Paavo Pylkkanen

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Richard Bright: How does the brain maintain the mind?

Paavo Pylkkänen: Pretty much everyone taking part in consciousness studies agrees that the brain plays a key role in maintaining the mind. For example, when one is dreaming and having a visual experience, the same brain areas are activated as when one is awake and having a similar experience. Yet there are a growing number of those who think that we should not localize the mind entirely to the brain. The Finnish psychologist **Timo Järvilehto** gives a nice analogy to illustrate this critical stance. When we are driving a car, the steering wheel plays an important role. Yet it would be strange to say that driving is localized in the steering wheel. Similarly, Järvilehto says that certain brain areas clearly play an important role in thinking. However, he sees our thinking as a whole process that involves the organism and the environment. Thus, to understand thinking properly it would be too narrow to focus exclusively upon studying certain brain areas - just as to understand driving it would be too narrow to study the behaviour of the steering wheel. He says that the basic mistake in any locating of mental functions to parts of the brain is very simple: some part of the complicated system is equated with the whole result of the system.

Now, the way a philosopher would answer the question about how the brain maintains the mind depends upon her view about the nature and relationship of mind and brain. Here are just a few examples of such views. Traditional substance dualists assume that mind and brain belong to independent and separate substances that nevertheless interact. So for a dualist, the brain does not maintain the existence of the mind. However, because of the assumed interaction between the substances, the brain provides the sensory information to the mind, and also carries out the actions initiated by the mind. The trouble with substance dualism is that the substances are assumed to have nothing in common and thus the interaction is left mysterious and unexplained.

The brain-mind identity theory solves the problem of interaction by assuming that types of mental states (such as pain states) are identical with types of brain states (such as C-fibre firing). So when we talk about the mind we are really talking about the brain, and mental processes are a subset of neural processes. One trouble with the identity theory is that it seems to leave conscious experience completely unexplained. Many philosophers just don't understand how an objective, mechanical physical process (such as C-fibre firing) could possibly be the same thing as a subjective, qualitative experience (such as a pain experience).

Yet another view is functionalism which finds the brain-mind identity claim too restrictive or "chauvinistic". If a type of mental state (say pain) is assumed to be identical with a type of neural state (say C-fibre firing), this seems to exclude in principle the possibility that non-neural physical states (such as silicon-based states in artificial intelligence) could be pain states. Thus functionalists say that what is important is not so much the stuff that a state is made of, but rather the function that the state performs in the organism. So, for example, when it comes to pain, as long as a state can perform the sorts of functions that pain states perform in us, a state counts as pain. In functionalism the brain is typically seen as a "hardware" that realizes the mind, when the latter understood as a kind of "software". In principle the same software could be realized in some other type of physical system (say silicon-based), as long as the hardware can perform the relevant functions. Now, functionalists have traditionally tended to think that the nature of the hardware that implements the software is a secondary issue, while the real challenge is to understand the

mind as software. There is, of course, a sense in which the brain maintains (or realizes) the mind even for most functionalists, but they assume the mind has an autonomous, abstract existence as a "software" kind of thing. A major trouble for functionalism, just as for the identity theory, is conscious experience. Philosophers have produced a number of arguments that purport to show that functional or relational descriptions cannot capture the intrinsic, qualitative features of conscious experiences, such as the redness of red or the painfulness of pain.

RB: Can Mind affect Matter?

PP: Again, how we think of this depends on our underlying assumptions. An interactive substance dualist would say "yes". However, the problem is that it is very difficult to understand how a non-physical mind could possibly affect physical matter and vice versa. One worry here is the so-called principle of the causal closure of the physical domain. This principle states that if a physical event has a cause, then this cause can be described in entirely physical terms. Assuming a non-physical cause for a physical event would thus violate this principle that many philosophers accept. According to the identity theory it is simple to understand how mind affects matter. If mental states are physical states, then the question about mind affecting matter reduces to the question about matter affecting matter – that is, to the question of physical causality. Of course, philosophers have found even that question problematic, but for the identity theorist there is no separate question about mind-matter causality. But, of course, if the idea that types of mental state are identical with types of neural state does not make sense in the first place, this way of explaining how mind affects matter does not have much value. A functionalist, as we saw above, thinks of mind as a bit like software, so the question is whether the software affects the hardware. There is clearly a sense in which it does – for example, a robot will do different sorts of things if there are relevant differences in the software. But here we think of software as something implemented in the hardware – the form or organization of the hardware, if you like. From the point of view of physics it looks like all the causal influences are at the physical level of hardware, leaving no room for the causal efficacy for any non-physical, abstract or mental properties of the software.

