## 7. KNOWLEDGE OR POTENTIA.

The original "Copenhagen" approach took quantum theory to be a practical tool that allows scientists to form, on the basis of past experiences, reliable expectations about future ones. The reality described by that theory was "our knowledge", and inquiry into the nature of the reality in which this knowledge is imbedded was discouraged. However, human beings are an inquisitive lot, and even Heisenberg was not immune to the disease of wanting to know more than one's philosophy allows.

The success of a theory that allows empirically measured numbers to be computed to an accuracy of one part in a hundred million says a lot about the reality. It rules out a host of possibilities, and places stringent conditions on the rest. Thus an understanding of the structure this immensely successful theory permits reasonable conjectures to be advanced about the nature of the whole of which our experiences are but a tiny a part.

Heisenberg in his 1958 book Physics and Philosophy allowed himself to speculate on the nature of the reality lying behind our streams of conscious thoughts. He ties his idea of Nature to the Aristotelian idea of "potentia", which is an objective tendency for some particular thing to happen. Each such `happening' is a transition from `possible' to `actual'.

Heisenberg's conjecture is compactly summarized in his statement:

"If we want to describe what happens in an atomic event we have to realize that the word `happens' … applies to the physical not the psychical act of observation, and we may say that the transition from the `possible' to the `actual' takes

place as soon as the interaction between the [atomic] object and the measuring device, and thereby with the rest of the world, has come into play: it is not connected with the act of registration of the result in the mind of the observer. The discontinuous change in the probability function, however, takes place with the act of registration, because it is the discontinuous change in our knowledge at the moment of registration that has its image in the discontinuous change in the probability function."
[Physics and Philosophy, Harper and Rowe, New York, 1958, p.54]

At first sight this passage seems self-contradictory: it says that the sudden change occurs at the device, not in the mind, and then says that it occurs in the mind. But there is no contradiction. The sudden change when the interaction between object and device comes into play refers to the transition from the `possible' to the `actual', which is what happens physically, but about which Copenhagen quantum theory officially says nothing, whereas the probability function is what quantum theory deals with, and it changes when our knowledge changes. Thus Heisenberg, by this two-level description, one dealing with physical reality, the other with psychological reality, reconciles the Copenhagen viewpoint with our desire to understand what is really going on.

This idea that some real event actually occurs when the interaction between object and measuring device comes into play accords well with the quantum mathematical description. One can believe that the quantum state in the mind of the physicist is a mental image of an external (to human minds) mathematical reality that corresponds to a potentia, or set of objective tendencies, for the physical device to respond in each of its alternative possible modes.

These objective tendencies can be measured by the relative frequencies of the various alternative possible outcomes. This idea of the connection between probability and reality is called "the propensity interpretation of probabilities", and it immediately gives an objective picture of a physical reality that accounts in a natural way for the success of the Copenhagen rules pertaining to our knowledge of that reality.

The "potentia" for the occurrence of some particular one of a set of mutually exclusive alternative possibilities naturally drops to zero when another one of the set of possibilities actually happens. So this model, based on the idea that physical reality is made out of potentialities, or objective tendencies, allows the faster-than-light effects to be understood as the instantaneous change in the real objective potentialities that constitute the physical world when one of the alternative possibilities is actualized.

Heisenberg thus refers in this single passage to two different possible ways of understanding nature, one based on the speculative notion of objective physical tendencies, the other on the more secure idea of subjective psychological realities.

## 8.SYNTHESIS.

John von Neumann is one of the premier minds of the twentieth century. A renowned mathematician and logician, he was also a principal creator of the concepts of the modern computer. In his 1932 book *The Mathematical Principles of Quantum Mechanics* he placed that theory on a firm mathematical foundation, and examined also the delicate issues associated with the role of the conscious observer. The original Copenhagen treatment of the observer relied heavily on the pragmatic premise that problems that do not intrude significantly into practical applications can be ignored.

If one seeks to go beyond merely a set of rules that work for us, and propound a rationally coherent conception of the reality in which our human experiences are imbedded, then the faster-than-light problem must be dealt with in some way. Heisenberg's idea of a world of "potentialities" is the most parsimonious possibility: it brings in no needless entities, except for the doubling of actual events: there are both physical events associated with the transitions from possible to actual, and also the psychological events, which occur in the mind of the observer. To make a cohesive theory a connection is needed between the physically described ontology (theory of what exists) and the psychologically described epistemology (theory of what we know).

