Paavo Pylkkänen

Cognition, the implicate order and rainforest realism

It is my proposal that future cognitive science needs to be developed in the context of a general scientific world-view that is based upon contemporary physics. It is within such a general world-view that the special sciences studying the mind (psychology, AI, neuroscience etc.) need to find their proper place, and will hopefully find new avenues for progress when doing so. One research programme which has attempted to articulate such a new worldview is due to the physicists David Bohm and Basil Hiley. They have developed both a general "implicate order" framework as well as a more specific "ontological interpretation" of quantum theory. Both schemes involve radically new ideas and concepts, which also promise to open up new possibilities for understanding the place of cognition and consciousness in nature.

Introduction

One question that has been underlying my research is what kinds of assumptions about the nature of the physical world there are in cognitive science and how such assumptions might reveal themselves in the theories proposed in cognitive science. For example, the traditional view of cognition as mechanical symbol manipulation is very much in harmony with the spirit of classical physics, for manipulable symbols are typical things of the macro world. Also, connectionism and dynamical systems theory often employ models relying on differential equations that are deterministic and are in this sense developed in the spirit of classical physics. However, it is not at all obvious that central aspects of human cognition – such as creative insight or conscious experience – are phenomena which can be explained in terms of mechanistic computation or dynamic evolution embedded in a classical physics framework.

Physics has changed radically in the course of the 20th century, and these changes imply the need to change our overall scientific worldview. Such changes in the general worldview in turn usually imply the need to rethink the nature and status of more specific theories, such as those central in cognitive science. In particular, and as already hinted above, one needs to ask to what extent cognitive science presupposes the worldview of classical physics, and how this may influence its theories. Further, one can ask whether it is justified to rely on classical physics assumptions as fundamental, given that physics itself has given up classical physics as fundamental and sees it instead as a limiting case or as a framework that only works in a given domain. And finally, the interesting question is whether we might be able to explain and understand the features of the mind – and especially its relation to matter - better in a framework that is based upon the new, more accurate developments in physics.

It is my proposal that the future cognitive science needs to be developed in the context of a general scientific worldview that is based upon contemporary physics. It is within such a general worldview that the special sciences studying the mind (psychology, AI, neuroscience etc.) need to find their proper place, and will hopefully find new avenues for progress when doing so. One research programme which has attempted to articulate such a new worldview is due to the physicists David Bohm and Basil Hiley. They have developed both a general "implicate order" framework as well as a more specific "ontological interpretation" of quantum theory. Both schemes involve radically new ideas and concepts, which also promise to open up new possibilities for understanding the place of cognition and consciousness in nature. Within philosophy, a particularly intense attempt to develop a new worldview has in recent years been made by James Ladyman and Don Ross in their 2007 book *Every Thing Must Go: Metaphysics Naturalized*. In this article I will briefly describe some key features of these research programmes and sketch tentatively how they might change our picture of cognition in the future.

Getting clear about quantum theory: the ontological interpretation

Let us first see what cognitive science might learn from Bohm and Hiley's ontological interpretation of the quantum theory (for an extensive presentation see, Bohm & Hiley 1993). For our present purposes what is particularly interesting about this interpretation is that it suggests that something analogous to information plays an active role at the level of fundamental quantum processes. Bohm himself felt that this idea of *active information* is relevant to broader philosophical issues, such as the relationship between mind and matter (Bohm 1990). To understand this suggestion better let us briefly consider the ontological interpretation of quantum theory.

When quantum theory was first interpreted in the 1920s, it was typically assumed that individual quantum processes (e.g. the decay of a radioactive atom) are inherently indeterministic, and that it is not possible to provide an unambiguous model of a single quantum system, such as an electron. Instead, it was either said that we must not try to picture the electron at all, or else that we in some situations may describe it as a wave, and in others as a particle (this is the mysterious "wave-particle duality"). Since the 1920s, there were also critics such as Einstein who felt that a fuller and possibly more deterministic description should be possible. A significant suggestion to this direction was made by Louis deBroglie in 1925 and especially by David Bohm, who in 1952-inspired by his many discussions with Einstein-re-discovered independently deBroglie's earlier approach and gave a fuller and more coherent presentation of it.

