MAKING SPACE AND TIME FOR CONSCIOUSNESS IN PHYSICS *

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ABSTRACT

It is argued that physics must eventually expand to accommodate mind and consciousness but that this will require a new paradigm. The paradigm required will impinge on two problems on the borders of physics and philosophy: the relationship between physical space and perceptual space and the nature of the passage of time. It is argued that the resolution of both these problems may involve a 5-dimensional model, with the 5th dimension being associated with mental time, and this proposal may relate to recent developments in brane cosmology. A description of consciousness must also entail a proper understanding of the specious present, the minimum timescale of conscious experience, this possibly being associated with a compactified extra dimension. There could even be a hierarchy of levels of consciousness, associated with a hierarchy of extra dimensions.

INTRODUCTION

There can be no doubting the striking success of physics in coming to understand the material world from the smallest scales of particle physics (M-theory) to the largest scales of cosmology (the multiverse). In particular, it has revealed a remarkable unity in the Universe, with everything being made up of a few fundamental particles which interact through four forces which are different manifestations of a single unified interaction. It is even sometimes claimed that our knowledge of the fundamental laws and principles governing the Universe is nearly complete, so that we are close to obtaining a "Theory of Everything" (TOE).

Another success of physics has been to explain the development of the dazzling array of increasingly complex structures in the 14 billion years since the Big Bang. This has culminated – at least on Earth – in the evolution of the human brain. Among the remarkable attributes of our brains is consciousness, so it is curious that this attribute is usually neglected by physics and assumed to have a purely passive role in the Universe. Indeed, most physicists assume that the study of consciousness is beyond their remit altogether because science is concerned with a "3rd person" account of the world (experiment) rather than a "1st person" account (experience). They infer that the focus of science should be the objective world, with the subjective element being banished as much as possible.

Nevertheless, the claim that physics is close to a TOE seems puzzling when such a fundamental feature of the world is neglected. It is therefore easy to sympathize with Noam Chomsky (1975) when he asserts that "physics must expand to explain mental experiences". There are already hints as to how this might be achieved. For example, Giulio Tononi (2012) has speculated that consciousness may be a function of some field associated with complexity, while Max Tegmark (2015) has proposed that consciousness may be another state of matter. Also, advances in neuroscience are clearly helping to explain how consciousness can be understood as an emergent phenomenon. However, all these developments relate to the correlates of consciousness rather than mentality itself. Indeed, the materialist perspective has no room for experience at all, this being the basis of Chalmers' (1996) hard problem of consciousness.

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One hint that consciousness may be a fundamental rather than incidental feature of the Universe comes from anthropic arguments, which suggest the some features of the Universe are fine-tuned so that complexity can arise (Carr and Rees, 1979, Barrow and Tipler, 1986). Such arguments used to attract scepticism on the grounds that they are too philosophical – or even theological – but they are now more palatable because the multiverse proposal allows the fine-tunings to be interpreted as a selection effect (Carr, 2007). Although it is not inevitable that consciousness is the relevant selection factor, it is likely to at least be an aspect or consequence of the complexity.

Of course, anthropic arguments shed no insights into the nature of consciousness itself. They just hint that it may not be irrelevant to the Universe. This raises the question of whether some future paradigm of physics may be able to accommodate consciousness explicitly. Clearly physics in its classical mechanistic form cannot achieve this, since there is a basic incompatibility between the localised features of mechanism and the unity of conscious experience. However, the classical picture has now been superseded by the quantum one, and this also hints that consciousness may be important.

For example, studies of quantum phenomena convinced Louis de Broglie (1963, p.143) that "the structure of the material Universe has something in common with the laws that govern the workings of the human mind", Eugene Wigner (1967, p.169) asserted that "it is not possible to formulate the laws of quantum mechanics in a fully consistent way without reference to the consciousness of the observer", John Wheeler (1977) inferred that "mind and Universe are complementary", and Bernard d'Espagnat (1979, p.158) attested that "the doctrine that the world is made up of objects whose existence is independent of human consciousness turns out to be in conflict with quantum mechanics and with facts established by experiments." Some physicists have even proposed that consciousness can influence how the wave-function collapses (Stapp, 1993), although this is not the mainstream view.

Even if quantum theory does involve consciousness in some way, nobody understands quantum theory anyway, so one cannot claim that it *explains* consciousness – it merely replaces one mystery by another. Thus, one probably needs some deeper paradigm that underlies both consciousness and quantum theory. Roger Penrose (1989, p.371) anticipates that "our present picture of physical reality is due for a grand shake-up, even greater, perhaps, than that provided by present-day relativity and quantum mechanics". The current paradigm is certainly incomplete – since we still need a theory which amalgamates quantum theory and relativity theory – so one cannot preclude some future paradigm of quantum gravity involving consciousness in some way (Penrose, 1994). As indicated in Figure 1, just as relativity theory links space and time via space-time, and quantum theory links matter and mind via observation, we seek some form of unification of matter, mind, space and time.

If some future paradigm of physics does eventually accommodate consciousness, this will inevitably impinge on two problems on the borders of physics and philosophy: the nature of time and the nature of mind. Within academic philosophical circles, these currently tend to be regarded as disjoint fields but the paradigm required must surely bring them together. Of course, some physicists are uncomfortable trespassing into philosophical domains. However, as science reaches its limits, the boundary between physics and philosophy necessarily becomes blurred, as illustrated by recent debates about the multiverse and M-theory (Carr, 2014).

As regards the philosophy of time, however keen physicists are to banish consciousness from the physical world, they cannot deny the relevance of time and yet these two mysteries are clearly related. For without the passage of time, there could be no change and without change there could probably be no self-awareness. It is therefore possible that both time and consciousness will play a key role in any putative TOE. Although some physicists (Barbour, 2001) argue that time is an illusion which is unlikely to play a role in any final TOE, this is contentious and a theory of quantum gravity should surely explain how space and time emerge.

