

Implications of Bohmian Quantum Ontology for Psychopathology

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Abstract

This article discusses the prospects of quantum psychiatry from a Bohmian point of view, which provides an ontological interpretation of quantum theory, and extends such ontology to include mind. At first, we discuss the more general relevance of quantum theory to psychopathology. The basic idea is that because quantum theory emphasizes the role of *wholeness*, it might be relevant to psychopathology, where breakdown of unity in the mental domain is a key feature. We then discuss the role of *information* in psychopathology, and consider the connections with quantum theory in this area. In particular, we discuss David Bohm's notion of *active information*, which arises in the ontological interpretation of quantum theory, and is suggested to play a fundamental role as the bridge between mind and matter. Some such bridge is needed if we are to understand how subtle mental properties are able to influence more manifest physical properties in the brain (all the way to the molecular and possibly microtubular level), and how changes in those possibly quantum-level physical processes are able to influence higher cognitive functions. We also consider the implications of the notion of active information for psychopathology. The prospects of implementing the Bohmian scheme in neuroquantal terms are then briefly considered. Finally, we discuss some possible therapeutic implications of Bohm's approach to information and the relation of mind and matter.

Key words: quantum psychiatry; ontological interpretation of quantum theory; active information; Bohm; quantum approaches to consciousness

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1. Introduction

The aim of this article is to provide a sketch of a further perspective on quantum psychiatry, alongside other articles in this volume (Globus, 2010; Mender, 2010; Woolf *et al.*, 2010). Before presenting this perspective let me, however, make some brief comments on these other articles.

I think Mender's (2010) article is a useful overview and raises the question of the need for "quantum psychiatry" in a

powerful way. Some of the ideas seem still fairly condensed and I hope that in future research this approach will be further spelled out and clarified so as to make the prospect of the emerging field of "quantum psychiatry" even more attractive and plausible to a wider audience.

Globus (2010) offers us an ambitious attempt to explain certain neuropsychiatric disorders (such as thought insertion) in terms of thermofield brain dynamics (TBD). The key new idea in Globus's approach is self-tuning: "Self-tuning from all levels functionally *attunes* memory for the convolution with sensory input. Consciousness (or existence) is the best match of self-tuned memory with sensory input...". Self-tuning can, however, "go

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wrong”, and this opens up an entirely new way of understanding “splitting” in psychiatric disorders: “...if self-tuning were split, fragmented, dis-integrated, ...it would be as if two discrepant images were *simultaneously* explicated from a hologram to which they had previously been *serially* enfolded.” This viewpoint can be summarized as follows: “TBD offers a new way of understanding schizophrenic splitting: as integration failure of the self-tuning function.”

Globus’s paper provides us with an elegant discussion of psychiatric disorders in terms of disorders of “self-tuning”. He also applies this scheme to radically rethink the clinical classification found in *the diagnostic and statistical manual of mental disorders* (DSM). I shall, however, not enter into a detailed discussion of Globus’s scheme here. One of the reasons is that the underlying thermofield brain dynamics is very complex, and I am not in a position to fully evaluate it. However, I also have a feeling that there exists a simpler way to develop a quantum ontology, proposed by David Bohm, and that it would be very useful for any “quantum psychiatry” to *also* be aware of this alternative. This is not to deny the potential value of the TBD scheme, but rather to remind that, given the inherent difficulty of quantum theory, and thus of any quantum psychiatry, we ought to give proper attention to the simpler schemes, as well as to the more complex ones. In the end, the various schemes are likely to complement each other, and each can play a role in unfolding the full meaning of any “quantum psychiatry”.

Woolf et al., (2010) provide a fascinating account of the possible role of microtubule dysfunction in mental illness. Given that microtubules are widely speculated to be plausible sites for quantum effects in the brain, there is a very concrete connection to “quantum psychiatry” in this paper. I am not in a position to evaluate Woolf et al.’s proposals in any detail. However, I will make some suggestions about how Bohm’s ontological scheme might connect with their discussion.

