

RESEARCH ARTICLE

On Carving Reality at Its Joints: Black Holes and Process, People, and an Experimental Challenge

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Abstract—Black hole event horizons provide us with an image of what the world looks like when it has been reduced to its smallest spatial components and all process has been squeezed out of it. It appears as a vast sheet of tiny, random dots. Since time is at the basis of ‘process’, the image highlights questions about temporality that also exercised philosophers, notably Henri Bergson and Alfred North Whitehead. Following a strategy suggested by Whitehead’s approach to the questions leads to a possibility, which is also at the basis of a particular panprotopsychist theory (‘SoS theory’), that the ‘time’ to which we ordinarily refer in everyday language may have two ontologically distinct but equally ‘real’ components—(a) the ‘objective’ metric spacetime of general relativity which refers to the organization of classical, causal relationships and (b) a ‘subjective’ sequence of ‘nows’ providing a basis for conscious experience—albeit ‘nows’ to which (usually very brief) objective durations can be attributed. If true, it is to be expected that macroscopic, conscious mind-related violations of energy conservation should occasionally manifest. There is a wide range of anecdotal evidence from ‘psychic’ phenomena suggestive of such violations. The main aim of this paper is to point to the potential value of investigating the energy budgets of candidate phenomena.

Keywords: black holes—consciousness—event horizons—panpsychism—process philosophy—SoS theory—time—Whitehead

Introduction

The main aim of this paper is to make a case for the possible value of investigating energy budgets of anomalous ‘physical’ phenomena, such as those that have been said to manifest in séances and elsewhere, on the assumption that they are sometimes genuinely anomalous and are not always products of fraud, mass hallucination, self-deception, or the like. It describes, in other words, a theory together with a range of related

considerations that may plausibly be thought sufficient to guide enquiry into weird physical happenings of a sort that have been widely reported and are sometimes investigated by parapsychologists. The possibility is also raised that short-lived violations of *objective* energy conservation may frequently manifest in effects on brain rhythmicity (see Pereira et al. 2018 for more detail).

The story I shall offer starts with a vindication of Henri Bergson's assertion of the greater importance to our existence of 'process' over 'structure'. He was especially doubtful about the completeness of general relativity's account of time, arguing that relativity theory excludes the central importance to temporality of both creativity and present moments. The vindication offered here depends on looking at implications of contemporary ideas, unavailable in Bergson's lifetime, about the nature of cosmological black hole event horizons.

It turns out that Bergson's 'process philosophy', as developed by Alfred North Whitehead, may be thought to lead on to a particular panprotopsychoist¹ theory of the ontology of consciousness, dubbed 'SoS theory' (Nunn 2013, 2015, 2016). I will argue that lines of thought pursued by Whitehead can be given a focused, albeit speculative, interpretation in SoS theoretical terms. A principal justification for considering this line of argument is that it implies a surprising and potentially testable prediction which, if fulfilled, would differentiate the view offered from all other currently extant theories of consciousness of which I am aware, while indirectly rehabilitating Bergson's claims (see, e.g., Canales 2015) about the inadequacy of the 'clock time' of general relativity to provide a complete account of temporality. SoS theory is of particular interest in connection with this because it is the only protopsychoist theory, so far as I know, to incorporate a built-in solution to the 'binding' or 'combination' problem (i.e. the problem of how it is that events in the brain that are apparently separated in time and space can give rise to unified conscious experiences) that presents major difficulties for other panpsychoist theories (Nunn 2013).²

Both Henri Bergson and Alfred North Whitehead placed great emphasis on the world's changeability, 'vitality', 'creativity', and the independent reality of what might be termed 'nowness'.³ Bergson (along, perhaps surprisingly, with the mathematician Henri Poincaré) was said to have taken the view that scientists, including Einstein, "do not measure time but cut it up into pieces that they declare to be identical so that their equations are as simple as possible" (Souriau 1937), the implication being that some of time's essence is lost in the process of dissection.