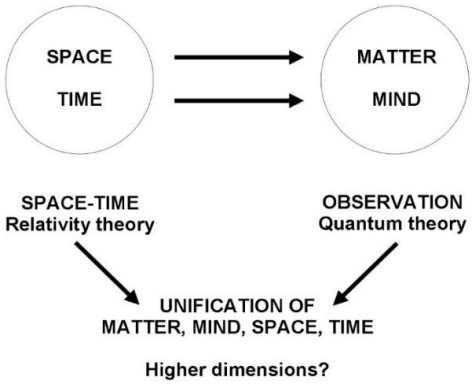

Figure 1. Unification of matter, mind, space and time as a natural extension of physics.

As regards the philosophy of mind, there has been a long-standing debate about the relationship between our perception of the world and the world itself. Some people have adopted the naïve realist view, in which one's perceptions are taken to be a direct apprehension of reality, while others have adopted the representative view, in which one's perceptions are just an internalized mapping of reality. Although almost everyone now adopts the latter view, it is clearly incomplete since the image one has of the world certainly *seems* to be "outside" and it is very improbable that extensive probing of the brain would ever locate the images themselves "inside" (like some sort of filmstrip). Also, the representative description usually assumes the 3-dimensional Newtonian paradigm, whereas physicists now adopt a description of the world with at least four and possibly more dimensions. This suggests that the "real" world bears very little resemblance to the world we actually experience and that our biological sensory systems reveal only a very limited aspect of reality. So the version of reality assumed by old-fashioned representative theory is itself a representation.

Here it will be argued that higher dimensions are likely to play a key role in the new paradigm. All physicists now accept the Einstein view that the world is 4-dimensional, with the 4^{th} dimension being time. However, a unified understanding of all the forces which operate in the Universe suggest that there are extra "internal" dimensions. This approach was pioneered in the 1920s with the suggestion that a fifth dimension can provide a unified description of gravity and electromagnetism (Kaluza, 1921) if it is wrapped up on the Planck scale of 10^{-33}cm (Klein, 1926). Subsequently, it was discovered that there are other subatomic interactions and recent unification theories suggest that these can be explained by invoking yet more wrapped- up dimensions, superstring theory suggesting there could be six (Green et al., 1987). There were originally five different superstring theories but it was later realized that these are all parts of a single more embracing model called "M-theory", which has seven extra dimensions (Witten, 1995). Although the extra dimensions are usually compactified on the Planck scale, in some models they can be much larger (Arkani-Hamed et al., 2000), and in one variant the fifth dimension is extended so that the physical world is viewed as a 4-dimensional "brane" in a higher-dimensional "bulk" (Randall and Sundrum, 1999). These development are illustrated in Figure 2.

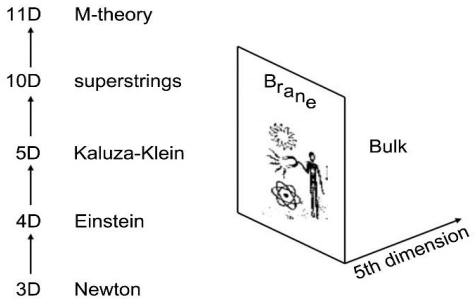

Figure 2. The sequence of dimensional shifts entailed in the unification of physics (left). The extra dimensions are usually assumed to be compactified but one is extended in brane theory (right).

This essay suggests that there is a link between the experience of time and the existence of higher dimensions. Indeed, it argues that the apparent flow of time can *only* be described from a higher-dimensional perspective, since from a 4-dimensional perspective one is bound to conclude that it is an illusion created by the mind. These higher dimensions must also relate to perceptual space, this being in some sense communal, and to the unification model indicated in Figure 1. This approach is described in more detail elsewhere (Carr, 2015). It is unlikely to be well-received by string theorists, since they already face the criticism that their ideas border on metaphysics (Woit, 2006) and this proposal might make them even more vulnerable to that accusation. Nevertheless, solving the problem of consciousness is bound to require some radical change of perspective and this will inevitably entail some discomfort.

RELATING PHYSICAL AND PERCEPTUAL SPACE

In this section, we discuss the relationship between our perception of the world and the world itself, emphasizing the distinction between the naïve realist and the representative view. According to the latter view, the internal space in which our percepts reside (perceptual space) is distinct from the external space in which the objects themselves reside (physical space). According to the former view, the two spaces are identical, so no such distinction applies. This issue is usually discussed in the context of the percepts associated with the "outer" physical world and we confine attention to this case here. The issue takes on a different perspective in the context of percepts associated with the "inner" mental world, as discussed elsewhere (Carr, 2015).

3D Reality Structure and Representative Theory

The term "phenomenal space" here refers to the space associated with those percepts which appear to be generated by the physical world via physical sensors. In representative theory, phenomenal space is just an internal construct of the brain. Since the physical and physiological processes whereby an object emits a signal, which is then registered by the sensory system and transformed into a pattern of neuronal firing in the brain, is well understood, very few people would support the naïve realist view in which the percept *is* the object. However, the crucial assumption of representative theory is that there is an external reality which reconciles how different observers perceive the world. So if two observers see the same object (e.g., a dog), the two percepts are *disconnected*, in so much as two consciousnesses cannot share the same experience, but *consistent* in that there is a consensual reality from which they derive.

But what is the nature of this consensual reality? If one were to ask a philosopher of the 19th century in what sense the physical world is real, he might have replied that there exists a 3-dimensional (3D) space in which are localised both the sensors through which we observe the world and the physical objects themselves. This is illustrated in Figure 3, where the physical dog is in the solid circle and the perceived dogs are in broken circles. Each observer has only partial information about that space because of the limitations of his sensory system. (For example, his eyes will provide him with a projection of the space which is essentially 2D.) However, the crucial point is that, given his location and the direction in which he is looking, one can always predict how he ought to see it.

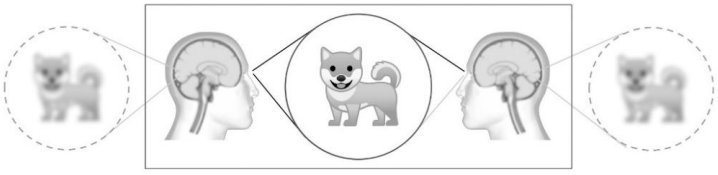

Figure 3. Relationship between object and percept in 3D model with percepts being in the brain.