What I want to do in the rest of this article is to discuss the prospects of “quantum psychiatry” from what might be

called a “Bohmian” point of view, where the emphasis is upon trying to provide a coherent ontological interpretation of quantum theory, and to extend this ontology to include mind. My discussion is tentative, for although I am quite familiar with the general field of consciousness studies, especially philosophy of mind, my knowledge of psychopathology is very limited. For the purpose of writing this article I have studied some recent reviews of the field, but I apologize in advance if the discussion below is too simplistic from the psychopathological point of view. In any case, I have found it personally rewarding to consider the prospects of the relevance of quantum theory to psychopathology. I would like to thank the authors of the other articles in this special issue for opening up a whole new dimension of thinking.

I will start by discussing the very general, indirect relevance which quantum theory might have to psychopathology (section 2). This has to do with the new general world-view that quantum theory and relativity seem to demand. An important feature of this world-view is *wholeness*, a theme relevant to psychopathology, where breakdown of unity in the mental domain seems to be a key feature. I will then discuss the role of *information* in psychopathology, and consider whether there are relevant connections with quantum theory in this area (section 3). In particular, I will discuss David Bohm’s notion of active information which arises in the ontological interpretation of quantum theory, and is suggested to play a fundamental role as the bridge between mind and matter. Some such bridge is needed if we are to understand how mental processes are able to influence physical processes in the brain (all the way to the molecular and possibly microtubular level), and how changes in those possibly quantum-level physical processes are able to influence higher cognitive functions. After presenting Bohm’s notion of active information, I will briefly consider its possible implications for psychopathology (section 4). The prospects of implementing the Bohmian scheme in neuroquantal terms is then briefly considered (section 5). Finally, I will discuss some possible therapeutic implications of Bohm’s approach to information and the relation of mind and matter (section 6).

2. Wholeness

It is a fairly common idea that health in general and mental health in particular are connected with wholeness. As Bohm often noted, this is also indicated by considering the etymological meanings of some of the relevant terms:

“...the word ‘health’ in English is based on an Anglo-Saxon word ‘hale’ meaning ‘whole’: that is, to be healthy is to be whole, which is ... roughly the equivalent of the Hebrew ‘shalem’. Likewise, the English ‘holy’ is based on the same root as ‘whole’. All of this indicates that man has sensed always that wholeness or integrity is an absolute necessity to make life worth living. Yet, over the ages, he has generally lived in fragmentation”. (Bohm, 1980; p.3)

Mental disorders often have to do with the breakdown of wholeness or unity, in one way or another (Globus, 2010; Stephens and Graham, 2007). One important general implication of quantum theory and relativity is that they underline the primacy of wholeness, a primacy that to some extent has been lost in the emphasis upon the mechanistic approach that classical physics has helped to reinforce, and which has spread to and been influential in other domains, such as the biological, psychological and the social, including medicine and psychiatry. In the psychological domain the mechanistic emphasis reveals itself in the tendency to give supreme importance to the self as a separate enduring entity, interacting fairly mechanically with other such selves. In the neurobiological domain mechanism reveals itself in the assumption that psychological phenomena can in the end be fully understood in terms of the interaction of neural elements. In this whole approach, it is presupposed that the basic realities at each level are entities that interact more or less mechanically. Mental and physical illness can then be seen as a failure of such connections and interactions between these separate entities that are considered as primary.

A holistic world view inspired by quantum and relativity takes *undivided wholeness in flowing movement* as primary (Bohm, 1980). Separate entities (particles) arise from such movement as a result of

certain enfolded and generative orders that prevail in the movement. Such entities are not separate substances but relatively autonomous sub-wholes, like vortices in a stream. Speaking in very general terms, this is strongly analogous to the notion that what is primary in the mental aspect is a stream of consciousness, out of which emerge relatively autonomous entities such as thoughts, beliefs, sensations, perceptions, intentions, desires, emotions, feelings, and selves. In this view mental health is essentially connected to the undivided wholeness and coherence in the underlying stream of consciousness; mental disorder results in part when this wholeness is lost for one reason or the other. For example, one might give too much emphasis to certain of the various divisions that naturally arise in the stream, thus setting the stage for the emergence of conflicts between such separate parts of the mind.

