

Fundamental Physics and the Mind – Is There a Connection?

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Abstract. Recent advances in the field of quantum cognition (Pothos and Busemeyer 2013; Wang et al. 2013) suggest a puzzling connection between fundamental physics and the mind. Many researchers see quantum ideas and formalisms merely as useful pragmatic tools, and do not look for deeper underlying explanations for why they work. However, others are tempted to seek for an intelligible explanation for why quantum ideas work to model cognition. This paper first draws attention to how the physicist David Bohm already in 1951 suggested that thought and quantum processes are analogous, adding that this could be explained if some neural processes underlying thought involved non-negligible quantum effects. The paper next points out that the idea that there is a connection between fundamental physics and the mind is not unique to quantum theory, but was there already when Newtonian physics was assumed to be fundamental physics, advocated most notably by Kant. Kant emphasized the unique intelligibility of a Newtonian notion of experience, and this historical background prompts us to ask in the final part of the paper whether we can really make sense of any quantum-like experience (whether experience of the empirical phenomena in the “external world” or the “inner world” of psychological phenomena). It is proposed that intelligibility is a relative notion and that, regardless of initial difficulties, quantum approaches to cognition and consciousness are likely to provide valuable new ways of understanding the mind.

1 Introduction

Recent advances in the field of quantum cognition (see e.g. Pothos and Busemeyer 2013; Wang et al. 2013) suggest a connection between fundamental physics and the mind that some may find puzzling. Perhaps to alleviate the puzzle, many quantum cognition researchers are keen to distance themselves from the more speculative research programs of “quantum mind” or “quantum consciousness”. Broadly speaking, these latter programs involve the hypothesis that mind and/or consciousness are in some more or less literal sense quantum phenomena, e.g. in the underlying (sub) neuronal processes. The situation reminds us of the field of artificial intelligence (AI), as characterized by Searle (1980), where “strong AI” refers to a claim that a suitably

programmed computer literally has intelligence and consciousness, while “weak AI” refers to much more modest claims to the effect that computer programs provide useful models of intelligent cognition. So, analogously we could say that there is “weak quantum cognition” (WQC, cognitive processes can be modeled by quantum concepts and formalisms; cf. Atmanspacher et al. 2002) and “strong quantum cognition” (SQC, cognitive processes have literally quantum mechanical aspects); see Pyllkkänen 2015.

Suppose that a broad consensus develops that certain principles and mathematical tools of quantum theory (such as quantum probability, entanglement, non-commutativity, non-Boolean logic and complementarity) provide a good way of modeling many significant cognitive phenomena (such as decision processes, ambiguous perception, meaning in natural languages, probability judgments, order effects and memory; see Wang et al. 2013). In such a situation many researchers may still be happy to see quantum ideas and formalisms merely as useful pragmatic tools, and not worry about looking for deeper underlying explanations for why they work. However, it is likely that others, especially philosophers of mind, would be tempted to seek for an *intelligible explanation* for *why* quantum ideas work to model cognition. Just think of the philosophical debates about conscious experience during recent decades. There a major focus of research has been the “hard problem” - the challenge of providing an intelligible explanation of how conscious experience might possibly arise from underlying (e.g. physical, biological, computational or non-conscious mental) processes. Analogously, *the hard problem of quantum cognition* would be to provide an intelligible explanation for *why* various principles and formalisms of the quantum theory seem to work so well to model cognitive phenomena and predict behavioral outcomes. And here, it seems, the most obvious thing to do, at least in the beginning, is to consider the various suggestions within the stronger quantum mind/consciousness programs (for a critical review of these, see Atmanspacher 2011).

This strategy should make sense for, say, a reductive materialist, who believes that mental states are identical with some neurophysiological states. According to physics the constituents of neural states obey the rules of quantum mechanics. So, if some mental states, too, obey quantum principles, perhaps the explanation for this is that the dynamics of those mental states reflects in some way the dynamics of the quantum mechanical aspects of the neural states that underlie or even constitute those mental states. Further, even someone who is a functionalist in philosophy of mind might be tempted to consider the role of quantum effects in the underlying dynamical structures that implement cognition. If some aspects of cognitive processes turn out to be radically quantum-like, perhaps their implementation requires some quantum mechanical structures and dynamics in the processes that realize them (regardless of whether these processes are neurophysiological or, say, silicon based).