RB: Do we need to radically rethink our understanding of matter in order to explain consciousness?

PP: I have briefly indicated above that there are serious problems with the traditional views. Dualism cannot explain the interaction of mind and matter, and the identity theory and functionalism seem to simply leave out consciousness, as **John Searle** has so vividly pointed out. Now, when you look at a typical mainstream debate in philosophy of mind, one issue is striking. The whole debate is framed as a problem between the physical and the mental, but very little attention is given to what "physical" actually means. As **Barbara Montero** has pointed out, it follows from this that the very mind-body problem itself is out of focus. It seems that most philosophers of mind are presupposing a common sense view of the physical, or else something along the lines of classical Newtonian physics. However, as is well known, there have been major revolutions in physics through relativity and especially quantum theory. It is not obvious that these revolutions are relevant to understanding the mind-matter relation or consciousness. But clearly, if the major candidate views in philosophy of mind seem hopeless, and if we know that scientific views of one side of the mind-matter equation (i.e. matter) have radically changed, I think it is legitimate to explore the possible relevance of quantum and relativity physics to understanding consciousness.

RB: David Bohm has been a great influence in your work. How does his concepts of active information and implicate order help to tackle problems in the philosophy of mind?

PP: To understand the significance of Bohm's work it is necessary to understand the development of physics in the 20th century. When quantum theory was emerging, people were trying to make sense of puzzling features such as wave-particle duality and a little later, entanglement. In particular they were attempting to develop ontological models of quantum systems such as electrons. In the 1920s de Broglie came up with the idea of an electron being a particle guided by a pilot wave, while Schrödinger was trying to describe the electron as some kind of a physical field. These models had some difficulties, though in retrospect we can see that at least de Broglie's ideas could have been developed further. What happened however was that the so-called "Copenhagen interpretation" won the day in the 1920s. There are actually many different versions of this interpretation, but it is typical of them that they emphasize epistemology – in the sense our ability to predict the results of measurement, rather than ontology – in the sense of a model of what quantum reality may be like also when we are not making measurements. As a result, physicists were not able to offer a new notion of objective physical reality, which philosophers could then use when discussing ontological issues, such as the mind-matter relation.

It is here that Bohm comes in. In 1952, after discussions with Einstein in Princeton, he independently rediscovered de Broglie's theory and formulated it in a more coherent way, providing a first consistent realistic model of quantum systems. Bohm's interpretation was initially resisted, but is today more and more widely acknowledged as one of the key possible interpretations of quantum theory. Later on further ontological models were proposed, for example Everett's 1957 "many worlds" interpretation and Ghirardi, Rimini and Weber's 1986 objective collapse theory, and currently the nature of quantum reality is intensively debated within the philosophy of physics community. For example, there is the brilliant new anthology *The Wave Function: Essays on the Metaphysics of Quantum Mechanics*, edited by **Alyssa Ney** and **David Albert**. We do not know which ontological interpretation (if any) is correct, but each may reveal something significant about the nature of physical reality at a very fundamental level. One should note that there are by now also different versions of the Bohm theory. Much attention has in recent years been given to a minimalist version known as "Bohmian mechanics". Bohm himself developed since the mid-1970s, with Basil Hiley, a philosophically more radical version they called the "ontological interpretation", culminating in their 1993 book *The Undivided Universe*.

How, then, might Bohm's theory be relevant to the mind-matter relation? It postulates that an electron is a particle, always accompanied by a new type of field, which guides its behaviour - thus the name "pilot wave theory" which is sometimes used. **Jack Sarfatti** has a cool way of characterizing the Bohmian electron by saying that it consists of a "thought-like" pilot wave, guiding a "rock-like" particle. This metaphor suggests that matter at the quantum level is fundamentally different from the sort of mechanical matter of classical physics that is presupposed in philosophy of mind by typical materialists. If even the basic elements that constitute us have "thought-like" and "rock-like" aspects, then it is perhaps not so surprising that a very complex aggregate of such elements (such as a human being) has a body, accompanied by a mind that guides it.