Although initially almost ignored, the deBroglie-Bohm approach has received increasing attention and approval in recent decades, due to the efforts of such leading physicists and philosophers as John Bell, David Albert, Sheldon Goldstein, Antony Valentini, James Cushing, Arthur Fine, and Hilary Putnam (see Goldstein 2009, which includes a historical discussion and also considers the criticisms against the approach).

What is potentially particularly important for the future of cognitive science is Bohm's and his long-time colleague Basil Hiley's extension of Bohm's original 1952 ontological interpretation. According to the usual interpretation of the quantum theory the wave function is often said to describe not a quantum system directly but rather our *knowledg*e of the quantum system to be observed (typically in terms of probabilities). In contrast, Bohm and Hiley were suggesting that the wave function describes an *objectively real field*, guiding a particle such as an electron. As a new development, they were drawing attention to the striking fact that according to the mathematical description favored by Bohm, this field does not push and pull the particle mechanically, but rather it is only the form (second spatial derivative) of the field that determines its effect on the particle. They suggested that what is going on is that the quantum field encodes information about the whole environment of the particle (e.g. slits) – the field literally in-forms or puts form into the motion of the particle.

The proposal is radical, for they are in effect suggesting that this type of information ought to be acknowledged as a fundamental

– perhaps the fundamental – category of physics. Indeed, they wrote in 1983: “The notion of a particle responding actively to information in the [quantum] field is … far more subtle and dynamic than any others that have hitherto been supposed to be fundamental in physics” (Bohm & Hiley 1983).

In my view Bohm and Hiley’s proposal is potentially very important to cognitive science which likewise sees information, and information processing, as its central notions. Bohm himself pointed out that the way information acts at the quantum level is at least closely analogous to the way information acts in human subjective experience. When I see something that means “danger” (e.g. a snake), the information content acts within the brain, not only via electric action potentials, but also via various neurochemical processes to prepare the body for an appropriate response (cf. Thagard 2002).

Bohm and Hiley’s approach opens up a whole new way of understanding such “psycho-somatic” processes. The idea here is that abstract information content is something intrinsically active and intrinsically able to cause changes in the more concrete underlying physical aspects of the system in question. This differs in interesting ways from the more standard, passive notions of information typically used in the standard accounts currently on offer in cognitive science (i.e. symbolic processing, neural networks, and dynamical systems). In my view, Bohm and Hiley’s notion of active information can capture more adequately what is taking place in actual cognitive processes that the standard accounts.

Bohm and Hiley suggest that information plays an active role at various levels, psychological, biological and even the quantum. What are the reasons for assuming that the notion of active information applies all the way to the quantum level? Importantly, this assumption enables one to understand such otherwise paradoxical quantum features as wave-particle duality, non-locality, and the multidimensionality of the many-body wave function. (It is characteristic of quantum theory that every interpretation needs to make some strange assumption(s), and then tries to avoid some even more unsatisfactory features with the help of this assumption. This is one way of trying to make sense of something very weird.) Information is here seen as an objective commodity that actively guides the particle - it is information for the electron rather than information for human beings. Fred Dretske had similarly emphasized in 1981 that information should be seen as an objective commodity, although his notion of information is in some key ways different from Bohm and Hiley’s.

I should note that Bohm and Hiley’s proposal about the quantum theoretical active information is controversial and still mostly ignored within the physics community. There are some technical issues with the proposal, but in my view a major reason is that it goes so much against the prevalent mechanistic way of thinking in physics. However, some leading thinkers do take it seriously, for example Quentin Smith (2003).

Bohm and Hiley see the existence and role of information at the quantum level as an instance of a more general principle of active information that prevails in various levels of nature. For example, it is commonly accepted that the DNA molecule encodes information that guides the growth of an organism; likewise information in a computer can guide a wide range of activities; and also, as we already mentioned above, information in human subjective experience (for example when we interpret some form to mean “danger”) can give rise to powerful psychosomatic activities.

Bohm was keen to point out the potential relevance of the active information idea to traditional puzzles about the place of meaning and mind in nature. In these traditional puzzles it is typically presupposed that the physical world is different from phenomena such as meaning and mental properties, thus giving rise to a dualism. By extending a kind of meaning (as active information) all the way to the (currently) fundamental laws of quantum theory, Bohm saw a possibility of transcending the dualism prevalent in much of Western philosophy and culture more generally.

