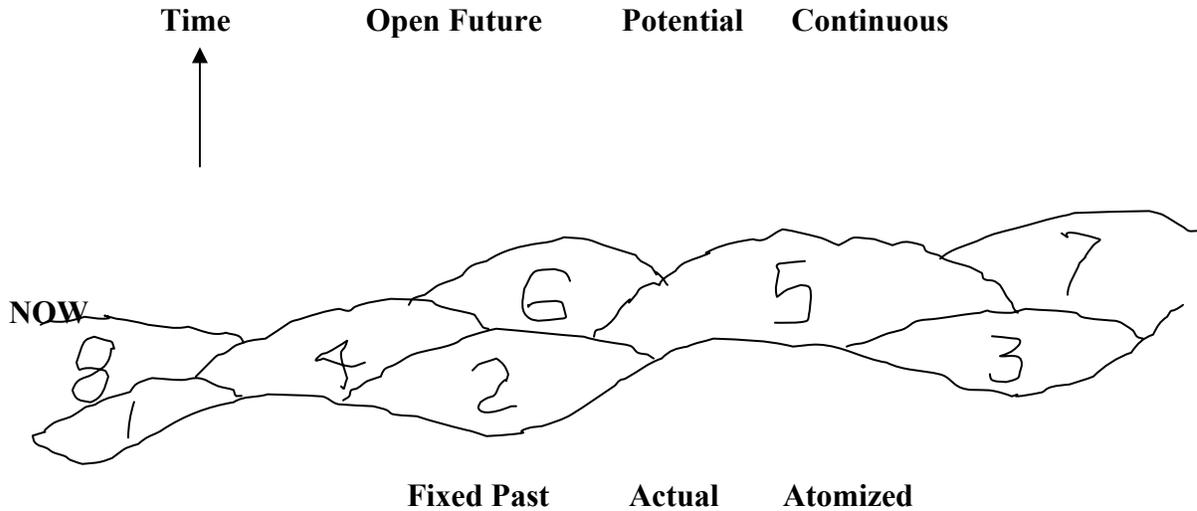
“The contemporary world is in fact divided and atomic, being a multiplicity of definite actual entities. These contemporary actual entities are divided from each other, and are not themselves divisible into other contemporary actual entities” (PR, p. 62)

The central idea in Whitehead’s philosophy is his notion of *process*

“The many become one, and are increased by one.” (PR p.21)

Thus in Whiteheadian process the world of fixed and settled facts grows via a sequence actual occasions. The past actualities are the causal and structural inputs for the next actual occasion, which specifies a new space-time standpoint (region) from which the potentialities created by the past actualities will be prehended (grasped) by the current occasion. This basic autogenetic process creates the new actual entity, which, upon becoming actual, contributes to the potentialities for the succeeding actual occasions.

Nature's process assigns a separate space-time region to each actual entity, and this process fills up, step-by-step, the space-time region lying in the *past* of the advancing sequence of space-like surface "now", as indicated by this diagram.



