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The Nature of Consciousness and its Relation to the Brain

The Pith of a Formidable Problem and its Possible Solution

Abstract: *This paper presents an enquiry into the essential nature of phenomenal consciousness and its relation to the neural correlates of consciousness in the brain (NCCs). It first combines critical accounts of current ideas about the nature of NCCs themselves and about what constitutes phenomenal consciousness. This is followed by an examination of how these two may be related with a particular focus on pointing out the defects in the currently most popular hypothesis in this field, namely the identity theory. The conclusion is that we need a better theory. A candidate for this theory is presented in some detail that involves higher-dimensional geometry.*

Keywords: consciousness; cortical networks; NCCs; epigenetic code; body image; Leibniz's Law; identity theory; stroboscopic patterns; special relativity; time; higher-dimensional space.

Introduction

At the present time the general opinion in the neuroscience community is that 'consciousness' is identical with the electrical activity of assemblies of neurons in the cortex arranged in a series of interconnected networks. These include the cognitive control network (CCN), the default modal network (DMN), and a number of salience networks (Cole *et al.*, 2010; Heine *et al.*, 2012). A role is also allotted to cortico-

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thalamic and cortico-claustral networks (Smythies *et al.*, 2012). In all these systems, synchronized oscillations play a major role. The global workspace theory proposes that consciousness depends on coherent neuronal activity between such groups, in particular fronto-parietal areas (Bartolomei, 2012). Such fine-grained differentiated and complex activity can be disrupted by excessive synchronization leading to loss of consciousness, as in the case of epileptic discharges (*ibid.*; Smythies and Edelstein, 2013a). Using an operational architectonics strategy based on the EEG, Fingelkurts *et al.* (2013) showed that in vegetative states, as compared with minimally conscious states, neuronal assemblies become smaller, more transient, and desynchronized. Melloni *et al.* (2007) performed an EEG study during a delayed matching to sample task related to the processing of perceived and unperceived words. They showed that both perceived and non-perceived words caused a similar increase of local (gamma) oscillations in the EEG, but only perceived words induced a transient long-distance synchronization of gamma oscillations across widely separated regions of the brain.

However, this account lacks clarity in three aspects. The first is what is the exact nature of a neuron's activity that leads to a conscious experience? Is it just the pattern of action potentials (spikes)? Or are dendritic sub-threshold potentials involved? Or is it the total electrical field? Or some combination of these? The second concerns the nature of the 'consciousness' that such activity is supposed to give rise to. The third is what is the nature of the correlation in NCCs? All these topics are currently in a state of some confusion but I will start with the second.

The Nature of Phenomenal Consciousness

The current confusion surrounding this concept is multifaceted and has ancient roots. Francis Crick (1995) famously stated that consciousness cannot be defined; it can, however, be described. The content of phenomenal consciousness (as opposed to 'consciousness' on the coma–waking scale, and to purely 'subjective' ego-related aspects) consists of our sensations, images, feelings, and thoughts as experienced. In the case of vision, for example, a conscious observer experiences an organized visual field 'out there' that is composed of shaped colours in a constant state of movement. These aspects have been studied by phenomenologists (such as Smythies, 1959a,b; 1960; Vernon, 1962; Gregory, 1981; Ramachandran and Blakeslee, 1998; Smythies and Ramachandran, 1998; and many more), who study the

contents of phenomenal consciousness in such phenomena as the filling-in of scotomata, after-images, eidetic images, constancy effects, number forms, the stroboscopic phenomena, hallucinations of various kinds, synaesthesiae, a very wide range of the effects of brain injuries on our experience, and many others. These studies produce information about the nature of phenomenal consciousness itself, which could not have been obtained by neurophysiological, behavioural, or brain-imaging methods.

Here we encounter the first source of confusion that is due to the failure to disentangle two mutually incompatible theories of perception, namely the 'naïve realism' (NR) of common sense and the scientific 'representative theory' of perception (RT). The former holds that these colour patches are literally the surfaces of external physical objects; the latter holds that they are literally constructs of the representative mechanisms of perception, and are in no way literally parts of external physical objects. The confusion arises in part because, whereas neuroscientists may support RT in the lab, they usually revert unwittingly to NR in the course of their own everyday lives.

