Wolfgang Baer

Introduction to the Physics of Consciousness

Abstract: *The 'Hard Problem' of consciousness and its 'Explanatory Gap' can only be explained if we develop a physical theory which recognizes the Universe as a cognitive being and is based upon a fundamental process that transforms mind into body and back again. The physical requirements needed to realize such a transformation cycle are investigated and an explicit implementation of the consciousness process is presented. This implementation consists of an integrated mind-body activity that explains mental experiences with a model of the activity itself. Such a self-referential loop is shown to be both a fundamental physical process and a container of primitive self-awareness from which complex experiences can be built.*

Explaining consciousness requires an expansion of current physical theories. To develop this expansion I will first associate the components of the consciousness process with individual operations occurring in the architecture of quantum theory. This will provide explicit mathematical equations required to describe conscious phenomena and show their limits. Because quantum equations apply to the content of space, but not to the sensation of space itself, they can only represent an approximate description of the consciousness process and are hence incomplete. I will, therefore, go on to discuss the approximations which limit quantum theory from providing a complete explanation of consciousness and suggest the metaphysical underpinnings required to expand quantum physics into a more complete description of reality.

Lastly, I will discuss the implications of a reality model in which all parts of the universe, including the reader, are fundamentally self-

Correspondence:
Wolfgang Baer, Naval Postgraduate School, Monterey, California 93924, USA.
Email: Baer@nps.edu

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measurement processes and the sensation of space is not that of an a priori container, but rather a 'what it feels like' to be a time-stable event.

Key Words: Consciousness, Reality Models, Process Ontology, Process Reality, Epistemology, Panpsychism, Ernest Mach

I: The Consciousness Process

The everyday experience of conscious perception was identified as a process by William James (1890, chapter X) and associated with a physical phenomenon called an 'actual occasion' by Alfred Whitehead (1978) in the early 20th Century. The claim implies that one does not simply 'see' an object when looking at a thing in front of one's nose, but actually engages in an event that makes objects appear. The 'I' has been called 'a strange self-referential loop' (Hofstadter, 2007). A more specific description of the consciousness process is given in a *JCS* article (Atmanspacher, 2006, p. 34) under the heading of 'Process Ontology' as a cycle of activity with mental experiences on one side and physical causes on the other. The connection between Process Ontology and quantum theory is discussed in many texts presenting Whitehead's theories (Sherburne, 1981; Nobo, 2004; see also Kafotos, 1989). My paper adopts Whitehead's idea of 'actual entities' described by Philip Clayton as 'Experiential units, constitutive of both process and objects, *that* are basic elements of reality' along with the notion that, 'temporal change is a fundamental feature of the physical world itself' (Clayton, 2004, p. 6).

To make these ideas more concrete, this paper explicitly depicts sensations inside a thought bubble, which acts as a mental reference frame, and draws their explanations inside a parallelogram, which acts as a material reference frame. *Primitive consciousness is then modeled with a process that transforms a description of one's sensations into a description of one's explanation of those sensations and back again.* A graphic depiction of the consciousness process is shown in the center of figure 1. Here the form of an apple, shown inside a thought bubble, is used to represent an everyday sensation. Below, in a parallelogram, the outline of an apple is shown to represent the general explanation of these sensations. The two are connected by ellipses to indicate transformations exist between sensations in one's mind and physical realities in one's body. Defining the exact nature of this connection and providing the physics of a universe built out of interacting process cycles is the main topic of this article.

I.a Historic development of physical reality models

The general explanation for sensation is called 'physical reality', i.e. most of us believe sensations are caused by the real physical world. Since no one can ever see this physical cause directly, the general explanation of sensation cannot refer to the physical world itself but rather a model or theory of it. The symbols of such theories in figure 1 point to the incorporation of beliefs we hold to explain our experiences. Drawings inside parallelograms are intended to represent the belief structures one uses to explain one's sensations. They cannot point to the explanation themselves.

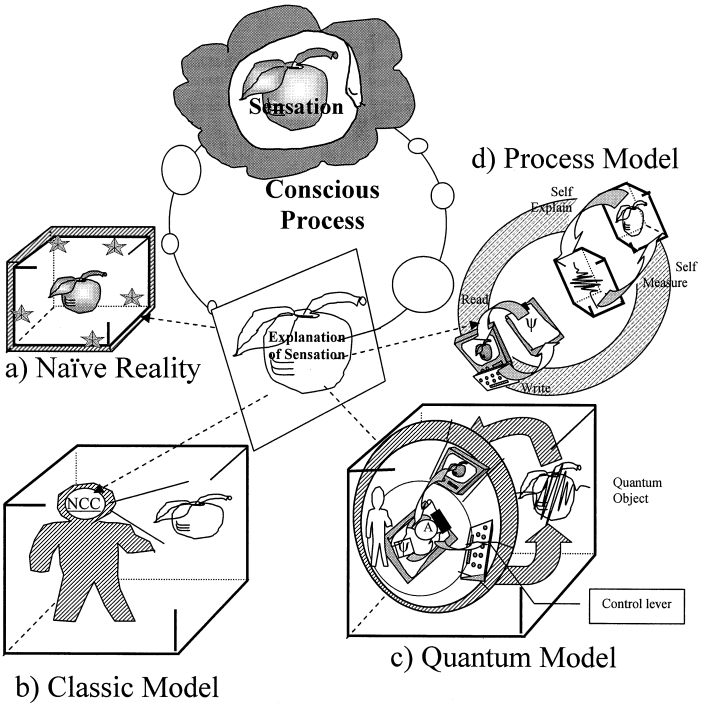


Figure 1. The conscious process with alternative physical reality models.

Thus the meaning of the expression 'physical reality' is by definition whatever physical entities explain our sensations. These explanations vary from individual to individual and culture to culture. To emphasize this point, dashed arrows connect the general explanation

of sensations in figure 1 with a sequence of alternative physical reality models that have been substituted into the explanatory role by various cultures throughout history.

The alternative explanations start on the left with the belief described by philosophers as 'naïve reality' and lead to an icon intended to represent a belief termed 'process reality' on the right. The intent of these drawings is to present selected examples of physical theories that show a progression of explanations culminating – at least for the time being — in the process model. I will start by describing 'naïve reality' and progress counterclockwise through the sequence.