Both philosophers emphasized the precedence that must be given to considerations of process over structure when it comes to understanding

our apparently separate subjective and objective worlds. Present-day conceptions of the nature of black hole event horizons, which of course were unavailable to these thinkers, can nowadays be used to provide a particularly vivid illustration of the value of their views about the primacy of process, with its dependence on time. Unger and Smolin (2015), too, have recently explored in detail the necessity of appreciating the essential ‘reality’ of time with its concomitant dynamic; a dynamic that may even span successions of universes, they speculate. Space, in their view, is a less fundamental circumstance than time.

I’ll be focusing especially in this paper on an attempt to elucidate what any ‘reality’ attributable to time may mean, how it may manifest in us and how the proposals offered might be tested. My first step involves taking a look at a paradoxical difference between the experience of, and information available to, people observing a black hole event horizon from the outside and the predicted experience of someone actually falling through a horizon—in the special case of black holes sufficiently massive to allow a faller to survive purely tidal forces while transiting their horizons. Holes of sufficient mass are thought to exist in the centers of most galaxies, and I will assume that the unlucky faller is adequately protected from radiation surrounding the hole.

Black Holes

Many lessons have been drawn from these black holes, and it is now familiar that a precise entropy, as well as a mass, charge, and spin, can be attributed to each. Black hole entropy was a big surprise when discovered (by Jacob Bekenstein in the early 1970s), and it was an even bigger surprise that this entropy relates to the surface *area* of their event horizon measured in Planck units, not to the volume enclosed by the horizon. The second surprise (about the importance of area) was a consequence of the fact that entropy provides a measure of ‘information’. It had been expected that objects falling into a hole would pack into its volume somehow, carrying all their ‘information’ with them. The discovery about area subsequently led some cosmologists to make an extrapolation from Bekenstein entropy and infer what has been termed the ‘holographic principle’, which has become an ever more popular concept in recent years; the claim is that the whole universe and, in principle, any subsection of it, is fully represented by ‘information’ spread over the surface of whatever equivalent (most often the ‘light horizon’ of the universe) to a black hole event horizon it may be thought to possess. How valid was the extrapolation and the subsequent inference?

The first point to make is that event horizons exist only from the point

of view of observers sitting outside them. The mathematical structure of general relativity shows that they would be expected to have no direct physical significance whatsoever for an observer unlucky enough to fall through one. They are, in a sense, an observer-dependent illusion. Therefore, any extrapolation of conclusions drawn from them to the entire universe has to be regarded as shaky at best, unless one supposes that they are a feature of the experience of a God sitting outside the visible universe; even with such a supposition, extrapolation would need to assume that God is an ‘observer’ closely resembling ourselves in this respect, which seems more than a little unlikely. We therefore need to try to unpack the origins of the illusion and its precise connection(s) with ‘information’.

The Bekenstein entropy of black holes can be regarded as dependent on the fact that, from the point of view of outside observers, anything falling into one takes an infinite amount of time to cross its event horizon, even though, from the point of view of an unlucky faller (assuming the hole is massive enough to allow her to survive tidal forces at the horizon and *have* a point of view), her clock keeps ticking away normally. Contrary to her own experience, it appears to outsiders that she gets ‘smeared out’ over the event horizon despite the fact that the crossing has no special physical effect on her that is independent of the smoothly increasing gravitational field to which she is subject. Because there is an infinite time, from an outsider’s point of view, during which the apparent ‘smearing’ occurs, it’s not really surprising that the process looks as though it grinds her down to her smallest (i.e. Planck scale) spatial components. The black hole is acting as a sort of measuring instrument or microscope that allows outside observers to ‘see’ the minimal spatial components of objects falling into it, after having apparently destroyed all previously existing connections between these components.

