The Journal of Cosmology

Journal of Cosmology, 2011, Vol, In Press.
JournalofCosmology.com, 2011

Consciousness and the Quantum

Don N. Page, Ph.D.
Theoretical Physics Institute
Department of Physics, University of Alberta,
Edmonton, Alberta, Canada

ABSTRACT

Sensible Quantum Mechanics or Mindless Sensationalism is a framework for relating consciousness to a quantum universe. It states that each conscious perception has a measure that is given by the expectation value of a corresponding quantum "awareness operator" in a fixed quantum state of the universe. The measures can be interpreted as frequency-type probabilities for a large set of perceptions that all actually exist with varying degrees of reality, so detailed theories within this framework are testable. The measures are not propensities for potentialities to be actualized, so there is nothing indeterministic in this framework, and no free will in the incompatibilistic sense. As conscious perceptions are determined by the awareness operators and the quantum state, they are epiphenomena. No fundamental relation is postulated between different perceptions (each being the entirety of a single conscious experience and thus not in direct contact with any other), so SQM or MS, a variant of Everett's "many-worlds" framework, is a "many-perceptions" framework but not a "many-minds" framework.

Keywords: Consciousness, quantum, universe, physics, perceptions, observations, cosmology, sensible quantum mechanics, mindless sensationalism, measure, probability, mathematics, reality, theories, simplicity, elegance, precision, time, awareness, experience, free will, epiphenomenon, epiphenomenalism

Consciousness and the Quantum

For hundreds of years, physicists have sought to find and understand at least one theory that will give a good description and explanation of our universe. It is typically preferred that such a theory have simple principles, an elegant form, and yet make precise statements. For these purposes, mathematical theories are often the ideal.

On the other hand, physics is usually regarded as necessarily resting upon observations (in contrast to, say, pure mathematics, which in principle can be divorced from experience, though in practice it too is usually based on observed patterns). However, observations themselves seem less simple, elegant, and precise than what physicists would often want for their theories. I am of the opinion that this is one of the causes for the tendency to regard the simple, elegant, and precise elements of theories of physics as more real than the apparently complex, sometimes ugly, and usually imprecise observations that we pay lip service to as the foundation of physics. Whatever we cannot understand in terms of the simple, elegant, precise elements of our mathematical theories, we tend to dismiss as less real.

In particular, I personally regard my own first-person subjective experience of consciousness as overwhelming evidence of its existence, but its apparent complexity, inelegance, and imprecision often seems to lead many physicists to dismiss it as less real than, say, elementary particles, spacetime, or quantum states. I am not at all decrying simplicity, elegance, and precision, which I do take to be extremely important, but I also do not wish to dismiss such a central feature of our experience as consciousness.

In fact, as a physicist, I take the observations that are considered to be the foundation of physics to be most simply and fundamentally conscious perceptions. This viewpoint raises the question of how consciousness is related to the structures that are more common in current theories of physics. In particular, the most fundamental structure of many of the current theories of physics is the quantum framework. Although we cannot be certain that our universe really is quantum, such a hypothesis helps explain so much of both our present theories and our observations that I shall take it as one of my central working hypotheses, along with the hypothesis of the existence of conscious perceptions.

In view of our desire to formulate the most simple, elegant, precise theories possible, I am not be content with leaving these two fundamental hypotheses unrelated but instead want to integrate them together. How might that be done?

Here I wish to describe and explore a framework I have developed for relating consciousness and the quantum, which I have called Sensible Quantum Mechanics (Page, 1995) or Mindless Sensationalism (Page, 2003). I should emphasize that this is so far just a framework, since the details to make it into a proper precise theory are not yet known. But even just the framework itself has various consequences that may be explored.

Because Sensible Quantum Mechanics builds upon quantum theory, I should first say what I regard that pillar to be. I regard the essence of quantum theory to be a C^*-algebra of quantum operators and a quantum state that gives expectation values to each operator.

I cannot go into precise details here, but let me give a crude dscription of these elements. Quantum operators are mathematical entities that may be adjointed, multiplied by complex numbers, added together, or multiplied together to give other operators. For example, if A and B are two operators and c is a complex number (so $c = a + ib$ with a and b real numbers and i the square root of -1), then the adjoints $A^\dagger$ and $B^\dagger$, cA, cB, $A+B$, AB, and BA are also quantum operators. (It is not assumed that $AB = BA$; the order of two operators that are multiplied together generally matters.) An operator A might represent the position of a particle, and B might represent its momentum, but for the general structure we do not need to assign specific meanings to the operators.

