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Quantum and Consciousness

A Cognitive Subsystems Perspective

Abstract: *A survey is presented of possible connections between quantum theory and consciousness that have been proposed in the past and those that have now opened as a result of work on cognitive subsystems of the brain in the past 10 years. It is argued that, in the light of such work and in contrast to speculations prior to it, these connections can now be seen as necessary and their investigation as feasible.*

1. The Pieces of the Jigsaw Puzzle

1.1. Introduction

The battles between heterophenomenologists and hard-problem-solvers may have subsided into occasional skirmishes, the combatants retreating to their fiefdoms each claiming victory… but could there still be a coherent and complete articulation of the many claims about the relevance of quantum theory to consciousness? I will argue for a positive answer, within the context of conventional quantum theory and a concept of consciousness that is neither epiphenomenal nor entirely derivative from mechanism.

This is achieved by introducing three less well-known actors into the drama, namely Teasdale, Barnard (Teasdale and Barnard, 1993), and McGilchrist (2009). The first two provide evidence from cognitive psychology that mental functioning is best modelled in terms of many 'interacting cognitive subsystems' of the mind. A good correspondence with the data is obtained by about nine such systems (including systems dealing with particular senses), and the overall meaning-making is covered by two coupled main subsystems rather

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than by a single boss-system. Meanwhile McGilchrist, working independently, greatly deepens our ideas about the different emphases of the two cerebral hemispheres by using an historical-cultural analysis. Through this he reaches a similar conclusion to Teasdale and Barnard, with the cerebral hemispheres roughly associated with their main subsystems. Following Teasdale and Barnard, I will call these two main subsystems the *propositional* (dealing with rational verbally-based reasoning) and the *implicational* (dealing with sensed occurrences that impinge, positively or negatively, on our own essential being).

An important part of my argument will be the idea, associated with Kant, that our knowledge of the world and of ourselves is a precise reflection of the nature of our capacity for knowing. This can be treated negatively, as the vacuous truism that when it comes to things lying outside our capacity to know we cannot know anything about them — indeed, in such a case we do not even know what it is that we do not know. Here I will instead be using Kant's approach positively, as a reminder that we may be in danger of needlessly cutting off a part of the world from our understanding if we ignore part of our capacity for knowing. In particular, we must explicitly bring into our analysis the distinctive and untranslatable contribution of our implicational knowing. I shall refer generally to the different modes of cognition described by these authors as 'ways of knowing' (Clarke, 2005).

The idea of cognitive subsystems helps us to specify particular meanings for both 'consciousness' and 'quantum theory'. 'Consciousness', in the meaning which I use here, denotes the underlying ground of all our internal and external senses, as this is understood primarily through our implicational subsystem (I will define it in more detail later). 'Quantum theory' is accepted by almost all physicists as the underlying theoretical ground of physics. Its ideas are largely understood through our propositional systems, while having resonances in the implicational.

1.2. Trans-systemic aspects

Perhaps the most important finding of brain imaging is the fact that practically all cognitive operations involve many separated regions of the brain and both hemispheres. When it comes to cognition, the brain does not have separate regions for separate functions, and so it is unlikely that we can model cognition exactly in terms of discrete systems. With this caveat, it turns out that Teasdale and Barnard's model of §1.1 does work well. In particular, consciousness can only be understood through both systems in interaction. In this we have to consider not only how each subsystem understands consciousness, but also how the propositional thinks that the implicational is understanding it, and vice versa. This is continuously an issue in everyday life. To give examples: I may be proceeding with a constructive rational analysis (propositional) of, for instance, the news that I have contracted a serious illness, only to be assaulted in midstream by a violent panic initiated by my implicational subsystem reinterpreting information from the propositional subsystem. Conversely, a buried childhood memory may trigger a feeling of nausea when I enter a particular landscape, which I then find myself rationalizing through my propositional system reinterpreting the implicational by propounding a far-fetched theory about the accumulation of radon from nearby granite rocks. This reciprocal reinterpretation is a persistent confusing factor in discussing consciousness and quantum theory.