The nature of this distinction may be clarified if we study how vision returns after injuries to the visual cortex (Schilder, 1942; Brown, 1988). Schilder, and his colleagues Goldstein, Gelb, and Poppelreuter, had access to a unique population of German soldiers with punctate shrapnel wounds of the brain during World War I. The first stage in the patients' recovery is seeing pure motion, usually rotary, without any form or colours. Then colours appear in the form of space or film colours but no objects. This is followed by the appearance of parts of objects that coalesce to form complete objects, into which the space colours enter to form the complete percept. This is explained by the fact that movement, colour, and shape are computed in different brain areas that show a differential recovery rate after injury. This phenomenon indicates that the tripartite visual mechanisms literally construct the phenomenal objects seen, and thus refutes the NR hypothesis. Another way to make this point is to follow Schilder's (1942) method of using primitive states of perception. Take, for example, the difference in the phenomenal visual field found in cases of retinal and cortical blindness. The former retain a visual field even though it is always uniform and black(ish); whereas the latter do not see anything, not even blackness. In fact they do not see at all, which they find terrifying. Thus the primitive visual field is a limited uniform area of black — black being a positive colour and not simply the absence of colour. It follows that a person's visual field can be described as a particular existent that has properties, namely a

limited spatial extent of coloured patches in constant movement. Wright (1983) argues for the existence of a 'phenomenal field' in which sensations and after-images are located as a primary field that actually exists. Fitzgerald (1978) says 'None [visual sensations] are located out in physical space: all are in a visual phenomenal space with causal relations with the observer's brain in that the brain's doings produce the sense-data in this space, and indeed the space itself'. The neurologist Jason Brown (1991) gets it right I think: 'Space itself is an object: volumetric, egocentric, and part of the mind of the observer… Mind is positioned in a space of its own making… We wonder about the limits of the universe but never ask what is beyond the space of a dream.'

There is a similar situation in the somatosensory field where we encounter an almost universal confusion between the neurological body image and the physical body (Smythies, 1952). Again common sense believes that the oh-so-familiar 'body' a person experiences throughout her waking life simply is her physical body. However, the fact is that we do not experience any extracerebral events in the physical body — only events in the body image — which is another construct of our representative mechanisms. As Schilder (1950) said, '…the empirical method leads immediately to a deep insight that even our own body is beyond our immediate reach, that even our own body justifies Prospero's words "We are such stuff as dreams are made on and our little life is rounded by a sleep"'. Thus the apparent 'out there' location of the visual field reflects, not the location of physical object in relation to the physical body, but the relation between the phenomenal visual field and the phenomenal body image.

The point of these examples is to show that the physiological mechanisms that mediate vision and somatic sensation do not engineer the experience of external physical objects and of our own bodies. We never experience external objects or any events in our own bodies in any way. Instead these mechanisms construct internal copies of these within phenomenal consciousness, and it is these copies that the observer describes by phenomenological experiences. From the point of view of brain–consciousness relations this entails that the physiological mechanisms of perception have an internal end stage, which is the construction of these sensory fields some of whose properties we can directly observe, e.g. that a red, round after-image has the properties 'red' and 'round'. Indow (1991) sums this up as follows: 'Visual space is the final product of the long series of processes from retina to brain, and phenomenologically it is articulated into individual objects, backgrounds and Self.' Theories of this relationship need to take

account of this end stage described by Crick (1995, p. 159) as 'a vivid internal picture of the world'. For an excellent review of phenomenal space see French (1987). The problem therefore is how is this vivid internal picture constructed?

We can picture the problem in the following way. The present scientific account of what is going on describes a human as a robot that has a variety of sensory inputs the information from which is fed to a vastly complex computer that selects and executes the behaviour appropriate for each circumstance. In all such complex computational systems there is an advantage of having an internal model that extracts and processes the most important informational features — like Churchill's War Room that Smythies *et al.* (2012) used in their model of such activity of the claustrum. This would include a sensory 'map' of what is going on in the environment. But there is no need for such a map in the robot's 'brain' to model, say, a house being looked at, by creating a miniature picture of the house in its 'War Room'. All can be done by processing the numbers in its neuronal software. Yet, in real humans, what is the mechanism whereby Crick's 'vivid pictures' are constructed in the phenomenal visual field?