A quantum state may be regarded as a positive linear functional σ on the quantum operators, a rule for assigning a complex number to each quantum operator that is called its expectation value in that quantum state. For example, the expectation value of the operator A in the quantum state σ, denoted $\sigma[A]$, represents a particular complex number associated with that operator. This rule is required to have the form that $\sigma[cA] = c\sigma[A]$ for any operator A and complex number c, so the expectation value of the operator cA that is the complex number c multiplied by the operator A is simply c times the expectation value of A. The rule is also required to give $\sigma[A + B] = \sigma[A] + \sigma[B]$ and $\sigma[I] = 1$, where I is the identity operator such that $IA = AI = A$ for each quantum operator A, as well as to make $\sigma[A^\dagger A]$ a nonnegative real number.

Quantum theory is often regarded as having other basic elements, but I shall regard them as either being part of this basic formalism or as not really being a necessary part of quantum theory. For example, often one talks about the time evolution of a quantum state, but one can reformulate this into the Heisenberg picture in which the quantum state stays fixed and the operators change with time, and then one can re-interpret the time dependence of each operator as representing a whole family of operators, each labeled by a time parameter in addition to other labels of what the operators are. The dynamics of the operators in the usual approach would expressed in terms of the algebra of all the operators in all the families labeled by the time parameter and by the other labels. In this view, there would be nothing fundamentally special about time; it would just be one of many labels for the operators.

The other pillar of Sensible Quantum Mechanics is consciousness. I shall assume here that there is a countable discrete set M of all possible conscious experiences or perceptions p. By a "conscious experience," I mean all that one is consciously aware of or consciously experiencing at once. Lockwood (2003) has called this a "phenomenal perspective" or "maximal experience" or "conscious state." It could also be expressed as a total "raw feel" that one has at once.

Because I regard the basic conscious entities to be the conscious experiences themselves, which might crudely be called sensations if one does not restrict the meaning of this word to be the conscious responses only to external stimuli, and because I doubt that these conscious experiences are arranged in any strictly defined sequences that one might define to be minds if they did exist, my framework has sensations without minds and hence may be labeled Mindless Sensationalism (Page, 2003). In this way the framework of Mindless Sensationalism proposed here is a particular manifestation of Hume's ideas (Hume, 1988), that "what we call a *mind*, is nothing but a heap or collection of different perceptions, united together by certain relations, and suppos'd, tho' falsely, to be endow'd with a perfect simplicity and identity" (p. 207), and that the self is "nothing but a bundle or collection of different perceptions" (p. 252). As he explains in the Appendix (p. 634), "When I turn my reflexion on *myself*, I never can perceive this *self* without some one or more perceptions; nor can I ever perceive any thing but the perceptions. 'Tis the composition of these, therefore, which forms the self." (Here I should note that what Hume calls a perception may be only one *component* of the "phenomenal perspective" or "maximal experience" (Lockwood, 1989) that I have been calling a perception or conscious experience p, so one of my p's can include "one or more perceptions" in Hume's sense.)

I should also emphasize that by a conscious experience, I mean the phenomenal, first-person, "internal" subjective experience, and not the unconscious "external" physical processes in the brain that accompany these subjective phenomena. In his first chapter, Chalmers (1996) gives an excellent discussion of the distinction between the former, which he calls the phenomenal concept of mind, and the latter, which he calls the psychological concept of mind. In his language, what I mean by a conscious experience (and by other approximate synonyms that I might use, such as perception or sensation or awareness) is the phenomenal concept, and not the psychological one.

The next idea is that not all possible conscious perceptions p occur equally, but that there is a normalized measure $w(p)$ associated with each one (a nonnegative real number which sums to unity when one adds up the values for all the p's in the full set M). This measure in some sense gives the level or degree of reality that the conscious perception p has. Perceptions with large measures have high degrees of reality, whereas perceptions with very low measures have tiny degrees of reality and effectively can be ignored. One can also say that the weight $w(p)$ is analogous to the probability for the conscious experience p, but it is not to be interpreted as the probability for the bare *existence* of p, since any conscious experience p exists (is actually experienced) if its weight is positive, $w(p) > 0$. Rather, $w(p)$ is to be interpreted as being proportional to the probability of *getting* this particular experience if a random selection were made.