In Bohm's proposal we have a more subtle aspect (information in the quantum field) guiding the behaviour of a more manifest aspect (the particle). We could generalize this to a principle that applies whenever meaning influences matter in other contexts. Bohm proposed such a principle and called it "soma-significance". In this terminology a process in which meaning acts somatically to organize the more manifest levels of matter is called a "signa-somatic" process. The term "soma-significant" refers to the inverse process, where a physical pattern is significant to a higher or more subtle level (e.g. when one is reading a text, the information is carried by different physical processes (ink, light waves, neural processes) to higher levels of physical organization where its meaning is apprehended). Bohm (2003) characterizes our existence as a "two-way movement" as follows:

> *We emphasize here that nothing exists in this process of soma-significance, except as a two-way movement between the aspects of soma and significance, as well as between levels that are relatively subtle and those that are relatively manifest. It is this over-all structure of meaning … that is grasped in every experience.*

He (2003) further illustrates the same point:

> *From each level of somatic unfoldment of meaning, there is … a further movement leading to activity on to a yet more manifestly somatic level, until the action finally emerges as a physical movement of the body that affects the environment. So one can say that there is a two-way movement of energy, in which each level of significance acts on the next more manifestly somatic level and so on, while perception carries the meaning of the action back in the other direction.*

Such two-way traffic between the mental and the physical is what we need for mental causation. Bohm assumes that each level has both a physical and mental aspect, and hopes this way to avoid the problem of dualism (i.e. the problem of explaining how a non-physical level could possibly interact with a physical level). The idea is that mental processes are carried by subtle physical processes, perhaps fields that are analogous to, but more complex than the quantum field. But how could such a "very subtle" field carrying information possibly be able to act upon the more manifest processes e.g. in the motor cortex? One possibility is that it would act via the quantum field. Indeed, Bohm (1990) writes:

> *…that which we experience as mind, in its movement through various levels of subtlety, will, in a natural way ultimately move the body by reaching to the level of the quantum potential and of the 'dance' of the particles. There is no unbridgeable gap or barrier between any of these levels. Rather, at each stage some kind of information is the bridge. This implies that the quantum potential acting on atomic particles, for example, represents only one stage in the process.*

It seems to me that Bohm assumes that the more subtle aspects of mind and conscious experience involve more subtle levels of information, which have not yet been discovered by the "3rd person" methods of cognitive neuroscience (although we are aware of at least some of them via our "1st person" introspection). The discovery of the quantum potential is very important as a first guide (prototype) to what the nature of such more subtle levels could be from the physical side. Indeed, Bohm suggested that by extending the ontological interpretation in a natural way, we could include the subtle mental aspects into the theory. But how can such an extension be done?

> *… one could begin by supposing, for example, that as the quantum potential constitutes active information that can give form to the movements of the particles, so there is a superquantum potential that can give form to the unfoldment and development of this first order quantum potential. This latter would no longer satisfy the laws of the current quantum theory, which latter would then be an approximation, working only when the action of the superquantum potential can be neglected. Of course, there is no reason to stop here. One could go on to suppose a series of orders of superquantum potentials, with each order constituting information that gives form to the activity of the next lower order (which is less subtle) (Bohm 1990).*

Bohm's radical suggestion thus is that a natural extension of his ontological interpretation of the quantum theory can include mental processes and even conscious experience into a single coherent view. From the point of view of the question about the causal powers of mental properties Bohm's view is particularly promising, for it makes it-at least in principle–possible to understand how mental properties, via their effects upon information at lower levels, could make a difference to physical process. If we can provide an intelligible theory about how mental properties can make a difference to information at lower levels, Bohm's scheme provides a view of how such informational differences can then affect manifest physical processes (see also Hiley & Pylkkänen 2005).

Toward a more general worldview: the implicate order

It is commonly agreed that the hardest problem in contemporary physics is the unification of quantum theory and general relativity. Bohm and Hiley's ontological interpretation of quantum theory, briefly described above, provides some insights that may be useful in this endeavour (for example, it is tempting to interpret Bohmian trajectories at the quantum level as geodesics, in some ways analogous to general relativistic concepts). However, one could also argue that the ontological interpretation, especially with its emphasis on non-locality, helps to bring the tension between quantum theory and general relativity into a sharper focus, rather than resolving it. Many physicists agree that something radically new is needed in physics if that tension is to be resolved (string theory and quantum loop gravity are well-known contemporary attempts to do this). Bohm started to develop his own general scheme–known as the "implicate order"–in the early 1960s, and was soon joined by Basil Hiley in this project.