Previously this problem was obscured by the folk psychological belief (i.e. naïve realism) that such 'pictures' were 'direct views' of the physical objects themselves. Now that we know that naïve realism is an impossible hypothesis, we have to look elsewhere for answers. The point of this paper is to argue that one proffered replacement — i.e. the identity theory — is also an impossible hypothesis.

This leads to the next step, which is to point out that there are formidable difficulties with the identity theory, which claims that these events in phenomenal consciousness are identical with certain events in the brain. The first difficulty is that this hypothesis fails to conform with Leibniz's Law of the Identity of Indiscernibles. This law states that, if A is identical to B, then they must have all properties in common: whereas events in neurons and their electrical fields on the one hand, and the phenomenal events described above on the other, have a number of properties (shapes, sizes, colours, movement), but none in common. For example, the neuron that participates in neural events is grey (according to Hercule Poirot), whereas the related after-image mentioned above — allegedly identical with activity in a collection of neurons — is red. The second problem is that 'identity' is a transitive relationship: if A is identical to B, then B is identical to A. We are used to suggestions that conscious sensations are nothing but events in certain neurons, but we are not used to the idea that this logically entails that certain neurons are nothing but events in conscious sensations.

For example, if we look at a red square on a black ground, we find it difficult to accept what the identity theory says — that the red patch is actually composed of (identical with) a group of neurons, and that the black surround is also composed of (identical with) differently stimulated neurons. I will return to this topic later.

The Nature of the Neural Correlates of Consciousness (NCCs)

We will now turn to the question of what the NCCs may be that the identity theory states are identical with our conscious experiences. Two issues are prominent here.

The first is that the modality of a neuron (e.g. whether its activation results in a visual or somatic sensation) depends on whence its afferent inflow derives. Furthermore, the modality of a neuron derivatively depends on the fine detail of its molecular microanatomy.

The second is that the conscious experience generated by an activated neuron appears to depend on how that neuron is activated (e.g. by an axonal pathway versus a dendrodendritic syncytium).

To consider these in turn:

1) Studies of deafferentation and reafferentation in the sensory cortex (Ramachandran *et al.*, 1992; Ptito *et al.*, 2008) have shown, for example, that a visual sensory neuron can be changed into a somatosensory neuron by first cutting off its normal visual input and replacing it with a somatosensory one. This change is effected in part by the extensive epigenetic code that consists of particular and different protein transcription factors and various forms of RNAs (including microRNAs) transmitted by exosomes between the presynaptic terminal and the postsynaptic neuron (Smythies and Edelstein, 2013b). Thus the modality of a sensory neuron is determined by the origin of its afferent inflow.

   Linden and Schreiner (2003) have conducted a comparative study of the microanatomical and physiological properties of intracolumnar organization in the visual, auditory, and somatosensory cortex. They found that these consisted of variations on a series of common principles. These variations are brought about in part by the epigenetic code. This conclusion is interesting. The great differences between phenomenal entities as we experience them — between a sound as heard (or an entire Beethoven symphony), a visual phenomenal object as seen (or a transcendentally beautiful psychedelic vision), a touch on my hand (or a pain

in my foot), and an odour (say of baking bread) appear to be linked to small differences between patterns of intracolumnar activation, not in any particular neuron(s), but in any one of a certain class of sensory neuron. This leads us to enquire what features about these patterns of columnar organization are important beyond the subtle variations described by Linden and Schreiner (2003). Is it just the pattern of action potentials (spikes)? Or are dendritic sub-threshold potentials involved? Or is it the total electrical field? One aspect of this question is addressed in the next section.