Because the specification of the conscious experience p completely determines its content and how it is experienced (how it feels), the weight $w(p)$ has absolutely no effect on that—there is absolutely no way within the experience to sense anything directly of what the weight is. A toothache within a particular conscious experience p is precisely as painful an experience no matter what $w(p)$ is. It is just that an experience with a greater $w(p)$ has a greater degree of existence and is more likely in the sense of being more probably chosen by a random selection using the weights $w(p)$.

Finally, Sensible Quantum Mechanics assumes the connection between consciousness and the quantum in the form that for each conscious perception p, there is an associated quantum "awareness operator" $A(p)$, and that the measure for the conscious perception p is the expectation value, in the quantum state of the universe, of the corresponding experience operator, $w(p) = \sigma[E(p)]$.

One can summarize this by saying that Sensible Quantum Mechanics or Mindless Sensationalism is given by the following three basic postulates or axioms (Page, 1995, 2003):

Quantum World Axiom: The "quantum world" Q is completely described by an appropriate C^*-algebra of operators O and by a suitable state σ (a positive linear functional of the operators) giving the expectation value $\sigma[O]$ of each operator O.

Conscious World Axiom: The "conscious world" M, the countable discrete set of all conscious experiences or perceptions p, has a fundamental normalized measure $w(p)$ for each perception p.

Psycho-Physical Parallelism Axiom: The measure $w(p)$ for each conscious experience p is given by the expectation value of a corresponding quantum "awareness operator" $A(p)$ in the state σ of the quantum world, $w(p) = \sigma[A(p)]$.

One might note that in comparison with the more general assumptions of (Page, 1995, 2003), here for simplicity I am making the more restrictive hypothesis that the set M of all conscious perceptions p is a countable discrete set. I am also assuming that the measure is normalized, $\sum_p w(p) = 1$.

The Psycho-Physical Parallelism Axiom is the simplest way I know to connect the quantum world with the conscious world. One could easily imagine more complicated connections, such as having $w(p)$ be a nonlinear function of the expectation values, say $m(p)$, of a positive "experience operator" $E(p)$ depending in the p (Page, 1995, 2003). Instead, my Psycho-Physical Parallelism Axiom restricts the function to be linear in the expectation values. In short, I am proposing that the psycho-physical parallelism is *linear*.

Of course, the Psycho-Physical Parallelism Axiom, like the Quantum World Axiom, is here also deliberately vague as to the form of the awareness operators $A(p)$, because I do not have a detailed theory of consciousness, but only a framework for fitting it with quantum theory. My suggestion is that a theory of consciousness that is not inconsistent with bare quantum theory should be formulated within this framework. I am also suspicious of any present detailed theory that purports to say precisely under what conditions in the quantum world consciousness occurs, since it seems that we simply don't know yet. I feel that present detailed theories may be analogous to the cargo cults of the South Pacific after World War II, in which an incorrect theory was adopted, that aircraft with goods would land simply if airfields and towers were built.

Since all conscious perceptions p with $w(p) > 0$ really occur in the framework of Sensible Quantum Mechanics or Mindless Sensationalism, it is completely deterministic if the quantum state and the awareness operators $A(p)$ are determined: there are no random or truly probabilistic elements in SQM or MS. Neither is there any free will in the incompatibilist sense, and consciousness may be viewed as an epiphenomenon (Page, 1995, 2003). Nevertheless, because the framework has normalized measures $w(p)$ for conscious perceptions, these can be interpreted as probabilities for the perceptions, given the theory. In particular, one can interpret the measure $w_i(p_j)$ that a theory T_i assigns to one's particular perception p_j as the likelihood of the theory. Then if one assigns different SQM or MS theories prior probabilities $P(T_i)$, one can use Bayes' theorem to calculate the posterior probability of the theory, given the observation or conscious perception p_j, as $P(T_i|p_j) = P(T_i)w_i(p_j)/\sum_k P(T_k)w_k(p_j)$. In this way different SQM or MS theories are testable.

