THE PHYSICS OF SYMBOLS EVOLVED BEFORE CONSCIOUSNESS

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ABSTRACT: The human brain appears to be the most complex structure for its size in the known universe. Consequently, studies of the brain have required many models and theories at many levels that involve disciplines from basic physics, to neurosciences, psychology and philosophy. For over 2000 years the two most controversial and unresolved models of brain phenomena involve what we call *free will* and *consciousness*. I argue that adequate models at all levels require epistemic *complementarity* – distinct necessary models that are not derivable or reducible to each other. The primitive irreducible complementarity at all levels is the *subject-object* distinction required by an *epistemic cut*. This complementarity first arises with self-replication where a *self*, the *subject*, must be distinguished from the *non-self*, the *object*.

KEYWORDS: Subject-object; Mind-matter; Self-replication; Epistemic cut; Free will; Consciousness

A strategy of basic physics research is to thoroughly understand the simplest case before attacking the hardest case. I have found that by exploring the meanings of *subject and object*, *symbols*, and *phenomena* at the level of the cell, their meanings can be more clearly understood at the higher evolved levels (Pattee, 1969, 1982).

This strategy means that to understand the foundations of human consciousness, one should first understand *awareness*, which requires understanding the *senses*, which in turn requires understanding the fundamental *subject-object relation* and the origin of *phenomena* and *symbols* (Pattee, 2015). Full understanding must also involve their origins and evolution. There are other reasons I do not find human consciousness as the most instructive, productive, or dependable level to begin a study of foundations.

First, from an evolutionary perspective consciousness, as understood at the higher levels, does not appear to have any necessary role in any individual organism being alive.[1]

Second, there is very little knowledge, and certainly no agreement, about when or why any level of self-awareness or consciousness first evolved. **Third**, the cognitive sciences now provide convincing evidence that the phenomena that appear to our conscious mind are only a small fraction of the brain's unconscious perceptual and cognitive activity. There are many levels of consciousness, and what appears at any conscious level is under the control of the unconscious brain. We have no dependable *subjective* access to any of the preconscious processing that results in conscious phenomenon (e.g., Churchland, 2002; Changeaux and Dehaene, 2011).

Fourth, most of our basic sensorimotor activities are unconscious, such as grasping, walking, gesturing, etc. At higher cognitive levels there is also good evidence that great discoveries in mathematics, physics, and creativity in the arts arise in the unconscious mind by unknown abductive search and incubation processes that appear in consciousness as a sudden epiphany.[2]

Fifth, conscious attempts at introspection are often deceptive and always reach a dead end.

Sixth, there is no fundamental physical theory that involves a conscious observer. This includes quantum measurement.

Finally, in context of the long-term evolutionary future of our species, the adaptive value of phenomena appearing to human consciousness is far from clear. The expressions of conscious thought, which include reason, religion, the arts and sciences are certainly impressive, and are considered as the species' greatest accomplishments. On the other hand, they are also responsible for deadly ideological conflicts and Promethean technologies that over evolutionary time scales have no certain or obvious survival value. So far, the lower species that lack the human level of consciousness have a far longer record of survival.

The phenomenologist's first objection to this approach is to point out that all our knowledge, including theories of evolution, physics, and the neurosciences, is still

[1] "It [individuality] depends not on consciousness, but on *being*; not on thought, but on *life*; it depends on the individual's empirical development and manifestation of life, which in turn depends on the conditions existing in the world" (Karl Marx, 1895).

[2] "It is certain that the combinations which present themselves to the mind in a kind of sudden illumination after a somewhat prolonged period of unconscious work are generally useful and fruitful combinations . . . all the combinations are formed as a result of the automatic action of the subliminal ego, but those only which are interesting find their way into the field of consciousness" (Poincaré, 1914).

ultimately derived from subjective human phenomena, which are our only source of experience. This is obviously the case, but to the physicist this raises the most interesting problem. The interesting problem is how these subjective phenomena correspond to what does not depend on subjective experience. Physics call this objective knowledge. Any concept of *subject* or *self* implies the existence of an *object* or *non-self*. For physics the relation of subject to object has always been the fundamental problem.