Of course, analysis into parts can work very well up to a point as an explanatory strategy both in the psychological domain and in the underlying neurophysiological processes. However, it is important not to lose sight of the underlying undivided wholeness in flowing movement in our stream of consciousness. Quantum theory and relativity, and the general world view arising from them (and possibly even the more specific “*neuroquantal*” models), can play an important role in helping to give attention to this wholeness. Thus, one of the more general underlying messages of any “quantum psychiatry” could be that we need to consider the importance of such wholeness for mental and physical health.

A holistic perspective can also radically change the way we understand the relationship between the individual and his or her social and physical environment. In a mechanistic view, we assume that society can be reduced to individuals in interaction. In a holistic view, we say that each individual is a manifestation of the whole, which includes society and the physical environment, information about which is enfolded in the memory of the individual. Thus, we no longer reduce society to a group of individuals, but rather *regard the individual as a state of the whole*. This turns the mechanistic view upside down (cf. Bohm,

1978). I think this is also important when considering psychiatric disorders. When we are feeling psychologically unwell, we easily see the disorder as a property of our separately existing self, which in turn can make us feel worse and even more isolated from other people. However, if the holistic view is correct, our mental disorders are likely often to be manifestations of the state of the social groups in which we participate. Suffering is universal. This is nicely captured in a Sikh story about the man in a village who one day climbed to the roof of his house, and to his amazement saw that many people in the village, out in their backyards, seemed to be suffering in very similar ways that he himself was. If the holistic view is correct, it implies that an important part of the efforts to maintain mental health ought to be directed to detecting various kinds of incoherence at the social level (e.g. in practises and failures of communication), instead of an exclusive focus upon the individual, whose suffering to some extent is just a manifestation of the social incoherence (Bohm, 1995).

3. Information

Many mental disorders can be understood in terms of failures in the flow of information and in the response to information. In hallucination one "...mistakes one sort of mental event, an imagined experience, for another, a veridical sense perception" (Stephens and Graham 2007; p.199). For example, a person might believe that he sees a giant rabbit in front of him. The hallucinatory subject "misattributes his or her self-generated private events to a source external to him- or herself" (Slade and Bentall, 1988, quoted in Stephens and Graham, 2007; p.199). Thus, in hallucination certain information is missing (*i.e.* information that the given mental event is self-generated), and as a consequence certain mistaken information prevails (*i.e.* information signifying that there is a giant rabbit in front of me "out there" in the world).

In thought insertion, the patient "...experiences thoughts that do not have the feeling of being his own, but he feels that they have been put into his mind without his own volition, from the outside" (Sims, 1995; Stephens and Graham, 2007; Globus, 2010).

When looked at in terms of information, it has been suggested by Frith (1992) that thought insertion essentially involves lack of information about volition or intention behind thoughts. For some reason the patient lacks information that he or she has intended certain thoughts appearing in his or her mind, and further attributes them to having been produced by someone else. Frith suggests that this might involve a breakdown in the system that monitors whether the subject intended to think a given thought. Stephens and Graham describe the idea succinctly: "Pathological impairments of this monitoring system might lead me to experience my intended thoughts as stimulus-driven responses to external events and thus not as mine." This explanation has an air of plausibility, but is it phenomenologically fully accurate? Frith writes: "If we found ourselves thinking without any awareness of the sense of effort that reflects central monitoring, we might well experience these thoughts as alien and, thus, being inserted into our minds" (1992: 81, quoted in Stephens and Graham, 2007; p.202). However, it is at least my experience that thoughts often just "unfold", without any sense of effort or deliberate choice (e.g. when one is driving a car, or thinking while also engaging in some other activity; or just "lost in thought" while relaxing); yet one does not typically experience these thoughts as alien. But there are also thoughts which typically require more effort and deliberate choice for their production; and if such thoughts should appear in my mind without my having any sense of having produced them, they might well feel alien, in line with Frith's explanation. One should also be open to the possibility that something more subtle might be going on in thought insertion, perhaps something more like Globus's "integration failure of the self-tuning function" which gives rise to the splitting of agency at a deeper level.