2) There is experimental evidence that the conscious experience generated by stimulation of neurons can depend on how the neurons are activated. If, with both eyes open, we stimulate the retina with a flashing stroboscopic light, the subject will see a series of simple flickering geometrical hallucinations with such forms as parallel lines, grids, checkerboards, spirals, concentric circles, and mazes (Smythies, 1959a,b; 1960) called the 'bright phase'. Then, on stimulation of only one eye, the subject will see something quite different. At first she will report the same geometrical patterns, but these are soon replaced by another very different series of hallucinations, comprised of non-flickering oily swirls, called the dark phase. These are described as being like oil on water, or boiling lava, and are composed of two colours, usually red and green. These two types of patterns then alternate in a way reminiscent of retinal rivalry. Brown and Gebhart (1948) have obtained experimental evidence that retinal rivalry is indeed involved. Thus it is likely that the dark phase patterns are being generated in the temporarily deafferented neuronal columns connected to the closed eye by cortico-cortical connections from the adjacent and interdigitated columns connected to the open eye. The required connectivity between these columns might be provided by the collateral axons of the large glutaminergic cells of Meynart in layers III and VI that penetrate several columns (Li *et al.*, 2003). But in this case one would expect the subject to see bright phase patterns with the closed eye. Another more likely candidate is provided by the 'boundless' network of gap-junction linked dendrites of GABAergic interneurons, reported in layers II and III of the cat visual cortex by Singer's group (Fukada *et al.*, 2006), that connect different columns. In this way the 'shut eye' neurons could be modulated by continuous slow dendritic potentials that might translate into the slow continuous oily swirls

observed in the visual field. This evidence suggests that the same group of neurons would generate quite different NCCs depending on how they were stimulated.

But it still remains quite unclear how slow inhibitory potentials in visual cortical neurons translate into the oily bi-coloured swirls observed in the visual field. The identity theory, I suggest, fails to do so on account of Leibniz's Law. The best solution seems to be that the relations between brain events and phenomenal events is causal, and not one of identity. I suggest that we need to come up with a better theory that can further develop this suggestion and so avoid these problems (Smythies, 1994).

Steps Toward Constructing a Better Theory

In two previous papers in this journal and elsewhere (Smythies, 1994; 2003; 2012) I have presented arguments in favour of the hypothesis that phenomenal space-time and physical space-time are different space-times being both different cross sections of a higher-dimensional space-time. This entails that the universe consists of two different types of event. The first type consists of physical events located in physical space-time. Assuming that the two systems share a common time dimension, physical events can be located by a system of Cartesian axes in three dimensions. The second includes phenomenal events located in phenomenal space-time. To locate these we add a fifth space dimension at right angles to the first three space dimensions and the common Minkowskian time dimension.

From a geometrical standpoint the system consists of two tesseracts (4D structures) that intersect about a common 3D cube. In the simpler model provided by *Flatland* this may be represented by two intersecting 2D planes at right angles to each other in a 3D space. These share a common 1D line. A further description of this system will be given below in the discussion of the special theory of relativity.

We experience only phenomenal events, some of which represent physical events. Events in the two systems are connected by causal relations between a subset of physical events in a brain (i.e. NCCs) and a subset of phenomenal events that constitute the phenomenal consciousness of the person who owns that brain. In vision these causal relations are logically (but not mechanically) the same as the relations between events in a TV studio and events in the TV set that depict what is going on in the studio. In a TV studio–TV set relation only three space dimensions are involved. In the physical object–phenomenal object relation one extra space dimension is involved.

In contemporary physics, M-theory postulates that physical space-time has eleven space-time dimensions, of which all but three are curled up into tiny tubes so small that we cannot see them (Hawking, 2010). This statement betrays a regrettable lapse into the naïve realist theory of perception of folk psychology. The reality is that we could not see higher dimensions, no matter how tightly they are curled up or how large they are, because events in higher dimensions lie outside the range of light rays. In any case it is not necessary to claim that the extra dimension of space-time, needed to include phenomenal space-time, come from M-theory. It may well be additional to the eleven dimensions of M-theory. It is perfectly possible that higher dimensions of space-time exist and have contents as described in my hypothesis. As Hawking (2010) says, 'We cannot predict discrete features such as the number of large space dimensions…'

This hypothesis greatly simplifies our problem, for example, of relating phenomenal events in the visual field to the NCCs that gave rise to them. Francis Crick (1995) commented on the vivid impression we get that the visual field is literally a picture of the external world, whereas no such pictures can be found in the brain. The answer may be that such pictures do in reality exist, but they may be located in a different space system than the space system in which the brain is located. In other words, a human organism may be composed of two parts that exist in time — a 3D physical body and what we can call a 3D phenomenal module, both taken together extended in five space-time dimensions and not merely four.