Of course this problem implies an epistemology that recognizes the *subject/object* distinction, and that is the issue I am going to discuss first because it is the basis of the interpretations of quantum mechanics.

Interpreters of quantum mechanics very often do not distinguish the unique quantum mechanical problems from the general epistemic problems that apply to all knowledge. Here are four important general examples: (1) the subject-object epistemic cut, (2) reversible vs. irreversible models, (3) deterministic vs. probabilistic models, and (4) general complementarity of models.

It is the *subject/object* distinction that stands out in the measurement problem in quantum mechanics because the *object* requires a quantum description and the *subject* requires a classical description. Where this essential distinction is made Heisenberg called the *Schnitt*, John Bell called the *shifty split*, and I call the *epistemic cut* to emphasize that it is not an ontological dualism.

What is often not understood is that the subject-object distinction and the epistemic cut is not just a problem of quantum mechanics. Born, von Neumann, and others have explained why *there must be an epistemic cut in any measurement process*. The reasons are: First, no laws can tell you what to measure or when to measure it. Second, measuring devices are special *boundary conditions*, and like *initial conditions* they are not derivable from or reducible to laws. Von Neumann explained that lumping system S and measurement apparatus M as one system (S + M) without a cut would require a new M^1 to measure new initial conditions – a process leading to an infinite regress.

Von Neumann's point was that this regress can be terminated only by choosing, seemingly arbitrarily, an *epistemic cut* – a separation of the *system* and *measuring device*, or more specifically, the separation of the *record* of a measurement (a *symbol*) from the physical event the symbol represents. This is not just QM. It is a requirement for any empirically testable theory.

> That this boundary [the cut] can be pushed arbitrarily deeply into the interior of the body of the actual observer is the content of the principle of the psycho-physical parallelism -- but this does not change the fact that in each method of description the boundary must be placed somewhere, if the method is not to proceed vacuously, i.e., if a comparison with experiment is to be possible. (von Neumann, 1955, p.420).

QM has nothing to do with the necessity of an epistemic cut.

My second issue is the reversible/irreversible complementarity. All treatments of quantum measurement emphasize the reversibility of fundamental laws and the irreversibility of measurements. But this is the case for a*ll* measurements (detections, records, symbols, etc.). ***All*** microscopic laws are reversible. The logician Emil Post noted that symbols have no dynamics. Symbols are created in time but preserved as timeless structures. All results of measurements are symbols. The reversing of a symbol is meaningless, because the symbol's relation to its referent is only an interpreter's convention. Again, quantum theory has nothing to do with measurements being irreversible.

The third issue is the "collapse of the wave function", also considered a central issue in quantum measurement. But again, in any irreducibly probabilistic model there will be an epistemic "collapse" of the state's probability distribution with any new information, i.e., measurement. This is a more obvious problem in QM, but it is a property of all probabilistic models.

Born explained that classical physics was probabilistic because measurements cannot be exact. He has argued that epistemic determinism is untenable or meaningless, and that ontologic determinism is *undecidable*. Born (1959): *"In view of uncertainties concerning the initial conditions due to inevitable experimental imprecision the predictions of classical mechanics never describe a unique trajectory but rather a group of trajectories defined by a probability distribution. The true task of mechanics is to predict the evolution of this distribution with time."*

For this reason, "the concept of determinism is unacceptable" (even without Heisenberg's uncertainty).

In his Nobel lecture, Born further emphasizes the importance of fallibility.

> I believe that ideas such as absolute certitude, absolute exactness, final truth, etc. are figments of the imagination which should not be admissible in any field of science. On the other hand, any assertion of probability is either right or wrong from the standpoint of the theory on which it is based. This loosening of thinking seems to me to be the greatest blessing which modern science has given to us. For the belief in a single truth and in being the possessor thereof is the root cause of all evil in the world. (C. S, Peirce would agree.)