Black hole entropy thus has to be regarded as a measure of *algorithmic* information content. This is consistent with the horizon’s dependence on outside observers since algorithmic information is defined as a measure of the length of the (minimal) computational program needed to fully describe some object. In the case of a black hole horizon, which is supposedly entirely random, any program describing it would have to exactly reflect in its complexity the entropy of the hole itself. Bekenstein entropy doesn’t even relate in any rigorous sense to the Shannon information of our familiar ‘bits’ and ‘bytes’ since there is no meaningful way of attaching an expectation value to a Bekenstein pixel. Despite the vast algorithmic information value attaching to black holes, their Shannon value is best regarded as summing to just a few bits; bits that relate to the presence or absence of a horizon

along with its position as perceived by outside observers. For anyone falling through it, it has no informational value at all since it has no reality for her and she has no means of ascertaining her position in relation to it. The ‘holographic principle’, insofar as it may be valid at all, thus describes only the potential for representing the minimal (Planck-scale) chunks of spatiality within a volume after they have been divested of any temporal component; it can say nothing about their relationships, especially not their temporal relationships.

Event horizons teach us what ‘reality’ and ‘information’ look like from an objective point of view when stripped of all relatedness (with the exception of those few Shannon ‘bits’); they appear as simply a vast sheet of tiny, random pixels. It wouldn’t be totally unfair to say that they show us the final goal of any program of extreme reductionism—random structure, devoid of life and meaning. But what is the true nature of the temporality that allows anyone falling through the horizon of a sufficiently massive black hole to retain their rich subjective life for a brief while, until they meet whatever fate awaits within the hole? It is certainly hard to believe that the metric, ‘clock time’ of general relativity can be sufficiently ‘real’ to offer a complete account of the very different temporalities and experiences of outside observers and fallers without any introduction of additional considerations. Indeed the very fact that an infinity crops up in the experience of observers (the infinite time taken by falling objects to cross an event horizon) ought to raise doubts about the likely completeness of general relativity’s account of time.

Henri Bergson and Alfred North Whitehead reached a very similar conclusion from more general philosophical considerations about a need for concepts over and above those offered by general relativity in order to reach an adequate understanding of temporality. Both philosophers admired and understood the elegance of Einstein’s general relativity (as so well described by Canales [2015] in her history of the Bergson/Einstein debates), but felt that it must provide an incomplete picture of temporality because its geometric structure, along with the ‘block universe’ implications of special relativity, left no adequate place for the changeability and ‘creativity’ associated with time; nor could it accommodate the ‘nowness’ of our own subjective experience, they felt. While Bergson never offered any very clear-cut suggestions for a solution to the problem, Whitehead described a detailed, highly technical approach to resolving it. I want to take a look at his proposal next because, although it turns out to have been at least partially incorrect, it suggests a strategy pointing to an alternative solution that may work and should prove testable.

Alfred North Whitehead (1861–1947)

One of the most profound thinkers of the first half of the 20th century, Whitehead made his name co-authoring *Principia Mathematica* with Bertrand Russell, subsequently becoming well-known for espousing the view that ‘reality’ is best considered a process comprising ‘actual events’, alternatively termed ‘actual occasions of experience’. Widely quoted as having opined that “[conscious]⁴ mind is simply the intrinsic temporality of a physical event,” he regarded the search for static ‘building blocks’ for the world, whether in the form of ‘Platonic’ mathematical structures or physical particles, as being of secondary relevance only to the actual basis of reality. Perhaps discouraged by the prevailing intellectual climate at the time, which was more concerned with structure than with process, he later diversified his interests, becoming, among other things, an assistant founder of the Harvard Business School. Nevertheless, he and Bergson were quite right to emphasize the primacy of process. The aridity of event horizons—those two-dimensional sheets of meaningless pixels—provides a far more striking image than any that was available to either of them of what is left when all process is squeezed out of the world.

Whitehead’s approach to our ‘what is temporality’ problem is best described in one of his books, *The Principle of Relativity with Applications to Physical Science* (1922). About two-thirds of it deals with the mathematics of tensor theory but the underlying ideas are relatively clear, although some of the terms that he used need translation for modern readers. Important ones include:

(1) ‘Actual events’: these appear often, and perhaps always, to equate to causative happenings (conceived classically and not in terms of ‘quantum measurement’, so far as I could see), which always carry some particular (‘adjectival’) character.