The Historical Development of the Theory of Material Dualism

The earliest form of material dualism (MD) was put forward by Hindu psychologists of the classic era. They suggested that the mind was material like the body, but of a form of matter so diaphanous as to be undetectable by ordinary instruments. The great chemist Joseph Priestly took up this topic:

> But how anything could have extension, and yet be immaterial, without coinciding with our idea of mere empty *space*, I know not. I am therefore bound to conclude, that the sentient principle in man, containing ideas which certainly have parts [is] not the simple, indivisible, and immaterial substance that some have imagined it to be; but something that has real *extension* and therefore may have the other properties of matter. (Priestly, 1777)

The Cambridge philosopher C.D. Broad took the next, and very significant, step in 1923 when he wrote:

> For reasons already stated, 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. (Broad, 1923, pp. 392–3)

The next advance was contributed by the Oxford philosopher H.H. Price (1953), who saw that these two entities must be connected by a new type of causal relation that connects events in parallel universes. Further details of this new theory were supplied by Smythies (1956) who provided links with both neurology and introspectionist psychology. The concept that phenomenal space and physical space are ontologically different spaces has also been expressed by Ayer (1940), Russell (1948), and Moore (1971). Bernard Carr (2008) was the first physicist to enter this field when he published his theory that phenomenal space and physical space are both cross sections of a higher-dimensional space. He writes: 'My proposal is that mental and physical space can be integrated into a communal space which is higher dimensional, in the sense that it has more than the three dimensions perceived by our physical sensors. This involves what I call a "Universal Structure"' (see Smythies, 1994, pp. 149–50, for details).

The Role of Consciousness in Special Relativity

Contemporary 'common sense' thinks of the world as a collection of material objects extended in three-dimensional space and enduring in a separate Newtonian time. Special relativity unifies Newtonian space and time into space-time. It does not recognize any special universal 'now' of time. Instead, it states that objects consist, not of 3D entities enduring in time, but as 4D world lines existing and extended from the big bang to the big crunch. For example, the earth is not a spheroid circling the sun, but a stationary hyperhelix wound around the world lines of the sun. Thus the buildings of imperial Rome still stand — it is just that we cannot see them any more. The buildings of future cities already exist — but we cannot see them yet. It should be noted, however, that there is no more a distinguished present in Newtonian physics than there is in special relativity, so all times must be treated symmetrically in regard to the distribution of matter. So, if one wants to account for our psychological impression that there is a 'now' in

time and moreover that time in some way flows, we must look elsewhere than contemporary physics, whether Newtonian or relativity, to find it.

Since I am not a physicist I thought it best to expound much of the argument in the words of the following physicists and philosophers of physics who have addressed this problem:

> Each observer, as his time passes, discovers, so to speak, new slices of space-time which appear to him as successive aspects of the material world, though in reality the ensemble of events constituting space-time exist prior to his knowledge of them… the aggregate of past, present and future phenomena are in some sense given *a priori*. (De Broglie, 1959)

> Physics itself recognizes no special moment called 'now' — the moment that acts as the focus of 'becoming' and divides the 'past' from the 'future'. In four-dimensional space-time nothing changes, there is no flow of time, everything simply *is*… It is only in consciousness that we come across the particular time known as 'now'… It is only in the context of mental time that it makes sense to say that all of physical space-time *is*. One might even go so far as to say that it is unfortunate that such dissimilar entities as physical time and mental time should carry the same name! (Stannard, 1987)

Penrose (1994) says that in the universe described by special relativity '…particles do not even move, being represented by "static" curves drawn in space-time'. Thus what we perceive as moving 3D objects are really successive cross sections of immobile 4D objects past which our field of observation is sweeping.

This position is supported by Lord Brain (1963): 'Moreover when we describe what happens in the nervous system when we are concerned with the movement of electrical impulses in space (i.e. along neurons), and though we use physical time to describe these movements, we can never abstract from such an account time as we experience it psychologically.'