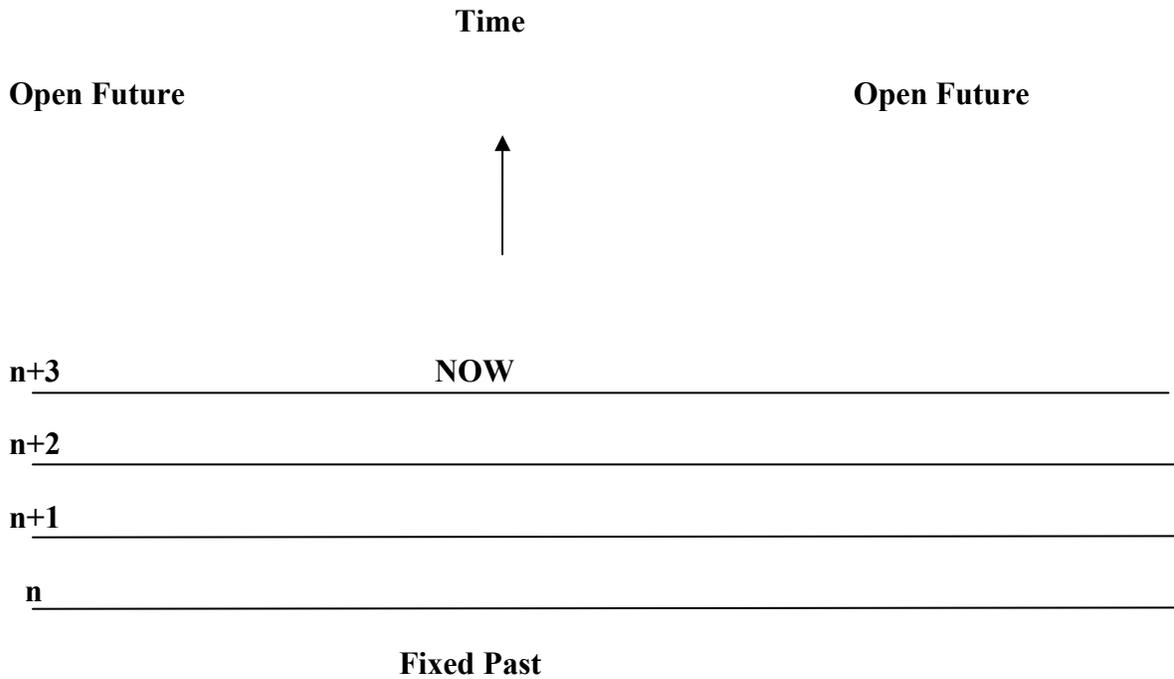
This conception of a growing actual space-time region, filled with (the standpoints of) the growing set of past actual occasions, and advancing into the strictly potential open future, constitutes a certain resolution to a famous debate between Newton and Leibniz about the nature of space. Newton's conception, described in the Scholium to his main work, "Principia Mathematica" was essentially a *receptacle* conception, in which space is an empty container into which physical objects can be placed.

Leibniz's argued for the relational view that space is nought but relations among actually existing entities: Empty space is a nonsensical idea.

In Whitehead's ontology *actual* space-time is filled by actual atomic (indivisible) entities: it is not empty. But there is also a yet-to-be-filled space-time, which, however, is a mere potentiality..

This Whiteheadian idea the growing "Past" can be contrasted with the corresponding idea in Non-Relativistic Quantum Physics.

In non-relativistic quantum physics the growing "past" lies behind an advancing (into the future) sequence of *constant-time instants* "now", as illustrated below.