Einstein would partly agree: "In so far as the propositions of mathematics are certain they do not apply to reality; and in so far as they apply to reality they are not certain."

This was his *epistemic* belief, but clearly *not his ontologic* belief.

Any irreducible probabilistic model cannot predict exactly the explicit symbolic outcome of a particular experiment, which while obeying the probabilistic model is not itself a probability, but a definite classical symbol. However, while the symbolic result is explicit, it is not exact if the measured observable is continuous. Even if the result is discrete, there is a finite probability that it is incorrect. (This was Peirce's argument for his tychism.)

According to Schrödinger and all the EPR experiments, the crucial difference (and conceptual problem) of QM is *non-locality* and *entanglement.* There is no adequate classical analogy. There is also the underlying issue of the interpretation of a probability, primarily whether it is real (objective) or nominal (subjective).

The fifth issue is Bohr's complementarity principle which was originally applied to quantum theory; but his general complementarity principle of irreducibility applies to all models. There is no model of everything. For example, you cannot *formally* derive a probabilistic model from a deterministic model (Weyl, Planck, von Neumann, see Appendix), or an irreversible model from a reversible model, or a discrete model from a continuous model. The hierarchy principle requiring different models at different levels applies to both classical and quantum theory: Different levels of organization are defined by their different models. Classical levels are particle dynamics, statistical mechanics, thermodynamics, structural chemistry, and the solid state. Lower level models apply to higher levels, but are not adequate for understanding higher levels. QM applies to all these levels, but QM *alone* is not an adequate model at higher levels. Hierarchies require complementary models. Bohr believed that *complementarity "bears a deep-going analogy to the general difficulty in the formation of human ideas, inherent in the distinction between subject and object."*

In spite of much evidence, the idea of the necessity two irreducible and often inconsistent models is often rejected on philosophical grounds. It still surprises me that the the necessity of general complementarity of models is so controversial, because it is evident that one universal model of reality does not exist, and everyone uses more than one model of their experiences even in everyday life. Nevertheless, much of the literature in many scientific fields is full of unproductive arguments over which of several complementary models is correct or superior to the others.

For example, a physicist, a phenomenologist, or any subject, can believe with confidence that the *image* of an objective lawful universe must exist as a construction of the conscious subject's material brain, which can influence matter as a boundary condition without violating these laws. At the same time the subject can with similar confidence believe that the material lawful universe existed before life and brains evolved, and therefore there are laws that are independent of the subject's consciousness, or in fact independent of life and boundary conditions. The *complementarity* of these two models is clear. Trying to eliminate either belief is a useless enterprise.

As I mentioned earlier, different hierarchical levels require irreducibly complementary models. In physics a change of scale in space, time, or energy of several orders of magnitude usually requires new observables and a new model, and current physics models cover over 60 orders of magnitude. Also, formal mathematical structures can be interpreted as having complementary literal and metaphorical meanings. There is still no consensus on the foundation of mathematics. I believe there is a good reason: there are many necessary complementary foundations. Why should there be only one?

In biology the *structure-function* complementarity is a universal necessity. Function cannot be logically derived from only a structural description, and a structure cannot logically be derived from only a defined function. In evolutionary terms, structure-function relations appear to be "discovered" by natural selection and often appear as frozen accidents. Animals recognize discrete objects and continuous motion in separate regions of the brain, and neither region would make sense without the other.

The general concept goes back at least to Heraclitus' *upward-downward path* describing the same path and to Aristotle's four complementary causes. Nicholas of Cusa was more explicit with his *coincidentia oppositorum* – unity of opposites. Euler pointed out that the Creator's laws can be described equally well by time-dependent efficient cause (time-dependent state-determined equations) or final cause (timeless extremum principles).