But, one might think, this is merely a vague metaphor. Now, Bohm himself realized in the early 1980s that the pilot wave might be more literally "thought-like" in a very interesting sense. He considered the mathematical expression of the so-called quantum potential, which describes the way the pilot wave affects the particle. He realized that the quantum potential, and thus the effect of the wave upon the particle, only depends on the form or shape of the wave, not on the size or amplitude of the wave (mathematically, the quantum potential depends only on the second spatial derivative of the amplitude of the wave). He went on to suggest that the quantum wave is literally putting form into, or in-forming the particle, rather than pushing and pulling it mechanically. Note

that we are here talking about information for the electron, not information for us – we are thus thinking about information as an objective commodity that exists out there in the world, independently of us, and guides physical processes. The form of the quantum wave reflects the form of the environment of the particle – for example the presence of slits in the famous 2-slit experiment. Subtle differences in the environment of the particle are then reflected in its behaviour – which is exactly what we observe in, say, the 2-slit experiment or the Aharanov-Bohm effect. What happens with the electron is somewhat analogous to a ship on autopilot, guided by radar waves that carry information about the environment of the ship. The radar waves are not pushing and pulling the particle, but rather in-forming the much greater energy of the ship.

Bohm generalized this into a notion of "active information" – which applies in situations where a form with small energy enters and informs a larger energy. We see this not only with various artificial devices, but also in the way the form of the DNA molecule informs biological processes, and even in the way forms act in human subjective experience (for example, seeing the form of a shadow in a dark night and interpreting it as "danger" may give rise to a powerful psycho-somatic reaction). Indeed, Bohm sketched how the active information approach could be developed into a theory of mind and matter.

He suggested that we understand mental states as involving a hierarchy of levels of active information. We not merely think about objects in the external world, but we can also become aware of our thinking. Bohm suggested that such meta-level awareness typically involves a higher level of thought. This higher level gathers information about the lower level. But because its essential nature is active information, it not merely makes a passive representation of the lower level. Rather, the higher level also acts to organize the lower level, a bit analogously to the way the active information in the pilot wave acts to organize the movement of the particle. And of course, we can become aware of this higher level of thought from a yet higher level, and so on.

How does then mind, understood as a hierarchy of levels of active information, connect with matter in the Bohmian scheme? First of all, Bohm suggested that it is natural to extend the quantum ontology. So, just as there is a pilot wave that guides the particle, there can be a super-pilot wave that guides the 1st order pilot wave, and so on. (He claimed that such an extension is "natural" from the mathematical point of view.) Now it seems that we have two hierarchies, one for mind and another for matter. Bohm's next step was to postulate that these are the same hierarchy, so that there is only one hierarchy. This then allows, at least in principle, for a new way of understanding how mind can affect the body. Information at a given level of active information in the mind can act downwards, all the way to the active information in the pilot waves of particles in, say, the synapses or neural microtubules, and this influence can then be amplified to signals in motor cortex, leading to a physical movement of the body.

Bohm's proposal differs strongly from the usual theories in cognitive neuroscience. Most neuroscientists ignore quantum considerations, and seek the "neural correlates of consciousness" in some macroscopic neural phenomena, which can presumably be understood in terms of classical physics. Yet Bohm is proposing that mind, understood as a hierarchy of levels of active information, is implemented in (or identical with?) a hierarchy of super-quantum fields. However, these fields are not separate from the macroscopic neural processes. On the contrary the role of the former is in the end to guide the latter and to gather information about them.