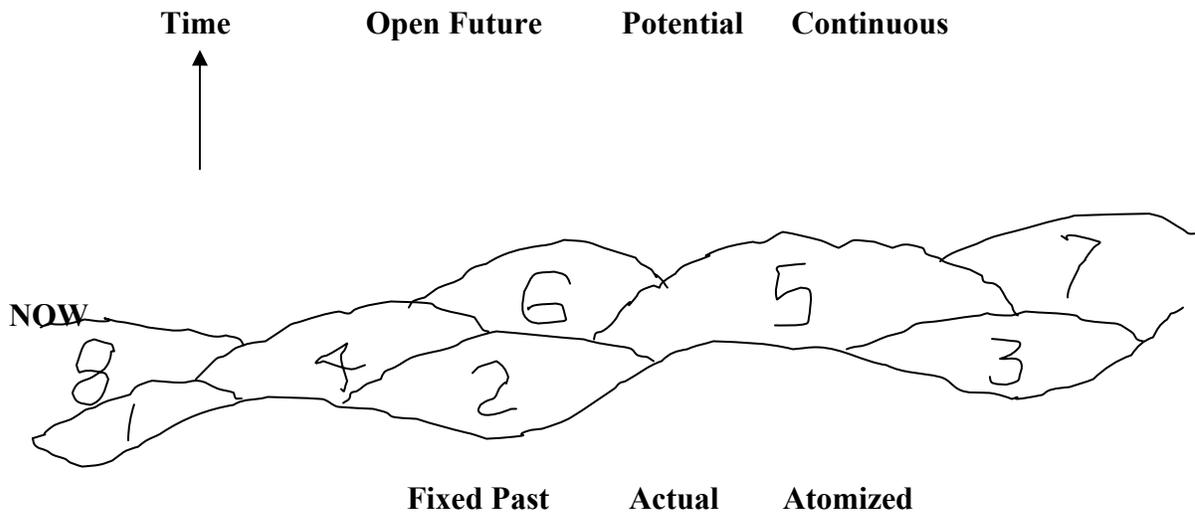


In non-relativistic quantum theory (NRQT) the fixed past advances into the open future in layer-cake fashion, one temporal layer at a time. Each quantum reduction event occurs at some particular time NOW, but over all of space. In von Neumann's nonrelativistic quantum theory this event produces the quantum state $\psi(t)$ of the universe at the instant labeled by the time t .

This non-relativistic space-time structure is replaced in Tomonaga-Schwinger relativistic quantum field theory (RQFT) by a very different kind of structure.

From Von Neumann NRQT to Tomonaga-Schwinger RQFT.

The NR quantum state $\Psi(t)$ is replaced by $\Psi(\sigma)$. Here t specifies a continuous three-dimensional surface in the four-dimensional space-time continuum, *with all spatial points lying at the same time t* . But σ specifies a continuous three-dimensional surface in the four-dimensional space-time continuum, *with every point on that surface spacelike-like-separated from every other point*.



The bottom wavy line represents some initial surface σ , an initial NOW. This surface pushes forward continuously, first through the space-time region labelled 1. This unitary evolution, via the relativistic generalization of the Schroedinger equation, leaves undisturbed the aspects of the state associated with the rest of the initial surface σ .

Then a new quantum “reduction” event occurs. It acts directly only on the new part of the surface, the part represented by the top boundary of region 1. But this direct change causes indirect changes along the rest of the surface σ , due to quantum entanglement. This indirect change accounts for the “nonlocality” effects in EPR (Einstein-Rosen-Podolsky) type experiments.

The evolutionary process then advances the surface NOW next through region 2, then through region 3, etc.. After each successive advance into the future, a quantum reduction event occurs. It is associated with a certain “projection” operator that acts directly only on the new part of the current surface NOW, but indirectly (via entanglement) on the entire surface NOW, at least in principle.

Similarities between Whitehead’s ontology and ontologically construed RQFT.

Notice the identity, as regards the space-time development indicated in the relevant diagrams, of the RQFT and the Whitehead ontologies..

But there are further correspondences, the first of which concerns the matching of the Whiteheadian connections between “Objective Potentia” and “Subjective Knowledge” with those of the quantum ontology.

Heisenberg: *“The probability function combines objective and subjective elements. It contains statements about possibilities or better tendencies (“potentia” in Aristotelian*

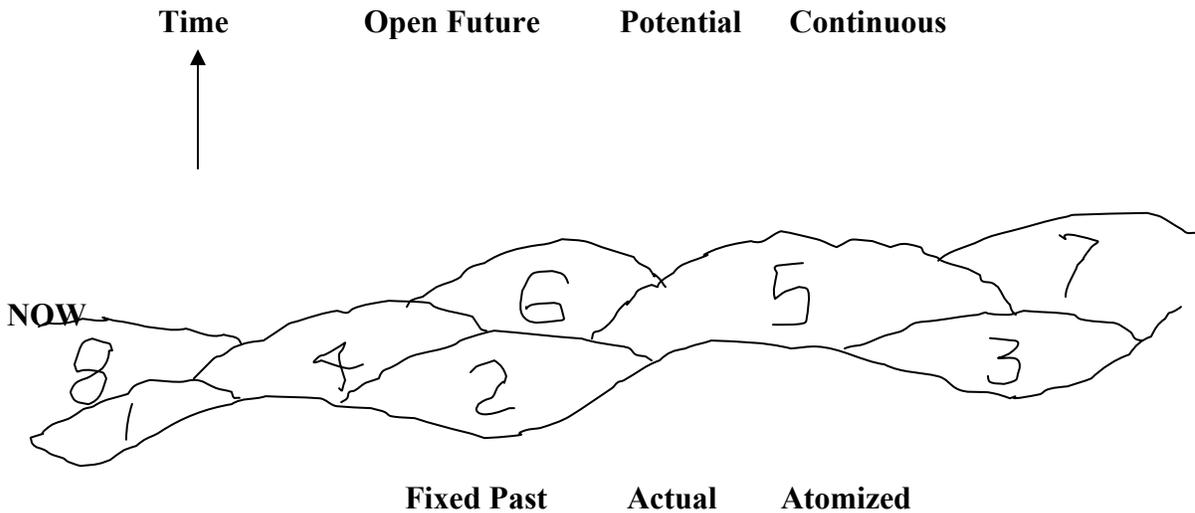
philosophy) and these are completely objective, ...and it contains statements about our knowledge of the system, which of course are subjective in so far as they may be different for different observers.” (1958 ,p.53)