(2) ‘Event particles’: the particular entities involved in ‘actual events’, which in many ways seem to have been regarded by Whitehead much as we would regard bits of active information (conceived in terms similar to Bateson’s ‘a difference that makes a difference’ and without any reference to Shannon information theory).

(3) ‘Adjectives’: descriptors of the characteristics pertaining to some particular ‘actual event’. Crucially, ‘adjective’ may refer either to a Galilean primary quality such as ‘contiguity’ (an example offered by Galileo himself) or to an experiential secondary quality such as ‘red’ (the example Whitehead often used). Even when referring to a Galilean primary quality, ‘adjectives’ also carry an experiential component.⁵ Whitehead was

thus a ‘pan-experientialist’ of some sort; his view may have been rather closer to modern panprotopsychism or dual aspect theory than to property dualism, despite his characterization of the nature of his ‘adjectives’ which he may have envisaged as quale-like and thus panpsychist (see Note 1). However, his ‘actual events’, sometimes termed ‘actual occasions of experience’, were clearly *protopsychist* equivalents. One can speculate that *sets* of ‘actual events’ get elaborated into ‘actual occasions of experience’, but Whitehead didn’t make this step explicit in his writings.

Because of these background concepts, Whitehead needed some place for a real ‘nowness’ in time that he couldn’t find in Einsteinian general relativity, which offers a wonderfully accurate metric for the description of classical, objective space–time. It is a smooth geometric structure, providing an apparently perfect model of the tempo–spatial organization of classical causative relationships. What it doesn’t have is any special niche for ‘now’ other than as a reference to the occurrence of some particular, local causative event, nor any clear means of accommodating the perceived flow of time. Whitehead needed, in other words, to introduce a duality of some sort into general relativity that might offer a foothold for a concept of ‘now’ as a real entity with some sort of independent existence and might also provide a basis for making more fundamental distinctions between past and future than are provided by the standard statistical arguments from entropy (i.e. arguments based on the fact that, in closed systems like the universe, entropy always increases in the future direction).

Inspired, perhaps, by his feeling that ‘Platonic’ mathematical structures can’t be part of the real world, he formulated general relativity in terms of *separate* geometric and gravitational tensors (instead of Einstein’s single tensor which incorporates, indeed identifies, both geometry and gravitation), regarding the geometric tensor as not part of ‘real’ physics. This maneuver allowed him to claw back a basically Newtonian notion of ‘now’. His formulation made predictions fully equivalent to those of Einsteinian general relativity for all phenomena that were under consideration during their lifetimes. It has, however, subsequently been shown to make a wrong prediction for certain very high energy phenomena, although a modified version of it may still prove useful (see, e.g., Alvedo 2015). Though Whitehead turns out to have been wrong about at least part of the detail, his overall strategy of introducing a duality of *some* sort into our concept of time’s basis is well worth consideration. That’s where I want to go next, taking as a guideline Whitehead’s belief in the existence of an intimate relationship between consciousness and temporality rather than his technical enquiry into tensors.

Two 'Times'?

Rather than look for two tensors to provide a basis for enquiry into the nature of time, it is a lot more straightforward to consider the possibility that time may present us with two distinct, but equally 'real' aspects. This is an idea with a long history, albeit one often ignored by mainstream thinkers. It dates back at least as far as McTaggart's (1908) suggestion that 'tensed' time (past, present, and future) is a concept distinct from that of 'tenseless' time (earlier than, contemporaneous with, and later than). McTaggart himself, writing some 20 years before Bohr's notion of 'complementarity' gained currency, supposed that incompatibilities between his two notions of time 'proved' that time is unreal. One can speculate that Whitehead ignored the idea because MacTaggart had used it to reach an opposite conclusion to the one he wanted. It is far more fruitful, however, to suppose that both of McTaggart's 'times' are equally real and that he reached a wrong conclusion from their apparent differences. The two 'times' may actually refer to different realms of reality, rather as waves and particles appear to belong to different categories from our point of view but are nevertheless aspects of an underlying unity, an idea that was adopted by Hans Primas (2003, 2009), for instance, who suggested that 'tensed' time might be 'the carrier of non-material, mental phenomena' while 'tenseless' time can be identified with the objective, clock time of general relativity.