In this paper I will first consider how the physicist David Bohm already in his 1951 discussion was engaged with both WQC and SQC. I will then briefly consider how Bohm’s discussion connects with contemporary philosophy of mind and cognitive science. I next point out that the idea that there is a connection between fundamental physics and the mind is not unique to quantum theory, but was there already when Newtonian physics was assumed to be fundamental physics, advocated most notably by Kant. Kant emphasized the unique intelligibility of a Newtonian notion of experience, and this historical background prompts us to ask in the concluding section

whether we can really make sense of any quantum-like experience (whether inner or outer experience).

2 Weak and Strong Quantum Cognition in 1951: Bohm's Early Discussion

The idea that mental phenomena and quantum processes are analogous to each other goes back to the founding architects of the quantum theory. For example, Niels Bohr had become familiar with the idea of complementarity in the field of psychology, and was led to propose that complementarity is a key feature of quantum phenomena (Wang et al. 2013, p. 678). Influenced by Bohr's ideas, the physicist David Bohm included a discussion of "analogies between thought and quantum processes" in his acclaimed 1951 textbook *Quantum theory* (Bohm 1951, pp. 168–172). Note that this book was written while Bohm was still a supporter of the standard interpretation of quantum theory; more precisely (as Bohm himself realized only later), the book's approach is close to Wolfgang Pauli's variant of the "Copenhagen interpretation". I have discussed these analogies elsewhere at some length (Pylkkänen 2014), so will here provide only a brief summary and some further reflection. I want to emphasize here that in his discussion Bohm not only pointed to various analogies between cognitive processes and quantum processes (in the spirit of WQC), he also moved on to consider (in the spirit of SQC) whether these analogies could be explained if there were non-negligible quantum effects in the neural processes underlying cognition.

Bohm drew attention to three analogies between human thought process and quantum processes, which can be denoted as follows:

- Effects of observation
- Unanalyzability
- Both have a "classical limit".

Let us consider these briefly in turn.

Effects of observation. Bohm first considered the fact that introspective observation of thought (say, an attempt to define the content of thought) typically introduces unpredictable and uncontrollable changes in the way thought proceeds thereafter. Analogously, in the quantum domain, the observation of the position of a particle introduces unpredictable and uncontrollable changes in the particle's momentum. So in both cases it may be difficult to measure properties of interest without profoundly influencing them. Thus "measurement" in both the introspective psychological domain and in the quantum domain cannot necessarily be assumed to be revelation of well-defined pre-existing properties (cf. Wang et al. 2013, p. 674). In quantum theory it is typical that the measurement influences the system under observation, and it seems that such influences are also characteristic of introspection. Note in particular that this analogy concerns *empirical* phenomena – on the one hand our attempts to empirically study the contents of the mind in introspection, and on the other hand our attempts to empirically study the properties of quantum systems. In this sense this analogy is not mere metaphysical speculation. It actually has to do with our empirical attempts to connect with the domains under interest.

Note also that partly due to these kinds of features of introspection, already Kant thought that empirical psychology (insofar as it relies on introspection) cannot be a science (Brook 1994, pp. 9–10). In contemporary discussions, while some have tried to rehabilitate introspection as a respectable method in psychological research (e.g., Jack and Roepstorff 2003), others have focused on bringing out its various biases and limitations (e.g., Pronin and Kugler 2007). Bohm's suggestion that introspection and quantum measurement are analogous suggests, at least in principle, the possibility of improving the status of introspection as a scientific method. One way to do this is to see how far the principles and formal tools of quantum measurement theory could be applied (*mutatis mutandis*) to characterize observation in introspection (cf. Wang et al. 2013, p. 674).