The Transition from “Potentiality” to “Actuality” in Quantum Mechanics.

Heisenberg: *“the transition from the ‘possible’ to the ‘actual’ takes place during the act of observation.”*

Heisenberg: *“The observation itself changes the probability function discontinuously; it selects of all possible events the actual one that has taken place. Since through the observation our knowledge of the system has changed discontinuously, its mathematical representation has also undergone the discontinuous change and we may speak of a ‘quantum jump’ ” (1958, p.54)*

Compatibility with Einstein’s (Special) Theory of Relativity



Within Tomonaga-Schwinger RQFT all predictions are independent of the sequential ordering of space-like separated events: e.g., switching the sequential orderings of the occasions labeled 1 and 2 changes no prediction of the theory.

Furthermore, no “signal” (controlled message) can be transmitted faster than the speed of light.

Quantum theory is a theory of predictions, and the *predictions* of RQFT conform to the demands of Einstein’s (special) theory of relativity: the predictions do not depend upon which one of any two space-like separated events occurs first in the sequential unfolding of actuality. Furthermore, by virtue of the detailed structure of the quantum rules, the indirect effect, via entanglement, of a quantum event occurring in one region upon

predictions/potentialities pertaining to a faraway (space-like separated) region cannot be used to transmit a “signal” (a controllable message) faster than the speed of light.

The Psycho-Physical Building Blocks of Reality

In the Whiteheadian ontologicalization of quantum theory, each quantum reduction event is identified with a Whiteheadian actual entity/occasion.

Each Whiteheadian actual occasion/entity has a “mental pole” and a “physical pole”.

There are two kinds of actual occasions. Each actual occasion of the first kind is an intentional probing action that partitions a continuum into a collection of discrete experiential possibilities. Each actual occasion of the second kind selects (actualizes) one of these discrete possibilities, and obliterates the rest.

The Whitehead/Quantum Ontology

Objective/absolute actuality consist of a sequence of psycho-physical quantum reduction events, identified as Whiteheadian actual entities/occasions.

These happenings combine to create a growing “past” of fixed and settled “facts”.

Each “fact” is specified by an actual occasion/entity that has a physical aspect (pole) and a physical aspect (pole), and a region in space-time from which it views reality. I take the physical pole or aspect of the actual occasion to consist of a physical input and a physical output. The physical input is precisely the aspect of the physical state of the universe that is localized along the part of the contemporary spacelike surface σ that constitutes the front of the standpoint region associated with the actual occasion. The physical output is reduced state $\psi(\sigma)$ on this space-like surface σ .

The mental pole consists of an input and an output. The mental inputs and outputs have the ontological character of thoughts, ideas, or feelings, and they play an essential dynamical role in unifying, evaluating, and selecting discrete classically conceivable activities from among the continuous range of *potentialities* offered by the operation of the physically describable laws.