It might be useful to consider Bohm's scheme in relation to the philosophical mind-matter theories I mentioned above. An interactionist dualist might like the idea of the mind as a quantum-like field, interacting with "rock-like" matter. Of course, this not the same as, say, Descartes's

dualism, but it nevertheless acknowledges that the mind belongs to a more subtle category than the mechanical matter of classical physics. Also, the interaction of mind and matter can understood through the notion of active information. An identity theorist might adopt Bohm's scheme by saying that types of mental states are identical with types of super-quantum field configurations, together with the neural processes that they guide. A functionalist Bohmian, in turn, could say that we should understand mind in terms of information and the functions or activities associated with information. It so happens that in our universe this information structure is implemented in the hierarchy of super-quantum fields, but it is at least conceivable that the same information structure could be implemented in other kinds of physics, as long as the relevant functions within and between levels of information can be carried out.

Of course, it is a tremendous challenge to work out an empirically testable theory along the Bohmian lines, but these ideas provide a scheme for such an endeavour. Bohm and I were discussing ways to develop the scheme already in the late 1980s and early 1990s, and after Bohm's death in 1992, I have continued to collaborate with Bohm's long-time colleague **Basil Hiley**. For example, in a 2005 paper Basil and I discuss the prospects of applying the Bohm scheme to Beck and Eccles's quantum model of synaptic exocytosis. While this may be a small step forward, problems remain. For example, **Henry Stapp** has pointed out that the sort of interference of the mind upon the laws of quantum mechanics that our scheme involves can lead to serious problems with special relativity. This is something we need to look into carefully in future research.

While the possibility of non-negligible quantum effects in the brain is often dismissed as implausible, there are interesting recent advances in quantum biology. And it is already part of mainstream neuroscience that the retina acts to amplify the effects of individual photons. Also, researchers such as **Roger Penrose** and **Stuart Hameroff** have discussed in great detail how quantum effects might play a role in neural processes via quantum coherence and collapse in neural microtubules. Connecting their work with the Bohm scheme is, I think, one very promising line for future research. Indeed, we have started to explore these connections together with Stuart and the philosopher **Rocco Gennaro**, who is a specialist on higher-order theories of consciousness (which seem to fit together with Bohm's idea of the mind as a hierarchy of levels of information).

Note that Bohm introduced a new category, namely information to the debate. Is information physical or mental? He suggested that it is simultaneously both physical and mental, or has these two as its aspects. This sort of view is called a double-aspect theory in philosophy of mind. The traditional worry with double-aspect views is that it is left into a mystery what the underlying thing, which has the aspects, is. The hypothesis that information is the fundamental, underlying feature of reality can be seen as a way to alleviate this worry.

We saw above that a major problem with both the identity theory and functionalism is that they leave out conscious experience, instead of explaining it. How might conscious experience fit into the active information scheme? While Bohm saw nature as a dynamic process where information plays a key dynamic role, he assumed that "99.9 % "of the activity of information is not conscious. Thus, for example, he thought it obvious that the particles of physics are not conscious. But how can one then solve the hard problem of consciousness in this scheme? In other words, why is there sometimes conscious experience associated with the activity of information (as seems obvious at least with humans and higher animals)? Why doesn't all the activity of information in humans proceed "in the dark", as it seems to do in physical and biological processes in general? As far as I remember, Bohm did not say much about the hard problem of consciousness (he died a little before the hard problem was made the centre of attention by **David Chalmers** in 1994). However, I think that the most natural context to explore this issue is some version of a higher order (HO)

theory of consciousness. A simple possibility would be to postulate that what makes a given mental state (or level of information or mental activity) conscious is that there exists a higher level of (typically) unconscious information, which has the content that one is in the first order mental state or activity. In future research, I hope to develop this idea further with Gennaro and consider its "neuro-quantal" implementation with Hameroff.

Note also that David Chalmers famously suggested that we tackle the hard problem of consciousness with a double-aspect theory of information. The idea is that information is a fundamental feature of the world, which always has both a phenomenal and a physical aspect. Now, we could take this idea to the Bohm scheme and postulate that active information, too, has phenomenal properties. This then raises the question about what we should think about the active information in the pilot wave of an electron. Does it, too, have phenomenal properties in some sense? Bohm went as far as to say that electrons have a "primitive mind-like quality", but by "mind" he was here referring to the "activity of form", rather than conscious phenomenal experience in any full sense. I think that it is reasonable to combine Chalmers's hypothesis to active information, but we need to restrict the hypothesis. For example, we could say that certain kind of active information (for example, a holistic active information that is analogous to quantum active information) has the potentiality for phenomenal properties, but this potentiality is actualized only in suitable circumstances (for example, when a given level of active information is the intentional target of a higher level of active information). Of course, this also opens up the possibility for genuine artificial consciousness. If we could implement quantum-like holistic active information in an artificial system and set of up a suitable higher-order relationship of levels in the system, phenomenal properties should actualize themselves, according to this hypothesis.