The fact that one can find a 3D configuration which predicts a set of 2D projections concordant with those actually presented to different observers is what is meant by stating that the physical world is real. One may say that it is a 3D structure (S_3) which consistently reconciles how everybody within that structure perceives it. The situation is depicted in Figure 4(a), which represents three perceptual fields (P_1, P_2, P_3) by squares and the reality structure S_3 by a cube.

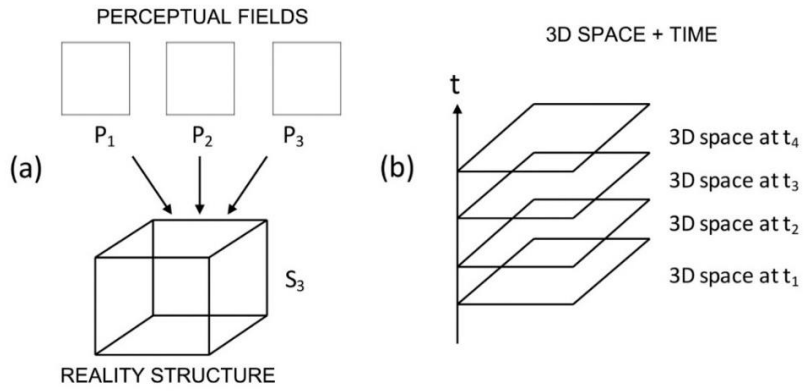

Figure 4. (a) Representing how a 3D reality structure S_3 reconciles different 2D perceptual fields P_i of observers within that structure. (b) Incorporation of time in Newtonian model.

4D Reality Structure and Extended Mind

The construction of S_3 only applies at a particular time. From a Newtonian perspective, time is absolute, so the 3D structures at successive moments can be trivially patched together to incorporate the flow of time, as indicated in Figure 4(b). However, special relativity shows that a consistent picture of how different observers perceive the world requires that it be 4-dimensional (4D), with the fourth dimension being time and material objects corresponding to world-tubes. Photons travel at 45 degrees in a space-time diagram, so the observer's visual perceptual field at any moment corresponds to part of his past light-cone. This is illustrated in Figure 5(a) with one spatial dimension suppressed. Since an observer's visual perceptual field at any moment corresponds to part of his past light-cone, the physical dog in the 3D description is the intersection of its world-tube with a spatial hypersurface of constant time, whereas the perceived dog is the intersection of its world-tube with the past light-cone of the brain. So the object and percept are merely different cross-sections of its 4D world-tube, as illustrated in Figure 5(a). The representation of Figure 3 can therefore be replaced by Figure 5(b), where the vertical positioning of the dotted dogs symbolises the role of time in the perceptual process.

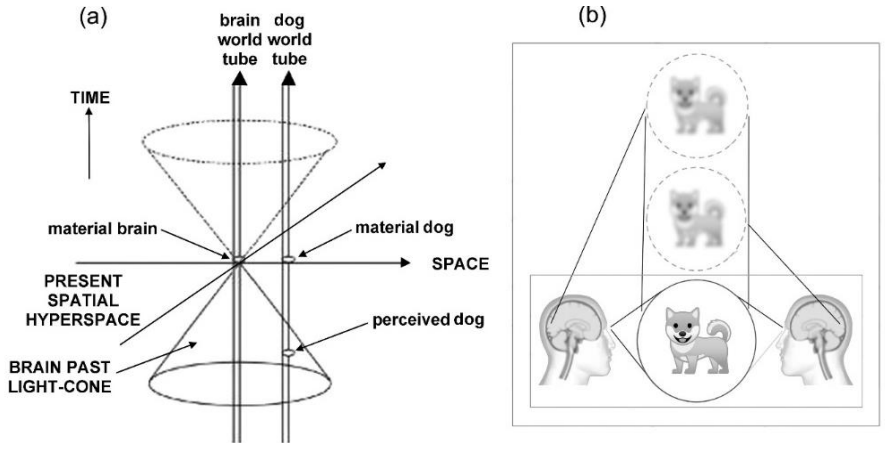

Figure 5. (a) Relationship between object and percept in a model which involves observation along past light-cone. (b) Modified version of Fig. 3

A 20th century philosopher would therefore argue that reality is a 4D structure (S_4) but the notion that the world is real because there exists a higher-dimensional structure which reconciles our perceptions of it is preserved. Indeed, the situation can still be represented by Figure 4(a), provided one interprets the squares as past light-cones and the cube as S_4. Of course, perception is generally more complicated than indicated in Figure 5(a). Not even visual perception is restricted to the past light-cone, since it may also involve mirrors, lenses, cameras, photographs etc., and there are also non-visual modes (sound and touch) which involve signals which travel slower than light. But perception can always be represented by some sort of space-time connection. Admittedly, physical perception is also dependent upon brain processes and higher-order cognitive functions, but even these can be described in terms of the (albeit very complicated) nexus of world-lines associated with the electrical signals between neurons.

The traditional view is that the percept is localised within the brain, as illustrated in Figure 6(a), but this just results from of the outdated 3D perspective. The 4D view suggests that perception corresponds to a sort of extended mind, in which conscious experience is associated with all the parts of space-time to which the brain is linked through a causal nexus of signalling world-lines, as illustrated in Fig. 6(b). This implies that perception is a 4D process and the brain is just one end of the causal chain. So in some sense, associated with the fact that the 4D distance is zero along the light-cone, the percept is where it appears to be and not within the skull. This has also been argued by Sheldrake (2003) and Velmans (2005) on philosophical grounds. In the context of physical perception, mind *is* space-time.