The paradigmatic example of an actual occasion is an event whose mental pole is experienced by a human being as an addition to his or her stream of conscious events, and whose output physical pole is the neural correlate of that experiential event. Such events are “high-grade” actual occasions. But the Whitehead/Quantum ontology postulates that simpler organisms will have fundamentally similar but lower-grade actual occasions, and that there can be actual occasions associated with any physical systems that possess a physical structure that will support physically effective mental interventions of the kind described above. Thus the Whitehead/Quantum ontology is essentially an ontologicalization of the structure of orthodox relativistic quantum field

theory, stripped of its anthropocentric trappings. It identifies the essential physical and psychological aspects of contemporary orthodox relativistic quantum field theory, and lets them be essential features of a general non-anthropocentric ontology.

Filling in the technical details of this ontology is the long-term task of science, which is still in its infancy. A lot of important structure is provided by the general precepts of this ontology described above, but this skeletal outline needs, of course, much fleshing out.

Part II: Jamesian Volition in Quantum Theory

How our conscious thoughts can affect our physical actions.

Contemporary science divides our descriptions of the totality of all things into two categories: descriptions in physical terms; and descriptions in psychological terms.

Physical properties consist basically of mathematically described properties localized at points or tiny regions of space-time. More generally they are the properties dealt with by physicists in physics courses, or by scientists in the other physical sciences that are non-problematically reducible to the basic physical properties, whereas, according to William James, the psychological properties consist of “thoughts, ideas, and feelings”. These psychological elements are collected into separate “streams of conscious experiences”, each associated, in orthodox psychology, with the subjective inner life of an individual human person.

Continuity and Causation in Classical Physics

Classical physics postulates a continuous process satisfying “causal closure of the physical”. This principle asserts that the physical description, by itself, provides for a causally complete deterministic account. The complete physical description over all of space during any interval of time determines the physical properties over all of space-time. No effects of mind or consciousness on the physically described properties need be considered or acknowledged.

This property of classical physics---the causal closure of the physical---leads to a puzzle expressed by William James as the observation that consciousness seems to be

“an organ, superadded to the other organs which maintain the animal in its struggle for existence; and the presumption of course is that it helps him in some way in this struggle, just as they do. But it cannot help him without being in some way efficacious and influencing the course of his bodily history.” (ibid. p. 138)

James goes on to an extensive analysis of the entry of consciousness into our lives, and ends up by saying:

“The conclusion that it is useful is, after all this, quite justifiable. But if it is useful it must be so through its causal efficaciousness, and the automaton theory must succumb to common sense.” (ibid. p.144)

Orthodox Quantum Theory is not Causally Complete: It Has Two Kinds of Causal Gap.

In quantum theory there are two kinds of decisions that are *not determined by the known laws of quantum theory*, yet are needed to make the theory work!

Gap # 1

Bohr: “In the great drama of life we are both *actors* and spectators.” [My highlight]

Bohr: “free choice of experimental arrangements for which the mathematical structure of the quantum mechanical formalism offers the appropriate latitude.” (Bohr, 1958, p. 73)

Conscious choices made human agents determine the experimental conditions, which affect subsequent physical properties. Von Neumann calls the physical correlates of these conscious choices by the name “Process 1” *interventions*. These physical actions *intervene* in the orderly continuous (Schroedinger-equation-controlled) evolution of the physical state of the universe.

The decisions of the first kind are identified as the “*Free choices*” made by conscious agents. These are the Process Zero *conscious choices* that in actual scientific practice determine the physically described partition, specified by a Process 1 action, of the continuous quantum mechanically described physical world into discrete experiential components. These decisions are choices to act in a particular way, with an intent to elicit a conceived experiential feedback. *These choices are made in actual practice by human agents. They are not determined within orthodox theory either statistically or in any other way: This indeterminateness constitutes the first kind of causal gap!*

Gap #2

Dirac: “Nature’s choice of the *outcome* of the experiment.”

The intended feedback/outcome may or may not actually occur. However, the quantum state of the universe just prior to the agent’s choice determines the *probability* for the intended feedback to occur. But it does not determine whether or not that feedback will actually occur. This indeterminateness constitutes the second kind of causal gap.

