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Quantum neurophysics: From non-living matter to quantum neurobiology and psychopathology

Sultan Tarlacı [a,*], Massimo Pregnolato [b]

[a] Sifa University, Department of Neurology, İzmir, Turkey
[b] Pavia University, Department of Drug Sciences, Pavia, Italy

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ABSTRACT

The concepts of quantum brain, quantum mind and quantum consciousness have been increasingly gaining currency in recent years, both in scientific papers and in the popular press. In fact, the concept of the quantum brain is a general framework. Included in it are basically four main sub-headings. These are often incorrectly used interchangeably. The first of these and the one which started the quantum mind/consciousness debate was the place of consciousness in the problem of measurement in quantum mechanics. Debate on the problem of quantum measurement and about the place of the conscious observer has lasted almost a century. One solution to this problem is that the participation of a conscious observer in the experiment will radically change our understanding of the universe and our relationship with the outside world. The second topic is that of quantum biology. This topic has become a popular field of research, especially in the last decade. It concerns whether or not the rules of quantum physics operate in biological structures. It has been shown in the latest research on photo-synthesis, the sense of smell and magnetic direction finding in animals that the laws of quantum physics may operate in warm-wet-noisy biological structures. The third sub-heading is quantum neurobiology. This topic has not yet gained wide acceptance and is still in its early stages. Its primary purpose is directed to understand whether the laws of quantum physics are effective in the biology of the nervous system or not. A further step in brain neurobiology, towards the understanding of consciousness formation, is the research of quantum laws' effects upon neural network functions. The fourth and final topic is quantum psychopathology. This topic takes its basis and its support from quantum neurobiology. It comes from the idea that if quantum physics is involved in the normal working of the brain, diseased conditions of the brain such as depression, anxiety, dementia, schizophrenia and hallucinations can be explained by quantum physical pathology. In this article, these topics will be reviewed in a general framework, and for the first time a general classification will be made for the quantum brain theory.

1. Introduction

More than a century ago, the beginnings of quantum physics brought two important points of discussion. The first was whether consciousness or a conscious observer had a role in determining the outcome of a quantum measurement. This argument got so heated that it was seen as a problem among quantum physicists and gained the name “the measurement problem”. Various solutions were suggested for this problem. Even the founding fathers of quantum physics became divided into various schools and factions on this point. This issue still remains unsolved among quantum physicists, and quantum measurement is still known as the “measurement problem” (Tarlacı, 2012c). Unending arguments still persist today about whether the person who in classical physics is merely the “observer” is in quantum physics an observer or a “participant” in the measurement, or even whether this person determines the outcome of the measurement. From the beginnings of quantum mechanics until today, answers have not yet been found to the place of the observer/experimenter in the Copenhagen interpretation (Cramer, 1986), or the concepts of many worlds or hidden variables or other suggested solutions. Theories on the effect of consciousness and the observer in quantum mechanics have been proposed by such eminent physicists as John von Neumann and Eugene Wigner (Wigner and Margenau, 1967), John A. Wheeler (Wheeler and Zurek, 1983), and Ewan H. Walker (Walker, 1977). However, objective theories have also been proposed which say that the observer has no relevance to the mechanism or result of a quantum experiment.

The second debate which started immediately after the birth of quantum physics was whether physics concerned only non-living materials or whether the laws or quantum physics operated in biological structures. However, this debate and field of thought did not approach the dimensions of the measurement problem. The most important

* Corresponding author at: Sifa University Hospital, Dept of Neurology, Karşıyaka, Izmir, Turkey. Tel.: +90 232 362 66 66; fax: +90 232 362 89 89.
E-mail address: sultan.tarlaci@sifa.edu.tr (S. Tarlacı).

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factor restricting the debate was the perception of biological structures as "warm-wet-noisy", and the impossibility of the operation of quantum physics in such an environment (Tegmark, 2000). However, when we consider biological entities, all biological structures can be reduced to biochemistry, and at a deeper level to quantum physics, down to processes at the level of ions, small molecules and proteins (i.e. receptors, ion channels and enzymes). In particular there is no "cut-off point" demarcating the boundary between classical physics and quantum physics (Tarlacı, 2011). These days quantum photochemical reactions are seen as normal, but it is only in the last ten years that it has been understood that quantum mechanics forms the base of the senses of sight and smell, photosynthesis, and magnetic direction finding in animals. The emergence of new evidence from similar studies has recently mediated the birth of quantum biology, despite long resistance. However, today the opponents of the quantum biology are fewer and hundreds of papers on the subject can be found in the archives of physics.

From the viewpoint of cognitive neurology, we now well understand the nature of nerve cell activity: the creation of action potentials, ion exchange, the use of energy, axonal transport, the vesicle cycle, and the production, cycle and breakdown of neurotransmitters. What we do not understand is how experience is formed in our material brains, and how consciousness is born from unconscious materials. In particular, classical physics has nothing to say on how to understand internal experience (Tarlacı, 2010b; Blutner, 2010). As a result of this shortcoming, a new concept, quantum neurobiology, has come into existence. Quantum neurobiology is a concept to which we are not yet fully accustomed to: it refers to a narrow field of the operation of quantum physics in the nervous system such as the emergence of higher cognitive functions like consciousness, memory, internal experiences, and the processes of choice and decision-making which are products of the warm-wet-noisy brain. According to quantum neurobiology, quantum physics is involved in biological processes, and consciousness, memory, internal experiences, and the processes of choice and decision-making, which are the products of the warm-wet-noisy brain, may be the result of the operations of quantum physics. According to this, and in contrast to the classical view, the information processing units are not the nerve cells but smaller quantum physical processes inside the cells and forming connections between them. As will be seen, this is an example of deep reductionism, and can be thought of from another viewpoint as *super-reductionism*. Theories relating to quantum neurobiology have been proposed which are verifiable or falsifiable experimentally.