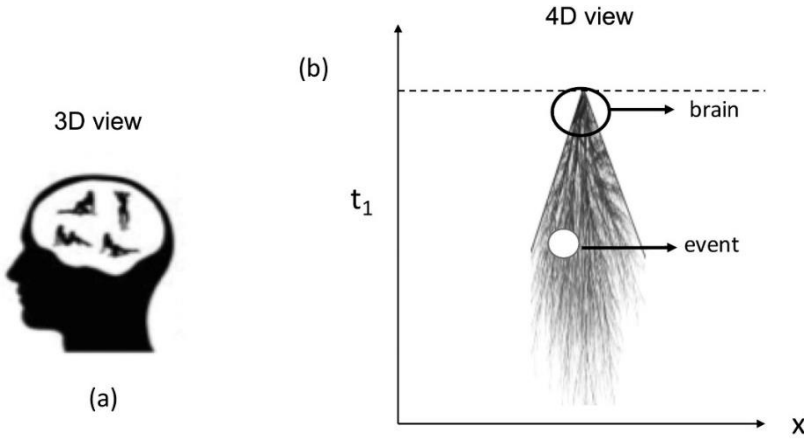

Figure 6. Relationship between object and percept in (a) a 3D model, in which the percept is in the brain, and (b) a 4D model, in which perceptual space is associated with the space-time region connected to the brain via a nexus of signalling world-lines.

This proposal is reminiscent of the "Space-time Reductive Materialism" model of Jim Culbertson (1973), in which consciousness is contained within what he terms the "space-time outlook tree" of the brain. This corresponds to the complete nexus of space-time connections between the brain and the events it perceives at any particular time. So awareness is an extended pattern in space-time, with the relationship between the different observers being like a global tapestry of entanglement.

The controversy between naïve realism and representative theory takes on a different perspective with the 4D model. Because both the object and the percept are lower-dimensional projections in the 4D description, neither is primary and the standard view of representative theory is superseded. Furthermore, while the percept is 2D in the 3D view, being just a geometrical projection, it is at least partly 3D in the 4D view because of all the extra information which can propagate from the object to the sensors via non-visual sense modes. The distinction between the 3D and 4D views may be summed up as follows:

3D view: 3D object → 2D percept.
4D view: 4D object → 3D object + 3D percept.

Of course, the identification of a percept with some cross-section of a 4D object only accounts for the geometrical aspects of perception and excludes secondary aspects (qualia), so it only partially addresses the philosophical distinction between object and percept. For a more complete resolution of the problem, one must go beyond the 4D description, as we discuss next.

THE FLOW OF TIME AND 5D REALITY STRUCTURE

A long-standing problem on the interface of physics and philosophy concerns the flow of time. The point is that relativity theory does not describe the basic experience of "now" which is such an essential ingredient of our perceptual world. For in the "block" universe of special relativity, past and present and future coexist. As indicated in Figure 5(a), the 3D object is just the "constant-time" cross-section of an immobile 4D world-tube and we come across events as our field of consciousness sweeps through the block. However, nothing within the space-time picture describes this sweeping or identifies the particular moment at which we make our observations. So if one regards consciousness as crawling along the world-line of the brain, like a bead on a wire, as illustrated in Figure 7(a), that motion itself cannot be described by relativity theory.

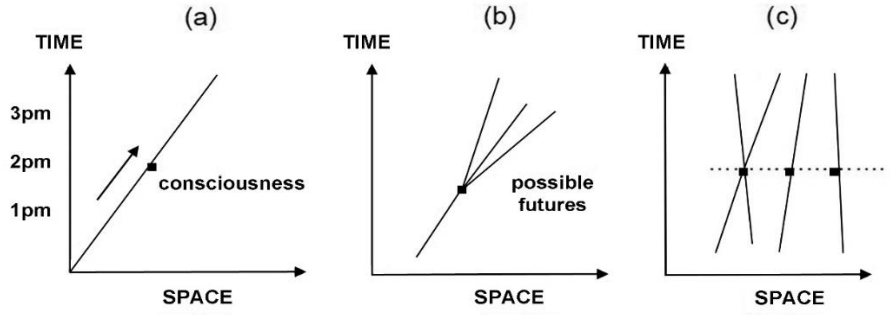

Figure 7. Three problems of consciousness from a relativistic perspective: (a) the passage of time, (b) selection of possible futures, and (c) coordination of time for spatially separated observers.

Thus there is a fundamental distinction between physical time (associated with special relativity and the outer world) and mental time (associated with the experience of now and the inner world). Many people have made this point (Broad, 1923; Eddington, 1928; Weyl, 1949; Brain, 1960; Price, 1996, 2011; Maudlin, 2012; Callender, 2017). Indeed, there is a huge philosophical literature on this topic and an ongoing controversy between the presentists and eternalists (Savitt, 2004) and between the tensers and detensers (Butterfield, 1984). The problem is not the change in the rate of flow of time, which could result from a variation in some internal clock rate within the brain, but the fact that time flows at all.

This also relates to the problem of free will. In a mechanistic universe, a physical object (such as an observer's body) is usually assumed to have a well-defined future world-line. However, one intuitively imagines that at any particular experiential time there are a number of possible future world- lines, as illustrated in Figure 7(b), with the intervention of consciousness allowing the selection of one of these. Admittedly, this choice may be illusory but that is how it feels. The middle line in the figure shows the unchanged (mechanistic) future, while the other lines show two alternative (changed) futures. This view implies that the past is fixed but that the future is undetermined.

Another question which arises is how the "beads" of different observers are correlated. If two observers interact (i.e., if their world-lines cross), they must presumably be conscious at the same time (i.e., their "beads" must traverse the intersection point together). However, what about observers whose world-lines do not intersect? Naïvely identifying contemporaneous beads by taking a constant time slice, as illustrated by the broken line in Figure 7(c), might appear to be inconsistent with special relativity, since this rejects the notion of simultaneity at different points in space. On the other hand, the notion of a preferred time is restored in general relativity because the large-scale isotropy and homogeneity of the Universe single out a special "cosmic time" measured by clocks comoving with the cosmic background

expansion. Even for an inhomogeneous cosmological model, preferred spatial hypersurfaces can be identified as the ones with constant proper time since the Big Bang (Ellis, 2006). This may be a necessary ingredient of a growing block universe model (Earman, 2008).