Naïve reality asserts that the experience in front of your nose is the way it is because a real world of physical objects exists the way it appears. An individual asked why he sees an apple would probably say, 'Because it is there.' The transformation between physical reality and sensory experiences is immediate and direct. In fact it is an identity operation since the content of both nodes in the consciousness process are equal. Naïve reality underlies classic physics and completely ignores the role of the observer and his consciousness. The primary advantage of this belief is one of speed. The individual using it simply reacts to the configuration of experiences as they appear without the overhead imposed by the awareness of the experience-generating mechanism. The naïve reality connections are learned in early childhood and for most of us persist without question throughout adult life. It is by far the most popular and practical reality model used by scientists and athletes alike. This is the way we were built to operate as animals. In the following discussion we will see that all models must retain some region of identity connection between sensations and their explanations in order to enable operational effectiveness.

If one takes the time to analyze one's experience when, for example, looking into a mirror, then one realizes that a calculation and a calculator are required to define a physical world. To accommodate this realization, the naïve reality model is modified into what I will call the 'classic model' shown in figure 1b. The classic model includes an observer and his brain among the mix of moving objects populating physical reality. In this model, a physical chain of cause and effect connects the physical apple through a boundary of sensors (shown as diagonal shading lines) with those part(s) of the brain thought to be responsible for generating conscious experiences. Individuals using the 'classic model' no longer believe the apple appears because it is there, but rather appears because some correlated physical phenomena occurs in their brain. The identity region in the naïve reality model has now been limited to the neural cortex shown as a white oval in

figure 1b. These regions, known as Neural Correlates of Consciousness (NCC), are no longer expected to contain a scale model of spatial experiences, but they are at least expected to provide a one-to-one correspondence between physical occurrences in the brain and the sensations experienced. It is hoped by most neurophysiologists (Koch, 1998) that a correlation will eventually be found and thus provide, not a solution to the 'hard problem' (Chalmers, 1997), but at least a working control of conscious experiences.

The structure of the classic model divides physical reality into the NCC and the Rest of the Universe. For humans the two regions are connected by a biological measuring apparatus that allows signals to flow into the NCC and an effecter system that allows commands to flow out. The barrier of sensors and effecters surrounding the NCC are shown as a diagonally patterned region within the body of the observer in the classic model icon of figure 1b. The NCC takes on the role of a control center within which conscious experience simply happens. One can make an analogy to a control room by imagining a homunculus inside the NCC looking at internal displays and acting on internal leavers.

If the barrier between the NCC and the objective world is pushed outside the body and into external instrumentation, the control room metaphor becomes more realistic. One can imagine an actual physical body, such as a military commander in a control room, taking the role of the homunculus, sensing internal displays, and moving command levers as though they were real. The analogy breaks down only because the commander can exit the control room and personally witness events outside the barrier of sensors and effecters and thus witness the difference between symbolic actions inside the control room and their meanings in the external world. This barrier is not penetrable in the case of a scientist investigating the structure of atoms or an astrophysicist investigating the properties of a black hole. By introducing an impenetrable barrier we reach the quantum model represented by the third explanation for sensations in figure 1c.

In our diagram we have deliberately pushed the impenetrable barrier from inside the brain of the scientist into external measuring instruments in order to emphasize the fact that in the quantum model the role of the NCC, as the control room, is taken by the ordinary world of naïve realism encountered in the laboratory. Of course the actual NCC is still in the scientist, but the content of the laboratory is treated as the region in which appearances are equated to physical reality.

Most discussions of the quantum measurement problem (Wheeler & Zurek, 1983) start with the sensor/effecter barrier (known as the von Neumann cut) between the classic and quantum worlds placed in the laboratory. The barrier is then moved into the brain through a series of analytic steps resulting in a complete quantum description of physical reality. The typical analysis treats a quantum system outside the barrier as a probability that is actualized into objects through the measurement process. When the measuring apparatus is also treated as a quantum object, the question, 'What actualizes the measurement apparatus?' is asked. The answer requires a second apparatus that measures the first apparatus combined with the initial quantum system of interest as a combined quantum system. These three systems must now also be actualized by the measurement of a fourth system, etc. etc. The analysis eventually includes the NCC in the brain of the physicist as a quantum component and the final measurement instrument becomes the consciousness of the observer who selects one classic physical state out of the possibilities present in the quantum world.

The goal of von Neumann analysis is to eliminate the classic component and treat all of physical reality a single quantum theory. This leaves physical reality with persistent uncertainties and leads to Everett's multi-world interpretation. Unfortunately it also leaves consciousness with the task of selectively actualizing one of the worlds without any physical means to do so (Mensky, 2006). Though credit must be given to the quantum theorists for acknowledging the critical role a consciousness must play in determining actual experiences, the treatment has shed little light on the nature of consciousness or how it performs its supposed actualization. Our treatment differs from the typical analysis by remembering that physical reality cannot be solely a quantum world and 'naïve reality' must be applied to some portion of a physical reality model. We embrace the classic quantum duality as an architectural feature not a flaw in our world view. Rather than eliminate the NCC from the observable portion of the reality model, we ask, 'What process might be happening inside to achieve conscious experiences?'

To answer this question we note that when appearances in the laboratory are treated as the things themselves the entire laboratory becomes a control room metaphor for the Neural Correlates of Consciousness. The operations in the laboratory can therefore be treated as externalized versions of what is happening inside the NCC of the scientist. The absolute impenetrability of the sensor-effecter barrier makes the quantum physicist, unlike you looking down upon the model or the military commander in a control room, a perfect analogy

for the homunculus. *By systematically mapping the physicist's theory onto symbol manipulation mechanisms in the laboratory we can document his own role and derive a purely classic physical world representation of the thinking and hence the process responsible for his consciousness.* Please note that figure 1c includes an icon of a notepad upon which his externalized thinking process is mapped. I will provide the quantitative description of this mapping in the next section and only give a brief qualitative overview in the paragraph below.