A major problem at the frontier of theoretical cosmology is essentially to develop one or more theories that give the measures $w(p)$ for conscious perceptions, except that most theorists are hesitant to focus on conscious perceptions and hence ask for the probability of an observation O_j given a theory T_i, $P(O_j|T_i)$. It is usually left rather vague what is supposed to constitute an observation. For me the most fundamental entities that can be identified with observations are conscious perceptions, so

I would take $P(O_j|T_i)$ to be $w_i(p_j)$, the normalized measure that theory T_i assigns to the conscious perception p_j. In Sensible Quantum Mechanics, a theory T_i would assign an awareness operator $A_j = A(p_j)$ to each conscious perception and give a quantum state σ_i so that $P(O_j|T_i) = w_i(p_j) = \sigma_i[A_j]$, the expectation value of the awareness operator in the quantum state. (Here, for compactness, I do not explicitly display the dependence of the A_j operators on the theory T_i, but different theories can differ not only in their quantum states but also in their awareness operators.)

For theorists hesitant to identify observations with conscious perceptions, they may still wish to say that the probability of an observation O_j given a theory T_i is $P(O_j|T_i) = \sigma_i[A_j]$. In this generalized view, A_j is simply the operator in the theory T_i whose expectation value in the quantum state given by that theory gives the probability of the observation O_j.

Quantum theories of this generalized form (whether or not an observation is taken to be a conscious perception) can be considered to have three parts: (1) the algebra of the full set of quantum operators, (2) the quantum state σ_i, and (3) the particular operators A_j for each observation (or for each conscious perception in Sensible Quantum Mechanics or Mindless Sensationalism). Part (1) includes the dynamical laws of physics, which historically have often been naïvely called a 'Theory of Everything' or TOE, though it certainly is not. Part (2) includes the boundary conditions that specify which solution of the dynamical laws describes our actual universe, but even Part (1) augmented with Part (2) is not sufficient. Part (3) includes the rules for extracting the probabilities of observations from the quantum state.

The logical independence of Part (3) is becoming widely recognized with the *measure problem* of cosmology (Linde, 1986; Garcia-Bellido et al., 1994; Vilenkin, 1995a,b; Guth, 2000; Tegmark 2005; Aguirre, 2007; De Simone et al., 2008; Linde & Noorbala, 2010; Bousso et al., 2010). If a universe had a definite number N_j of occurrences (each occurrence with the same degree of reality) of each kind of observation O_j, and a finite total number of occurrences $N = \sum_k N_k$, it would be natural to say that the probability of the observation O_j is the fraction of the number of its occurrences, $P(O_j) = N_j/N$. However, theories of eternal inflation (Linde, 1986; Garcia-Bellido et al., 1994; Vilenkin, 1995a,b; Guth, 2000; Tegmark 2005; Aguirre, 2007; De Simone et al., 2008; Linde & Noorbala, 2010; Bousso et al., 2010) suggest that the universe may have expanded to become infinitely large, in which case most of the numbers N_j of occurrences are infinite, and the ratio N_j/N is ambiguous. Therefore, a lot of work has gone into different proposed schemes for regularizing the infinities.

I have pointed out that even in finite universes, quantum uncertainties in the numbers of occurrences also leads to ambiguities in the probabilities of observations (Page, 2008, 2009a,b,c, 2010). In particular, I have shown that Born's rule does not work in the sense that the operators A_j cannot be projection operators, so that one must choose other operators, and the ambiguity of that choice is the measure problem. The ambiguity occurs even for finite universes, but it is particularly severe for infinite universes. So whether or not the operators A_j whose expectation values give the the probabilities of observations are interpreted to be awareness operators in Sensible Quantum Mechanics or Mindless Sensationalism (in which the observations are conscious perceptions), it is now recognized that there is the challenge of finding these operators, in addition to the challenge of finding the dynamics or algebra of all operators and the quantum state.

In conclusion, I am proposing that Sensible Quantum Mechanics or Mindless Sensationalism is the best framework we have for understanding the connection between consciousness and the quantum universe. Of course, the framework would only become a complete theory once one had the set of all conscious experiences, the awareness operators, and the quantum state of the universe.

This research was supported in part by the Natural Sciences and Engineering Research Council of Canada.

Bibliography

Aguirre, A. (2007) On making predictions in a multiverse: Conundrums, dangers, and coincidences. In: Carr, B. J. (Ed.), Universe or Multiverse?, Cambridge University Press, Cambridge, UK, pp. 367-386 [arXiv:astro-ph/0506519] <http://arxiv.org/abs/astro-ph/0506519>.