Some explanations of misattributions might be offered by neural studies: "...electrophysiological studies recently conducted by Ford and Mathalon (2004) found ... that talking and inner speech resulted in a dampening of responsivity of the auditory perception areas in the temporal lobes (a process that they identified as indicating a corollary discharge from the

frontal cortex which prevents one's own speech from being attributed externally) but not in hallucinating patients" (Bentall, 2007; p.135). This is an example of how a mechanistic explanation (emphasizing the role of separate parts/areas and their connection/interaction) might play a useful role in understanding mental disorders. Such explanations need to be compared and contrasted with the more exotic, quantum brain dynamical models of "mental splitting", such as that offered by Globus (2010).

Common psychiatric disorders such as depression and anxiety can also be seen to involve information in an essential way. According to Bentall (2007; p.132), evidence suggests that "...they are associated with systematic biases in the extent to which different kinds of stimuli become available to awareness. For example, [...] depressed patients preferentially recall negative information [...], whereas feelings of anxiety are associated with excessive attention to threat-related stimuli". Further, obsessional problems, too, can be understood as essentially connected to the way we respond to and try to control information, as Bentall (2007; p.132) points out: "Unwanted, intrusive thoughts (e.g., about embarrassing past experiences) seem to be an almost universal phenomenon and obsessional patients appear to differ from ordinary people in their catastrophizing response to these kinds of experiences" (Salkovskis, 1998).

Thus, it seems clear that many mental disorders essentially involve information, and more specifically lack of information, mistaken information (misattribution) and various kinds of failures to respond to and control information adequately. Can quantum theory throw any new light upon the nature of information, which might also help us to understand the role of information in psychiatric disorders? I suggest that the best place to start exploring this issue is David Bohm's ontological interpretation of quantum theory, some features of which will now be briefly described (for an extensive presentation see Bohm and Hiley, 1993).

One of the famous questions in quantum theory concerns the nature of

quantum systems, such as electrons. Is an electron a particle or a field? This question arises because in classical physics it is a basic point that elementary systems are typically either particles (such as atoms) or fields (such as the electromagnetic). However, in a typical quantum experiment (such as the two-slit interference experiment) an individual system exhibits both particle properties (it arrives at the detector at a single spot) and wave properties (the place where the spot appears is determined by the mathematics of wave behaviour). Bohm's interpretation resolves this duality by postulating that an electron is a new kind of entity that has always *both* a particle aspect *and* a wave aspect. To simplify the discussion let us say that the electron is a particle always accompanied and guided by a new type of field.

In the two-slit experiment, when both slits are open, the particle goes through one of the slits, and then appears at a point in a photographic plate (which explains why we see the appearance of a spot - note especially that in this interpretation there is no need to assume that there is a collapse of the wave function). The accompanying field goes through both slits, interferes afterwards, and guides the movement of the particle so that the particles collectively, spot by spot, build up an interference pattern. The key feature for our discussion is that according to Bohm the quantum field contains something he calls "active information". The quantum field typically contains information about the entire environment of the particle (e.g. slits) and is able to mediate this to the particle. The field gives rise to a potential, which Bohm called the "quantum potential". The radically new feature is that this field does not push and pull the particle mechanically; rather the influence of the field upon the particle only depends upon the form of the field (mathematically the quantum potential depends on the second spatial derivative of the quantum field, which reflects the shape of the field). If you like, the field literally *IN-FORMS* (or puts form into) the energy of the particle. This influence should not, however, be understood in too mechanical terms. What is involved is not a mere form imposed from without. The active information contained in the quantum field can rather be seen as an ordered and structured "inner"

movement that is essential to what the electron as a whole (i.e. as a union of a particle and a field) *is* (cf. Bohm 1980; p.12). Information is a key factor of the being of an electron. In Bohmian quantum field theory, this idea is even more fundamental, for information contained in the so-called “super-quantum” field plays a key role in the creation, sustenance and annihilation of “particles”.

The relevant idea here is that information is an important part of the essence of physical processes. Something like this is at least implicitly recognized in biology, where information contained in the DNA-molecule is assumed an important generative part of the essence of the organism. In addition, of course, as we come to the psychological domain, it seems obvious that information is a key factor of mental phenomena. This has, of course, been recognized in cognitive science, with its assumption that the human brain/mind can be seen as a system that receives and stores information, and uses such information in the intelligent control of behaviour. Bohm’s radical suggestion is that there is at least a strong analogy between the operation of information at the quantum level, and the operation of information at the various levels of mind.