The mapping begins by writing a description of the television displays through which the physicist 'sees' the outside world onto the notepad. This is represented by the 'A' in the circle, which stands for the action pattern 'A[q]' recorded during an observation of some quantity 'q'. From this basis of observation the physicist seeks an explanation in the form of a physical world model. The quantum explanation consists of possibility waves shown as squiggles outside the sensor boundary in figure 1c. Much like the objective apple outside the body in the classic model, these waves can never be experienced directly, even in principle. Instead, they can only be inferred from evidence available in the form of classic objects inside the sensor/effecter boundary and referred to with symbols of the theory. The path of inference is represented on the clipboard as a curved processing arrow leading from the symbol 'A[q]' to the symbol of their explanation 'ψ[q]' seen on the notepad without the quantity parameter. Once a description of the explanation that caused the observable sensation has been formulated it can be verified by applying a symbolic measurement process. This process is represented by the second curved arrow. It re-calculates the symbol of sensations on the monitor screen. If 'ψ' is the correct explanation for sensations, then the calculated and measured sensations coincide and reinforce each other. Thus, a resonance between external stimulation and an internal processing cycle amplifies the activity. The physicist would say he is looking through the monitor and seeing the inside of an atom 'ψ'. In a very real sense 'ψ' is the *name* of the entity beyond the sensor/effecter boundary. This name is recorded in his memory, while the internal processing paths could equally well be labeled 'read' and 'write' operations to that memory.

For completeness one should remember that the symbol of the environment in which 'ψ' finds itself is in quantum theory described by the energy operator traditionally written as the Hamiltonian $\mathbf{H}(\mathbf{p},\mathbf{q},\alpha,\beta)$. The **p** and **q** are momentum and position operators of the quantum system while the α,β represent additional parameters that define its quantum environment. An example of such a parameter might be the

setting of a rheostat in the laboratory that controls magnetic field strength surrounding 'ψ'. These settings must also be described by the scientists experience description symbol 'A'. Arrows leading to and from the notepad refer to both sensor and control lever states at two times respectively. The loop can therefore operate like a gate in which the sensor input controls the lever output states.

To what extent such a self-referential loop is actually occurring, in the biological system we have asked to record his activities, is speculative. What we do know from the analysis of nervous systems by Maturana is that a nervous system does not operate in response to a representation of the environment, but rather 'the structure of the system determines its interactions by specifying which configurations of the environment can trigger structural changes in it' (Maturana & Varela, 1992, p. 135). The architecture of this structure is, according to Maturana, a kind of processing loop which incorporates a set of self optimizing configurations. A scientist outfitted with a belief is a structure that can only absorb information when the stimulation explanation nodes in the processing loop reinforce each other. That a quantum physicist executes such a loop when applying his craft is therefore a general property of his nervous system. If such loops are generally executed by nervous systems, the theme of this paper could equally well be stated as an attempt to generalize Maturana's findings to all physical objects, living or not, and therefore provide a physical rather than a merely a biological basis for consciousness.

The quantum model in our analysis figure 1c has deliberately kept the division between an inner world and an external quantum system in order to incorporate the externalized cognitive processing cycle executed by the scientist. If we eliminate the homunculus role played by the scientist by automating his operations and remove all the ancillary equipment not critical to the cognitive observation of the quantum object, we will arrive at the architecture of the process model similar to that shown in figure 1d. Here the scientist is one loop. In addition the quantum object has also been replaced by a cognitive processing cycle. This replacement is a conceptual jump from the quantum to the process model world view. Justification for this jump will be discussed in subsequent sections. Here it is required to achieve a consistent physical reality since the alternative is to make the scientist a quantum object and maintain a non-physical consciousness with mysterious actualization capabilities rejected in previous arguments. Instead, physical reality in figure 1d is shown as a set of interacting conscious cycles. The scientist and his sensations of his laboratory have been reduced to the physical process that is being executed. This

process, which converts his actual sensations into explanations and back in a self measuring feedback loop, contains a form of conscious awareness whether or not external interaction channels are actually open, i.e. the scientist could be dreaming.

The entire cycle as a stand-alone activity is therefore a legitimate candidate for the physical cause of the sensation defined in the consciousness process of figure 1 and can be substituted for the 'Explanation of Sensation' in order to produce the relationship shown in figure 2. If we remember that this process involved a transformation between what was taken to be a classic observable and a symbol of its cause, then we have in figure 2 the sensation of an apple explained by the existence of a physically real process instead of simply being explained by the existence of a 'naïve reality' object. In other words, the explanation of sensation is a model of the process happening when the sensation takes place.

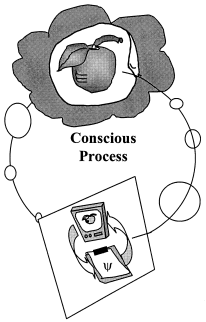


Figure 2. The explanation of consciousness

The last paragraph is not a proof that either consciousness is a process or that physical reality is a process, but only a statement of consistency. However, if the consciousness process hypothesis is accepted, then certain characteristics of physical reality are logical consequences. If consciousness is contained in a process then its explanation must refer to a process as well. This process is not built from moving objects, such as a horse race or a production cycle in a factory, but rather is a Whiteadean fundamental event. Moving objects as well as the space and time in which they move are derived from the properties of such fundamental events, not the other way around. *It is not elementary particles, but elementary events that are the building blocks of physical reality in the process model.* That this theory is indeed an improvement of our understanding of physical reality in addition to a belief that is logically consistent with our consciousness hypothesis will be argued in subsequent sections.

The four models discussed represent alternative beliefs that can all be substituted in place of the 'explanations of sensations' in a process we assume includes consciousness. It is the process that is fundamental. The exact nature of a physical model is less important than the fact that it has an explanatory role in this process. Each alternative has advantages and disadvantages depending on the problem at hand. In this paper the problem at hand is our understanding of consciousness.

For this reason the process model of physical reality has the advantage of logical consistency over other beliefs. If consciousness is to have a physical explanation then our model of physics must contain a symbol of the entity that implements it. By proposing the process model as our physical reality belief this requirement is automatically satisfied because the explanation of sensations is the model of a cyclic activity that refers back to the process of consciousness itself. In short, we have a scale model of the conscious event. It is a symbol of the consciousness process, whereas all other physical models contain an explanatory gap that must be bridged by some ad-hoc magic to explain consciousness. In the process model consciousness is — paraphrasing Nagel (1974) — what it is like to be a cycle of activity and all parts of the universe exhibit this characteristic.