The failure of relativity to describe the process of future becoming past and different possible future world-lines may also relate to quantum theory (Butterfield, 2012). This is because the collapse of the wave-function to one of a number of possible states entails a basic irreversibility. One way of resolving this is to invoke the "many worlds" picture of Hugh Everett (1957), which is reminiscent of the representations in Figure 7(b). Although one must be wary of interpreting free will itself as a quantum effect, because the latter is intrinsically random, both violate determinism. One also needs some concept of simultaneity at different points in space in quantum mechanics in order to describe the Einstein-Podolsky-Rosen (1935) paradox. The problem of reconciling relativity theory and quantum mechanics may thus connect to the problem of understanding consciousness.

One way of describing the passage of time – originally suggested by C.D. Broad (1923) – is to adopt a a second type of time (t_2), or at least a higher dimension, with respect to which our motion through physical time (t_1) is measured. This is illustrated in Figure 8(a), which represents the progress of consciousness as a path in a 5D space. At any moment in t_2, a physical object will have either a unique future world-line (in a mechanistic model) or a number of possible world-lines (in a quantum model). The intervention of consciousness or quantum collapse allows the future world-line to change in the first case or to be selected from in the second case. Since the future is not absolutely predetermined in this model, there is still a difference between the past and the future. As illustrated in Figures 8(b), at any point in t_2 the past in t_1 is uniquely prescribed but the future is fuzzy.

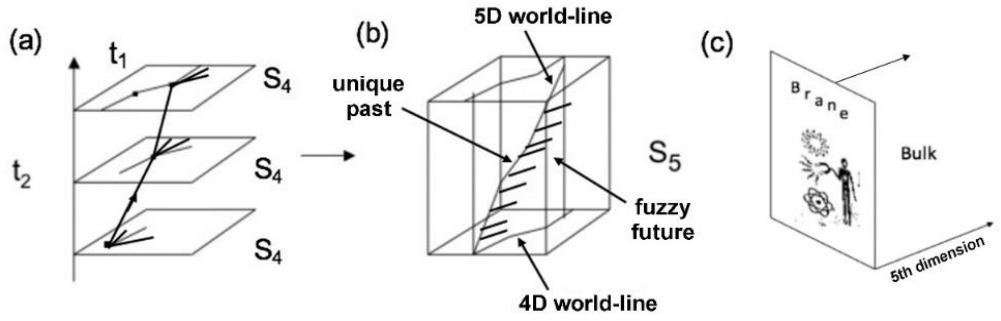

Figure 8. (a) Describing passage of time with a second time dimension. (b) Associated 5D structure. (c) Comparison with brane cosmology.

The invocation of an extra dimension is reminiscent of the "serial time" approach of J.W. Dunne (1927). He also invoked an extra dimension to explain the flow of time but went further. Since consciousness is moving through t_2, he argued that one also needs a third time (t_3) in order to describe this motion, and then a fourth time (t_4) to describe the motion through t_3 etc. Dunne's approach therefore had the unpalatable feature that it led to an infinite regress. No such regress arises here because t_2 is not introduced to describe motion through t_1 but to assign a time coordinate to mental sense-data. Indeed, there might in principle be other time dimensions associated with other perceptual modes since the different t_r just corresponds to the different windows through which consciousness perceives the world.

This interpretation of the flow of time may also be suggested by the Randall-Sundrum proposal, in which space-time is regarded as a 4D brane embedded in a 5D bulk. In the simplest case, the brane corresponds to the flat space-time of special relativity. However, there is a cosmological version of this picture – called "brane cosmology" – in which the brane is curved and space is expanding (Maartens, 2004). The cosmic expansion can then be interpreted as being generated by the brane's motion through the 5th dimension, as illustrated in Figure 8(c). The present proposal identifies this 5th dimension with the extra dimension associated with mental time. It therefore uses a cosmological model to resolve a long-standing philosophical problem.

PSYCHO-PHYSICAL SPACE-TIME

The model proposed above should be seen within the context of a long history of philosophical enquiry into the relationship between physical and perceptual space. That these spaces are ontologically different was first stressed by philosophers like Freddie Ayer (1940) and Bertrand Russell (1948). The prime feature of our proposal is that perceptual space exists in its own right rather than just inside our heads. Even the staunch reductionist Francis Crick (1995) advocated this: "The reason we have such a vivid impression that the visual field is a picture of the external world, when no such picture can be found in the brain, may be that such pictures exist in a different space system from the one in which the brain is located." Indeed, perceptual psychologists study the geometry of phenomenal space (Rosar, 1985).

More radical is the proposal that these two spaces can be merged into a single space of more than three dimensions. This suggestion was first made by C.D. Broad (1923, pp. 392–93): "It is impossible that sensa should literally occupy places in scientific space, though it may not, of course, be impossible to construct a space-like whole of more than three dimensions, in which sensa of all kinds, and scientific objects, literally have places. If so, I suppose that Scientific Space would be one kind of section of such a quasi- space, and *e.g.*, a visual field would be another kind of section of the same quasi-space." The notion that phenomenal space should be afforded equal status to physical space was taken further by John Smythies (1956), who explored the relationship between these spaces implied by developments in neurology and introspectionist psychology. He argued that physical and phenomenal space-time should be regarded as different cross-sections of a single higher-dimensional space. We experience only phenomenal events but some of these represent physical events, and there is then a causal relationship via the brain, like the causal relationship between events in a TV studio and on a TV screen. These ideas were developed by H. Hart (1965), H.A.C. Dobbs (1965) and Smythies himself (1994, 2003, 2012).

In the current proposal, the relationship between perceptual and physical space is rather similar to this but more subtle, perceptual space being a complicated projection of 4D space-time. Also, it has been argued that one needs a separate time dimension to describe mental experience. The amalgamation of these two arguments suggests that a unified description of perception must involve a 5D reality structure S_5. As illustrated in Figure 9(a), physical space-time (x,t_1) and phenomenal space-time (x,t_2) are just different slices of (x,t_1,t_2) space where x denotes the spatial coordinates. Although this might be described as a "psycho-physical" model, to avoid terminological confusion, I will describe S_5 as a "hyperphysical space" and reserve the term "physical space" for S_4 since the latter is the one accessible by physical sensors. However, it must be stressed that physical and phenomenal space are equally "real" from a 5D perspective.