Because any fundamental split in time implies that a symmetry of some sort has been broken, it is reasonable to ask where the break may be thought to occur. One possibility is that it coincides with those quantum 'measurements' that result in energy eigenstate manifestations (Nunn 2013). The idea, which depends on attributing ontological rather than purely epistemic status to the temporal component of quantum theory's time/energy relationship, is that little chunks of non-objective or 'mental' time occur along with actualization of objective energies. The manifestations of objective eigenstates of course adhere to the metric time and causative structure of general relativity. The hypothetical units of 'mental' time,⁶ which I dubbed 'scintillae of subjectivity' (SoSs), can be conceptualized both as elementary units of 'nowness' and as the 'temporal', subjective flipside of the virtual particles that play such essential roles in quantum field theory. Because of the Heisenberg time/energy uncertainty relationship, each SoS will have a duration (usually a very brief duration) from an objective point of view. This 'objective' duration can be calculated (in principle at least) from the energy uncertainty associated with some particular energy eigenstate 'measurement'. For instance, if the energy 'measurement' has an uncertainty of 10–33 joules, the associated SoS will exist, from an objective

point of view, for 0.1 second. From its own, subjective point of view—and it is not misleading to think of it as owning a point of view—it will simply exist in a durationless ‘now’ which may be pictured as analogous to the ‘now’ that would have to be attributed to a photon traversing the visible universe according to special relativity theory. ‘Nowness’ may not be attributable to photons because they probably don’t *have* a point of view, but the postulate here is that SoSs *are* a point of view. I’ve described elsewhere (Nunn 2016) how SoSs might be envisaged to provide a basis for our form of subjective conscious experience, but there are also questions to ask about their possible implications for relativistic, physical time and the objective world.

If SoSs exist, they have the potential to provide relativistic time with grounds for distinguishing between present, past, and future. ‘Future’ is when relativistic, clock time is unaccompanied by any SoS; ‘present’ is when a clock time event duration overlaps with the objective duration of an SoS (more usually the durations of a large number of individual SoSs in the context of our own conscious experience); ‘past’ is when such overlap no longer exists from the clock time perspective. From the SoS perspective, however, which occupies a durationless ‘now’, there is no ‘past’. SoSs thus have to be regarded as forming an ever-accumulating ‘memory’ for events occurring in relativistic time, thereby providing the sort of independent reference frame for general relativity that is required by many convergent lines of thought, especially those mentioned earlier in this paper.

But there’s a huge ‘but’ in that the alleged ‘memory’ would have to be regarded as entirely epiphenomenal, ineffective, and functionless unless it can reciprocally influence in some manner, from its ‘subjective’ existence, ongoing events in the ‘objective’ world. Given that SoSs are envisaged as manifesting along with energy eigenstates, it would not be surprising if they can indeed affect the objective world in some way, if only because of Newton’s principle that actions of any sort are generally accompanied by reactions. However, one can hardly be sure that the principle applies across a subjective/objective split of the sort envisaged. Empirical evidence is needed here.

Looking for Evidence

Since SoSs are regarded as being at the basis of our conscious, subjective experience, one might suppose that the best option to take, when searching for evidence of any effects they may have, would involve taking a close look at our own conscious memories. The problem here is that neural functions and memories are so closely tied in with relativistic time and

indirect experience of a range of neural and other ‘clocks’ that untangling any independent contribution of SoSs to memory could prove to be a ‘looking for a needle in a haystack’ task, even though some aspects of near-death experience, for example, may ultimately turn out to be relevant. Are there any simpler, potentially achievable options?