The advantage of the process model to explain consciousness as a fundamental property of nature has in the past been outweighed by its inability to match the speed of the naïve reality model and its practical calculation immaturity compared the classic or quantum models. If, in fact, process reality was only an idea invented to explain consciousness it would hardly be worth considering further. If, however, process reality can be developed into a useful physical theory from which quantum mechanics can be derived as an approximation, then it may be advisable to retool our thinking apparatus so that we can grasp the world in process terminology. The next section discusses details of the quantum approximation applied to the consciousness process while section III will show that quantum theory is indeed an approximation to a more comprehensive theory.

II- Quantum Physics as the Consciousness Process

In the last section we argued that the operations of a quantum physicist can be taken as a blue print for a cognitive process. In this section the details of this blueprint will be identified with quantum theory.

Quantum theory and its equations were originally developed by classic physicists who tried to use a 'naïve reality' philosophy to deal with atomic particles. The fact that atoms could not be seen objectively, even in principle, forced them to include a measurement processes that reached beyond the sensor barrier into a realm that could never be verified directly. To describe this realm a symbolic structure,ψ, which could not be directly connected to objective events became part of the theory. This lack of objective meaning for the symbols of the quantum realm is crucial to understanding them. The symbols of classic physics point to some past, present, or future events in

an observable classic universe. The symbols of the quantum realm are information storage structures that hold our belief of the world beyond the sensors and are connected to the observable world of sensations through a cyclic architecture of measurement and explanation.

The structure of quantum theory was initially analysed by Von Neumann in 1932, who defined a measuring Process I and a quantum Process II. Process II is governed by the Schrödinger Equation acting upon de Broglie waves and is deterministic in time (see von Neumann, 1955, chapter VI, Sec. 1). Process I is random and fraught with difficulties including the collapse of the wave function at the measurement instance, Schrödinger's Cat paradox, and the introduction of consciousness as the final measurement instrument. Active discussions of the measurement problem (Wheeler & Zurek, 1983) have lead to alternative, but by no means agreed upon interpretations, of quantum theory. Henry Stapp (1993) extended Von Neumann's analysis by including a Process 0 that produces a probing question and a Process 3 that produces a response. Further discussions with Professor Stapp have shown that his definitions are not equal to the expansion I am proposing in this paper, hence only his idea that the architecture of quantum theory must be enlarged to include additional processes beyond those defined by von Neumann us utilized here. With these clarifications, I define Process 0 as our classic world of observable action distributions governed by classic Hamilton's equations and

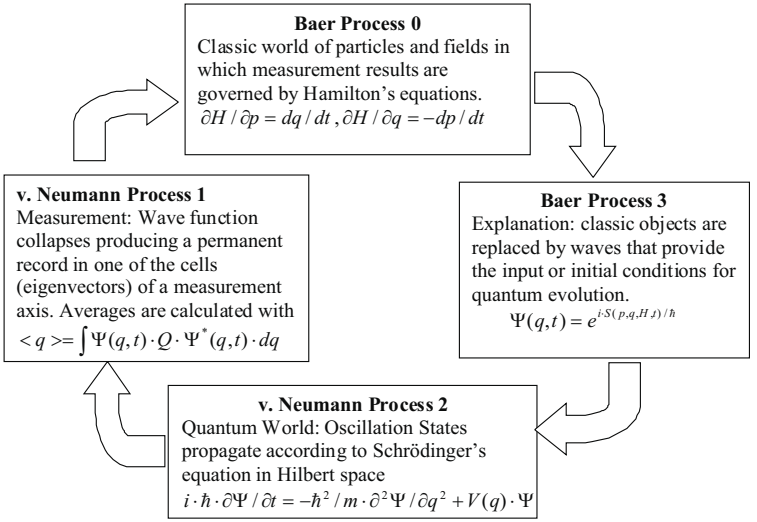


Figure 3. Process Architecture of Quantum Theory

Process III as the mechanism by which the action distributions are converted into the de Broglie waves. These definitions give quantum theory a suggestive four processes architecture shown as a single connected activity in figure 3.

The mapping of this architecture to the consciousness process is straight forward once one accepts the everyday world as sensations being explained, rather than as the things themselves (Baer & Pizzi, 2008; 2009b). In this case the world of appearances, described by classic physics, are mapped into the thought bubble of the consciousness cycle. Similarly the cause of those appearances, described by quantum physics, is mapped into the physical reality parallelogram of the conscious cycle. The measurement and explanatory transformations between these two worlds is mapped into the ellipses of the consciousness cycle. The resulting structure, shown in figure 4, attaches the mathematical rigor of both classic and quantum physics to the process responsible for the consciousness phenomena. The identification of quantum theory with the consciousness process allows us to associate quantitative descriptions of tangible physical occurrences with the phenomena of conscious experience. The ellipses in figure 1 as well as the measurement and explanation connections in figure 1d have now been defined in exact mathematical terms.

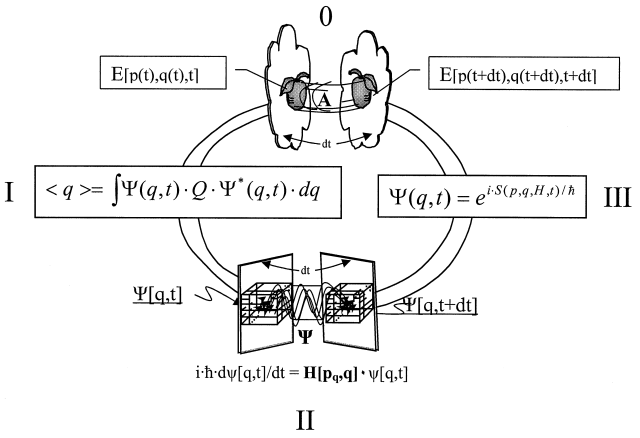


Figure 4. Structure of Quantum Theory as the Conscious Process

Table 1. English to Physics to Mathematical Terms Definition.