The need for this bridge leads to the technical problem of what defines the "devices" where the transitions from possible to actual are supposed to occur. Micro-fabrication techniques allow extremely tiny device-like structures to be built. Their behaviors are probed by bigger devices etc., and the nerve cells with receptors in the retina can also be regarded as measuring devices, as can higher-level brain structures. The quantum rules allow all of these structures to be represented in principle as quantum systems. Yet in a more precise sense none of them can. For each such system is imbedded in a larger whole from which it cannot be disentangled within the mathematical quantum framework. The only physical system that is strictly describable within quantum theory is the entire universe.

Von Neumann bit the bullet. He showed how the validated predictions of quantum theory, which were based on the idea of restricting the quantum system to the small system being probed by the measuring device, could be preserved and understood by expanding the quantum system to include the entire universe, including the complete brains of all the observers, provided he identified the physical events as brain events that actualize the neural correlates of an associated psychological event. This identification of the subjective experience upon which Copenhagen formulation of quantum theory is based as an aspect of the physical brain event that actualizes the pattern of brain activity that corresponds to that psychological experience synthesizes the two interpretations offered by Heisenberg, and it establishes a close natural correspondence the two parts of nature that Rene Descartes put asunder. It places the experiences that are the realities upon which the Copenhagen interpretation rests into the physical world of potentialities that Heisenberg identified as external reality that is the carrier of the real "happenings." This identification of, or association of, experiential events with quantum brain events establishes a direct mathematically defined causal linkage between the experiential and physical aspects of Nature. It repairs the terrible damage inflicted on natural and moral philosophy by the followers of Descartes. (Descartes himself allowed these two aspects of nature to interact within brains, in accordance with intuition, common sense, and quantum theory, but the mechanical dynamical completeness of classical physical theory seemed to forbid any kind of interaction between these two so differently conceived kinds of reality. However, the freedom given to experimental agents by the quantum laws rehabilitates Descartes original position.)

This solution is perhaps a quantum version of the "identity theory" solution of the mind-brain problem in classical physics. However, here it arises from a natural synthesis of two incomplete theories that each separately require events that the synthesis amalgamates. The important difference, however, is that this psychophysical event is not just a passive automatic consequence of the micro-causal deterministic evolution specified by the Schroedinger equation, which is the quantum analog of the classical laws of motion. There is an element of freedom that lies beyond the compass of the known laws of nature. A second process is needed to complete the dynamics. This is the "twenty questions" procedure, which involves first a free choice of question posed by the actor/observer, and then a statistically governed answer delivered by nature. In von Neumann's step-by-step passage from the Copenhagen version of quantum theory to the final synthesis, the psychologically described actor/observer always retains the function of freely choosing which question to be put to nature, and this freedom persists in the limit. This freedom associated with the second process, which von Neumann calls Process I, must be retained in the limit because the questions must get posed for the dynamics to work, and the discrete questions cannot be naturally selected by the continuous dynamics. The question thus naturally arises: To what extent can this very limited freedom, granted to the human actors, to pose questions, be used to influence that person's mental process, and hence bodily behavior?

## 9. THE EFFICACY OF MENTAL EFFORT.

We feel innately that our thoughts themselves actually do things: that they influence our succeeding thoughts and actions; that our felt mental effort is actually causing our muscles to bulge as we strain to budge our trapped vehicle. Classical physics tells us that this most deeply felt of all our convictions, and the basis of all our mental actions, is shear poppy-cock; a queer illusions that besets our addled mind.

Brain does it all, we are told, and our thoughts and feeling are but some ineffectual supernumeraries, or nothing beyond the functional complex patterns of motion of tiny atomic particles.

But if common sense be any guide then our thoughts and feelings must be doing something that our classically conceived brains alone cannot do as well. For why else would nature produce, in addition to the motions of the particles, such realities as feelings and ideas. And how could these logically unnecessary and disjoint supernumeraries evolve if they *themselves* contribute nothing to our fitness.

Quantum theory provides a natural place for our thoughts, and an essential dynamical role for them to play. Our psychologically described essence does what our physically described brains alone cannot do: it selects the questions associated with the crucial collapse process. This latter process actualizes certain of the potentialities that inhere in the quantum state of the brain, and that are carried forward in time by the Schroedinger equation of motion. That physically described evolution creates multiple continua of potentialities but cannot actualize any one of them.