In fact the most characteristic and easily readable signature of any SoS back actions that may occur is likely to manifest in violations of energy conservation. Any such violations would be especially significant and striking because these are thought to be impossible in the context of contemporary thermodynamic, relativity, and quantum theories. Energy conservation is a consequence, so Noether’s theorem tells us, of the indifference of physics to *smooth* translations in clock time. Conservation follows from the fact that it will make no difference to the behavior of physical systems whether you do your experiments at lunchtime or teatime, this year or next. However, any actions that SoSs may have on objective systems will inevitably involve non-smooth temporal transitions because of the split between the two types of time involved. Within the context of the theory, SoS back actions on neural systems at least must occur *unless* it is supposed that consciousness is entirely epiphenomenal; a view which had plenty of adherents 40 years ago but is becoming ever less popular for a very wide range of good reasons. Events that encompassed both types of time could never be modeled by differential equations. Therefore, Noether’s theorem⁷ won’t apply to them, and failures of energy conservation may sometimes manifest in relation to any fairly large-scale reciprocal interactions between ‘subjective’ and ‘clock’ times. Where best to look for them?

There’s actually a vast amount of anecdotal evidence that might be taken to indicate that violations of energy conservation relating to the activities of conscious minds can and do occur. Many of the stories about the ‘miracles’ of saints or some of the capacities of sadhus, if the events reported were not all attributable to fraud, fakery, mass hallucination, or the like, have to raise questions about the source(s) of the energy needed for those feats. The same applies to reports of physical phenomena manifesting during séances. An especially intriguing, if bizarre, example of the sort of phenomenon that might reward investigation from an energy conservation point of view is available in Stephen Braude’s (2007) careful account of the ‘gold leaf lady’. She is, or was, an apparently unsophisticated woman who exuded flecks of brass foil from her skin (a feat that professional magicians who were consulted could neither emulate nor explain).⁸ If no fraud was involved (and Braude’s investigation certainly seems to have excluded this), energy balances relevant to the phenomenon would be quantifiable because the flecks could be (and were) collected and weighed.

Because ‘everyone knows’ that energy conservation is an unbreakable law, there’s only anecdotal evidence to consider (so far as I know). That’s the challenge I’d like to put to anyone with access to suitable subjects and technology—to turn some intriguing anecdote into a rigorous investigation. Parapsychologists have of course often conducted careful investigations into various types of ‘psychokinesis’, but these are unfortunately of little direct relevance in the present connection. The phenomena they have investigated in the laboratory mostly demonstrate only very small effect sizes and generally involve the occurrence of biases in probabilistic outcomes of some sort. It would be hard to demonstrate violations of energy conservation in relation to such phenomena because it would be difficult to exclude contributions from thermal or other sources, perhaps operating via some sort of ‘negentropy’ effect. More robust phenomena with larger energy requirements would be needed for any convincing demonstration. My own guess is that investigators based in India might have the best chance of success because there are quite frequent reports of sadhus and yogis who have managed to do without food, water, or even air for unfeasibly long periods. If true, how did they manage their energy balances? Perhaps there are people out there able and willing to demonstrate their abilities under adequately controlled conditions.

There’s also a possibility that similar, but much smaller-scale, apparent violations might operate all the time, allowing consciousness to modulate brain function, via an inherent (Heisenberg uncertainty–derived) indeterminacy of clock time manifestation of SoSs. It is thus possible that patterned SoSs may have a probabilistic influence on the precise ‘objective’ timing of environmental ‘measurements’ of wave functions associated with classical oscillatory events in the brain as these evolve.⁹ The situation can be pictured as analogous to that of pendulums swinging in a gravitational field with oscillating macroscopic events in the brain playing the part of pendulum swings and ‘consciousness’ playing the part of gravitational potential energy, but a form of potential energy that is objectively ‘invisible’. Modulations of any such invisible ‘potential energy’ could be expected to affect objective oscillatory events in the brain. The ‘invisibility’ of this hypothetical source of potential energy would almost certainly be hard to demonstrate but might just become apparent in the context of relating the energy requirements of calcium wave fluxes, for instance, to ATP (adenosine tri-phosphate) usage in the relevant neurons and astrocytes.