Unanalyzability. Bohm next suggests that a part of the significance of each element of thought process (and language) originates in its indivisible and incompletely controllable connections with other elements. He notes that if we try to analyze a thought into smaller and smaller elements we eventually come to a point where further analysis seems impossible. Analogously, some of the essential properties of a quantum system (e.g. whether it is a wave or a particle) depend on its indivisible and incompletely controllable connections with surrounding objects. This suggests that both thought and quantum phenomena are characteristic of a radical type of wholeness, unanalyzability and context-dependence. Again such wholeness can be considered a challenge for any informative scientific analysis of the holistic phenomenon. However, quantum theory (and its various interpretations) involve novel ways of tackling radically holistic phenomena both mathematically and conceptually. Indeed, quantum cognition researchers have made use of such ways when modeling holistic cognitive phenomena, such as the holistic features of concepts. For example, Gabora and Aerts (2002) have described the context-dependence of concepts in generalized quantum terms, while Bruza et al. (2009) have explored meaning relations in terms of the quantum-like concept of entanglement.

Both thought and quantum processes have a “classical limit”. Bohm then moves on to suggest that the logical process corresponds to the most general type of thought process as the classical limit corresponds to the most general quantum process. The idea is that the rules of logic are analogous to the causal laws of classical physics, while concepts are analogous to objects, in the sense that logically definable concepts play the same fundamental role in abstract and precise thinking as do separable objects and phenomena in our customary description of the world. At the same time, he notes that there is also an analogy between pre-logical thinking and quantum process. He suggests that the basic thinking process probably cannot be described as logical. For example, a sudden emergence of a new idea seems analogous to a “quantum jump”.

The classical limit analogy implies that we have “two physical worlds” - i.e., the general quantum world which contains as its part the special case of a classical world. But it also suggests that we have “two minds”, i.e. the mind in the sense of a general alogical and aconceptual thinking process, which in some conditions gives rise to the special case of the mind as logical thinking process with logically definable concepts. So there are, in a sense, two levels of thought. This is similar to e.g. Smolensky's (1988) view of the relation between connectionist and symbolic cognition (see below); it also anticipates Aerts's (2009) notion of two modes of human thought.

From weak to strong quantum cognition. Bohm finally raises the question of whether these analogies between quantum processes and thought are just a co-incidence, or whether they instead might be a sign of a deeper connection between the two domains. He acknowledges that they could be a mere co-incidence, but goes on to consider an alternative, namely the possibility that the physical aspect of thought might involve quantum processes in some important way. This, he suggests, would explain in a qualitative way many features of our thinking. For example, if the physical aspect of thought involved quantum processes in a non-negligible way, this would enable us to develop a qualitative account of why the direction (“momentum”) of thought is disturbed by an attempt to define its content (“position”). Similarly, if the physical aspect of thought and language involved quantum processes (e.g. indivisible links), it might be possible to develop a qualitative naturalistic explanation of some holistic features of language and meaning. Further, the “classical limit analogy” might be explainable if the physical aspect of the general (alogical, aconceptual) thought process involved quantum processes (with inseparability, discontinuity etc.), while the physical aspect of the logical and conceptual thought process involved classical processes (e.g. classically describable, separable neural “activation patterns” governed by the classical laws of physics).

3 Comparison with Contemporary Philosophy of Mind and Cognitive Science

A fair amount of recent philosophy of mind and cognitive science has emphasized the non-conceptual or aconceptual aspect of the human mind (see e.g. Bermúdez and Cahen 2012 and the references therein; Pylykkö 1998). For a physicalist it is natural to ask what the proposed physical or computational concomitants of such aconceptual mental processes might be. Connectionist models are one candidate for the computational concomitants. But, as e.g. Pylykkö (1998) has pointed out, these are (mostly) mechanically computable and thus deterministic. They are thus an implausible candidate to be the physical aspect of a truly non-mechanical level of aconceptual mental processes.

More plausibly, one could propose that ideas and perceptions about classical objects supervene on some classically describable neural processes. Then, just as it is possible for the body to manipulate external objects, so it might be possible in the mind to “manipulate” representations, symbols etc., which latter are assumed to supervene on classical neural patterns. But let us then further assume that there is another kind of (i.e., aconceptual) activity of the mind which supervenes on some neurophysiological process in which quantum effects play a non-negligible role. Now, just as classical and quantum levels are related in physical reality, so the classical and quantum-like mental processes (and their classical and quantum mechanical neural correlates, respectively), might be related via particular types of mutual influences, amplifications, etc. (cf. Smolensky 1988).