Now, Bohm is also known for his notion of the implicate order – a conceptual framework in which he tried to understand quantum theory and relativity on a common basis. This framework also provides the more general background in which Bohm's pilot wave theory can be embedded. Our traditional mechanistic view deriving from classical physics assumes that the universe is made up of basic elements (particles and/or fields) that are independent from and outside of each other and interact mechanically - the order of the classical universe is "explicate". However, according to Bohm quantum theory and relativity challenge this view radically. They imply that the whole universe is in some way enfolded in everything and each thing is enfolded in the whole. Thus, the order of the quantum-relativistic universe is "implicate" – strictly speaking everything actively enfolds or implicates everything. However, the laws of quantum theory and relativity have a classical limit, which means that in the domain of everyday experience things are relatively independent and thus the usual mechanistic view which sees reality as an explicate order of separate, interacting things works as a useful approximation.

In a Whiteheadian manner, Bohm saw the quantum-relativistic reality more fundamentally as a dynamic movement in which the implicate order prevails - a "holomovement" which is in a constant process of change and development. Things exist as potentialities in the holomovement, from which they unfold into the explicate order and to which they ultimately fall back to. They endure in the explicate order, but only for a limited time. And even while they endure, they do not exist as collections of particles that have a continuous particle-like existence. Rather, their endurance is sustained in a constant process of unfoldment and re-enfoldment of quantum fields. The "particle" is then a recurrent phase in a process in which the wave amplitude continuously localizes (enfolds) and de-localizes (unfolds). This applies, of course, even to Bohm's own pilot wave model. As Basil Hiley has recently emphasized, the particle assumed in this model ought to be seen as a relatively autonomous center of energy, rather than as a traditional point-like particle.

Bohm was keen to point out that the implicate order also applies to mind. In our stream of consciousness we find a constant flow of thoughts, feelings, desires and impulses which actively implicate each other – for example, a thought may unfold into a desire which in turn may give rise to new thoughts, impulses and so on. Most notably, the implicate order prevails among the contents of thoughts, where we customarily say that one thought is implicit in another. A train of thought can be seen as a process of unfoldment of a succession of implications. While the Cartesian dualist tradition of Western philosophy has emphasized the difference between mind and matter, Bohm felt that they have the implicate order in common, and are thus at least analogous in an important respect.

A good illustration of the implicate order is provided by the structure of conscious experience, for example the structure of musical experience. When listening to music, we are not merely apprehending a process that proceeds step by step, say, paying attention to one note/chord now and another a bit later. No, in a musical experience we also seem to perceive a melody as a whole, a theme that grows, develops, and transforms. Typically, of course, we do hear some notes for the first time "now", but we also seem to directly perceive (rather than, for example, just passively remember) the notes that were first heard some time ago, and also anticipate the perception of future notes. We perceive a whole structure, a total order that is in some sense timeless. The various notes and chords can then be seen as co-present elements at different degrees of enfoldment. I discuss such a Bohmian model of time consciousness in my 2007 book *Mind, Matter and the Implicate Order.* If you like, this sketches a kind of quantum phenomenology – an attempt to use ideas from quantum theory to capture the holistic structure of conscious experience.

RB: What is scientific metaphysics and how is it related to the understanding of consciousness?