If quantum physics is involved in the neurobiological operation of the normal and healthily functioning brain, then it may be considered to have a role in the pathological processes of mental illnesses (Pylkkänen, 2010). This has now been given a name: quantum psychopathology (Globus, 2010; Mender, 2010). The idea of quantum psychopathology is that it will work in the same way in which quantum neurobiology successfully explains the conscious workings of the healthy brain (Woolf et al., 2010). So far, theoretical and experimentally testable papers have been published on depression (Cocchi et al., 2010; 2012; Rasenick, 2012), schizophrenia (Zizzi and Pregnolato, 2012a, 2012b, 2012c; Zizzi and Pregnolato, 2012a, 2012b, 2012c), anorexia nervosa (Marlow, in press) and Alzheimer's dementia (Georgiev, 2002, 2009), and the topic has attracted a great deal of interest and attention. The next step will be an approach which will provide treatment (Cocchi et al., 2010, 2012).

In the past 30 years, the concepts of the dynamics of the quantum brain, mind and consciousness and the quantum brain theory have increasingly come up both in scientific publications and at congresses (Tarlacı, 2010a; Başar, 2010). However, the terminology has been used somewhat loosely. For example, "quantum mind theory" has been used when discussing whether the mind is involved in the measurement problem. The same term is used for the theories that attempt to explain how consciousness is created in the brain through the use of quantum mechanical calculations. As a result, it is necessary when using the term "quantum brain theory" to shed light on the subject under discussion. These concepts have also been reflected in popular culture, and wherever you go you see the mysterious word "quantum", and everybody trying to make money out of the mystery of quantum physics (Tarlacı, 2012a). A serious consequence of this cultural drift is the fact that the prefix "quantum" has earned a bad image among that part of the academic community with an interest in physics.

In this overview article, the quantum measurement problem will be briefly discussed. This is a topic which journals of theoretical physics have discussed from a philosophical point of view since the birth of quantum physics, almost as much as they have discussed advanced mathematics. The subheadings of quantum neurobiological theories and quantum psychopathology will be discussed from a quantum biological standpoint. The working of the brain according to quantum monadology (Nakagomi, 2006; Harrison, 2006), which is a metaphorical theory of the quantum brain, and S-matrix or Feynman diagrams (Başar, 2009) will not be dealt with in this article. All these topics were unofficially described as quantum neurophysics, quantum brain dynamics, or more narrowly as quantum brain/mind/consciousness, until they gained an official status with the regular publication from 2003 to the present of the journal *NeuroQuantology*, which covers these topics (Tarlacı, 2003). Today, NeuroQuantology is not just the name of a journal but of a scientific discipline (Tarlacı, 2012b; 2014). Because of the publication of an increasing number of quantum brain theories, the need was felt for a review to explain the position of the theory. A general review of quantum brain theory will be done in this article on the basis of a new classification (Fig. 1). The topics in this overview article will be examined on the basis of this new classification. We hope that this classification will be a guide for future publications.

2. The quantum measurement problem and consciousness

Since this heading is outside the scope of a neuroscience journal, only a general view will be presented here. The quantum measurement problem, or to use a more technical expression the collapse of the wave function, appeared soon after the birth of quantum mechanics, and a clear solution to this problem has yet to be proposed. The topic was transferred to the macroscopic level by the thought experiment of Schrödinger's cat (Tarlacı, 2012c). In this imaginary experiment, a cat is totally isolated from the environment in a box together with a radioactive atom with a half-life of 10 min. If we examine the state of the atom at the end of 10 min, we will see one of the two possible results, namely that its nucleus has either split or not split. If the atomic nucleus splits the cat will die, and if it does not, the cat will live. According to quantum physics, until an experimenter opens the box and sees the cat inside it, the cat is simultaneously both alive and dead. Or in technical terms, the living and dead states are superimposed. The observation of the experimenter who opens the box removes the cat from this superimposed state, and reduces it to one of the states of living or dead. If you think this is strange when you consider your cat at home, well, this is how things work in the quantum world.

When Erwin Schrödinger described the paradox of the cat (the cat that was both alive and dead at the same time) through his thought experiment, in search of a solution to the quantum world, ended up confusing both the experimenter and the cat. And it cannot be said that the confusion has been cleared up yet. The solution of the Bohr-Heisenberg Copenhagen School (Cramer, 1986) and von Neumann–Wheeler–Wigner (Wigner and Margenau, 1967) involves the observer or consciousness. When there is a conscious observer, anything which is observed presents us with all of its superimposed content as a single one of all the possible and potential states. Wigner goes further and wants to include consciousness as a hidden variable in the equations of quantum mechanics. In Everett's many-worlds/minds proposal, there is a branching and dividing wave function. Reality separates here into infinite and different consciousness, which have no knowledge of

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