8. PSYCHO-PHYSICAL THEORY AND "WILL."

I have concentrated so far on what is basically new: on the crucial difference between classical physics and quantum physics that allows our thoughts to be an essential player in the causal description of brain process. This new element needs to be placed in the context of what I take to be otherwise a fairly standard psycho-physical theory, perhaps the orthodox theory to the extent that any such thing exists.

As already mentioned, I follow William James and take all conscious experiences to be essentially "feelings" of one kind or another. Experiencing a major chord "feels different" from experiencing a minor chord. The exhilarating experiencing of a rapid piano run up the scale feels different from the tip-toe-y feeling of a lightly fingered sequence of high notes, or the satisfying feeling of the final chord of a work of Beethoven or Wagner. Einstein described the feeling of his theoretical reflections in terms of muscular feelings, and a mathematician knows his proof is valid because of a deep feeling that all bases have been well cover: there is no feeling of discord, or incompleteness, or incursion of doubt.

A person's thoughts are dynamically linked to patterns of brain activity that are his brain's representations of his physical body and its relationship to the world around him. Called the body-world schema, this momentary brain representation is, during wakeful periods being continually updated by the brain on the basis of its interpretation of clues provided by the sensory apparatus, and it is closely tied into his bodily actions and their sensed connections to the outer world. His actions are controlled by activating patterns in the body-world schema, and he learns through experience the relationship between his felt intentions and the subsequent feed-back in terms of sensed experiences. The body-world schema is the intermediary physical link. The dynamical interplay between these intentional acts, the body-world schema, and sensory feedback tunes the connection between mind and brain, and links the felt quality of the intentional act to a mental image of the intended consequences.

A person's experiential life is a stream of conscious experiences. The person's experienced 'self' is *part* of this stream of consciousness: it is not an extra thing that is outside or apart from the stream. In

James's words "*thought is itself the thinker*, and psychology need not look beyond." The "self" is a slowly changing "fringe" part of the stream of consciousness. It provides a background for the central focus.

The physical brain, evolving mechanically in accordance with the local deterministic Process II does most of the work, without the intervention of Process I. It does its job of creating, on the basis of its interpretation of the clues provided by the senses, a suitable response. But, due to the wave nature of its component parts, the brain necessarily generates an amorphous mass of overlapping and conflicting templates for action, formulated in terms of possible structures for the body-world schema. Process I selects from among these possibilities, on the basis of high-level coherency and stability criteria that access the entire structure of the brain *as a whole*, the possible state PSP, which is the 'Yes' branch of the state S' = PSP + (I-P)(S(I-P) created by Process I.

Intentionality acts by controlling attention. Intention activates a Process I event that grasps a state PSP in which attention is focused on actualizing the intended state. The corresponding physical state is built around a projected body-world schema. The body-world schema is created by interaction between intention and feed-back, and a sustained persistence of a projected body-world schema tends to initiate the appropriate motor actions, monitoring actions, and follow-up events.

The phenomena of "will" is understood as a condition in which an initial Process I event leads to the occurrence of a very rapid sequence of follow-up events defined by very nearly the same P: a "mental effort" causes a rapid repetition of Process I events with almost identical projection operators P. Then the quantum equations of motion have the effect of preventing any transitions of 'Yes' states to 'No' states. The state is held in a state of the form PXP, with fixed or slowly changing P, in spite of all sorts of disruptive and distracting mechanical influences that would otherwise cause a wandering of attention. The mental effort is thereby causing a large deviation of brain activity from it would otherwise be. Mental effort is importantly influencing brain process.

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

This theory 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 tendencies for Process I events to occur.

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 psychology 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 admitted 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 empirical 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, appears 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 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.

Quantum theory automatically accounts for all the successes of classical physical theory. So the fact that classical ideas work well in neuroanatomy and for other large scale phenomena is not evidence that classical physics will work in domains where quantum effects ought to come in, such as the migration of calcium ions inside of nerve terminals. The quantum description becomes necessary only when treating subtle dynamical effects, which, however, can have important large scale effects. The effect of mental effort to hold ideas in place longer than classical computations would predict seems to be the most crucial dynamical difference between the classical and quantum models. This effect could eventually become important in neuroscience, but it immediately entails a major revision in the scientific conception of human beings.