Significance

The mainstream neuroscience “materialist” assumption is that “any effect of mind is causally reducible to the physically describable aspects of nature”. This presumption is in no way a consequence of basic physical principles: it is neither demanded nor supported

by contemporary orthodox physical theory According to twentieth century physics, consciousness can *intervene* in brain dynamics in an essential and non-eliminable way, and thereby select and actualize physical actions that without this intervention would remain pure quantum potentialities.

It is, however, one thing to notice that the shift from classical mechanics to quantum mechanics involves in an essential way the injection of conscious choices into the causal physical structure of the theory, and to observe that this opens a theoretical door to *possible* effects of minds upon brains, but it is quite another thing to spell out in detail how such an effect could actually occur.

Filling the First Causal Gap.

A Simple Example

Suppose the idea “I shall now raise my arm” pops into your stream of consciousness, and this experience is colored by a strong feeling of *the positive value to you* of that contemplated action’s actually occurring. It is concordant with normal experience to presume that this experience will often have a successor in which the core idea “I shall now raise my arm” is colored now with a feeling of making an “effort to raise now my arm”. The felt connection between “effort” and the “intensity of experience” makes it natural to suppose that the intensity of the effort is correlated to the rapidity at which the experiential events are occurring: that increased effort will be correlated to an increased rapidity of the sequence of actual occasions associated with the idea of raising the arm.

The timings of the actual occasions are not specified by the known quantum mechanical rules. This opens the door to the possibility that psychologically describable elements, not reducible to physically described properties, are entering into the causal structure. But even if that were true, the issue would arise: How can the conscious effort influence what physically happens. How can a *conscious effort* to raise the arm “cause” in some sense, the physical arm to rise?

What is the neural correlate of the experience of “making an effort to raise the arm”? Presumably, it is a pattern of neurological activity that if sustained over a sufficiently long time will tend to cause, via the neural machinery, the arm to rise. This correlation will have become established through trial and error learning involving the comparison of effortful intentional actions to their experiential feedbacks. I call such a pattern of neurological activity by the name “template for action”.

Let us suppose, in accord with the earlier remark, that the experience of “effort to raise the arm” causes an immediate (within a few milliseconds) repetition of that experience, and that this causes another immediate repetition, and so on. This rapid sequence of actualizations of the associated “template for action” will tend---by virtue of the well known quantum Zeno effect---to hold that template for action in place for longer than would otherwise be the case. This persisting excitation of the template for action will, by virtue of its defining property, tend to cause your arm to rise.

This effect is in exact accord with the observations of William James(1892, p.227):

I have spoken as if our attention were wholly determined by neural conditions. I believe that the array of things we can attend to is so determined. No object can catch our attention except by the neural machinery. But the amount of the attention which an object receives after it has caught our attention is another question. It often takes effort to keep mind upon it. We feel that we can make more or less of the effort as we choose. If this feeling be not deceptive, if our effort be a spiritual force, and an indeterminate one, then of course it contributes coequally with the cerebral conditions to the result. Though it introduce no new idea, it will deepen and prolong the stay in consciousness of innumerable ideas which else would fade more quickly away. The delay thus gained might not be more than a second in duration---but that second may be critical; for in the rising and falling considerations in the mind, where two associated systems of them are nearly in equilibrium it is often a matter of but a second more or less of attention at the outset, whether one system shall gain force to occupy the field and develop itself and exclude the other, or be excluded itself by the other. When developed it may make us act, and that act may seal our doom. When we come to the chapter on the Will we shall see that the whole drama of the voluntary life hinges on the attention, slightly more or slightly less, which rival motor ideas may receive. ...

In the chapter on Will, in the section entitled “Volitional effort is effort of attention” James (1892. p.417) writes;

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.

and

Consent to the idea's undivided presence, this is effort's sole achievement.”...“Everywhere, then, the function of effort is the same: to keep affirming and adopting the thought which, if left to itself, would slip away.

Empirical Support

Empirical support for this explanation of the way in which our consciousness affects our brains can be found in Stapp (2001) and Schwartz, Stapp, and Beauregard (2005).