In brief, there are reasons to suppose that, if ‘subjectivity’ is indeed equivalent to MacTaggart’s ‘tensed’ time, it should be possible to demonstrate the equivalence by looking for apparent, consciousness-related, violations of energy conservation.

Notes

- ¹ It is sometimes said that the ‘proto’ in panprotopsychism is surely redundant, but this is not so. Panpsychists generally envisage their psychism as something vaguely quale-like. Panprotopsychists, in contrast, suppose their psychism to bear much the same relationship to the content of our consciousness as do action potentials in the brain, for example, to the content of our minds. There seems to be some degree of overlap between panpsychism and ‘property dualism’, whereas panprotopsychism has more in common with dual aspect (of information) theory. However, no good account exists, so far as I know, of relationships between these ideas since they are generally held by very different groups of theorists. Panpsychism had distant origins in philosophical and religious thinking while property dualism and dual aspect theory are concepts recently introduced by philosophers and others (building on a proposal made by Baruch Spinoza in the 17th century) to ‘explain’ the apparently magical emergence of consciousness from neural activity. My personal view is that both property dualism and dual aspect theory, if unconnected with pan(proto)psychism as is often the case in contemporary writings, are fudges needed to preserve a belief in monistic materialism, analogous to the epicycles required to make Ptolemaic astronomy work. Any true monism is probably best regarded as belonging to a pre-manifest reality; a realm that houses wave functions, Jungian ‘archetypes’, and perhaps mathematical forms among other descriptive concepts (see Pereira, Nunn, Nixon, & Pregnoiato 2018). The apparent dualism of our manifest world is consequent on a broken symmetry of the pre-manifest monism, according to this picture, but is real enough from our point of view.
- ² Neural emergentist theories of consciousness generally appeal to ‘gamma coherence’ of EEG activity to account for ‘binding’. Quantum consciousness theories regard it as dependent on quantum coherence. However, gamma coherence doesn’t appear to be *always* necessary, though it is *usually* associated with ‘binding’, while there are major doubts about whether any widespread quantum coherence in brains could survive ‘decoherent’ processes. Given these doubts about the adequacy of relatively ‘mainstream’ theories to account for ‘binding’, there’s certainly room for consideration of possible alternatives.
- ³ Bergson often referred to this concept as ‘duration’, which can be confusing nowadays because it relates only indirectly to clock time durations.

- ⁴ I added ‘conscious’ because Whitehead, as a pan-experientialist, almost certainly used ‘mind’ to mean ‘conscious mind’.
- ⁵ Of course Galileo’s distinction between primary and secondary qualities is iffy at best and sometimes downright misleading (see, e.g., Nunn 2016: Chapter 7). I mention it here because it was widely thought valid in Whitehead’s time.
- ⁶ Similarly conceived ‘units’ of conscious mentality have sometimes been referred to as ‘psychons’ or ‘qualions’. I’ve avoided hijacking those terms because they may mislead, in the context of the theory on offer here, by suggesting similarity to an objective particle with an ‘-on’ ending such as a photon or electron, while SoSs are conceived as belonging to a wholly different branch of reality.
- ⁷ Emmy Noether proved that “any differentiable symmetry of the action [i.e. Lagrangian] of a physical system has a corresponding conservation law.” Hamiltonians are generally thought to be equivalent to Lagrangians in this context. Translations in clock time (e.g., doing your experiment at teatime instead of lunchtime) thus involve a symmetry that entails energy conservation.
- ⁸ Braude himself speculated that the flecks of brass foil might be ‘apports’.
- ⁹ I’m assuming here that decoherence theory provides an adequate picture, for practical purposes, of the ‘measurement’ process.

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