Adopting this more general approach does not mean that one discards the ontological interpretation of quantum theory as useless. The ontological interpretation can still be seen to provide insight into an important though limited domain of fundamental physics, (non-relativistic) quantum theory. But if one wants a more general scheme new ideas are needed.

When seeking such a more general scheme, Bohm first gave attention to the fact that the basic concepts of quantum theory and relativity seem to be in complete contradiction. While relativity requires continuity, determinism and locality, the usual interpretation of quantum theory points to discontinuity, indeterminism and non-locality. This being the case, how could we ever hope to unite these two theories? Bohm's strategy was to ask whether there is anything these theories have in common. His answer to this question was: *undivided wholeness*. Relativity points to this by giving up the notion of particle as fundamental, while quantum phenomena such as wave-particle duality and non-locality clearly underline the status and role of the whole over the autonomy of the parts. Bohm felt, however, that our entire scientific and philosophical tradition is dominated by what he called "mechanistic order", and this makes it difficult to even think about the undivided wholeness of quantum and relativistic phenomena. A new "notion of order" is needed, and his suggestion was the "implicate" order. While in the mechanistic (or "explicate") order things exist outside each other and interact mechanically, in the implicate order the whole is typically enfolded into each part, and each part is enfolded into the whole.

This is illustrated by light (electromagnetic waves). At each point of a room, light waves coming from all the other parts of the room interfere – in this sense information of the whole is enfolded into each region. This means also that information about each part (e.g. the clock on my table) is present in each region of the room, and in this sense each part is enfolded in the whole. Similar considerations apply in quantum field theory, which describes particles such as electrons in terms of fields. We are thus invited to think that the implicate order is the fundamental order of the universe, while the explicate, mechanistic order arises from this under suitable conditions. The implicate order framework thus enables us to think of our usual every-day physical world as something that constantly unfolds from a deeper implicate ground. Bohm's hope was that as the mathematical description of the implicate order focuses on the common ground of quantum theory and relativity (undivided wholeness) it should be able to derive these theories as limiting cases and approximations without contradictions. This research programme was developed by Bohm, Hiley, and their research students. It has given rise to some promising results, but needs further development.

Bohm was keen to point out that something like the implicate order prevails in other phenomena, such as biological, psychological (phenomenological, linguistic) and social. Let us next consider briefly what relevance it might have to cognitive science, especially the problem of explaining conscious experience.

Discussions about the potential relevance of the "New Physics" (quantum theory and relativity) to explaining consciousness tend to focus on the possible role of quantum effects in the neural/physical correlate of consciousness (see Atmanspacher 2006. However, there is another "quantum route" to consciousness, which relies on the new scientific worldview that the New Physics demands. Exactly what that new worldview is has been subject to a long debate. As we saw above, Bohm and Hiley proposed that New Physics requires above all a new notion of order. We need to give up as fundamental the "Cartesian order", exemplified by the Cartesian co-ordinates. Translated into physical ontology, this means giving up the 3+1-D space-time as fundamental. Bohm's proposed new notion is that of the "implicate order". It gives rise to the "Cartesian order" as a special case, but also allows a natural description of such quantum phenomena as non-locality, discontinuity of motion and wave-particle duality.

Most of contemporary cognitive science and consciousness studies (cognitive neuroscience, philosophy of mind, etc.) proceeds as if there had not been any revolution in physics. Many of these researchers agree that conscious experience typically involves a "virtual reality" or "world simulation" (consider dreams), but tacitly this world is understood in terms of Newtonian notions of space and time, and thus the "Cartesian order". But what is the order that actually prevails in conscious experience? Bohm proposed that the notion of implicate order that seems necessary to deal with quantum phenomena, also captures some essential features of conscious experience. The basic idea is that the usual "Cartesian world simulation" we typically encounter in conscious experience can be seen as a special case of a more fundamental implicate order that prevails in conscious experience.

Let me say a little more about how we might be able to explain aspects of consciousness in the implicate order framework. One of the central features of conscious experience is its spatio-temporal, phenomenal structure (van Gulick 2011). Connected with this is the metaphor that consciousness is a kind of "virtual reality" associated with the brain (e.g. Velmans, Revonsuo, Metzinger, Lehar). An adequate theory of consciousness thus has to tell a story about how the virtual reality of consciousness is created. One place to look for inspiration in this endeavour is contemporary physics and algebraic geometry. For some physicists such as Wheeler and Bohm & Hiley have been led to consider how space-time emerges from some deeper structure they often call "pre-space". The interesting question is whether the work in physics, which describes the ground of the "real spatio-temporal reality," could be useful also when trying to describe the ground of the "virtual, phenomenal spatio-temporal reality" of consciousness.