We saw above that the suggestion is that at the quantum level information *acts* – it actively guides the movement of particles. Similarly, in human subjective experience, information content acts. When I see something that in a given context means “danger” (e.g. a snake), this information content acts within the brain, not only via electric action potentials, but also via various neurochemical processes to prepare the body for appropriate response (cf. Thagard (2002)). Bohm emphasizes that “...this is not merely a mental process, but includes an involuntary and essentially unconscious process of hormones, heart-beat, and neurochemicals of various kinds, as well as physical tensions and movements” (1990). But how does information content act upon matter? How does such an abstract quality as the experienced meaning of information (e.g., “danger”) result in a wide range of electrical and chemical processes in the brain?

This question is very difficult to answer in contemporary philosophy of mind, which is still based upon a very strict division between the categories “physical” and “mental” (Kim, 2006). Meaning is typically considered to be located at the “mental” side of the division, and there is currently no coherent theory that explains how meaning *qua* meaning can influence physical processes. It is assumed that meanings are typically carried by some physical “vehicles”, and any causal influences associated with meaning are assumed to be the result of the operation of the physical vehicle that carries the content or meaning. The meaning itself is assumed to be causally inefficacious.

Bohm’s approach changes this in a subtle way. Notice that in Bohm’s model of the electron, the information is carried by the quantum field that is a qualitatively new type of field in physics (it has some very exotic properties; not only does it influence the movement of particles via its form, it also lives in a multidimensional configuration space and is able to mediate Einstein-Podolsky-Rosen type non-local influences between particles). Thus 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 organizes the manifest levels of matter is called a “signa-somatic” process.

Thus, in the context of the human mind we could speculate that information contained in mental processes and conscious experience is carried by some subtle medium. Of course, it seems likely that a great deal of information that enters consciousness is at some stage carried by neurophysiological processes that exist at the “classical level” of reality (e.g. in processes where quantum effects have a negligible effect). But it is possible that the information that is experienced in consciousness is carried by some much more subtle medium, analogous to the quantum field, but capable of much more complex properties, including qualia, subjectivity and conscious experience. This information then

typically “acts downwards” toward the manifest levels of the brain, ultimately guiding behaviour. 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.”

Bohm was not too specific about what he meant by the “various levels of subtlety”. Are these new types of fields, similar to but more complex than the quantum field? Or can they include levels of processing in the more classical domains of brain function (e.g. the various levels of processing of visual information)? I think Bohm’s view was quite inclusive; he did not deny the obvious role which classically describable processes play in the processing of information that enters consciousness (Bohm & Hiley, 1993; p.179). However, I also think he felt that the more subtle aspects of mind and conscious experience involve more subtle levels of information, which have not yet been discovered by cognitive neuroscience. The discovery of the quantum potential is very important as a first guide to what the nature of such more subtle levels could be. 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).

This, then, is a schematic view of the way “mind acts on matter” in Bohm’s extended ontological interpretation of the quantum theory. In my view, it is to date the most elegant attempt to tackle the problem Descartes left behind himself: how can mind and matter, which seem so completely different, nevertheless manage to influence each other? Bohm’s solution has two parts. On the one hand he argues on the basis of quantum theory that matter has far more subtle properties than Western mechanistic science has thus far assumed. On the other hand he suggests that minds are very subtle but adds that it is a mistake to assume that minds are entirely non-physical. Instead he assumes that every mental process has a subtle physical aspect which carries the information that is part of the essence of that process. Quantum theory is important even for this second hypothesis, for quantum theory makes plausible the idea that it is possible for there to exist very subtle physical processes. In Bohm’s extended quantum theory, these physical processes are assumed so subtle that they can justifiably be characterized as “mental” (for a further discussion of this view see Pylkkänen 2007; for a critical review see Globus 2007).