I will argue that the propositional way of knowing can develop an almost complete account of the quantum phenomena that form the foundation of the physical world, but it can only be completed through the importation of structures from the implicational way of knowing. From the propositional viewpoint this importation appears to the propositional as awkward and *ad hoc*. Its justification is to be found in the implicational. Conversely there is a great deal of embarrassing (for me) material assigning, for example, god-like properties to quantum fields, which arises from how the propositional appears to the implicational way of knowing (Clarke and King, 2006).

1.3. The meaning of 'consciousness' in this article

Producing a definition of 'consciousness' is only meaningful within a specified context; thus Dennett's (1991) definition, for example, has little in common with mine. My context in which I discuss consciousness here is not only homophenomenological — consciousness is private to each experiencer — but it is also firmly linked to implicational knowing. Within these constraints, 'consciousness' denotes the phenomenon of 'what it is like to be me' as discussed by Nagel (1974), including the subjective processes or states underlying this.

Many of the following attributes will be elaborated later; but I give them here in order to give a clearer feel for this usage. Consciousness is distinct from self-consciousness, either in the latter's sense of a conception that I have of myself that guides my thoughts and actions, or in the sense of a self-image that enables me, for instance, to cognitively grasp the difference between the 'me' in a mirror and the 'you' beside me. Consciousness is open-ended, and not dependent on any particular content, so that it makes sense to talk about the consciousness of very small organisms (at least hypothetically).

As noted in §1.1 above, human consciousness is particularly linked with the implicational subsystem, but since this subsystem evolved well after the emergence of primates that we would naturally regard as conscious in the sense used here (Barnard *et al.*, 2007), consciousness is certainly not confined to this subsystem. Rather, in human beings it is this subsystem that gives to our particular consciousness its distinctive flavour.

While this is not a necessary consequence of the above definition, this consciousness in my sense *does* something. That is, it is not an epiphenomenon. In principle, what it does could cover the whole of Descartes' list of 'doubts, understands, conceives, affirms, denies, wills, refuses,… imagines… and perceives' (Descartes, 1641/1901). We could, for example, include the operation of 'willing' from Descartes' catalogue. It is widely thought that this is ruled out on the basis of experiments conducted by Libet and others, but later work has made it clear that this is not the case (Clarke, 2013, p. 171, note 7).

Perhaps the most basic 'doing' by consciousness is the *conatus* (literally 'effort' or 'endeavour') which Spinoza was to introduce, writing:

> Everything, in so far as it is in itself, endeavours to persist in its own being… The endeavour ('conatus'), wherewith everything endeavours to persist in its own being, is nothing else but the actual essence of the thing in question. (Spinoza, 1677)

A similar property that might also be a candidate is the *appetition* of Leibniz (1698/1898, #15), defined as 'The activity of the internal principle which produces change or passage from one perception to another'.

I take the core of what consciousness does to be a combination of *conatus*, the dynamic striving for one's own existence amid a changing environment, and appetition, the maintenance of a dynamic flow within perception. This core is at the same time the most basic form of that which, from a propositional perspective, we would call 'life'. One could regard it as the essential nature of implicationally known consciousness. Its more elaborate manifestations, as we find in our own consciousness, are then the result of a progressive evolutionary development of all the cognitive subsystems. The core of *conatus*/appetition is reached through a paring down of consciousness as we experience it, to the point where we can see how the elementary foundations of consciousness can complete the foundational level of quantum theory.

2. Incorporating Quantum Theory

2.1. The forest of interpretations

We can now begin to complete this three-piece jigsaw puzzle by bringing in quantum theory. First we should note the many versions of the theory that complicate the discussion from the start, some involving different mathematical methods, others using different interpretations of the mathematical method (or both). Some of these relate to the technical formalism used, which became diversified to suit different sorts of problem. The following is a shortlist of some of the variations on the basic structure (as opposed to largely notational variations) that we need to be aware of here.

(a) The Copenhagen interpretation:
Developed by Bohr and Heisenberg around 1927; remains the 'standard' interpretation , unrivalled until 1957 and still the starting point for teaching the theory.
- It is based on a quantum state (sometimes called 'wave function') which undergoes periods of continuous change governed by the Hamiltonian (a mathematical operator) interspersed by discontinuous 'jumps' (alternatively called 'collapses') produced by 'observation'.