Bousso, R.,Freivogel, B.,Leichenauer, S., Rosenhaus, V. (2010). Geometric origin of coincidences and hierarchies in the landscape. arXiv:1012.2869 [hep-th] <http://arxiv.org/abs/arXiv:1012.2869>.

Chalmers, D. J. (1996). The Conscious Mind: In Search of a Fundamental Theory. Oxford University Press, New York, USA.

Garcia-Bellido, J., Linde, A. D., Linde, D. A. (1994). Fluctuations of the gravitational constant in the inflationary Brans-Dicke cosmology. Physical Review D, 50, 730-750 [arXiv:astro-ph/9312039] <http://arxiv.org/abs/astro-ph/9312039>.

Guth, A. H. (2000). Inflation and eternal inflation. Physics Reports, 333, 555-574 (2000) [arXiv:astro-ph/0002156] <http://arxiv.org/abs/astro-ph/0002156>.

Hume, D. (1988). A Treatise of Human Nature. Clarendon Press, Oxford, UK.

Linde, A. D. (1986). Eternally existing self-reproducing chaotic inflationary universe. Physics Letters B, 175, 395-400.

Linde, A., Noorbala, M. (2010). Measure problem for eternal and non-eternal inflation. Journal of Cosmology and Astroparticle Physics, 1009, 008 [arXiv:1006.2170 [hep-th]] <http://arxiv.org/abs/arXiv:1006.2170>.

Lockwood, M. (1989). Mind, Brain and the Quantum: The Compound 'I.' Basil Blackwell Press, Oxford, UK.

Lockwood, M. (2003) Consciousness and the quantum world: Putting qualia on the map. In Smith, Q., Jokic, A.(Eds.), Consciousness: New Philosophical Perspectives, Oxford University Press, Oxford, pp. 447-467.

Page, D. N. (1995). Sensible quantum mechanics: Are only perceptions probabilistic? arXiv:quant-ph/9506010 <http://arxiv.org/abs/quant-ph/9506010>.

Page, D. N. (2003) Mindless sensationalism: A quantum framework for consciousness. In Smith, Q., Jokic, A.(Eds.), Consciousness: New Philosophical Perspectives, Oxford University Press, Oxford, pp. 468-506 [arXiv:quant-ph/0108039] <http://arxiv.org/abs/quant-ph/0108039>.

Page, D. N. (2008). Cosmological measures without volume weighting. Journal of Cosmology and Astroparticle Physics, 0810, 025 [arXiv:0808.0351 [hep-th]] <http://arxiv.org/abs/arXiv:0808.0351>.

Page, D. N. (2009a). Insufficiency of the quantum state for deducing observational probabilities. Physics Letters B, 678, 41-44 [arXiv:0808.0722 [hep-th]] <http://arxiv.org/abs/arXiv:0808.0722>.

Page, D. N. (2009b). The Born rule fails in cosmology. Journal of Cosmology and Astroparticle Physics, 0907, 008 [arXiv:0903.4888 [hep-th]] <http://arxiv.org/abs/arXiv:0903.4888>.

Page, D. N. (2009c). Born again. arXiv:0907.4152 [hep-th] <http://arxiv.org/abs/arXiv:0907.4152>.

Page, D. N. (2010). Born's rule is insufficient in a large universe. arXiv:1003.2419 [hep-th] <http://arxiv.org/abs/arXiv:1003.2419>.

De Simone, A., Guth, A. H.,Salem, M. P., Vilenkin, A. (2008). Predicting the cosmological constant with the scale-factor cutoff measure. Physical Review D, 78, 063520 [arXiv:0805.2173 [hep-th]] <http://arxiv.org/abs/arXiv:0805.2173>.

Tegmark, M. (2005). What does inflation really predict? Journal of Cosmology and Astroparticle Physics, 0504, 001 [arXiv:astro-ph/0410281] <http://arxiv.org/abs/astro-ph/0410281>.

Vilenkin, A. (1995a). Predictions from quantum cosmology. Physical Review Letters, 74, 846-849 [arXiv:gr-qc/9406010] <http://arxiv.org/abs/gr-qc/9406010>.

Vilenkin, A. (1995b). Making predictions in eternally inflating universe. Physical Review D, 52, 3365-3374 [arXiv:gr-qc/9505031] <http://arxiv.org/abs/gr-qc/9505031>.