Others have come to the same conclusion. For example:

Quine (1982): 'A drastic departure from English is required in the matter of time. The view to adopt is the Minkowskian one, which sees time as a fourth dimension on a par with the three dimensions of space.'

Lloyd (1978): 'For the Quinean, what differences we see between past, present and future pertain to our limited mode of access to reality.'

Heller (1984): 'I propose that a physical object is not an enduring hunk of matter but an enduring spatio-temporal hunk of matter.'

Eddington (1920): 'Events do not happen: they are just there, and we come across them … [as] the observer on his voyage of exploration.'

Weyl (1922): 'The objective world simply *is*, it does not *happen*. Only to the gaze of my consciousness crawling upward along the life-line [world line] of my body does a section of this world come to life as a fleeting image.'

Werth (1978) makes the important point that this new formulation applies to somatic sensation as well as to vision:

> Our apparent body ['body image' is the neurological name for this] at each instant is simply a 'slice' of our four-dimensional body. That is the experiencing subject sequentially 'intersects' his four-dimensional body and 'projects' the sequence of three-dimensional intersections upon the 'screen' of his consciousness: his body appears to him as being ever changing though in physical reality it is a static and immutable four-dimensional object.

Lastly Broad (1953):

> …if we assume one additional spatial dimension beside the three we can observe, and if we suppose that our field of observation at any one moment is confined to the content of a {3,4}-fold which moves uniformly at right angles to itself along a straight line in the {3,4}-fold, then there is no need to assume *any other* motion in the universe. This *one uniform rectilinear* motion of *the observer's field of observation*, together with the *purely geometrical properties* of the *stationary* material *threads* in the four-fold, will account for all the various observed motions (various in both magnitude and direction) of the material *particles* which are the appearances of these threads in the successive fields of observation.

By the term '{3,4}-fold' Broad means a space-time that has three dimensions of space and one of time. By the term 'four-fold' he means the four-dimensional space-time of relativity. Broad also points out that this formulation requires two 'times'. Time 1 has become amalgamated with space into space-time. But a real time — t2 — is still required in which the 'observer's field of observation' moves through space-time. At what velocity? Eddington (1920) suggested this must be the velocity of light. Time 2 may correspond with Stannard's 'mental' time.

However, these statements raise a problem. De Broglie speaks of 'each observer', Lloyd of 'our limited mode of access to reality', Eddington of 'the observer', Broad of 'the observer's field of observation'. In these instances the terms 'observer' and 'our' cannot refer, as is usual, to the physical body of the scientist, for this is composed of

the 4D world lines of its constituent atoms strung out immobile in space-time, as is every other physical object. In contrast, Weyl talks of 'the gaze of my consciousness' and Werth of 'the experiencing subject'. The experienced 'now' of time in a block universe is where consciousness, or the experiencing subject, is, not where his or her physical body and brain are. As Alexander (1975) put it '…the present being a moment of physical Time fixed by relation to an observing mind'. Thus the observer in a block universe with a shifting 'now' of time must be some entity in addition to the physical body. So how could the conscious observer, or subject with its 'gaze of consciousness', be additional or external to the brain? As we saw earlier the new theory suggests that the consciousness module is indeed external to its brain because it is located in a space (brane) of its own that encloses the phenomenal space of a person's consciousness.

The question might be asked 'Is our subjective experience of time merely our phenomenal impression of the causal relations between the parallel brane of space-time and phenomenal space?' The answer is that we do not experience these postulated causal relations that connect the contents of the brain located in physical space-time and of the consciousness module located in phenomenal space-time. What we experience are the *end results* of these causal relations — namely our own sensations, images, and thoughts.