(b) The variant of the above with observation linked to consciousness (London and Bauer, 1939/1982).
This is the basic idea linking quantum theory and consciousness.

(c) The many worlds interpretation:
Proposed by Everett (1957) and refined by Hemmo and Pitowsky (2007); essentially the same as (a) above, except that, instead of the state collapsing every so often, the entire universe at these moments splits into many separate branches, each carrying a different quantum state.
- Mathematically, the original state is expressed as a sum of these many states, and then each of these components produces a separate universe.
- Since (a) and (c) are indistinguishable to anyone inside the universe (as we are) rather than situated outside the universe, and since neither of these interpretations offer any

mechanism for the collapse/splitting, I will regard (a) and (c) as essentially equivalent.

(d) Consistent histories:
Developed by Griffiths (1984) and Dowker and Kent (1996); replaces discontinuities in the dynamics at the moment of observations by a continuous evolution of a state that determines the probability of a *sequence* of observations.
- While elegant, it shirks the question of what an 'observation' is, and why an observation does not simply participate in the evolution of the state.

(e) Statistical decoherence:
Basic idea from H. Dieter Zeh (1970); developed by a succession of co-workers (Joos *et al.*, 2003).
- This is generally regarded as the completion of quantum theory and the nail in the coffin of the idea of consciousness as an agent.

(f) Sensation and consciousness:
Main contributions from Donald (1990) and Page (2001).
- These are the first serious attempts to pin down what might be meant by 'consciousness' in quantum observation. Page's version is akin to a reduction of a history (d) to a single moment of sensation.

(g) Modern consciousness-based theories:
- Stapp, in particular, has carefully examined the biological basis for the interaction of consciousness with quantum theory (Schwarz *et al.*, 2005).

(h) Non-algorithmic collapse:
- The logical and physical side of this was developed in a series of books by Penrose (1989 *et seq.*) with the biological aspect completed in Hameroff and Penrose (1996): an important body of work which introduces a strong argument for collapse with implications for quantum gravity.

These all have their adherents, but here I shall focus on London and Bauer (b) and Zeh (e). Apart from their chronological gap, these two bodies of work can be thought of as face-to-face contenders in a debate that could determine the validity of a link between quantum theory and consciousness.

2.2. Questioning the completeness of quantum theory

The book title *Decoherence and the Appearance of a Classical World in Quantum Theory* (Joos *et al.*, 2003) succinctly describes the culmination of work started by Zeh. When considering large-scale phenomena, classical physics — the physics of the whole world in Newton's conception — is claimed to emerge automatically, as a very good approximation, from the quantum theoretical description of the world. Quantum theory is thus complete, in the sense that it explains not only microscopic events, but the whole of 'classical' physics as well.

The argument that quantum theory can deliver, where appropriate, the Newtonian world hinges on the distinction between a *superposition* (which is distinctively quantum mechanical) and a *mixture* (which involves classical probabilities). The basis of the formalism of quantum theory is the idea that a system can be described in terms of its 'state' and that states can be combined by using complex numbers. To set this out explicitly, using the notation of Dirac (1939): if $|a\rangle$ and $|b\rangle$ denote physically realizable states, then for any two complex numbers α and β there is a state symbolized by the expression $\alpha|a\rangle + \beta|b\rangle$. The numbers α and β give rise to probabilities for observing the states $|a\rangle$ and $|b\rangle$, but they have a further role in determining the way states can combine by superposition, which is fundamentally different from the way in which probabilities can be combined. For example, the states $\alpha|a\rangle + \beta|b\rangle$ and $\alpha|a\rangle - \beta|b\rangle$ when added will cancel out and eliminate the component $|b\rangle$, something which cannot happen with probabilities. States where this sort of cancellation can happen are called 'coherent' by analogy with light beams which can cancel each other out if their phases are exactly opposite. Coherence depends on the relative 'phases' of the amplitudes multiplying the states. Processes that destroy these phase-related properties are termed 'decoherence'.