The actualization procedure is a two-step operation. First a specific question must be selected. This choice must be rooted in the psychologically described aspect, because making a discrete choice of question, represented by a specific projection operator P, lies beyond the capacity of amorphous continuum of potentialities represented by the state vector V: it cannot discriminate one set of N perpendicular vectors from others differing only infinitesimally from the first set. Given the selected question, nature delivers her answer, which is both psychologically experienced and etched in the brain structure by the quantum collapse $V \rightarrow PV$. This model of the mind-brain connection provides a contemporary-science-based alternative to the classical-physics-based model.

In this model the dynamical role of consciousness is extremely restricted: it can do nothing but influence the choices of questions associated with von Neumann's process **I**. That severe restriction is, in fact, what gives the theory its predictive and explanatory power.

But how can the mere selection of questions influence behavior? In classical physics it could not, since everything is predetermined, and while asking a question and getting an answer may illuminate the mind of the passive observer, it cannot actually influence what happens. But in quantum mechanics the situation is quite different. There is an important and well-studied effect in quantum theory that depends on the timings of the reduction events arising from the queries put to nature. It is called the Quantum Zeno Effect.

The effect is simple. If the same question is put to nature sufficiently rapidly and the initial answer is Yes, then any noise-induced diffusion, or force-induced motion, of the system away from the subspace where the answer is `Yes' will be suppressed: the system will tend to be confined to the part of the Hilbert space where the answer is `Yes'. The effect is sometimes called the ``watched pot'' effect: according to the old adage ``A watched pot never boils''; just looking at it keeps it from changing. Also, a state can be pulled along in some direction by posing a rapid sequence of questions that change sufficiently slowly over time. In short, according to the dynamical laws of quantum mechanics, the freedom to choose which questions are put to nature, and when they are asked, could allow mind to influence the behavior of the brain. However, the effect is extremely limited: it is merely the tendency to hold in place the focus of mental attention. The drift in attention that would normally arise from quantum uncertainties, noise, and even ordinary forces, is held in check by incessant probing.

A person is aware of almost none of the processing that is going on in his brain: unconscious brain action does almost everything. So it would be both physically unrealistic and theoretically unfeasible to give mind unbridled freedom: the questions posed by mind ought to be determined in large measure by the brain itself.

But then what freedom is given to mind?

According to quantum theory, the freedom given to Nature herself is merely to provide Yes or No answers to questions posed by subsystems. It seems reasonable to restrict in a similar way the freedom given to human minds.

It is easy to construct a simple dynamical model in which the brain does most of the work, and the mind, merely by means of choices of whether or not pose the question presented by the brain, influences the course of mental---hence also bodily---action.

Consider the set of projection operators P that act only on the brain of some individual, and that correspond to possible mental events of that individual. Quantum theory assigns a probability to each such P at each instant of time t. Consider at each time t the P that has the greatest probability. It represents the ``best possible'' question to ask at that moment: it has accumulated the greatest statistical weight. Suppose that when the probability associated with this possible event reaches a maximum the associated question "shall the possible experience associated with P be actualized?" is put to nature. If nature returns the answer `Yes', then the transition V→PV occurs, along with the associated experience. The new dynamical postulate is that the "feel" of this event can activate an "effort" that can instigate a sequence of posings of this same question that is rapid on the time scale of the evolution of PV. The dynamical rules of quantum theory then ensure that the rapid-fire posings of this question will keep the brain in the subspace associated with the answer Yes.

If a process like this operates then the course of brain and body events would be influenced by the effort produced by the "feel" of mental events.

The Quantum Zeno Effect will not freeze up the brain completely. It merely keeps the state of the brain in the subspace where attention is focussed on a particular idea.

Does this theory of the connection between mind and brain explain anything?

Essentially this model was already in place when a colleague, Dr. Jeffrey Schwartz, brought to my attention some passages from ``Psychology: The Briefer Course'', written by William James. In the final section of the chapter on Attention James writes:

``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 writes:

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

and later

``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.''

Still later, James says:

``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.''