Thus to recapitulate, the system proposed consists of two components. The first is the 4D Monkowskian block universe of special relativity that contains the world lines of physical objects, including those of the brain. This is intersected by a second 4D system that contains mind stuff, including the events in the different phenomenal spaces belonging to different humans, just as two 2D planes can intersect in a 3D space. This can be generalized to the statement that any two (x) D spaces, located in an (x+1) D space, can intersect and share a common (x–1) space. To account for the 'now' and the movement of time we posit that the two systems are in relative motion in real time t2 along the Minkowskian time axis from the past to the future. This entails that both systems share a 3D space at, and only at, the locus of intersection. This makes the proposed interactions between the mechanisms in phenomenal space, that actually construct what we observe in phenomenal consciousness, and their correlated brain mechanisms easier to picture. This is because, at the 'now' of time, and only then, the two systems share a common 3D space. Thus information can be exchanged between the two systems and does not have to cross a dimensional interface. A dimensional interface is the surface that an N

dimensional space presents to an N+1 dimensional space surrounding it: e .g. the surface that a plane presents to a cube that it intersects.

Linde's (1990) theory of consciousness suggests that, in a comprehensive physical theory of the universe, space-time, matter, and consciousness will all become ontologically equal partners in a single overriding physical reality in a multidimensional hyperspace. Wagner (2006) takes a similar position: 'I believe… that consciousness is at least as important and fundamental as the physical world.' Linde himself does not discuss what the nature of consciousness might be other than its independent ontology. Nor does he comment on what might be the nature of the relations between a consciousness and its brain. However, some of the details of this hypothesis have been filled in by the people quoted such as Price, Broad, Russell, and myself. My own contribution to this theory is to present the case that a consciousness may have its own space-time system and its own system of ontologically independent and spatio-temporally organized events (sensations and images) that have as much right to be called 'material' as do protons and electrons. Price (1953) and I also have suggested that the relations between a consciousness and its brain are causal. So the new formulation of reality might consist of the following ontologically equal partners — (A) physical space-time (10 or more dimensions) containing physical matter (protons, electrons, etc.); (B) phenomenal space as an intersecting not parallel universe containing mind stuff (sensations and images); and (C) real time (time 2). A and B are in relative motion along the time 1 axis *in* time 2. Their contents are in causal relations via the brain. The psychological 'now' of time marks the point of contact of the two systems.

Objections to the Theory

A common hypothesis in current use in this field is the idea that to solve the problem of how NCCs and phenomenal events are related it will be sufficient to pile up more data about each separately and more temporal correlations between them, for example by more extensive fMRI studies. However this is a category mistake. It will provide evidence that the two *are* correlated, and details of *which* events are correlated: but it does not explain the *mechanism* that is involved in this correlation. The philosopher A.J. Ayer (1940) made plain when he famously said that if one is trying to build a bridge across a river it does not help merely to raise one of the banks [or even both banks]: what is needed is the bridge.

Take fMRI studies for example. These provide quantities of information that a wide variety of stimuli induce a wide variety of changes in brain activity and the contemporaneous phenomenal events that result. For example, a visual stimulus pattern S1 induces a pattern of excitation A in one part of the cortex. This is accompanied by the subject experiencing a phenomenal event X in his visual field. Another stimulus pattern S2 induces a different pattern of excitation B in another part of the cortex. This is accompanied by the subject experiencing a different phenomenal event Y in another part of his visual field. Small changes in A induce small changes in X, and small changes in B induce small changes in Y. However, none of this answers the question 'Are relations between A and X (and between B and Y) relations of identity, or are they relations of causality?' This, in essence, is Chalmers' hard problem. Neuroscientists use other techniques besides fMRI in their studies of consciousness — transcranial magnetic stimulation (TMS) for example. This can be used to evoke conscious experiences by stimulating particular brain areas *in vivo* (see Ptito *et al.*, 2008, for example). However, the problem still remains as to how we relate the evoked neural activity with the experience.

Take, for example, a situation where a subject is looking at a square red after-image in the centre of his visual field. He can observe that the experience is of a phenomenal entity (a visual sensation) that has properties. It is red (and not green), square (and not round), and is located in the centre of his visual phenomenal field. He can further observe that it has topological properties — for example its boundary forms a Jordan curve that uniquely divides visual space into one inside and one outside. If he knew every detail of the NCCs concerned in this episode he would still not know what the relation is between the NCCs and the phenomenal experience. To do this he must use an hypothesis in the correct category. The correct category chosen depends on answering a fundamental question: 'Are NCCs and the correlated phenomenal events identical or not?' If they are identical that answers the question and nothing more can be said. If they are not, then the relation may be causal, or emergent, and the hypothesis has to be expanded to explain in what way they are not identical. For this there are currently two candidates besides the hypothesis presented in the paper.