English	Physics	Mathematics
Description of a Sensation	Description of Classic World	pf(t),qf(t)
Description of Explanation Process	Description of Classic to Quantum Transform	(q,t) $e^{iS(p,q,H,t)/}$
Description of an Explanation	Description of Quantum World	(qf,t)
Description of Measurement Process	Description of Quantum to Classic Transform	q (q,t) Q * (q) dq

Where:

qf = Coordinate in the f'th degree of freedom (f is implied when omitted)

pf = Momentum in the f'th degree of freedom(f is implied when omitted)

(q,t) = Schrödinger wave function related to explanation storage

H(p,q,t) = Hamiltonian , equal to energy E[p,q,t] for conservative systems related to instantaneous sensation

A = S(p,q,H,t) = Hamilton's principle function defines the action in the instance dt related to recordable sensation over an interval dt

Q = The operator used to extract the value any quantity 'q' from (q,t)

II.a – Programmatic Definition of the Consciousness process

The classic action represented by 'A' in the top node can be directly equated to the recordings defining a classic instance of duration 'dt'. The quantum displacement pattern 'ψ' explains this action as caused by a motion during the same interval. What has been presented in figure 4 is a symbolic structure that constitutes a *program* or instruction sequence originally introduced as the operations of the quantum physicist homunculus in figure 1c. The program instructions themselves can be identified with English words or with more precise physics and mathematical terminology as shown in Table 1.

Whichever definitions are used, their precise application as programming instructions will now be demonstrated. The figure 4 instructions ask *one* to take the content of a variable called 'description of a sensation', find its meaning, and transform it into the meaning of the content of a variable called 'description of an explanation'. When writing 'description of sensations' as a variable, it should be clear that these words must be substituted with an actual description, which in turn must be substituted with the meaning of this actual description, i.e. an actual sensation, upon which a process is intended to operate when the program is executed. Since a first-person human is the loop, these actual sensations are the color-intensities seen on the retina. For an automaton they are the photon hits recorded at the sensor plane. When writing 'description of explanation' as a variable, the actual description must be substituted, and this in turn points to a meaning. For an automaton the meaning is the data structure in memory. For a first-person human the memory structures cannot be seen directly but must be read out through an internal measurement process and displayed as a sensation. Through this cycle a typical human will process an optical sensation into a memory and then make a measurement on that memory to generate the expectation of what it would feel like to touch the entity. This expected touch sensation is displayed in the dark psychological space surrounding oneself when ones eyes are closed.

Once it is clear that what has been presented is a set of instructions translated into more precise mathematical terminology, it makes sense to ask, 'who is the *one* asked to carry out these instructions and how does one become a loop?' In section 1 the *one* was identified as the Homunculus Scientist who recorded his own activities while processing measurement observables from a quantum experiment to get the blueprint expanded in figure 4 above. We then simply transferred his cognitive role into the cycle by stating we would automate the

program. The flippant word automate hid an important difficulty that must now be explained clearly. The path around the cycle is in the time direction. Time here is defined as the name of a state which is derived from the internal configuration of the system. A closed time line implies both a finite and repeating set of states. When looking at a symbol of the cycle from outside *one* can read the instructions which tell *one* to go from one state to the next. But how can *one* actually execute these instructions? In a very real sense this means getting into the cycle and feeling time flow through *one* rather than watching it pass by from the outside. This 'getting into' — accomplished by realizing that *one is* actually a cycle because all parts of the universe, whether dead or alive, are cycles — will be qualitatively discussed in the next section.

II.b – Getting Into the Consciousness process

Assume the cycle in figure 4 applies to the universe as a whole, so that 'A[x,y,z,t]' defines everything in a classic naïve reality context. We call the cycle 'U' and visualize it as implemented by a universal third person who carries out the instructions. Of course neither you nor I are that person but we can adopt a god's eye role when looking down upon a description of the world, so that while executing the instructions defined in figure 4, the resulting activity models the universal conscious event. Figure 5 shows an anthropomorphic simplification of a process cycle in which the 'A[x,y,z,t]' is represented by a classic box with moving objects and fields. Now assume U has this sensation of a universe in front of him and wishes to know, i.e. become conscious of, what it is. To do so U must recognize it and, acting as a writer, record the result of his recognition in some form. U's memory is visualized as a gigantic externalized note pad in which these forms are recorded. Consistent with the naïve reality concept his sensing operations are so delicate that they do not disturb the universe in the least. Let's further assume that U is very meticulous and wishes to

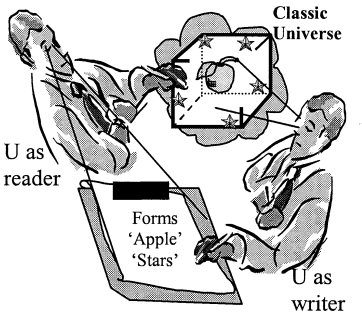
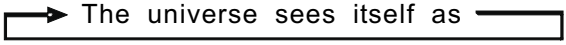


Figure 5. 3rd Person Knowing Objective world

know every little bit of the universe in detail. Thus every quantum of action happening sometime somewhere is recorded in representative forms. When all the actions in the sensation are recorded as forms in the note pad, U has reached the half point in the program. He now has the form 'universe' summarizing all its details on the pad. Does he/she know the universe? Well, he has symbolic forms, such as 'apple, stars or ψ', recorded in his memory but he does not know what they mean until they are read and turned into meaning. Thus the reader phase of the consciousness process begins: U now interprets the forms filling his memory. These forms were constructed precisely to tell him where and when each bit of action happened and can be turned back into meaning by pointing to the objective bits he originally sensed. At the end of this 'read' process he has again identified the sensation of the universe as an action structure in front of him.

A single cycle of this process identifies an objective universe with a symbolic representation and back again. If you and I can be neglected then U is completely isolated, and the process would repeat exactly. In this case, the sensation would not change, there would be only one event, and the cycle would capture exactly one state of that event. It would be the perpetual 'now' existing forever. During the process, U recognizes something that means what it sees. Expressed in words U, the process, would be a perpetual self-measurement cycle of transformation between object and subject as described with the following verbal cycle.



This is the essential property of a conscious being and thus we have visualized the execution of a process in which the universal third person, or whatever you want to call it, is conscious of everything. This consciousness in not in the nodes, but it is in the nodes being processed. To be conscious of the universe the cycle must be happening.