The above implies that the explanation for the possibility of quantum-like cognition experience is that the matter we are composed of has quantum properties. The problem here is, of course, that it is currently very difficult to test hypotheses about, say, non-negligible quantum effects in neural processes. However there is currently a growing

body of promising theoretical and empirical work on the role of quantum effects in biological systems, which might make the above speculations more plausible - or at any rate more testable – in the future (see Ball 2011; Craddock et al. 2014; see also Atmanspacher 2011 for a critical review of a number of quantum approaches to consciousness).

4 Fundamental Physics and the Mind in Kant’s Critical Philosophy

We started off by noting that many researchers may find puzzling the connection between fundamental physics and the human mind that seems implied by recent advances in quantum cognition, not to mention the speculations in the quantum mind/consciousness programs. However, the idea that there is a connection between fundamental physics and the mind is not new in Western science and philosophy. Most notably, Kant’s critical philosophy suggested that there is a strong connection between the principles of Newtonian physics and experience. Toulmin (2003) points out that Kant attempted to give a philosophical justification for Newton’s results by claiming that a scientist can arrive at a coherent, rational system of empirically applicable explanations only by constructing her theories around Euclidean and Newtonian concepts. In other words, Kant assumed that Newton had hit on a uniquely adequate system of physics. But even more radically, Kant held that these principles are necessarily a part of human every-day experience of the world, and not just scientific experience. More precisely, he thought that the presuppositions of Newtonian physics are part of the *necessary conditions of the possibility of experience in general* (Strawson 1966).

To get a better idea of Kant’s thoughts on this difficult issue it is useful to consider the opening words of Peter Strawson’s acclaimed 1966 book *Bounds of Sense: An Essay on Kant’s Critique of Pure Reason*:

“It is possible to imagine kinds of world very different from the world as we know it. It is possible to describe types of experience very different from the experience we actually have. But not any purported or grammatically permissible description of a possible kind of experience would be a truly intelligible description. There are limits to what we can conceive of, or make intelligible to ourselves, as a possible general structure of experience. The investigation of these limits, the investigation of the set of ideas which forms the limiting framework of all our thought about the world and experience of the world, is, evidently, an important and interesting philosophical undertaking. No philosopher has made a more strenuous attempt on it than Kant.” (1966, p. 15).

So, according to Strawson, Kant was centrally concerned with the “bounds of sense” – with the “...limits to what we can conceive of, or make intelligible to ourselves, as a possible general structure of experience” (1966, p. 15). Kant’s own view of these limits was closely tied with Newtonian physics. For as we already mentioned, Kant thought that the presuppositions of Newtonian physics are part of the necessary conditions of the possibility of experience in general. So in this sense it is fair to say that Kant’s view of the general structure of experience is Newtonian. Indeed, when we consider the main general theses of what Strawson (1966, p. 24) calls Kant’s “metaphysics of

experience”, we find in them a strong emphasis upon features of Euclidian geometry and Newtonian physics. For example, according to Strawson Kant argues that “...there must be one unified (spatio-temporal) framework of empirical reality embracing all experience and its objects” and that “...certain principles of permanence and causality must be satisfied in the physical or objective world of things in space.” (1966, p. 24). Kant (1787) himself wrote:

“Other forms of intuition besides those of space and time, other forms of understanding besides the discursive forms of thought, or of cognition by means of conceptions, we can neither imagine nor make intelligible to ourselves; and even if we could, they would still not belong to experience, which is the only mode of cognition by which objects are presented to us.” (B263).

In retrospect we can say that Kant was, even by his own standards, mistaken in assuming that Newton had discovered a uniquely adequate system of physics. For, as Toulmin (2003) points out,

“...20th-century astrophysics and quantum mechanics have succeeded in giving non-Euclidean and post-Newtonian concepts an entirely coherent empirical application in the scientific explanation of natural phenomena - and this was something that Kant was not prepared to contemplate.”

However, does the fact that Newtonian physics fails to account for natural phenomena in the quantum and relativistic domains imply that Kant was wrong in claiming that the principles of Newtonian physics are part of the necessary conditions of human everyday experience? And what is the relation of Kant’s view of the connection between experience and physics to the quantum view of experience sketched earlier in the paper?