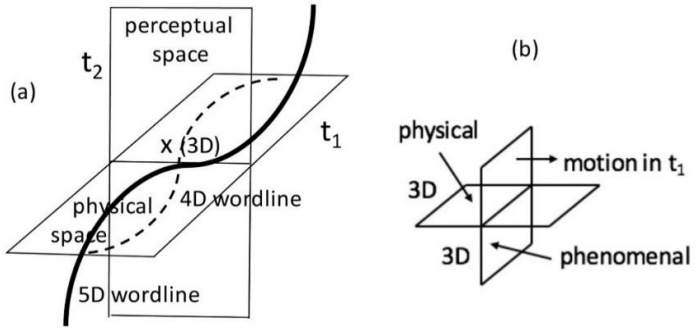

Figure 9. (a) represents a unified 5D psychophysical space with 3D phenomenal and physical spaces having distinct times. (b) represents Smythies' original model, in which there is a separate 3D perceptual space in motion relative to the physical 3D space but no extra time dimension.

This model might be compared with that of Smythies. In his original model, physical and phenomenal space-time have a separate set of spatial dimensions but a common time dimension, so he requires seven

dimensions for each observer, as illustrated in Figure 9(b). Also his original model makes no connection between the phenomenal spaces of *different* observers, so if there are n observers, he needs $3n+4$ dimensions. But the whole point of the present approach is that the different phenomenal spaces are supposed to be different slices of a single 5D space. His later model is also 5D but differs from the present one in that the 5th dimension is an extra space coordinate rather than a second time coordinate t_2. He envisages the phenomenal plane moving through the physical plane but this motion is not itself described by the model because he chooses not to spatialize t_2. Obviously, however, the two diagrams look similar.

Our 5D model for physical perception also has interesting implications for the nature of memory. The mainstream view is that all memories are stored in the brain, but this is hard to demonstrate since we do not yet understand the process of memory storage. Furthermore, if percepts are not inside the head, the same must apply to memories of those percepts. Indeed, the view encouraged by Figure 6(b) is that memories of physical events reflect the direct access of consciousness to the physical space-time which contains those events. For since what is past relative to physical time (t_1) may be experienced concurrently with respect to mental time (t_2), the brain need not store the memory itself but only some link to the original space- time event. This suggests that it contains a tag rather than a trace. This accords with Culbertson's model of memory, although higher order cognitive processes in the brain would still influence the form of the memory and induce distortions in it. However, there is a subtle difference from Culbertson's model since this does not invoke a fifth dimension. This reflects the fact that the *experience* of memory is associated with S_5 rather than S_4.

The crucial feature of this proposal is that the distinction between mind and matter becomes blurred. In the words of Paul Brunton (1941), "we must learn to mentalize space and spatialize mind". Also mental space in some sense becomes *communal*, which suggests that individual minds are connected as part of some Universal Mind, as asserted by Ralph Waldo Emerson (1983, p.237): "There is one mind common to all individual men". It also suggests that individual consciousness is part of a Universal Consciousness, as asserted by David Bohm (1986, p.41): "Deep down the consciousness of mankind is one". This implies that the brain is a filter rather than a producer of consciousness, as argued by Aldous Huxley (1954). However, this still leaves open the question of the nature of self-identity and this is addressed next.

THE SPECIOUS PRESENT AND THE NATURE OF SELF

The invocation of a second time dimension, as represented in Figure 8, only generates a *global* flow of time and does not describe the sense of individual identity (or 1st person perspective). This is because the experience of time – and hence the existence of consciousness itself – only makes sense with respect to what is termed the specious present (SP), which might be regarded as the minimum timescale of experience (Dummett 2000). Of course, we can intellectualize about shorter timescales or construct instruments to measure them but we cannot *experience* them directly.

The concept of the SP was first introduced a long time ago (Kelly, 1882) but can be understood in modern times as arising because our physical sensory systems have a resolution time somewhat below 0.1 second and so we cannot observe a process shorter than this. For example, if a light source moves in a circle around some central point faster than around 10 times per second, then one just sees a continuous circle of light rather than motion. So in some sense time becomes space-like on too short a timescale. There is a similar effect for all perceptual processes, whatever the sense mode. Indeed, it has been suggested that consciousness is associated with a brain-scanning process of 40Hz, which corresponds to a time of 0.025s (Gold, 1999). More recent experiments suggest that the SP is of order a millisecond (Hertzog et al., 2016).

There is also an *upper* limit to the timescales we can experience since our brains are not aware of changes that are too slow. For example, if mountains were "talking" to each other through seismic shifts on a timescale of millions of years – though this is not being suggested! – we would not be around long

enough to appreciate the fact. One would have to speed the tape-recording up a million times to listen into the "conversation". The upper limit on the timescale for human consciousness cannot be specified as precisely as the lower limit. Clearly it would need to be below 100 years, since brains do not last longer than that, but in practice we do not notice changes on far shorter timescales. Since the apprehension of change depends on a comparison of systems at different times, it probably relates to the timescale associated with short-term memory. We mainly focus on the minimum SP timescale.

Although the SP is well-determined during the usual waking state and roughly the same for everyone, it appears to change in some circumstances, in the sense that the passage of internal (mental) time may change relative to that of external (physical) time. For example, in a circus, the SP becomes shorter for a trapeze artist, so that external time slows down. On the other hand, it becomes longer for a balance artist, so that external time speeds up. The change may be more dramatic in some circumstances. For example, time may slow almost to a halt during an accident (so that external events appear to freeze) or speed up during a fever (so that the rising and setting of the sun appears as a flickering light at the window). The SP may also change as a result of taking certain drugs. Presumably all these variations can be described by neuronal processes, as illustrated in Figure 10, in the sense that the brain has some internal clock whose rate may change somewhat. Indeed, there is a huge neuroscientific literature on time perception and its variability (Eagleman, 2005).

