

Can Bohmian brains make minds? — On shadows, puppets and zombies

Shan Gao

Research Center for Philosophy of Science and Technology,
Shanxi University, Taiyuan 030006, P. R. China
E-mail: gaoshan2017@sxu.edu.cn.

August 31, 2022

Abstract

In Bohmian mechanics, it is assumed that the physical state that determines the mental state of an observer is not the wave function but the configuration of the Bohmian particles. In this paper, I argue that the Bohmian particles are like shadows and puppets, and the Bohmian observers have no conscious minds and they are zombies when assuming that quantum entanglement plays no role in generating the conscious mind. It remains to be seen if Bohmian brains can make minds by rejecting this common assumption in neuroscience and philosophy of mind.

In Bohmian mechanics, the physical state, which determines the result of a measuring device and the mental state of an observer, is not the wave function but the configuration of the Bohmian particles (Goldstein, 2021). These particles have only positions and velocities in three-dimensional space, and they have no mass and charge, and they have no interactions with each other either (when their effective wave function is not an entangled state). An intriguing question then arises: can these Bohmian particles compose brains that generates conscious minds? or do Bohmian observers have conscious minds?

Let's first compare the Bohmian particles with two familiar things: shadows and puppets. Shadows have the shapes of objects, but they have no other physical properties of objects such as mass and charge. Shadows always move

with the objects they belong to. When objects interact with each other, their shadows appear to also interact with each other. But there are no real interactions between shadows. The motion of one shadow does not affect the motion of other shadows. Moreover, the shadow of an object may disappear (when there is no light illuminating the object), and its disappearance does not affect the motion of other shadows either. When including both the wave function and the Bohmian particles in the ontology of Bohmian mechanics, the Bohmian particles are like shadows of the effective wave functions (when the entanglement between the effective wave functions can be ignored).

Take cats as an example. The (typical) Bohmian particle configuration of a cat has the shape of a cat, but it has no other properties of a cat represented by its wave function, such as mass, color and temperature etc. The Bohmian particles of a cat always move with the wave function of the cat. When two cats fight with each other and their wave functions interact with each other, their Bohmian particles also appear to interact with each other. But there are no real interactions between the Bohmian particles of the two cats. The motion of the Bohmian particles of one cat has no causal consequences upon the motion of the Bohmian particles of the other cat. The Bohmian particles of one cat may escape to infinity or disappear (when they reach a node of the wave function of the cat), and their escape or disappearance does not affect the motion of the Bohmian particles of the other cat either.

When there are only Bohmian particles in ontology, these particles are more like puppets than like shadows. Puppets are controlled by a unified force, just like the Bohmian particles whose motion is governed by the universal wave function being a law (on the nomological view). Also like the Bohmian particles, puppets have no interactions with each other. The motion of one puppet does not affect the motion of other puppets. A puppet may be removed, and its removal does not affect the motion of other puppets either.

Our brain can generate the mind and make us have conscious experiences. But few people would think that a group of shadows or puppets, which mimics the neural activities in our brain, can also generate the mind. What is the essential difference between shadows or puppets and neurons? It is that there are real connections and interactions between neurons, but there are no real connections and interactions between shadows or puppets. The motion of every shadow or puppet does not affect the motion of other shadows or puppets. Removing any shadow or puppet does not affect the motion of other shadows or puppets either. But the activity of every neuron will affect the activities of nearby neurons, and removing any neuron will also affect the activities of nearby neurons in general.

Today it is a fundamental postulate in neuroscience and philosophy of

mind that the parts of a system must be strongly connected to each other so that it can generate the conscious mind. A typical example is the Integrated Information Theory of consciousness (IIT), which is one of the leading theories of consciousness (Tononi, 2008, 2015; Fallon, 2022). According to IIT, consciousness requires a grouping of elements within a system that have physical cause-effect power upon one another, and the level of consciousness of a system is described by the integrated information of the system, which can be represented by a precise mathematical quantity Φ . A system whose elements have strong connections will have high Φ , while a system whose elements have weak connections will have low Φ . Our brain has very high Φ , and it is therefore highly conscious. By contrast, as for a system composed of shadows or puppets, since there are no connections between these shadows or puppets, the system will have zero Φ , which means that it is not conscious at all.¹

Now let's turn to the key issue: what if our brain is composed only of the Bohmian particles? can this Bohmian brain generate the conscious mind? We need a common assumption in neuroscience and philosophy of mind to answer this question. It is that our conscious mind is generated by the activities of some quasi-classical systems such as neurons in our brain without involving quantum entanglement. Due to environment-induced decoherence in our brain (see, e.g. Tegmark, 2000), the effective wave function of these quasi-classical systems is a product state, or in other words, each system has its own effective wave function or wavepacket, and the motion of its Bohmian particles is guided only by its wavepacket.

Then, by analogy with the shadows and puppets, we can similarly argue that such a Bohmian brain cannot generate the conscious mind. In other words, a person with a Bohmian brain will be a zombie.² For example, according to IIT, a Bohmian brain will have zero Φ and thus have no conscious experiences, since there are no connections between the Bohmian particles of the nonentangled quasi-classical systems in the brain, and the whole system does not integrate information.

Here it is worth pointing out that the wave function does not necessarily represent a physical entity in a high-dimensional space as some Bohmians often criticized, and there are also ontological interpretations of the wave function in three-dimensional space such as the multi-field interpretation (Hubert and Romano, 2018) and the RDM of particles interpretation (Gao, 2017, 2020), which are usually ignored by some Bohmians (deliberately?).

¹Another popular example is digital camera's photodiodes. Since all the photodiodes are in isolation from each other, the system does not integrate information and has zero Φ .

²This presents a real example of zombies for philosophy of mind.

Thus, we can have other pictures of quantum reality in three-dimensional space besides the picture of Bohmian particles.

There are two possible ways to avoid the above result. One way is to insist that Bohmian brains can generate conscious minds even though there are no connections between the Bohmian particles. In this case, one must reject the fundamental postulate that the parts of a system must be strongly connected to each other so that it can generate the conscious mind. In particular, one must also admit that a group of shadows or puppets, which mimics the neural activities in our brain, can also generate the conscious mind. I think few people would take this step.

The other way is to conjecture that our conscious mind is not generated by the activities of some quasi-classical systems such as neurons in our brain, but generated by the quantum activities of some smaller systems in our brain which involve quantum superposition and entanglement (see, e.g. Hameroff and Penrose, 1996, 2014). In this case, the Bohmian particles for entangled states will have nonlocal connections, and the brains composed of these particles may be able to integrate information. Then IIT may also predict that such Bohmian brains can generate conscious minds. However, one must reject the common assumption that quantum entanglement plays no role in generating the conscious mind. Moreover, one also needs to construct a quantum theory of brain/mind to see if Bohmian brains in the theory can indeed generate conscious minds. Maybe some Bohmians would like to choose this way.

To sum up, I have argued that the Bohmian particles are like shadows and puppets, and the Bohmian observers have no conscious minds and they are zombies when assuming that quantum entanglement plays no role in generating the conscious mind. It remains to be seen if Bohmian brains can make minds by rejecting this common assumption in neuroscience and philosophy of mind.

Acknowledgments

This work was supported by the National Social Science Foundation of China (Grant No. 16BZX021).

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