The use of a large ethereal being to demonstrate the operation of the consciousness cycle would certainly rankle the sensibilities of most scientists. So let's repeat the program only this time we assume U is implemented by a negligibly small being with a negligibly small mind outside of the material universe. Again U begins to sense the universe and has a sensation in his mind. Soon his mind fills up and he is forced to externalize his knowledge as material symbols in a large recording tape. Since there is nothing outside the universe the tape must be built from material already there. To avoid disturbing the universe before it

is measured he must build the tape out of material scavenged from parts he has already measured. Thus, as he proceeds to gain knowledge, the universe is divided into two regions: one is the object he still wishes to know while the other is his externalized memory. Eventually all the material in the universe has been measured and he is completely surrounded by a symbolic structure that constitutes his memory. Wherever he looks he sees the universe as a big symbolic structure.

His situation is like being inside a big library filled with books. On one hand he knows everything because it is all written in the books, but on the other hand he knows nothing until he picks out each book, sees each page, and translates them into meaning. Thus the Universe is divided into two parts once more. One is filled with symbols not yet read the other filled with objects that constitute the meaning of those symbols that have been read. At the end of this process the entire universe has been restored to its original objective configuration.

The anthropomorphic story just told describes an execution of the consciousness process in small steps that can be laid out graphically in figure 6. Here the initial state in which the physical universe is seen as a classic object is at the top. The interim state in which the universe is seen as another object, but interpreted as a symbol, is at the bottom. Sequential cycles between these two extremes are shown in the transformation boxes in the middle. The process described in figure 6 converts one observable configuration into a symbol of that configuration. The fact that we interpret the world symbolically half way through the cycle is not a property of the physical configuration but rather a property of ourselves looking down on the model. The process described would simply convert one observable configuration into another because the 'physical reality' portions of the cycles occur inside the transformation boxes. Looked at in this way, a classic physical description of an evolving universe emerges. If the top node, seen as naïve reality objects surrounded by stars, is our

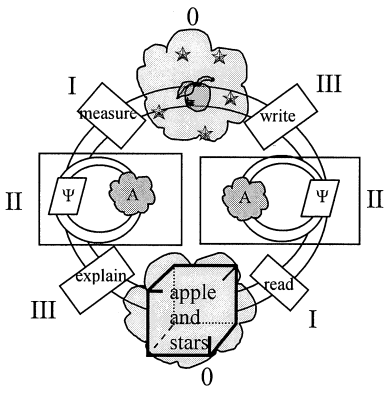


Figure 6. Universe event between Now and its explanation

current experience of the physical universe, then its opposite node would be both the beginning and end experience of the universe.

Given the direct association of the Figure 4 program with the evolution of the classic physical universe one may ask what happened to consciousness? We started this second story with the assumption that the executor of the program was no longer a gigantic personage who could grasp the Universe in one mental image but a small being with a vanishing number of mental storage locations. The trade-off between memory space and execution time is a well known property in computer science. If all the cycles are performed in parallel, it takes one time. If half are performed in parallel it takes two times. In the extreme, all cycles are performed sequentially and only one mental place remains for each cycle and it takes all the time there is. Figure 6 shows the experience of the origin of the universe 'written' into the explanation form '$\psi(0)$' in one node of a transformation process. The process shown graphically as a cycle, repeats the exact number of times required to propagate the universe explanation to 'ψ(now)' and then performs a measurement projection into its current appearance.

Anthropomorphically these repetitions are cycles of sensation and explanation. Consciousness is contained in this activity. The sensation node is the interval between two states of ψ. In quantum physics the observable sensation aspect described in classic physics terms is ignored and the evolution of the universe from the origin to its present state is a unitary transformation between two quantum states, identified by von Neumann as a quantum Process II. Consciousness is to be found not in the beginning or end product but in the execution of the transformations between the two.

The realization that not only a conscious being, but the universe as a whole, can be equated to a cycle of activity and is therefore a conscious being has now been achieved. This is the main purpose of this section. It requires the adoption of a new process model of reality. How such a model can provide the underpinnings of quantum theory and advance our understanding of physics will be discussed in the next section.

III: Quantum Theory Approximation of the Process Model

Quantum theory was conceived in the framework of a classic space-time container. The mapping of this theory to the consciousness process neglects the fact that space and time are also conscious sensations that must be included in that process. Quantum Theory, as conventionally presented, calculates both de Broglie waves and probability

predictions of actualizations in Cartesian space or its generalization called Hilbert space. It does not deal with the origin of these spaces and therefore is an incomplete description of the consciousness process. To address the origin of space and time we move outside the realm of physics and into its meta-physical underpinnings. Typical texts in classical mechanics (e.g. Goldstein, 1965, p. 1) assume the concepts of space, time, material, charge, and a host of other properties are simply understood by the reader as *a priori* knowledge. These concepts can now be derived from more primitive event characteristics which I will discuss in this section.

From an information processing point of view, the key insight revolves around the fact that both the display of sensations and the memory in which explanations are recorded are incorporated in some underlying structure that provides the container within which the processing takes place. One thing we know about successful processing machinery is that *the data being processed must not destroy the machinery doing the processing*. In other words only small perturbations in the bulk of such processing systems can be accepted. If you, I, and the Rest of the Universe are indeed processing cycles, then such processing must occur in a permanent underlying structure that is stable and serves as host to the small perturbations that constitute our content. The situation is analogous to watching a television screen

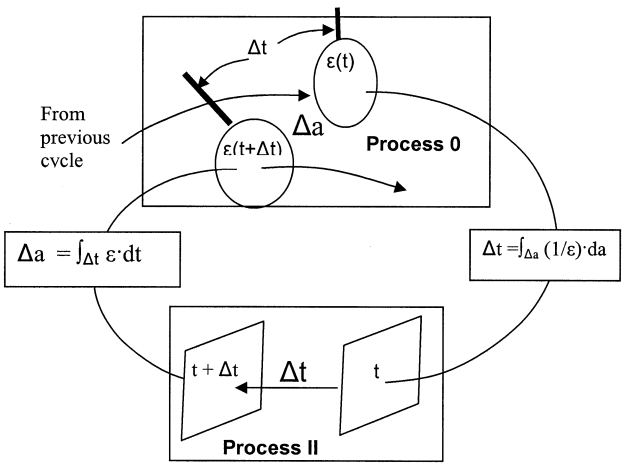


Figure 7. Fundamental Transformations of the Conscious process for a time step in a single space cell

without a picture. The display space may be empty of visual objects but certainly not empty of the phosphor dot cells with which these objects can be made to appear. Likewise empty perceptual space for you and I and inertial space of U are related to each of our bulk background structures. Since the fundamental entities in the process model are events, there must be a field of permanent stable activities to act as space cells within which sensations and memory explanations occur. I will now show the reader that such a structure of stable activities underlies the appearance of both personal space for you and I, and inertial space for the Rest of the Universe.[1]