The key part of the claim for the emergence of the classical world rests on the way in which the phases of the components in a quantum superposition, as a result of their natural kinetic motion, continuously rotate through the 360° of a complex number at a rate that increases dramatically if the effective energy of the system involved increases — for example, through its being coupled with large systems of recording apparatus. Whereas the frequency of the quantum mechanical phase changes of an electron in a hydrogen atom are in the order of 10^{15} per second, that associated with a physical 'pointer', such as a 1g. particle executing small movements over a timescale of seconds, is of the order of 10^{23} per second. A complex number whose phase rotates at this speed is indistinguishable from zero. A similar argument can be made to show that perturbations of the apparatus from the general environment (such as changes in temperature or small magnetic fields) in the same way also reduce a coherent quantum superposition to a probability mixture. As a result the state of a quantum superposition in any system that is not kept carefully isolated will be converted into a classical probability mixture — a familiar ingredient in classical physics based on Newton's laws. The classical world has emerged.

Or has it? It is indeed the case that decoherence moves a quantum theoretic physical process into the familiar classical ground of probability theory, but there is a crucial difference in context between the quantum and classical cases. The classical theory of probability is underpinned by Newtonian physics and probabilities are a result of lack of information about a situation which in reality is determinate. In the quantum case, however, where the acceleration of a quantum phase reaches a speed where it is undetectable, making the quantum state like a probability distribution, the basic indeterminism of quantum theory remains unchanged. In classical physics we calculate probabilities for processes that are determined but not open to exact prediction. In quantum physics we calculate probabilities for processes that by their nature are always indeterminate. The classical world has not 'appeared' as a result of physical laws, but as a piece of logical sleight of hand. We have no theory that actually explains how it is that a quantum process turns itself into a definite classical (and perceivable) situation.

The confusion around this issue is illustrated in the different ways in which it is handled by supporters of a quantum–consciousness link. The founders of the idea, London and Bauer, are, however, clear that

> [the observer] has with himself relations of a very special character. He possesses a characteristic and quite familiar faculty which we can call the 'faculty of introspection.' He can keep track from moment to moment of his own state. (London and Bauer, 1939/1982, p. 39; see (b) in §2.1 above)

On the other hand, Stapp (2007), who pioneered the subsequent study of quantum-consciousness, simply assumes that whatever it is that allows us in classical physics to pass from a probability to an underlying definite reality still holds in a quantum mechanical universe. He quotes in support a rather vague description attributed to Dirac by Bohr (1958, p. 51) that when it comes to passing from a statistical distribution to an underlying actual instance 'we [are] concerned with a choice on the part of "nature"'. It is in fact clear that, while decoherence is a vital part of the story, it is not the whole novel. There is an explanatory gap between a mixture and a definite outcome, and if consciousness is to fill that gap there remains more work to be done in order to understand its *modus operandi*.

2.3. Possible roles for consciousness

At the rational level of repeatable scientifically observed phenomena, decoherence seems to deliver all that is required: namely, an explanation of what happens in certain experiments, including statistical data thereon, and an account in general terms of how the world in the form in which we find it is constituted as a result of these data. And yet there is a problem: the statistical data refer to the frequency of outcomes in collections of particular individual experiments, and yet the theory says nothing about individual outcomes. Its calculations start with a quantum state and then finish with a quantum state, which might be a close approximation to a statistical ensemble, thus lending itself to an interpretation involving statistics. What is missing, what I require when I go beyond the statistics of experiments, is the fact of me, here, now, experiencing a particular instance of the events to which the statistics relate. The situation is ambiguous: on the one hand I feel the need to complete the story by finding a process that delivers particular instances and not just statistics, but on the other hand the idea of my individual presence causing a sort of crystallization of the state into an event, without any additional physical intervention, seems even more unacceptable.

A lifeline is thrown in London and Bauer's paper (1939/1982, p. 218) when Langevin in a preface proposes that:

> The wave function used to describe the object no longer depends solely on the object, as was the case in the classical representation, but, above all, states what the observer knows… For a given object, this function, consequently, is modified in accordance with the information possessed by the observer.