4. The possible role of active information in psychiatric disorders

What might be the relevance of Bohm’s ontological interpretation of quantum theory to psychiatry, what might a “Bohmian quantum psychiatry” look like? It would clearly approach mental disorder from the perspective of active information. We saw above briefly how psychiatric disorder essentially seems to involve failures in the flow of information, and in the response to information. Bohm’s emphasis on the idea that information is typically active seems to be very useful if we want to understand how

various failures at the level of information lead to psychiatric disorders.

In hallucinations self-generated information is mistaken for externally produced information; as a result this information acts to give rise to a perception of, say, a giant rabbit. This perception, in turn, can give rise to all sorts of reactions in the person, as the state of the body unfolds the meaning in subtler levels of thought.

We saw earlier that it has been suggested that thought insertion involves a breakdown in the system that monitors whether one intends to think certain thoughts, which can result in misattributions of these thoughts to external agents. This suggests that our sense of agency depends upon the presence and activity of a certain kind of information, namely (what seems to be a kind of) self-referential information about our own intentions. Usually we are not aware of the activity of this kind of information, but only realize its importance when considering puzzling clinical cases such as thought insertion.

We also considered the idea that "...depressed patients preferentially recall negative information compared to positive information..." (Bentall, 2007; p.132). In Bohmian terms, this could be seen as a situation in which for some reason negative information is "overactive" while the meaning of positive information is inhibited from entering into awareness – positive information has become somewhat "inactive".

Bentall further suggests "...feelings of anxiety are associated with excessive attention to threat-related stimuli", as in panic disorder. In Bohmian terms anxiety can be understood as a failure to deal with active information. While a 'normal' person can usually deal fairly calmly with different types of information, the person with an anxiety disorder cannot very well deal with the information consisting of certain kinds of stimuli, and as a result a panic attack can be triggered. Panic attacks are an example of the power of information to act, whether or not the "subject" likes or intends it. Would an increased understanding and awareness of this relatively autonomous power of information help to relate to information in

such a way as to control that power? It is an interesting question whether an increased understanding of the active nature of information along Bohmian lines could help to develop therapeutic techniques that in turn could help to tackle anxiety and even depression. I will return to this issue at the end of the article.

We noted above that obsessional problems, too, could be understood as essentially connected to the way we respond to information. Recall Bentall: "Unwanted, intrusive thoughts (e.g., about embarrassing past experiences) seem to be an almost universal phenomenon and obsessional patients appear to differ from ordinary people in their catastrophizing response to these kinds of experiences". Bentall suggests that obsessional patients are dysfunctional in their attempts to control the contents of consciousness. It seems that 'normal' people are able to deal with their unwanted, intrusive thoughts in a fairly calm way. In contrast, Bentall (2007; p.132) points out that obsessional patients have "...excessive expectations about their mental efficiency, catastrophic fears about losing control of their thoughts, and superstitious beliefs about the consequences of this happening ("If I did not control a worrying thought, and then what I worried about really happened, it would be my fault") (Wells and Papageorgiou, 1998)". The worry here seems to be, at least in part, about the active and autonomous power of thoughts, and the sense of a need to control this power.

5. NeuroQuantal considerations

We saw above how Bohm suggested schematically that "...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." In other words, "mind" involves a hierarchy of "levels of subtlety", which includes the level of the quantum potential at the bottom of the hierarchy. By controlling the shape of the quantum field, the "mind" can control the movement of particles, such as electrons. Electrons, in turn, can control more macroscopic, classical neural behaviour via amplification of quantum effects.

Alternatively, in a quantum field theoretic model, the mind can control the behaviour of e.g. the electromagnetic field by controlling the form of the super-quantum field. This is the naïve idea, or the general principle. To implement the principle into concrete neuroquantal models we need to look for sites in the brain, where amplification of quantum effects is likely to play a role in determining more macroscopic neural behaviour (e.g. resulting in the activation of motor neurons). Hiley and Pylkkänen (2005) considered Beck & Eccles's quantum model of synaptic exocytosis (Beck, 2008) from the point of view of the ontological interpretation. We wrote there: "...[the] action of the quantum potential effectively reduces the height of the barrier to increase the probability of exocytosis. Thus we could regard the "mind-field" as initiating a subsequent neural process which finally activates the motor neurons to produce the outward behaviour. In this sense, active information is merely the trigger for the usual classical processes that follow the gating of ion channels." Later on, we added: "There may be other brain processes where the notion of active information could be more appropriate. One suggestion that we presently investigate is the behaviour of dendritic fields, where it has been suggested that important information processing may be going on (Pribram 2004). Here statistical processes involving active information may be important, as discussed in a preliminary way by Hiley (2004)."