Bohm and Hiley (1984) generalized the Penrose twistor theory to a Clifford algebra, paving the way for a description which allows continuous space-time to emerge from a deeper pre-space they call an implicate order. Bohm (1986) further proposed that the "explicate" space and time that we consciously experience is likewise projected from its enfoldment in deeper implicate orders. In neural terms what becomes interesting here is Pribram's (1991) holographic theory of neural memory, for the hologram (where information about the whole is stored in each part) is a paradigmatic example of an implicate order (of course, similar ideas have been explored in connection with artificial neural networks). One of the challenges for future research is to develop a more detailed account of the spatio-temporal, phenomenal structure of consciousness in the implicate order framework.

To summarize, the notion of implicate order has a number of features that seem to make it particularly suitable to explain some puzzling features of conscious experience, such as its phenomenal structure, unity and dynamic flow. First of all, it is possible to give a description of how physical space-time arises in terms of the implicate order. As we already mentioned, it might be possible, analogously, to provide an explanation of the phenomenal, especially spatio-temporal, structure of conscious experience in terms of the implicate order. Secondly, the implicate order captures the undivided wholeness of quantum phenomena, and this feature might well prove a useful analogue when trying to explain the unity of consciousness. Thirdly, the implicate order takes movement (as opposed to things that move) as fundamental, and in this way it is likely to be useful when trying to explain the dynamic flow of consciousness. Further, given the possibility that the implicate order prevails in both matter and in conscious experience, it might also throw new light upon the perennial puzzle about the relation of matter and consciousness. In my 2007 book Mind, Matter and the Implicate Order, I have discussed the prospects of the implicate order as an explanatory framework in consciousness studies. In particular, I focussed upon explaining the temporal structure of our conscious experience of listening to music (or "time consciousness") in terms of the implicate order constituted of the individual notes (Pylkkänen 2007, ch5).

Ladyman and Ross's rainforest realism

I have above indicated briefly how the various ideas emerging from Bohm and Hiley's research programme, primarily developed in the context of physics, might also prove useful in areas such as cognitive science and consciousness studies. This research programme invites us to rethink many of our basic categories, such as space, time, matter, causality and information. These categories are also central in cognitive science, and thus new ways of thinking about them open at least potentially new avenues for theorizing in cognitive science. At the same time my own feeling is that development in this respect can be slow and speculative, as one often needs to proceed by analogies. Also, attempts to develop general schemes of naturalistic metaphysics that are based upon contemporary physics have been fairly rare in recent philosophy, leaving Bohm and Hiley's research programme fairly isolated from other research. A refreshing exception to such tendencies in contemporary philosophy is James Ladyman and Don Ross's ambitious "rainforest realism", proposed in their 2007 book *Every Thing Must Go*.

Ladyman and Ross (2007) launch an attack against contemporary analytic metaphysics or 'neo-scholastic' metaphysics as they call it. According to them, it "contributes nothing to human knowledge and, where it has any impact at all, systematically misrepresents the relative significance of what we do know on the basis of science" (p. vii). Their view is no doubt an extreme one, but if they are correct, this would have important implications for consciousness studies. For example, 'neo-scholastic' philosophers of mind typically rely on their intuitions when reasoning about the place of consciousness in nature, but Ladyman and Ross remind us that intuitions are "the basis for ... everyday practical heuristics ... they are not cognitive gadgets designed to produce systematically worthwhile guidance in either science or metaphysics" (p. 10).

Ladyman and Ross present a naturalized metaphysics which aims to unify weakly the special sciences by reference to fundamental physics. So, for them the key point is unification, and fundamental physics plays an important role in this. Fundamental physics is fundamental not because it describes some putative fundamental level of reality, but because of its generality. Ladyman and Ross see it as that part of physics that is implicitly tested by every measurement that could be taken at any scale of reality and in any region of the universe. The unification their metaphysics aims for is 'weak' because it is not reductionist. Because fundamental physics by definition applies in all contexts it constrains all special sciences (including the parts of physics that are not fundamental). However, trying to describe the world in terms of fundamental physics will not get us very far. Ontology is scale relative in the sense that the "real patterns" that the special sciences are trying to capture are not detectable at, say, the quantum scale. This is why there is no point in trying to reduce the patterns studied by chemistry, biology, geology, economics etc. into the patterns that fundamental physics describes. Ladyman and Ross's view allows for the existence of a wide range of things, as long as things are understood as real patterns. Their view is thus an ontologically rich "rainforest realism", as opposed to the "desert ontology" favoured by Quine.