But, in the first place, if the 'wave function' is only modified *after* an observer has obtained a definite outcome, it cannot itself cause that outcome (at any rate, not in the physics of 1939). And the possibility of pure 'information' modifying the wave function with no specific physical substrate is just as baffling as is its modification by consciousness. We need to consider consciousness, or something like it, seriously, and we could do worse than examine London and Bauer's own formulation:

> It is precisely this increase of knowledge, acquired by observation, that gives the observer the right to choose among the different components

> of the mixture predicted by the theory… We note the essential role played by the consciousness [conscience] of the observer in this transition from the mixture to the pure case. (*Ibid.*, p. 251)

For London and Bauer consciousness exercised an active choice — it was about a consciousness that does something, not merely the presence of a passive spectator. This idea replaces Dirac's 'choice on the part of nature' (§2.2) by a choice on the part of the conscious observer.

The idea would also fit with those interpretations of quantum theory that are already connected, implicitly or explicitly, with conscious choice, such as consistent histories (§2.1 (d)) or the work of Page, Donald, and others (§2.1 (f)). For these, quantum theory could have two parts, one concerning the dynamics and evolution of the state as determined by the Hamiltonian, and another the selection of a particular component of a state that was reduced to a statistical ensemble. While the histories interpretation can make the link with statistics by considering the probabilities attached to sequences of observation, Page's approach focuses interestingly on a single sensation, in isolation from its past or future, on the grounds that the only experiential connection that we have with past events is produced by our memory, and memory is itself simply a part of the total experience happening *now*.

These approaches seem, however, to be *dei ex machinis*, brought in for no other reason than to fix a theory that does not quite work. The aim of introducing consciousness has to involve justifying a role for consciousness in its own right.

3. Quantum Consciousness

3.1. The seat of consciousness

We can now address likely scenarios for the operation of consciousness while bearing in mind the issue raised in §1.2: that a full understanding of consciousness particularly involves the implicational way of knowing. It is not reducible to an added physical phenomenon, which would be provably false because it would interfere with existing theory, because it operates in a different manner. In particular, its logic must be a contextual logic or an inconsistent logic such as that of Matte Blanco (Clarke, 2013, pp. 97 and 83ff).

For this to be credible, that action of consciousness as discerned in our implicational knowing must not only be concordant with our lived experience, but in addition it must link appropriately with our propositional knowing. This means that what our propositional *thinks* that the implicational is doing (§1.2) needs to fit with what the implicational is itself discerning. To examine this propositional view of the implicational we need to formulate a *model* of consciousness — as in a model of the economy or of an industrial process — that reflects the salient points of this implicational-to-propositional transaction in abstract form.

The obvious model is one in which consciousness simply *chooses* one of the possible outcomes from a decohered state and thereby 'collapses the wave function' to a single outcome, essentially as described by London and Bauer. This, however, would imply that we could get what we wanted just by wishing it. More precisely, it is at odds with parapsychology experiments in psychokinesis (Helfrich, 2007) which provide evidence that, although there appears to be a *significant* effect, the effect *size* (the ratio between the mean effect over many trials and the standard deviation of a single trial) 'is minute'. 'Choice' in this sense seems to be ruled out if it is referring to the outcome of external events.

Two ways ahead then present themselves. First, we could examine more closely the basis of consciousness in *conatus*/appetition (§1.3). From this point of view, consciousness does not 'choose' a particular item which is specified by mechanical processes in the brain (and which therefore fall under the remit of conventional physics): rather, consciousness witnesses the productions of our action and our passion, and so shapes the direction of attention within the organism. The second alternative is to suppose that the narrowing-down to a single outcome happens not within the most prominent consciousness in the organism, but further down in smaller systems (even at the cellular level) within a hierarchical model of consciousness indicated below.

From either viewpoint, consciousness does something (it is not an epiphenomenon), but because it operates as a quantum measurement its action can be complementary to the mechanical laws that govern the large-scale actions of the brain and body, not a subversion of them. Consciousness is thus ideally placed to fill the incompleteness that we have noted within quantum theory itself.

To complete the picture we need to know what physical things can be conscious. Loosely speaking we say that human beings are conscious; but we would qualify this by suggesting that what matters is the brain, perhaps some particular part of it. On the other hand, without the attached body and its action in the world the brain would have little meaning. So we would be looking for a physical system in a particular context, endowed with a feeling of selfhood that incorporated this context. This would be what was called the 'seat of consciousness' (for Descartes, the pineal gland, for example) as distinct from the organism as a whole. So we need to ask what system would qualify for this: what systems, and what sizes or complexities of systems, can support these combined quantum and experiential conditions.