In recent years, much attention has been given to the idea that quantum processes in neural microtubules might be essentially connected with higher cognitive functions and even conscious experience. It is tempting to consider the microtubules from the point of view of the ontological interpretation of quantum theory. For example, standard quantum theory has no clear notion about *what* an individual electron is (i.e. it has no coherent ontology). Thus, for example, when we try to consider an electron being in a tubulin dimer, standard quantum theory provides us with no clear ontological picture of the situation. In contrast, Bohm's ontological interpretation provides, in principle, an unambiguous model of the electron in the dimer. If one could calculate the quantum

potential for this situation, one could look at the behaviour of the electron in the dimer, and study in a more concrete way how the effects of the electron behaviour might be amplified to control more macroscopic neural behaviour. In the Bohmian mind-matter scheme, the microtubules are one possible site where the quantum field might persist in a form that could be influenced by mind (when the latter understood as involving a hierarchy of super-quantum fields). The changes in the form of the quantum field in the relevant microtubules would result in the change of the behaviour of the electrons, which in turn might, in principle, be amplified to control large-scale neuronal behaviour.

Of course, to account for cognition we also need to discuss perception, where (typically) information about the manifest, classical world is carried toward the more subtle, quantum levels. This requires that the Bohmian scheme is modified to include "back-action", i.e. an influence from the particle to its guiding quantum field (or in the field theory from e.g. the electromagnetic field to its guiding super-quantum field). The need for this has been emphasized especially by Jack Sarfatti, and here is a sample of his take on developing Bohmian mind-matter theory in the context of microtubules: "...the back-action of the electro-chemical signals, from the nerve cells via the [tubulin] dimers, on the wavefunction of the collective Fröhlich mode provides the information stream required for perception. The reverse quantum force of the wavefunction on the nerve matter is the action stream for intent (volition or free will). The two opposing streams of bits, nerve matter to mental wavefunction and vice versa, form a new kind of feedback-control loop which is absent in dead matter..."

An eager and able defender of Bohm's ontological interpretation of quantum theory is Mike Towler of Cavendish Laboratory, Cambridge University. He writes in his 2009 lecture slides: "Experimentalists have been able to 'diffract' 60 C-atom fullerene molecules passing through small holes, so such objects definitely fall on the quantum side of the classical-quantum boundary. The TCM group in Cambridge is a leading centre for

doing molecular dynamics (e.g. with the CASTEP code). So if trajectories don't exist, and particles don't have objective reality, what exactly do we imagine our molecular dynamics movies are depicting?". Towler is referring to the fact that standard quantum theory allows for neither the notion of particles existing when not observed, nor for the notion that particles move along trajectories. In contrast, the ontological interpretation provides a mathematically precise hypothesis of what might be going on at the level of, say, 60 C-atom fullerene molecular motion. At least in principle, the ontological interpretation should also make it possible to make movies about "electron dynamics in the microtubules", and such visualizations might well be useful as we try to understand microtubules better. I admit that such suggestions are very general and vague, no doubt reflecting my limited knowledge of this area, but I have a strong intuition that more attention to the ontological interpretation ought to be given in the research on the role of microtubules in quantum mind theories. At the very least, this would complement the pictures offered by the two other paradigms, the Penrose-Hameroff Orch-or theory and the TBD theory. On the whole, Towler's lectures provide an excellent overview of the different aspects of the "deBroglie-Bohm theory" (as the ontological interpretation is often called), and I highly recommend the reader to visit the website of the course (Towler, 2009).