This description of the effect of mind on the course of mind-brain process is remarkably in line with what had been proposed independently from purely theoretical consideration of the quantum physics of this process. The connections specified by James are explained on the basis of the same dynamical principles that had been introduced by physicists to explain atomic phenomena. Thus the whole range of science, from atomic physics to mind-brain dynamics, is brought together in a single rationally coherent theory of an evolving cosmos that consists of a physical reality that is constituted not of matter but of potentia for events to occur. And these events include, but are certainly not restricted to, collapses to reduced states that bring this physical reality into accord with the increments of human knowledge that pragmatic quantum theory is based upon.

Much experimental work on attention and effort has occurred since the time of William James. That work has been hampered by the apparent nonexistence of any physical theory that rationally explains how our conscious experiences could influence activities in our brains. The behaviorist approach, which dominated psychological during the first half of the twentieth century, and which essentially abolished in this field the use not only of introspective data but also of the very concept of consciousness, was surely motivated in part by the fact that consciousness was excluded from any role in brain dynamics by the physics of the preceding century

The failure of the behaviorist programs led to the rehabilitation of ``attention'' during the early fifties, and many hundreds of experiments have been performed during the past fifty years for the purpose of investigating empirically those aspects of human behavior that we ordinarily link to our consciousness.

Harold Pashler's 1998 book ``The Psychology of Attention'' [32] describes a great deal of this empirical work, and also the intertwined theoretical efforts to understand the nature of an information-processing system that could account for the intricate details of the objective data. Two key concepts are the notions ``Attention'' and of a processing ``Capacity''. The former is associated with an internally directed selection between different possible allocations of the available processing ``Capacity''. A third concept is "Effort", which is linked to incentives, and to reports by subjects of ``trying harder''.

Pashler organizes his discussion by separating perceptual processing from post-perceptual processing. The former covers processing that, first of all, identifies such basic physical properties of stimuli as location, color, loudness, and pitch, and, secondly, identifies stimuli in terms of categories of meaning. The post-perceptual process covers the tasks of producing motor actions and cognitive action beyond mere categorical identification. Pashler emphasizes [p. 33] that ``the empirical findings of attention studies specifically argue for a distinction between perceptual limitations and more central limitations involved in thought and the planning of action.'' The existence of these two different processes, with different characteristics, is a principal theme of Pashler's book [p. 33, 263, 293, 317, 404].

In the quantum theory of mind-brain being described here there are two separate processes. First, there is the unconscious mechanical brain process governed by the Schroedinger equation. As discussed at length in my earlier book, Mind, Matter, and Quantum Mechanics, this brain processing involves dynamical units that are represented by complex patterns of neural activity (or, more generally, of brain activity) that are ``facilitated'' by use, and such that each unit tends to be activated as a whole by the activation of several of its parts. The activation of various of these complex patterns by cross referencing, coupled to feed-back loops that strengthen or weaken the activities of appropriate processing centers, seems to explain the essential features of the mechanical part of the dynamics.

The function of the brain is to create and direct courses of action appropriate to the circumstances in which the organism finds itself. Accordingly, the brain ought to create a template for a possible plan of action. Detailed examination of the quantum uncertainties associated the motion in nerve terminals of incoming calcium ions from the ion channels to the triggering sites for the release of vesicles of neurotransmitter entail [MM&QM, p.152] that a host of different possibilities will emerge. This mechanical phase of the processing already involves some selectivity, because of the enhancing and inhibiting feedback loops. But the essential point is that the evolution of the brain according to the Schroedinger equation *must* generate not just one single template for action, but a host of alternative possibilities. Hence the action of the second process, von Neumann's Process **I** must come into play in order to select what actually happens from the continuum of alternative possibilities generated by the mechanical aspect of the full quantum dynamics. But Process **I** involves the element of freedom that feeds into the Quantum Zeno Effect.

This conception of brain dynamics seems to accommodate all of the perceptual aspects of the data described by Pashler. But it is the high-level processing, which is more closely linked to our active mentally controlled conscious thinking, that is of prime interest here. The data pertaining to this second process is the focus of part II of Pashler's book.

Mental intervention has, according to the quantum-physics-based theory described here, several distinctive characteristics. It consists of a sequence of discrete events each of which consents to an integrated course of action presented by brain. The rapidity of these events can be increased with effort. Effort-induced speed-up of the rate of occurrence of these events can, by means of the quantum Zeno effect, keep attention focussed on a task. Between 100 and 300 msec of consent seem to be needed to fix a plan of action.