The complementarity of discrete and continuous models is a fundamental aspect of the symbol-matter problem. Evolution prepared the simplest brains to distinguish discrete objects from the continuous motion of objects, thereby allowing effective sensorimotor control. Our everyday experience as well as classical physics is based on a clear and objective distinction between discrete particles and continuous motion, which are processed in different regions of the brain. Modern science depends on artificial instruments that have extended our senses many orders of magnitude beyond what our brains can recognize without cognitive dissonance. It is not reasonable to expect to eliminate this dissonance of complementarity by adding new concepts and patterns.

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REFERENCES

Bohr, N. 1958. Physical science and the problem of life. *In Atomic Physics and Human Knowledge*, New York: Wiley, p. 101.

Born, M. 1969. *Physics in My Generation, 2nd ed. Springer Verlag, Chapter title: Symbol and Reality. First published in Universitas Vol. 7 pp. 337-353 (1965) Quote on p. 133.*)

Born, M. 1959. Dans quelle mesure la mécanique classique peut-elle prédire les trajectoires? *J. Phys. Radium,* 1959, 20 (1), pp.43-50 [To what extent can the classical mechanics predict trajectories?] https://hal.archives-ouvertes.fr/file/index/docid/235987/filename/ajp-jphysrad_1959_20_1_43_0.pdf

Changeaux, J-P. and Dehaene, S. 2011. Experimental and theoretical approaches to conscious processing, *Neuron 70*, pp. 200-227.

Churchland, P. (2002). *Touching a Nerve*. New York: W. W. Norton. Chapter 9.

Einstein, A. 1949. Remarks Concerning the Essays Brought together in this Co-operative Volume. In Schilpp, P. A. *Albert Einstein: Philosopher-Scientist.* The Library of Living Philosophers, vol. 7. Evanston, IL: The Library of Living Philosophers. pp. 665-688.

Hertz, H. 1894. *The Principles of Mechanics*, Dover, NY, 1984, [orig. German ed., *Prinzipien Mechanik*, 1894] Quote: pp.1-2.

Marx, K. 1845. Individuality in Thought and Desire, *The German Ideology*, published by Marx-Engels Institute, Moscow, 1932.

Pattee, H. H. 1969. How Does a Molecule Become a Message? *Developmental Biology Supplement* 3:1-16
<https://www.academia.edu/863859/How_does_a_molecule_become_a_message>

Pattee, H. H. 1982. Cell Psychology: An Evolutionary Approach to the Symbol-Matter Problem. *Cognition and Brain Theory* 5, no. 4:325-341.
<https://www.academia.edu/863857/Cell_psychology_an_evolutionary_approach_to_the_symbol-matter_problem>

Pattee, H. H. 2015. Cell phenomena: the first phenomenon. *Progress in Biophysics and Molecular Biology*, Special Issue of on Integral Biomathics: Life Sciences, Mathematics and Phenomenological Philosophy. http://dx.doi.org/10.1016/j.pbiomolbio.2015.06.010

Planck, M.1936. Causality in nature. In *The Philosophy of Physics.* New York: W. W. Norton, p. 55.

Planck, M. 1960, *A Survey of Physical Theory*. New York: Dover Publications, p. 64.

Poincaré, H. 1914. *Science and Method*, Chapter 3, Mathematical Discovery, 1914, New York: Dover, p. 58.

Schlosshauer, *et al*: Snapshot poll http://arxiv.org/pdf/1301.1069v1.pdf

Schlosshauer, M. 2011. Ed, *Elegance and Enigma*. Springer

von Neumann, J. 1955. *Mathematical Foundations of Quantum Mechanics*, (translated from the German by Robert T. Beyer) Princeton University Press, pp. 419-420 Quote p. 420.

Weyl, H. 1949. *Philosophy of Mathematics and Natural Science*, Princeton Univ. Press, p.144.