Implicationally, the scope of 'me' is highly flexible. As my awareness merges in connectivity with the wider universe its scope becomes vast and unfocused. It might comprise all that I feel at one with in a particular moment — whether a bee dipping for honey or a rare glimpse of the Andromeda nebula on a very dark night. But propositionally, if consciousness is to operate quantum mechanically there must be a component of its quantum state that is not itself subject to decoherence. On the usual method for analysing decoherence the size of such a system has to be very small — at most of the size of a single cell, with many estimates drawing the line at organelles within cells.

One possible way through this apparent contradiction of sizes for the seat of consciousness is the notion that consciousness is hierarchical: that the consciousness of one system and that of its subsystems might be interdependent. If we reflect on what is happening 'downwards' from our broad consciousness, focusing on a perception of the other 'voices' of which the main consciousness is comprised, then we realize — as convincingly argued by Lockwood (1989) — that our own 'I' is, in Lockwood's phrase, a 'compound I'. Moving, on the other hand, in the upward direction of the hierarchy towards a larger consciousness encompassing one's own, we can find that not only does the content of consciousness expand, but that there is only one consciousness embracing individuals. As expressed in Tibetan Buddhism, 'There is only one *rigpa*, one origin, one basis. It is the true nature of our mind' (Dzogchen Ponlop, 2003, p. 81).

From the very different propositional perspective, the quantum coherence of a system is significantly extended in scale if the information contained in it is held in the differences between the states of neighbouring smaller elements (such as organelles in cells) and if, in addition, consciousness acts to maintain, as far as possible, those differences at the quantum level. In this way the seat of consciousness can maintain its overall coherence by drawing on the coherence of adjacent parts of itself. (See Clarke, 2013, pp. 137ff: the viability of this mechanism now seems more robust than indicated in the appraisal there.)

3.2. Panpsychism

The proposals of §3.1, of which many are tentative, suggest that consciousness can be associated with a wide range of systems: the approach is panpsychic, in the sense that 'everything' is conscious, but with a restricted quantum mechanical definition of a 'thing' on the propositional side. This is reminiscent of Döring and Isham'a paper (2011) 'What is a Thing?' (which is diametrically opposed to the implicationally oriented book of this name by Heidegger, 1967). The world is panpsychic in the sense of Matthews (2003). Rather than discrete things that are the object of analysis, one sees the world as a tapestry of interconnecting and merging beings in fluid relationships with each other, and oneself as a part of this flow. In so far as this viewpoint has a logic, it is a context-dependent one. Each being is simply a part of the whole, but at the same time it resonates with Hopkins' 'goes itself; myself it speaks and spells, / Crying *What I do is me: for that I came*' (Hopkins, 1918).

While often unrecognized, there is no reason to think that this mode of consciousness is absent from an encounter with anyone or any thing that appears as a being in its own right. The natural response to this, as described by Hopkins, is *affirmation*, which I see as yet another synonym for *conatus*/appetition. Affirmation does not thrust a particular form on what is before it, but it shares in the being of that other so as to affirm a form, however humble, or even trivial, that may be. I see this as the activity to which the ideas of London and Bauer are pointing. The challenge of finding a complete account of consciousness thus becomes the task of echoing this implicational knowing in the propositional knowing of quantum theory. The gulf between these has been narrowing, with a major step on the propositional side contributed by Döring and Isham (2011).

4. Conclusion

The division of our knowing into propositional and implicational, with their very different structures, greatly enlarges the scope for finding a coherent account of consciousness in conjunction with quantum theory. We have almost an *embarras de richesses*. What is now required is a more explicit exploration of the interaction of propositional and implicational in the study of consciousness, each addressed in their appropriate manner, and related through the implicational generating propositional models of consciousness. This is clearly a multidisciplinary undertaking, requiring not only multidisciplinary journals and conferences, which are already helping a great deal; but also a willingness of more academics to step further out of their own disciplinary comfort zone in order to engage with the different facets of the problem. The implicational side of this enterprise leads us into a more effective understanding of our relationship with the rest of the world, in the process enlarging are picture of what 'the world' is. It is an undertaking appropriate for the times in which we now live.

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