The prominent role Bohm's interpretation gives to information makes it at least *prima facie* a very strong candidate to be considered in attempts to develop quantum mind theories. It is almost universally accepted that information is a key factor of mental processes. If information also plays a key role in guiding quantum processes, there is at least potentially a new kind of connection between mental processes and physical processes at a very fundamental level. Different quantum mind theories postulate different reasons why quantum theory might be relevant to understanding the mind-brain relationship. The possibility that information plays an objective and active role at the quantum level certainly adds to the initial plausibility of quantum mind theories (see also Smith, 2002; for criticisms of the active information

at the quantum level hypothesis, see e.g. Riggs, 2009; for an early discussion of the issues that Riggs considers, see Hiley, 1994).

6. Conclusion

Let us return to our discussion of what might be the relevance of Bohm's partly quantum-inspired theorizing about information in a psychiatric context. Firstly, we remember that Bohm draws attention to the idea that information should be seen as typically *active*, even if we typically may see information as a fairly passive entity that we are free and able to manipulate at will. We have seen above how many psychiatric disorders can be seen as connected to information and our response to it. Our failure to perceive and understand the active nature of the various kinds of information in our mental lives might well explain some of these disorders. This is at least implicitly understood in cognitive behaviour therapy, where one has developed clinical techniques that try to manipulate cognitive processes that seem to give rise to disorders. Bentall (2007; p.38) writes: "Most cognitive behavioural interventions involve challenging the dysfunctional belief systems of patients, and these approaches have shown considerable promise in the treatment of both the common psychiatric disorders and also the psychoses (Rector & Beck, 2001)." Also in the Bohmian picture it seems that incoherent information – which constantly appears in cognition – plays a key role in mental disorder, and thus the road to mental health is the movement toward coherence. However, challenging incoherent beliefs may not be the only way to tackle them. Indeed, Bentall (2007; p.138) observes: "...there has been recent interest in the development of strategies to help patients change their attitude toward their thoughts and feelings, rather than the thoughts and feelings themselves. These approaches, which have borrowed from the mindfulness meditation techniques developed within the Buddhist tradition, have shown especial promise in the treatment of patients with chronic, recurring conditions (Segal *et al.*, 2002)".

In Bohmian terms this would involve trying to be aware of the meaning of the active information contained in the various

incoherent and disturbing thoughts, without accepting or condemning this content. The idea is that this very awareness is able to reveal to the mind that these contents lack coherent meaning, and in such awareness, these incoherent meanings dissolve. Bohm's approach is similar to that of Krishnamurti, with whom he had many discussions. Krishnamurti spoke of "choiceless awareness" in this context, but Bohm felt that the use of the term "choice" was not very apt here. Rather, it is the question of being able to be aware of the meaning of the various mental states, without judging them (this reminds one of Pyrrhonian skepticism, which held that such suspension of judgment is an important means to achieving peace of mind). Thus, one does not "argue with" incoherent thoughts – that might just produce more confusion. Instead, when trying to understand their meaning, one might be able to perceive their incoherence, and this very perception might start a movement toward coherence (Bohm and Pylkkänen, 1991).

In this article, I have with some enthusiasm and optimism considered the possible role Bohm's notion of active information could play for a better understanding of psychiatric disorders. Of course, there is a great danger of being overly naïve about the extent of the relevance of this notion. The fruitful way of making use of the notion of active information in this context is not to try to replace existing approaches to psychiatric disorder by a theory based on

this notion. Rather, the notion of active information can be used to sharpen up the views provided by existing theories. In particular, this notion draws attention to the way information content acts to organize the lower, physiological levels of the brain, and how changes in these lower levels can, in turn, cause changes in the higher cognitive levels. This idea, I think, is potentially very important for understanding the mind-matter relation in general and psychiatric disorders in particular.

One of the advantages of Globus's TBD scheme is that he has connected it to the hermeneutical-phenomenological philosophical tradition, which includes a very sophisticated way of understanding the human condition. This allows Globus to make use of, say, and Heidegger's philosophical notions in a quantum neuropsychiatric context. Much further work needs to be done if the active information scheme is likewise to be properly connected to the various more humanistic schemes that have proved successful in the attempts to understand psychiatric disorders. In addition, the neuroquantal implementation of the Bohmian scheme is still at very early stages. In this paper, we have only been scratching the surface of "quantum psychiatry" from a Bohmian perspective, but hopefully we have been able to show that the idea is at least worthy of further development.

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