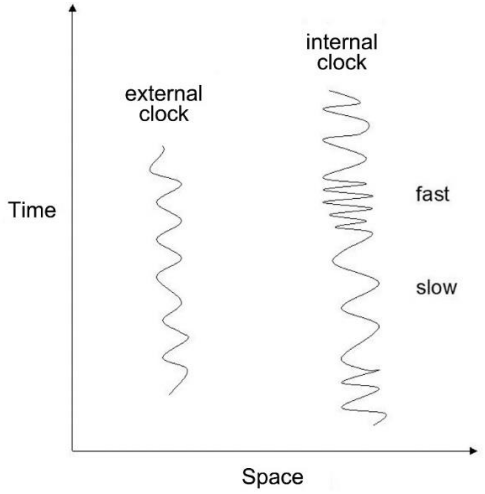

Figure 10. Illustrating how psychological time can appear to speed up or slow down relative to external physical time due to variation in internal brain clock.

Some reported changes in the SP are even more dramatic. For example, in some dreams a short period of external time may correspond to a far longer dream time and in a Near Death Experience one may see one's whole life 'instantaneously'. In certain mystical states, the changes in the SP may be even more extreme, sometimes shrinking almost to zero, so that only the present moment exists, or expanding almost to infinity, so that the entire history of the entire cosmos appears to be instantaneous. Ed Kelly (personal communication) points out a similarity between the description of mystical experiences produced through the stages of *samādhi* characterized by Patañjali and an early anatomist twisting the focus knob on his microscope: "It's as though the meditator is adjusting the focal length of his hyperphysical sensors and encountering systematically different worlds depending on the settings achieved." These states are described by I. K. Taimni (1961). On the other hand, Sri Aurobindo associates the *highest* state with pure consciousness, in which space and time cease to exist altogether.

It is not clear whether these more dramatic SP variations can be explained in neurological terms. This depends on whether the brain is a *generator* of consciousness (as most scientists believe) or merely a *filter* for it (Bergson, 1946). In the latter case, it is possible that consciousness can be decoupled from the brain in some circumstances, allowing more dramatic SP variations. Such a notion has also been advocated by Josiah Royce (1901).

The fact that we only experience consciousness over a few orders of magnitude of time ($0.1 – 10^3$ s) is similar to our only perceiving electromagnetic radiation over the narrow range of frequencies associated with visible light. This suggests that there could be other forms of consciousness in the Universe – not necessarily associated with brains and perceiving the world through organs sensitive to a different frequency range – with a very different SP from humans. Indeed, since complex physical structures exist over a vast range of scales, it is not inconceivable that these could also be associated with consciousness (i.e., contain memories and an internal model of the world). For example, if computers ever develop consciousness, perhaps they would have a SP of order nanoseconds and maybe there are life-forms with a SP of order millions of years.

The notion of the SP is also relevant to the problem of personal identity (i.e., how does what we have termed "Universal Consciousness" fragment into a myriad of individual consciousnesses – why am I me?). Since one's identity is defined by the sequence of unique perspectives of the set of events provided by one's brain (i.e., one's memories), it must be associated with the nexus of space-time connections shown in Figure 6(b). However, there can be no experiences to remember on a timescale less than the SP. Nor can one's sense of identity persist on a timescale longer than one's lifetime. Thus the disappearance of time on long and short timescales also implies the dissolution of personal identity. An analogous problem arises in the *spatial* context. For if one were to view the dog in Figure 3 with a resolution much smaller than the interatomic spacing, there would be no clue that one was looking at a single coherent structure. Similarly, the dog would lose its identity if one looked at it from such a large distance that it could not be resolved.

Of course, identifying oneself with a 4D nexus of signalling world-lines in space-time does not solve the problem of identity, because it does not explain why one associated with a *particular* nexus. However, expanding the nexus to higher dimensions does elucidate this problem. This is because two lines which are disconnected in a lower-dimensional space may be connected in a higher-dimensional one. Thus, while one has a distinct identity at the level of t_1, one may be connected with other consciousnessses at the level of t_2. The multi-level time perspective therefore explains how there can be many manifestations of a single unitary consciousness.

So what are these higher levels of consciousness? Since the Earth has a collective memory and intelligence, one might speculate that there is a *planetary* level of consciousness. Similarly, if some of the billions of other stellar systems in the Galaxy harbour intelligent lifeforms, we may eventually be able to communicate with them and gain access to some collective interstellar intelligence. This would correspond to a *Galactic* level of consciousness. Since there are billions of galaxies in the Universe, one might even speculate that there is a *cosmic* level of consciousness. These possibilities are depicted in Figure 11, where the timescales indicated are just notional and associated with physical processes on these levels. It would be very difficult to communicate with such forms consciousness but that does not mean that they do not exist and they might conceivably be contacted in mystical states.

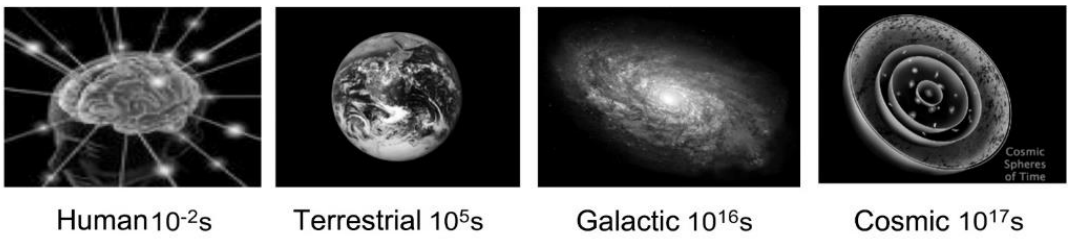

Figure 11. Hierarchy of SPs associated with different levels of physical structure.

NON-PHYSICAL REALMS

The discussion up to now has only covered those percepts (including memories) which derive from the physical world. But what about the percepts (such as dreams and imagery associated with altered states of consciousness) which have no physical counterparts? The controversy between direct realism and representative theory is different in this context since one might argue that the percept is now primary and that there is no outside world to be represented. However, there still seems to be a space, as stressed by J.H.M. Whiteman (1986, p.6): "in all kinds of nonphysical sensing, objects have extension, position, direction and shape, and are capable of being moved about in that space relative to other objects there".