Let us assume a space point is smaller than the Plank length and can be modeled with the mathematics of a classic physical system. The nature of space cells is an active area of investigation in quantum cosmology and not much is known about them yet. I have shown in Appendix A that no matter how complex such a cell may turn out to be, it can be viewed in a phase space reference frame in which all coordinates are constant except the time 't' and all momenta are zero except for the energy 'ε' — in other words, a clock that measures its own time. Time here is used as a state label, not as a geometric fourth dimension, i.e. 'time is what clocks measure' (Green, 1999, p. 37). Such a clock can be objectively visualized as a pointer moving, but not necessarily uniformly, against a dial. The position of the pointer at location 't' on the dial specifies the time the clock measures and its motion defines a time increment 'Δt'. If completely isolated the action required to execute this motion is given by ($\Delta a = \varepsilon \cdot \Delta t$). Thus we have a sensation that can be seen, i.e. a bit of action, and how it is explained, i.e. by the form of a bit of change in time. Figure 7 shows an open curve of a single 'Δt' step. The curve connects the nodes of the consciousness cycle with process I and III equations. They differ from those shown in figure 4 because they define a direct transformation between action and time instead of the small oscillation approximation of quantum theory.

In general terms, the consciousness process transforms material into form and back again. Since an isolated classic physical system can be reduced to a clock with a single degree of freedom, the basic form available is a length of time. Similarly the basic material is action. Viewed as a process, a running clock is action in a form of time. Thus we could say *the fundamental consciousness process transforms action into time and time into action.*

[1] See Cahill (2006) for a review of the evidence for an inertial space attached to fixed star backgrounds.

A single empty elementary space cell would be modeled as the smallest isolated clock executing along a closed process line with no time increment ($\Delta t=0$) on one node and no action ($\Delta a = 0$) on the other. It may be visualized as a clock in a single state of time without the hand moving. The single bit of awareness associated with such a process is that of empty space with no sense of time, in other words, awareness of absolutely nothing. Such self-aware space cells are the elementary events of the process model and replace elementary particles as the building blocks of physical reality.

To build a space that corresponds to the feeling of psychological space, i.e. the television screen without pictures, we must let the clock run so as to generate a series of background events that can be labeled by the name of the clock 'q' and the name of its states 't'. Such a process sequence is built by connecting the single segments shown in figure 7 together, making a closed curve that sums up a complete self-measuring period. The total amount of action A(q) in the period could be calculated by integrating over the total period of all time states T(q). Rather than watching the clock from the outside we 'get into the consciousness process' by taking on the role of an observer who rides along with the clock dial. This generates the illusion of empty space since such an observer feels no time increment ($\Delta t=0$) and no action ($\Delta a= 0$) when in actuality the clock process is built of A(q) action and T(q) time cycles. The awareness associated with this illusionary emptiness of space is awareness of self-existence and is far different from absolute nothing. The generator of the transformation that implements the 'get into the consciousness process' is called Hamilton's Principle Function 'S(p,q,H,t)'. It was introduced in table 1 and is used in Appendix A to formally illustrate how quantum oscillations are derived as an approximation from the process model of space. The next paragraph will discuss this derivation in qualitative terms.

Let us now suppose that instead of one clock 'q' we have a field of clocks each of which is labeled x,y,z. Assume these are stacked up close enough together so that they are no longer isolated but instead interact with each other very slightly. A cognitive being built out of a field of space cells will therefore contain small displacements $\Delta t[xyz]$ around the equilibrium time in each of the isolated clocks. This will lead to the appearance of an action deviation $\Delta a[xyz]$ from each isolated clock's background action. It can be shown from the classic theory of small oscillations (Goldstein, 1965, chapter 10) that the non-relativistic approximation for small oscillations executed by any classic system that is subject to very small disturbances will satisfy the

Schrödinger wave equation of quantum theory. The derivation of such a wave equation for the simplest case of a particle moving in flat interstellar space is provided by the author (Baer, 2009a).

The pattern of small displacements $\Delta t[xyz]$ in the clock field at time 't' is traditionally named the Schrödinger wave function $\psi[x,y,z,t]$, which describes patterns of oscillations known as de Broglie waves. The additional action due to the small disturbance in each clock is proportional to the square of the displacement amplitude, $\psi^*[x,y,z,t] \cdot \psi[x,y,z,t]$, which is proportional to the action pattern found at x,y,z and thus equal to the probability of an interaction at that location. The sum of interactions is interpreted as evidence of a mass-charge structure in classic perceptual space. The motion of the center of this mass is governed by the classic Hamilton's Equations when looked at in classic space or alternatively by the Schrödinger equation when looked at as a disturbance in a field of clocks.

The consciousness cycle in figure 4 shows a field of displacements ψ in a space of cells labeled 'q' as they progress through states labeled 't' on the bottom. On the top the 'q' references the implicit sensation of empty space locations in which observables appear. The quantum interpretation of observables is that they are 'really' a displacement pattern in a set of Hilbert space cells defining an a-priory background of the quantum world. The discussion above proposes that these displacements are small oscillatory approximations to the much larger self-measurement process that relates the feeling of space with a set of mass-charge structures which generate that feeling. The larger underlying process generates the sensation of space itself which in our view clearly does not come from nothing.

Viewed from the outside a heuristic model of this larger self-measurement process would look like a set of bed springs attached by sensors to a display monitor. The sensors measure the amplitude of the oscillations in the springs and display their corresponding intensity patterns on the monitor. These intensities are in turn viewed by a camera that controls the amplitudes so that we have a feedback cycle. The springs represent the forces holding the clock pointer to its empty space position in the space cell model discussed earlier. If the springs are all stationary, the monitor is empty and stays empty. If a cycle is slightly disturbed, a spring oscillation amplitude is induced and images appear on the monitor. If the disturbance stops, the amplitudes and images captured in the cycles continue to move around the bedsprings. These motions are governed by the small interactions between the springs and satisfy a Schrödinger equation. The moving images are the display of latent knowledge the system carries within

itself as an accommodation to influences from external sources. Typically this knowledge fades with time as the amplitudes are distributed throughout the system and shows up as noise on the monitor but never disappears. A model of the consciousness process universe consists of a set of such interacting self-measuring loops.