Effort can, by increasing the number of events per second, increase the mental input into brain activity. Each conscious event picks out from the multitude of quasi-classical possibilities that comprise the quantum brain the sub-ensemble that is compatible with the conscious experience.

The correspondence between the mental event and the associated physical event is this: the physical event reduces the prior physical ensemble of alternative possibilities to the sub-ensemble compatible with the mental event. This connection constitutes the core postulate of Copenhagen quantum theory: the physical event reduces the prior state of the system to the part of it that is compatible with the experience of the observer.

Examination of Pashler's book shows that this quantum-physics-based theory accommodates naturally all of the complex structural features of the empirical data that he describes. He emphasizes [p. 33] a specific finding: strong empirical evidence for what he calls a central processing bottleneck associated with the attentive selection of a motor action. This kind of bottleneck is what the quantum-physics-based theory predicts: the bottleneck is precisely the single linear sequence of mind-brain quantum events that von Neumann quantum theory is built upon.

Pashler [p. 279] describes four empirical signatures for this kind of bottleneck, and describes the experimental confirmation of each of them. Much of part II of Pashler's book is a massing of evidence that supports the existence of a central process of this general kind.

This bottleneck is not automatic within classical physics. A classical model could easily produce simultaneously two responses in different modalities, say vocal and manual, to two different stimuli arriving via two different modalities, say auditory and tactile. The two processes could proceed via dynamically independent routes. Pashler [p. 308] notes that the bottleneck is undiminished in split-brain patients performing two tasks that, at the level of input and output, seem to be confined to different hemispheres.

The queuing effect for the mind-controlled motor responses does not exclude interference between brain processes that are similar to each other, and hence that use common brain mechanisms. Pashler [p. 297] notes this distinction, and says ``the principles governing queuing seem indifferent to neural overlap of any sort studied so far.''

The important point here is that there is in principle, in the quantum model, an essential dynamical difference between, on the one hand, the unconscious processing carried out by the Schroedinger evolution, which generates via a local process an expanding collection of classically implementable possible courses of action, and, on the other hand, the process associated with the sequence of conscious events that constitutes a stream of consciousness. The former are not limited by the queuing effect, because all of the possibilities develop in parallel, whereas the latter do form elements of a single queue. The experiments cited by Pashler all appear to support this clear prediction of the quantum approach.

An interesting experiment mentioned by Pashler involves the simultaneous tasks of doing an IQ test and giving a foot response to a rapidly presented sequences of tones of either 2000 or 250 Hz. The subject's mental age, as measured by the IQ test, was reduced from adult to 8 years. [p. 299] This result supports the prediction of quantum theory that the bottleneck pertains both to `intelligent' behavior, which requires conscious processing, and to selection of motor response.

Another interesting experiment showed that, when performing at maximum speed, with fixed accuracy, subjects produced responses at the same rate whether performing one task or two simultaneously: the limited capacity to produce responses can be divided between two simultaneously performed tasks. [p. 301]

Pashler also notes [p. 348] that ``Recent results strengthen the case for central interference even further, concluding that memory retrieval is subject to the same discrete processing bottleneck that prevents simultaneous response selection in two speeded choice tasks.''

In the section on ``Mental Effort'' Pashler reports that ``incentives to perform especially well lead subjects to improve both speed and accuracy'', and that the motivation had ``greater effects on the more cognitively complex activity''. This is what would be expected if incentives lead to effort that produces increased rapidity of the events, each of which injects into the physical process, via quantum selection and reduction, bits of control information that reflect mental evaluation.

Studies of sleep-deprived subjects suggest that in these cases ``effort works to counteract low arousal''. If arousal is essentially the rate of occurrence of conscious events then this result is what the quantum model would predict.

Pashler notes that ``Performing two tasks at the same time, for example, almost invariably... produces poorer performance in a task and increases ratings in effortfulness.'' And ``Increasing the rate at which events occur in experimenter-paced tasks often increases effort ratings without affecting performance''. ``Increasing incentives often raises workload ratings and performance at the same time.''

All of these empirical connections are in line with the general principle that effort increases the rate of conscious events, each of which inputs a mental evaluation and a selection or focussing on a course of action, and that this resource can be divided between tasks.

Additional supporting evidence comes from the studies of the effect of the conscious process upon the storage of information in short-term memory. According to the physics-based theory, the conscious process merely actualizes a course of action, which then develops automatically, with perhaps some occasional monitoring. Thus if one sets in place the activity of retaining in memory a certain sequence of stimuli, then this activity can persist undiminished while the central processor is engaged in another task. This is what the data indicate.