This is clearly evident in dreams, where the space appears so similar to physical space that it can sometimes be difficult to determine whether one is awake. Indeed, H.H. Price (1953, p.33) suggested that dream space and physical space are causally related parallel universes: "we inhabit these two worlds simultaneously, the world of common experience governed by physical law and another space, quite as real, which obeys other laws ... a continuous dream-life goes on all through our waking hours, and ... occasionally we may catch a glimpse of it". This implies that dreams are going on all the time but only occasionally accessed by consciousness. A.N. Whitehead (1922, p.5) expresses a similar view: "The dream-world is nowhere at no time, though it has a dream-time and a dream-space of its own"

Transpersonal experiences suggest the existence of even "higher" spaces. So just as S_5 merges physical and phenomenal space for physical percepts, maybe one can envisage some form of merged space for all types of percepts. This possibility motivates an extension of the 5D model of perception in which the reality structure has further extra dimensions. With the addition of each dimension, the number of "objects" and "sensors" incorporated increases, so one generates a hierarchy of reality structures of increasing dimensionality (S_4, S_5, S_6,...). One eventually reaches a maximum dimensionality D, at which point one has extended the reality structure as much as possible. The final one (S_D) is termed the *Universal Structure* and represented symbolically in Figure 12 by a hypercube (the 4D analogue of a cube). The lowest member of the hierarchy is taken to be the 4D reality structure of special relativity (S_4). The dimensionality of each mental perceptual fields M_i is unclear, so it is symbolized by a cube.

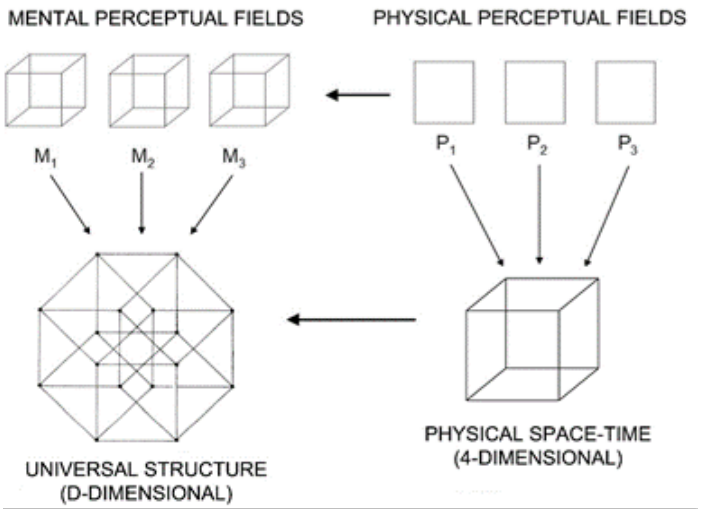

Figure 12. Illustrating how the notion of a reality structure can be extended to include non-physical percepts by generalizing from a 4D structure to a higher-dimensional one.

The crucial step in this proposal is the identification of the Universal Structure with the higher-dimensional space of modern physics. In particular, it is related to the Randall–Sundrum version of M-theory, illustrated in Figure 2, in which the physical Universe is regarded as a 4D brane in a higher-dimensional bulk. For if physical objects occupy only a limited part of that higher-dimensional space, it is natural to ask whether anything else exists there. Since the only nonphysical entities which we

experience are mental ones, and since it has been argued that all mental experiences have to exist in some sort of space, it seems natural to associate this with the "bulk". The fact that the phrases "bulk" and "brane" are adopted need not imply commitment to M-theory itself. However, one does require some form of higher-dimensional model.

But what is the nature of the extra dimensions? In standard M-theory they are spatial and compactified on the Planck scale. However, in principle the compactification scale could be much larger and we have seen that one dimension is extended in brane cosmology. On the basis of the above discussion of the specious present, it is tentatively suggested that the extra dimensions could be compactified on a hierarchy scales, with each scale relating to a particular SP.

CONCLUSION

This essay has argued that some future paradigm of physics may accommodate mind – not just implicitly (in the sense suggested by anthropic arguments or some interpretations of quantum theory) but also explicitly (in the sense of linking mental space to physical space). Of course, the term "mind" has many connotations, so this proposal does not aspire to provide a complete theory of mentality. We have only focussed on its perceptual aspects since these involve the metrical features which relate to physics. We have mainly confined attention to the perceptual space associated with the physical world. In this context, the key point is that both percept and object are viewed as the projections of some higher-dimensional structure, so the distinction between matter and mind becomes blurred. Although this approach can be extended to other types of percepts (cf. Carr, 2015), whose link with the physical world is less direct, their ontological status is less clear, so we have only mentioned them briefly.

We have stressed that the problem of consciousness links two longstanding philosophical problems: (1) the relationship between physical space and phenomenal space; (2) the passage of time. The proposed model connects these problems by regarding physical space and perceptual space as slices of a 5-dimensional space, with the 5th dimension being associated with mental time, as distinct from physical time. This notion may be consistent with the model of brane cosmology since this also has an extended 5^{th} dimension. From a philosophical perspective the model has features of idealism (Kastrup, 2019) and panpsychism (Strawson et al., 2006). However, the meaning of these terms may need to be revised in a paradigm which extends physics to accommodate mind. In the context of a model which distinguishes between Universal Mind and individual mind, the model might be classified as Idealistic but not idealistic.

The key problem in this paradigm is explaining how Universal Consciousness fragments into a myriad of individual consciousnesses. We have argued that this requires the notion of a specious present and suggested that there could be a hierarchy of consciousness operating in the Universe, corresponding to a hierarchy of specious presents. Linking this to a hierarchy of compactified extra dimensions, such as might arise in some models of particle physics, is clearly very speculative and certainly does not represent mainstream physics. Indeed, most physicists will be very sceptical of this idea since the invocation of higher dimensions is often disparaged even within standard physics. Nevertheless, the proposed model illustrates how physics might at least in principle be extended to accommodate mind.

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