Wikipedia: Interpretations of QM http://arxiv.org/pdf/1301.1069v1.pdf

APPENDIX NOTES

H. Weyl, 1949: . . . we cannot help recognizing the statistical concepts, besides those appertaining to strict laws, as truly original. (p. 203).

Max Planck, 1960: For it is clear to everybody that there must be an unfathomable gulf between a probability, however small, and an absolute impossibility (p. 64) Thus dynamics and statistics cannot be regarded as interrelated (p. 66).

Einstein on complementary epistemologies:

Einstein (1949). "*Epistemology without contact with science becomes an empty scheme. Science without epistemology is—insofar as it is thinkable at all—primitive and muddled. However, no sooner has the epistemologist, who is seeking a clear system, fought his way through to such a system, than he is inclined to interpret the thought-content of science in the sense of his system and to reject whatever does not fit into his system. The scientist, however, cannot afford to carry his striving for epistemological systematic that far. He accepts gratefully the epistemological conceptual analysis; but the external conditions, which are set for him by the facts of experience, do not permit him to let himself be too much restricted in the construction of his conceptual world by the adherence to an epistemological system. He therefore must appear to the systematic epistemologist as a type of unscrupulous opportunist: he appears as realist insofar as he seeks to describe a world independent of the acts of perception; as idealist insofar as he looks upon the concepts and theories as free inventions of the human spirit (not logically derivable from what is empirically given); as positivist insofar as he considers his concepts and theories justified only to the extent to which they furnish a logical representation of relations among sensory experiences. He may even appear as Platonist or Pythagorean insofar as he considers the viewpoint of logical simplicity as an indispensable and effective tool of his research.*"

Hertz (1894) was also clear on the limits of subjective knowledge: "As a matter of fact, we do not know, nor have we any means of knowing, whether our conception of things is in conformity with them," except by how our subjective images correspond to our experience.

Nicholas of Cusa (1401-1464): *If the transcendental is accessible to us only through the medium of images and symbols, at least let the symbols be as distinct and unambiguous as mathematics will permit.* (*De docta ignorantia*) [Predating Galileo by 150 years: The laws of nature are written in the language of mathematics.]

Laws and measurements are communicable only by symbol systems

Planck, 1936: It is not therefore the case, as is sometimes stated, that the physical *world image* can or should contain only directly observable magnitudes. The contrary is the fact. The *world image* contains no observable magnitudes at all; *all that it contains is symbols.*

Weyl, 1949: However, the only decisive feature of all measurements is, it seems, *symbolic representation*; even numbers are in no way the only useable symbols**.**

Born, 1964: Symbols are the carriers of communication between individuals and thus decisive for the possibility of objective knowledge.

Misunderstanding of the "Copenhagen Interpretation"

Quoted from "Copenhagen interpretation of quantum mechanics" at

http://plato.stanford.edu/entries/qm-copenhagen/#MisCom

Second, many physicists and philosophers see the reduction of the wave function as an important part of the Copenhagen interpretation. But Bohr never talked about the collapse of the wave packet. Nor did it make sense for him to do so because this would mean that one must understand the wave function as referring to something physically real. Bohr spoke of the mathematical formalism of quantum mechanics, including the state vector or the wave function, as a symbolic representation.

Bohr's own words: "in each case [of measurement] *some ultimate measuring instruments, like the scales and clocks which determine the frame of space-time coordination on which, in the last resort, even the definitions of momentum and energy quantities rest, must always be described entirely on classical lines, and consequently kept outside the system subject to quantum mechanical treatment" (Bohr, 1939)*

What characterizes a frame of reference is that it has a well-defined position and a well-defined momentum, and treated classically measuring instruments act exactly as frames of reference. The implication is that Bohr did not exclude the application of quantum theory to any system. Every system can in principle be treated quantum mechanically, but since we always need a frame of reference to describe experimental outcomes, not all systems can be treated quantum mechanically at once.