Pashler remarks that "These conclusions contradict the remarkably widespread assumption that short-term memory capacity can be equated with, or used as a measure of, central resources."[p.341] In the theory outlined here short-term memory is stored in patterns of brain activity, whereas consciousness is associated with the selection of a sub-ensemble of quasi-classical states. This distinction seems to account for the large amount of detailed data that bears on this question of the connection of short-term-memory to consciousness. [p.337-341]

Deliberate storage in, or retrieval from, long-term memory requires focussed attention, and hence conscious effort. These processes should, according to the theory, use part of the limited processing capacity, and hence be detrimentally affected by a competing task that makes sufficient concurrent demands on the central resources. On the other hand, ``perceptual'' processing that involves conceptual categorization and identification without conscious awareness should not interfere with tasks that do consume central processing capacity. These expectations are what the evidence appears to confirm: ``the entirety of...front-end processing are modality specific and operate independent of the sort of single-channel central processing that limits retrieval and the control of action. This includes not only perceptual analysis but also storage in STM (short term memory) and whatever may feed back to change the allocation of perceptual attention itself.'' [p. 353]

Pashler describes a result dating from the nineteenth century: mental exertion reduces the amount of physical force that a person can apply. He notes that ``This puzzling phenomena remains unexplained.'' [p. 387]. However, it is an automatic consequence of the physics-based theory: creating physical force by muscle contraction requires an effort that opposes the physical tendencies generated by the Schroedinger equation. This opposing tendency is produced by the quantum Zeno effect, and is roughly proportional to the number of bits per second of central processing capacity that is devoted to the task. So if part of this processing capacity is directed to another task, then the applied force will diminish.

Pashler speculates on the possibility of a neurophysiological explanation of the facts he describes, but notes that the parallel versus serial distinction between the two mechanisms leads, in the classical neurophysiological approach, to the questions of what makes these two mechanisms so different, and what the connection between them is. [p.354-6, 386-7]

After analyzing various possible mechanisms that could cause the central bottleneck, Pashler [p.307-8] says ``the question of why this should be the case is quite puzzling." Thus the fact that this bottleneck, and its basic properties, follow automatically from the same laws that explain the complex empirical evidence in the fields of classical and quantum physics means that the theory has significant explanatory power.

Of course, the fact that this theory seems to work so well does not mean that it is the only theory that can work. But in the past science has been well served by the endeavor of trying to understand various complex high-level processes in ways that all fit together coherently with basic physical theory. The brain is a physio-chemical structure that rests in principle on quantum processes, and the quantum principles lead in a completely natural way to a specified kind of dynamical linkage between the aspects of the mind-brain that are described in psychological and physical terms. All classically described features are accounted for in the quantum description, which however provides also a natural dynamical place for mind whereas classical physics does not.

There is, of course, no empirical evidence that favors the classical model over the quantum model described above. Quantum theory automatically accounts for all the successes of classical physical theory. So all simple physiological and anatomical features of the physical brain can, according to quantum theory, be treated classically. The quantum description becomes necessary only when treating subtle dynamical effects. The effect of mental effort to hold ideas in place longer than classical computations would predict would seem to be the most crucial dynamical difference between the classical and quantum models.

Brain science has suffered through a century of trying to force itself into a mold it did not fit, namely a now superceded physics that left a key player out. Ought it not now try just as hard to fit itself into the framework of the more correct science that explicitly brings in, rather than denying the existence of, the efficacious thoughts and feelings that are prima facie features of the structure it studies? And should not psycho-physics benefit from having a theoretical model that accords with all physics requirements, yet includes both the psychological and biological elements it studies, and specifies their ontological and dynamical relationship to each other. Should not psychology and psychiatry benefit from having a model of the human being as a psychologically described agent that interacts with the rest of nature through his body in specified ways, rather being forced to conceive the human being as a bundle of cells that behave in wholly mechanical ways that contradict the basic laws of nature. If basic physical theory was forced to adopt the realistic view of the human person as a psychologically described agent why should psychology not follow suit? Finally, ought not evolutionary biology benefit from allowing human person's to have efficacious minds that can contribute to their fitness, and thus naturally evolve in step with their physical carriers?