But beyond the detailed experimental findings described in those works there is the practical benefit of having a conception of nature, and our role in nature, that is a harmony with our intuitive feeling that our intentional thoughts can influence our

physical actions, or with the more scientifically well informed idea that conscious intentional efforts can evoke associated brain activities in ways that can, through learning or training, be correlated to experiential feedbacks. The vast literature on biofeedback, and the mounting evidence from nerve-activated prosthetics, attest to the utility of this conception of the mind-brain connection.

Insofar as one grants that a conscious experience is not simply an aspect of the activity of a brain that is completely expressible in terms of the physical concepts of (classical or quantum) physics, but instead has qualities that cannot be expressed in terms of, or reduce to, the quantitative properties that occur in the physical description of the world used by physicists, then one's ontology should specify whether or not these further properties, which are felt, and which are parceled into streams of consciousness, are needed to fix the flow of physically described events, or whether, as in classical physics, the physically describable flow of events is completely determined in terms of the physically describable aspects alone.

In that latter case one has difficulty explaining the success of nerve-activated prosthetics. Suppose one were to build a computer model of that situation, with consciousness represented by a higher module that can integrate and evaluate brain data, and make selections, but that has no causal effect on the physical machinery that implements or obeys the physical laws that by themselves determine all physical effects. One would then have to understand how this module *could be trained* to come into good alignment with the causal processes upon which it has no causal effect. There is certainly no automatic uniform concordance between the mental and physical descriptions, as the numerous examples of mismatches cited by proponents in mechanistic or materialistic conceptions of reality attest. But if there is no automatic concordance between conscious thoughts, ideas, and feelings and physical actions then how can the empirically occurring correspondences come into being through practice, if the mental module cannot act upon the physical ones?

Why, I must ask, would anyone ever want to postulate the existence of such an unnatural and awkward, and perhaps *impossible to comprehend*, reality, when its only virtue is to conform to ancient laws that are now known to be false, and to be moreover inapplicable *in principle* to the causally important motions of the ions in nerve terminals, when empirically validated laws of physics that are completely applicable to warm, wet, and noisy brains provide a way of understanding a causal influence of mental effort upon brain activities that can render perfectly natural and understandable the empirically manifest phenomena of effortful guided learning.

Comments.

1. Every aspect of the preceding analysis is in strict accord with the orthodox laws of quantum physics. No rule has been stretched or altered. An existing causal gap in the theory has merely been filled in a natural way, by exploiting effects explicitly assigned by the theory to conscious free choices, and then applying the known causal laws.

2. The quantum Zeno effect is itself a decoherence effect, and it is not diminished by environmental decoherence. *Thus the usual argument against using quantum mechanics to explain the influence of conscious thought upon brain activity is nullified.* Environmental decoherence does reduce pure quantum states to “a mixtures”, to a smear of quasi-classical states, but this does not resolve the problem of the discreteness of our experiences

3. The fundamental reason why the effect of conscious thought upon bodily action is explainable within quantum mechanics, but not within classical physics, is that orthodox quantum theory *itself* introduces, as a key innovation (with respect to classical physics), the needed causal efficacy of our conscious choices. The logically needed Process 1 physical choices have no causal roots in the physically described aspect of reality specified by the theory, but they are strongly correlated with sufficient reasons and other motivations describable in psychological terms. This configuration of causal connections suggests that the consciousness is the cause, and the correlated Process 1 physically described action is the effect. This is the point of view that ties quantum theory most naturally and directly both to common sense and to our deepest intuitions, as well as to actual scientific practice, where the experimenter chooses on the basis of reasons and goals which of the options will be pursued. In this connection, Bohr speaks pertinently of “the free choice of experimental arrangement for which the mathematical structure of the quantum mechanical formalism offers the appropriate latitude”.(Bohr, 1958,p, 73) What motive could possibly induce any rational philosopher or scientist interested in the connection between mind and matter to close his or her mind to this hugely pertinent development of physics, and cling instead to fundamentally false and puzzling nineteenth century materialism.

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