PP: Traditional metaphysics was subjected to heavy criticism in the first part of the 20th century, both in analytical philosophy (especially by logical positivists) and in continental philosophy (e.g. by Heidegger). However, Quine's critique of positivism led to a revival of analytical metaphysics, in the Aristotelian sense of a study of being *qua* being. Some, like **Huw Price**, think that this revival was a result of a misunderstanding of the profoundly pragmatist spirit of Quine's philosophy. In recent years, analytical metaphysics has been criticized particularly strongly by **James Ladyman** and Don **Ross**, in their 2007 book *Every Thing Must Go: Metaphysics Naturalized.* Ladyman and Ross not only suggest that much of contemporary analytical metaphysics is worthless, they also propose their own positive programme which aims to weakly unify the sciences by reference to fundamental physics. They interpret quantum theory and relativity to imply that relational structures are primary to things, leading to a metaphysical view they call ontic structural realism. They underline that it is not enough that metaphysics is consistent with current science. Rather, a genuinely scientific metaphysics must be directly motivated by and in the service of science.

I think scientific metaphysics is one of the most exciting intellectual endeavors of our time. It connects some of the most difficult and fascinating ideas from modern science to sophisticated philosophical reflection. Many philosophers pay lip service to science and announce themselves to be physicalists. Yet a closer look at the literature - especially in philosophy of mind – reveals a very superficial engagement with natural science, especially physics. Now, philosophers of mind could try to defend themselves by saying that, say, quantum phenomena cancel out at the macroscopic level of those neural phenomena that are most relevant to mental phenomena. However, Ladyman and Ross (just like Bohm) emphasize that quantum and relativity call for a change in our general metaphysical framework. We need to rethink the general structure of reality, and changing the big picture is likely to open up new perspectives in specific areas of science and philosophy, including philosophy of mind. I also think that Bohm's admittedly difficult work on consciousness and the implicate order can be much better understood in the light of structural realism. For he proposed

that the structure of conscious experience is similar to the fundamental structure of the physical world, as revealed in quantum and relativistic phenomena. For him this did not imply reducing consciousness to the physical domain, but rather a kind of unification, the possibility of understanding consciousness and matter as relatively autonomous aspects of an undivided whole. In this view, dynamically evolving holistic structures are prior to mechanically interacting individual elements. This is in some ways similar to what structural realists such as Ladyman and Ross are saying.

Now, Ladyman and Ross may themselves be more skeptical than typical consciousness researchers about the status of features of conscious experience, such as qualia. However, I think their work is important because it urges philosophers – including philosophers of mind – to stop ignoring the challenge that quantum theory and relativity pose to our general world-view. And I think that Bohm at least began to show us the way regarding how we might be able to understand the structure of conscious experience in relation to the structure of physical reality at a fundamental level.

One interesting thing to note in this context is that the structuralist approach in physics, and Hermann Weyl's work in the 1920s in particular, was inspired by Husserl's phenomenology. It is still fairly common that analytical and continental philosophy see each other as mutually irrelevant enterprises. Now, scientific structuralism (which also includes empiricist views such as that of van Fraassen) is no doubt the most scientifically informed part of contemporary analytical philosophy. The fact that Husserl's phenomenology inspired very significant developments in early scientific structuralism provides a valuable example of the way analytical and continental philosophy can be mutually relevant and enriching.

RB: Do you think the mechanistic framework of classical physics and neuroscience can be complemented by a more holistic approach?

PP: I think what I have said above suggests that the answer is "yes".

RB: Recent debates on the hard problem of consciousness has once again brought panpsychism into discussion. What is your view on panpsychism?

PP: Gary Malinas, after hearing my talk on Bohm's active information in Prague in 1993 suggested that I look up **Nagel**'s chapter on panpsychism, published in his 1979 book *Mortal Questions.* As a result I wrote an article "On baking a conscious cake with quantum yeast and flour" where I consider the prospects of combining the panpsychism-related views of Nagel and Bohm. You see, the amazing thing was that here we had a philosopher suggesting, out of philosophical considerations, that the material constituents of organisms, i.e. the particles of physics, must have non-physical properties which, when suitably combined, give rise to mental properties. And then there was a physicist arguing quite independently that the best way to understand quantum phenomena is to assume that electrons are guided by active information, which he characterized as a "primitive mind-like quality". Could Bohm's active information at the quantum level be the sort of thing Nagel's argument was pointing towards?