The chief problem with this visualization is that you are not in it. The process of 'getting into the consciousness process' was discussed in section II.b, and here it would mean getting in between one of the monitors and its camera and taking over control of one of the loops. Falling into a game and developing a second nature is a well known phenomenon. That you have fallen into life and are living your first nature is the highly suggestive metaphor the process model supports.

IV: Discussion and Summary

I have approached the problem of consciousness by examining the physical foundations suggested by William James' and Alfred Whitehead's process hypothesis. These hypothesis suggest sensations and their physical reality explanation are two nodes in a conscious existence cycle. This cycle connects substance with form or action with time. I showed that by selecting processes, rather than particles, as fundamental entities, an underlying physical reality can be conceived within which the equations of quantum theory can be identified with consciousness processes and quantum theory itself can be anchored in a tangible process reality rather than the probabilistic world of uncertainty.

The consciousness process has been described in several terms: In English, it transforms feelings into objective explanations and back again. In Physics, it transforms the classic world into the quantum world and back again. In Mathematical terms, it transforms action patterns into time fields and back again. In physiologic terms, it transforms sensations into neural correlates of consciousness and back again. In general it forms a recognition of a fundamental shift in our world view from a three dimensional space with moving objects, past quantum theory and onto a process reality.

The philosophical implications of the process reality are significant. If correct then we are not merely bodies in a box, but larger processing elements executing a metamorphosis cycle in which here-and-now is simply defined as the point of interaction. The process universe is conceived as a set of interacting event loop structures. Our daily experiences are not those of independent external objects, but rather are our personal accommodation and knowledge display of

interactions with other events. Other events in turn have their own internal vocabulary with which to accommodate our influence.

Of special importance is the suggestion that a permanent underlying stable process exists which provides the space and time reference set within which both experiences and their explanations occur. If true, such structures would explain the reversibility of fundamental physical laws since the content of space and hence all physics here-to-fore developed would be limited to small reversible perturbations that cannot destroy the space in which the physical phenomena occur. If, furthermore, we conscious individuals are such structures, then each of us possesses a permanent existence form. Life experiences would then be small perturbations that accommodate external influences and, in turn, our external body would be the accommodation of the Rest of the Universe to our interaction. Death, in this case, would be a cessation of connection between our permanent existence structure and our influence in the Rest of the Universe.

Proof of the veracity of the process model of physical reality is not to be expected in the normal sense of the word. Proof of right or wrong usually requires a rigid framework against which these concepts are defined. A major theme in my approach is that 'physical reality' is a string of words that reference explanatory processing elements. Many beliefs can serve an explanatory purpose in our thinking process. If such processing elements are themselves processes that convert symbols into meaning then the explanation of conscious experience can become a scale model of the consciousness process one is trying to explain. Logical consistency is currently offered as the major argument for accepting the process hypothesis. The value of such consistency must be judged relative to the problem at hand. I would not recommend entering a lions den armed only with a logically consistent reality model. A well oiled revolver and 'naïve reality' might be more useful.

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APPENDIX A:
Physics of a Completely Isolated Classic System

A classic system can be defined by the coordinates 'qf' and momenta 'pf' in all the degrees of freedom 'f'. The equations of motion specifying the complete evolution of the system are given by the 2f functions pf(t) and qf(t). If the system is completely isolated, no external time is available and time must be defined from the internal configuration with a function t(qf,pf). And likewise its conjugate momentum called energy, is defined with a function E(pf,qf). Since time and energy are no longer independent of the momentum and coordinates, these four

relations can be viewed as a contact transformation between a coordinate frame in which qf,pf defines the system and one in which E,t defines the system. The transformation equations between the two ways of looking at the system in questions then look like,

System propogation	Time and Energy definition
$pf = pf(E,t)$	$t = t(pf,qf)$
$qf = qf(E,t)$	$E = H(pf,qf)$ f=1 to all degrees of freedom.

The action required by the system is invariant under all contact transformations and can be calculated in each of the two coordinate frames as,

$$A = \int \Sigma_f pf(E,t)\cdot dqf \qquad A = \int H(pf,qf)\cdot dt$$

The generator of the transformation, called Hamilton's Principle function, can be calculated by taking the difference between these two expressions for action.

$$S = \int \Sigma_f pf(E,t)\cdot dqf - \int H(pf,qf)\cdot dt$$

Which can be reduced to

$$S = \int \{\Sigma_f pf(E,t)\cdot dqf / dt - H(pf,qf)\}\cdot dt$$

The principle of minimum action states that the actual path the system will take in configuration space, i.e. the actual system propagation, will be such that small variations around the actual path will be zero. The variation is typically defined by the letter δ, and variations can be expanded in a perturbation sequence.

$$\delta S = \delta^0 S + \delta^1 S + \delta^2 S + \ldots$$

The minimum action principle only requires that the first order variation $\delta^1 S$ is zero for classically physically realizable systems. This condition will be satisfied if the following two equation sets are satisfied

$$\partial H(pf,qf) / \partial qf = -dpf/dt \,,\ \partial H(pf,qf) / \partial pf = dqf/dt.$$

These 2f partial differential equations are known as Hamilton's equations and define the motion of any classic system including the physical universe as a whole.

Because the Universe is by definition all there is, this system is completely isolated and therefore time must be defined as a unique

state label derived from internal variables rather than from an independent Newtonian external time. Viewed in this way the evolution of any isolated system, even one as complex as the universe, can be viewed in a coordinate frame that makes it look like clock i.e. a single pointer particle moving around a circular path against a stationary dial.

The second order perturbation $\delta^2 S$ need not be zero but gives rise to small oscillatory motions around the classic orbits.

$$q_a[f][t] = q[f][t] + \psi[f][t]$$

For the nearly isolated clock systems used to model space cells in section III these oscillations are identified with deBroglie waves and satisfy a Schrödinger equation determined by the coupling between cells.

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