One of the interesting metaphysical hypotheses of Ladyman and Ross proposes that there is no fundamental level:

> *…we … have a … basic problem with the idea of a fundamental level, namely, its presupposition that reality is structured into levels in the first place. The standard way in which these levels are distinguished is according to size. So, for example, the domains of different special sciences are identified with different scales, the atomic for physics, the molecular for chemistry, the cellular for biology, and so on. A moment's reflection makes the limitations of this obvious since economics can be applied to an ant colony or the world economy, and evolutionary theory can be applied to entities of any size (even, according to Smolin …, to the whole universe). Furthermore, in accordance with physics, we regard the structure of space and the metric used to measure length as themselves emergent structures. Hence we can hardly treat them as a fundamental framework within which to describe*

the levels against which everything else exists. (2007: 179)

Note how Ladyman and Ross, like Bohm and Hiley, take seriously the idea that physical space is an emergent structure, rather than a fundamental framework that can just be presupposed. These ideas are truly radical in relation to traditional Western metaphysics, where individual things in space-time are typically assumed to be ontologically fundamental.

What is the fate of cognition and consciousness in Ladyman and Ross's naturalistic metaphysics? Some hints are provided by the following quotes:

> *Peter Unger … argues that our knowledge of the world is purely structural and that qualia are the unknowable non-structural components of reality. On our view, things in themselves and qualia are idle wheels in metaphysics… (p.154) …If cognitive science concludes that mental concepts do not track any real patterns then the theory of mind will have to go. (p. 254)*

However, Ladyman and Ross do not at present think that behavioral and cognitive sciences are tending in this direction, though they think that the folk theory of mind is false in all sorts of important ways. They want to leave the question open, however, and refer to Dennett's work:

> *In any given instance, it may be that our concepts and intuitions about the real patterns we are tracking may be widely mistaken, as with intuitions about qualia and phenomenal conscious states. (p.254)*

So it seems that their universe is not very consciousness-friendly, even though cognition and mind in some weaker sense may find a place there.

Conclusion

In summary we can note that Ladyman and Ross's project is a refreshing attempt develop a world-view implied by contemporary physics and the special sciences. But for those whose intuitions suggest that conscious experience is a real their project is frustrating. Of course, as we saw above, they remind us that our intuitions may lead us astray in science or metaphysics. But for many researchers conscious experience is real phenomenon, not merely an illusion created by old-fashioned intuitions. This leads us to ask whether there are other schemes of naturalistic metaphysics that are more consciousness-friendly. I suggest that one such scheme is Bohm and Hiley's implicate order framework, complemented by the more narrow and specific "ontological interpetation" of quantum theory that includes the idea of active information.

There are many important similarities between the research programmes of Ladyman & Ross (LR) and Bohm & Hiley (BH). Neither considers separate objects as fundamental, but see structures (LR) or movement and order (BH) as primary. Neither assumes that there is a fundamental level, and there is a similarity between LR's scale relativity of ontology and Bohm's idea that ontology is always relative to context. Further, in both schemes causality can be understood in a radically new way. The fact that both schemes are based upon contemporary physics and that they make similar suggestions is a sign that they may well be on the right track. (I am grateful to Ilkka Pättiniemi (2011) for drawing my attention to some similarities between LR and BH.)

When it comes to understanding cognition and consciousness, it seems to me that Bohm and Hiley's framework is a more liberal one. I think history teaches that the study of cognition and consciousness has suffered from overly verificationist attitudes, as during behaviorism. This is why I favor Bohm and Hiley's scheme as a more promising one in which to develop specific theories about cognition and consciousness in the future. But this is not to deny the potential value of

Ladyman and Ross's rainforest realism to cognitive science. Perhaps the creative tension between these similar but yet different schemes is just what is needed to give the necessary dialectical power needed to push theories of cognition and consciousness into new domains.

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