Now, to emphasize that the mental aspect associated with inanimate matter is very primitive, and that no full consciousness is attributed to all elements of reality, researchers have coined the term "panprotopsychism". Bohm's suggestion can be seen as an important contribution to panprotopsychism. Quantum theory is currently our most fundamental theory of matter, and Bohm suggests that quantum theory, when ontologically interpreted, reveals a proto-mental aspect of matter. This is the quantum information field, described mathematically by the wave function,

which is governed by the Schrödinger equation. This suggestion makes panprotopsychism into a much more concrete scientific and philosophical proposal than it has hitherto been.

During the summer of 1993 in Prague I also had to opportunity to listen to and interact with John Searle, who was visiting Ivan Havel. Searle emphasized that to explain a macro-level property in terms of the interactions of components at a lower level, we do not need to assume that the components themselves have the macro-level property. So, for example, to explain liquidity in molecular terms, we do not need to assume that an individual water molecule has the property liquidity. Analogously, Searle argued, to explain conscious experience in terms of underlying physical elements in the brain, we do not need to assume that these elements are conscious. Nagel replied to Searle that in the case of liquidity we understand its emergence in terms of the behaviour of elements at a lower level. However, the situation is completely different with conscious experience. While it may seem obvious that conscious experience arises from brain processes, we have no idea how this happens (this is, of course, the hard problem of consciousness). Thus, some version of panprotopsychism remains a live option.

Now, my early excitement with panprotopsychism was somewhat defused when I realized that Nagel's and Bohm's schemes were in some ways very different. Nagel was thinking in a mereological way, asking whether we could explain the subjectivity of an organism in terms of some kind of proto-subjectivity of the constituents of the organism. While Bohm's scheme allows for this kind of mereological analysis up to a point, he was emphasizing much more that what is fundamental at the quantum level is undivided wholeness, and that separate constituents (such as individual electrons) have only a relative and limited autonomy. So a Bohmian panprotopsychism would presumably attribute mind-like properties to the whole of reality - i.e., to the hierarchy of multidimensional wave functions of the universe in the implicate order.

There is then a sense in which reality is psycho-physical at a very fundamental level. This is, of course, implied also by the idea that information is simultaneously mental and physical in nature. Now, if we abstract a part from this reality, there will be some trace of this basic psycho-physical quality in it. If we abstract the "elementary particles" of physics, we find that they are not completely physical, but demonstrate a rudimentary mind-like quality through their quantum field and the active information it contains. If we go to the other end of the spectrum and consider some very subtle states of consciousness, these will still have a material aspect in an underlying neural state that they are indivisibly connected to via the hierarchy of super-quantum fields. In this sense there are different kinds and levels of mind and each of these may have a relative autonomy and stability.

RB: William James proposed that the mind should be studied not only by way of behaviour and brain functions, but should include introspection. Scientists have taken up the first two very keenly, but have been reluctant to take up the method of introspection. Recently, the practice of what is called 'contemplative science' has been called for, a coming together of 'contemplative' (meditative) and 'scientific' methods of inquiry. How might science and contemplative practice collaborate in the study of consciousness and what, if any, do you see as the benefits of such a collaboration?

PP: Meditation can involve altered states of consciousness, and these are an important object of study for consciousness studies. There have been many studies of the neural correlates of meditative experience. I find this kind of work valuable and relevant, but haven't focused upon it in my own work**.**

RB: The neurosciences are profoundly changing our conception of ourselves, how do you see this progressing?

PP: There are many fascinating new research programs in cognitive neuroscience. I have above given a glimpse of the speculations that involve the quantum theory. But there is much else going on. For example, in Helsinki **Riitta Hari** is engaged in social neuroscience, which involves studying the neural correlates of people who interact with each other. This is an example of an attempt to bring neuroscience closer to understanding real-world cognitive phenomena. I understand from **Antti Revonsuo** and **Stuart Hameroff** that anesthesia is another area where much cutting-edge neuroscientific research is taking place. But there are also critical voices. For example, **Margaret Boden**, whose master-level course in philosophy of cognitive science I studied in the University of Sussex in the mind-1980s, just recently said that most work going on in brain imaging is of no scientific value. As she sees it, these studies look for correlations between behaviour or experience and activity in the brain, but are rarely guided by theoretical questions.