5 Concluding Remarks: Extending or Traversing the Bounds of Sense?

In the previous section we considered an idea that has been a key part of Western philosophy since Kant, namely that philosophy should be concerned with investigating the “bounds of sense” – i.e. the limits to “...what we can conceive of, or make intelligible to ourselves, as a possible general structure of experience” (Strawson 1966). We noted that Kant himself thought that Newtonian physics played a key role in defining these limits. According to this view, our experience typically consists of a self-conscious subject perceiving a law-governed world of objects. However, our discussion in the earlier sections explored the possibility that quantum rather than Newtonian principles might play a key role in human cognition and experience.

So, what should we make of the Newtonian, classical character of Kant’s view of experience? Note that in our sketches of a more general, quantum view of experience described earlier in this article, we were not denying the validity of the Kantian view altogether. We were rather implying that Kant was describing the “classical limit” of human experience. Note also that an aconceptual view of the mind is typically asubjectivist (e.g. Pylkkö 1998). It is assumed that a fully self-conscious subject is typically not present or dominant in the more general, aconceptual experience. Rather, such a subject is something that only emerges in the classical limit of experience, i.e., when

aconceptual experience in some typical circumstances divides and crystallizes into concepts and objects. So a quantum view of human experience need not deny altogether the role that Kant gives to the self-conscious subject. However, such a subject is no longer seen as a fundamental aspect of human experience. Of course, as Pyllkkö (1998) has emphasized, asubjectivist views have also – independently of any quantum considerations – been proposed in the “post-phenomenological” approaches of e.g. the late Heidegger, Merleau-Ponty, Bataille and Patocka.

There is a potential difficulty that any quantum view of experience needs to face. Note that Strawson gives great weight to *intelligibility* as a criterion. For the challenge, according to him, is to find the limits to *what we can make intelligible to ourselves*, as a possible general structure of experience. Now, quantum theory is notoriously difficult to understand, so much so that some philosophers, like G.H. von Wright (1986) have indeed spoken about a “crisis of intelligibility” in connection to it. The obvious risk is that any attempt to develop a quantum view of experience (whether experience of the empirical phenomena in the “external world” or the “inner world” of psychological phenomena) will inherit the lack of intelligibility characteristic of quantum theory. Such a view would then traverse, rather than extend, the bounds of sense and risk leading to descriptions empty of meaning.

However, it is here important to bear in mind that intelligibility is a relative notion. In recent years this has been particularly vividly brought out by Ladyman and Ross, e.g. in their provocative and ground-breaking 2007 book *Every Thing Must Go: Metaphysics Naturalized* where they, among other things, discuss the role of intuitions and common sense in metaphysics. For example, they point out that “[w]hat counts as intuitive depends partly on our ontogenetic cognitive makeup and partly on culturally specific learning” (2007, p. 10). Surely the same applies for intelligibility. From time to time scientific research involves encountering puzzling empirical phenomena (e.g. the experimental results that necessitated the development of quantum theory) and making sense of these puzzles often requires us to develop new concepts or even whole new conceptual frameworks (e.g. Bohr’s complementarity or Bohm’s implicate order). Often such new concepts and frameworks are very difficult to grasp at first, but they justify their existence by the light they are able to throw upon the puzzling phenomena that prompted their development in the first place. In line with this, Wang et al. (2013, p. 681) are optimistic about the intelligibility and explanatory power of the quantum cognition approach:

“Perhaps in contrast to the common impression of being mysterious, quantum theory is inherently consistent with deeply rooted psychological conceptions and intuitions. It offers a fresh conceptual framework for explaining empirical puzzles of cognition and provides a rich new source of alternative formal tools for cognitive modeling.”

To be sure, in the course of ground-breaking scientific research (whether in physics or in cognitive science) there are times when some may feel that others have traversed rather than extended the bounds of sense. And, of course, the very notion of aconceptual experience (Pyllkkö 1998) that a quantum view of experience may involve suggests that our possibilities to give intelligible conceptual descriptions of the aconceptual aspects of experience are likely to be limited. But, if one is allowed to indulge in a bit of anachronistic speculation, given Kant’s aspirations to develop a *scientific*

metaphysics, he himself might well have attempted to incorporate quantum principles into his view of experience – both “outer” and “inner” - had he been aware of the empirical results that led to the development of quantum theory.

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