Two Rival Theories

1. Cartesian dualism

The Cartesian hypothesis states that brain events are extended in space whereas mental events, including phenomenal events, are not. This theory is usually rejected on the grounds that extended entities and unextended entities cannot causally interact. However, this objection is invalid as there is nothing in the logic of causality to say that this is the case (H.H. Price, personal communication). That said, a fatal objection is that the theory holds that mental entities lack extension in space. This may be true for some mental entities such as thoughts, but it does not apply to visual and somatic sensations that certainly are extended in phenomenal space. The division between extended and unextended entities lies within phenomenal consciousness itself and not between it and the physical world.

2. The theory of emergent properties

A third possibility is that phenomenal events are emergent derivatives of brain events. Just as water has different properties from hydrogen and oxygen, so, it is argued, complex brain events could have different properties, i.e. phenomenal properties, from the neurons that comprise them. However, the objection could be raised that hydrogen, oxygen, and water may have different properties, but these are all physical properties, whereas neurons and sensations have different categories of properties — physical and phenomenal respectively. For example, a neuron has mass and is electrically charged, whereas a sensation does not possess these qualities. Even in the realm of the common property of spatial extension (in physical and phenomenal space respectively) there are over 30 different topographic maps of the external visual world in the cortex, whereas there is only one such map in phenomenal consciousness — the visual field. How can thirty maps be identical with one map? However, unlike Cartesian dualism, I suggest that this hypothesis should be kept in our portfolio.

Advantages of the theory of material dualism

One advantage of the theory is its simplicity. The geometry is elementary and the concept that there may be more than one form of matter in the Megaverse does not strain the imagination: neither does the concept that these two forms of matter are located in different 3D cross sections of a high-dimensional space and are linked by causal reactions of a format made familiar by television. The essence of these

ideas is contained in E.A. Abbott's nineteenth-century publication *Flatland* (1884). Moreover the theory is testable by experiment.

How to Test the Theory of Material Dualism (MD)

1. Experiments on reported 5D vision in NDEs

The Broad-Price-Smythies-Carr hypothesis (MD hypothesis) can also account for the remarkable findings reported by Jean-Pierre Jourdan (2000; 2010) in his examination of cases of near death experiences. In particular, he focuses upon the singular nature of the changes in the perception of the physical world that occur during the period when the EEG is flat. He confirms previous reports that (i) the interior of external objects can be seen in clear detail, as well as objects behind walls and inside cupboards, etc. (ii) Objects can be seen clearly and simultaneously from all directions. Normally when we look at someone we can see only his front side: in some cases of NDEs the subjects see his front, sides, and back simultaneously in a Picasso-esque way. (iii) The field of vision can expand to 360 degrees. This expansion can extend to the time dimension as well, and the object is seen as a 4D object in space-time as described in the theory of special relativity. A particularly detailed and comprehensive account of these phenomena in blind people has been given by Ring and Cooper (1997). Jourdan suggests that these experiences are based on the location of the observing Self in a fifth dimension relative to the events in the operating room, and other locations in the 4D spatio-temporal physical world, being observed in some cases of the NDE state. This hypothesis was independently suggested by Brumblay (2003). It seems to me unlikely that terminal neuronal activity in the dying brain would engineer phenomenal events as outré as 5-dimensional vision.

During an NDE what may happen may be a shift in its field of observation away from its normal site within the consciousness module, out into the wider phenomenal space around from where the physical world may be observed 'directly'. In the Flatland model this is equivalent to the Observer leaving his 'consciousness module' and looking down on Flatland from a point in Cubeland surrounding. It may be as though the prisoners in Plato's cave were released from the stakes to which they had been tied and were able to leave the cave and get a glimpse of the world outside.

Dr Jourdan is conducting an active research programme to test this hypothesis.

2. Other Experiments

Sir John Eccles (1953) suggested that there might be minute 'mind influences' (i.e. causal relations) at a high degree of 'poise' operating between the brain and phenomenal consciousness. I have suggested experiments to test this theory elsewhere (Smythies, 1994).

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