Why mind matters in quantum mechanics

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Abstract

In a recent paper (Synthese, 2019. https://doi.org/10.1007/s11229-019-02101-3), Oldofredi presents a critical analysis of my mentalistic formulation of the measurement problem of quantum mechanics. Here I answer these criticisms, and explain more clearly why the formulation is helpful to understand and solve the measurement problem.

The conventional formulation of the measurement problem of quantum mechanics is given by Maudlin (1995), according to which the problem originates from the incompatibility of the following three claims:

(C1). the wave function of a physical system is a complete description of the system;

(C2). the wave function always evolves in accord with a linear dynamical equation, e.g. the Schrödinger equation;

(C3). a measurement yields a single definite result.

In a previous paper (Gao, 2019), I proposed a new formulation of the measurement problem, which states the incompatibility of the following three assumptions:

(A1). the mental state of an observer supervenes on her wave function;

(A2). the wave function always evolves in accord with a linear dynamical equation, e.g. the Schrödinger equation;

(A3). a measurement by an observer yields a single mental state with a definite record.

Recently Oldofredi (2019) presents a critical analysis of this mentalistic formulation of the measurement problem. In this paper, I will answer his criticisms, and explain more clearly why the new formulation is helpful to understand and solve the measurement problem.

In order to evaluate the criticisms of Oldofredi, let us first compare the two formulations of the measurement problem and see if the later is more appropriate with respect to the former. The key is to understand the claim (C3) in Maudlin's formulation of the measurement problem, namely "a measurement yields a single definite result." Where does this claim come from? Is it really true? Here we only consider the one-world case, since both (C3) and (A3) are not true in the many-worlds case. As Oldofredi (2019) also admitted, the claim (C3) comes from the *empirical* evidence. He said, "macroscopic objects can be in superposition, contradicting empirical evidence, i.e. uniqueness and definiteness of measurement outcomes. This is in essence of the famous measurement problem of quantum theory" (Oldofredi, 2019). Then, if the claim (C3) indeed comes from the empirical evidence, then it actually means that an observer observes that a measuring device yields a single definite result after a measurement. In other words, an observation or a measurement by an observer yields a single definite record, such as a pointer being in a definite position, in her mental state.

In fact, what we know with certainty by experience is only that we as observers obtain a definite record after a measurement by having a definite mental state with the record. While we don't know whether a measuring device really obtains a definite result (e.g. the pointer of a device indicates a definite position) after a measurement. For example, if the mental state is determined randomly by one branch of the post-measurement superposition as in the single-mind theory (Albert and Loewer, 1988), then the pointer of a device does not indicate a definite position after a measurement, but an observer will obtain a definite record after an observation of the position of the pointer.

Therefore, what the claim (C3) in Maudlin's formulation of the measurement problem really means is (A3), namely that a measurement by an observer yields a single definite record in her mental state. Moreover, the three claims in Maudlin's formulation of the measurement problem are not necessarily incompatible (when the measurement is made by an observer). When the three claims are compatible, the formulation is invalid; there is no contradiction and thus no problem in this case. This strongly suggests that a more appropriate formulation of the measurement problem based on (A3) is needed. What is it, then?

Since (A3) concerns the mental state of an observer, we need an assumption about the psychophysical connection (i.e. the connection between the mental state and the wave function) in order to derive a contradiction. This means that (C1), which says that the wave function of a physical system is a complete description of the system, should be replaced by another assumption about the psychophysical connection. It can be seen that this assumption may be (A1), namely that the mental state of an observer supervenes on her wave function. In fact, (C1) implies (A1) by the principle of psychophysical supervenience.

Thus we will obtain the mentalistic formulation of the measurement problem as given above (see also Gao, 2017, 2019). This new formulation of the measurement problem is valid in the sense that the three assumptions in the formulation are always incompatible, and thus it is more appropriate than Maudlin's original formulation of the problem.

The question now is: can we have a physical formulation of the measurement problem that does not refer to the mental state? It seems that the answer is negative. The essential reason is that we don't know what physical state a mental state corresponds to in quantum mechanics. When removing the reference to the mental state, (A1) can be replaced by (C1) or another assumption such as that wave functions represent measurement results (and other things in the world that can be perceived by us). But (A3) cannot be replaced by another assumption that refers only to the physical state, such as "a measurement by a device yields a single definite result", since we don't know what physical state a definite mental state corresponds to. As noted before, although we see the pointer of a device being in a definite position, this does not necessarily imply that the pointer of the device is in a definite position as a matter of fact. Thus we cannot derive a contradiction between quantum mechanics and experience when removing the reference to experience or the mental state. In other words, there is no physical formulation of the measurement problem. In this sense, the measurement problem of quantum mechanics is essentially the determinate-experience problem indeed (Barrett, 1999).

It should be pointed out that the above conclusion is true only in a strict sense. We may also have a physical formulation of the measurement problem in a restricted sense, namely when assuming what we see reflects what it is truely (in the one-world case). In this case, when we see the pointer of a device being in a definite position, the pointer of the device is indeed in a definite position. Then, the mentalistic formulation of the measurement problem may reduce to a physical formulation of the problem, which states the incompatibility of the following three assumptions:

(B1). the wave function represents the measurement result;

(B2). the wave function always evolves in accord with a linear dynamical equation, e.g. the Schrödinger equation;

(B3). a measurement by a device yields a single definite result.

The result assumption (B1) seems better than the completeness assumption (C1) in Maudlin's formulation, since in order to lead to a contradiction, the wave function of a physical system is not necessarily a complete description of the system, and it is only required that the post-measurement state of the measuring device represents the measurement result.

The mentalistic formulation of the measurement problem highlights the important role of psychophysical connection in causing the measurement problem. By this new formulation, we can look at the solutions of the problem from a new angle. In particular, Bohm's theory, Everett's theory and collapse theories correspond to three different forms of psychophysical connection (as well as three different result assumptions). In fact, there are only three types of physical states that may determine the mental state of an observer, which are (1) the wave function in collapse theories, (2) certain branches of the wave function in Everett's theory, and (3) other hidden variables such as particle configuration in Bohm's theory.

Oldofredi (2019) gives a good introduction of how Bohm's theory and collapse theories solve the measurement problem. His line of reasoning seems well accepted. A quantum theory such as Bohm's theory is constructed as follows. We first have an ontology and its dynamics that can explain definite localization of macroscopic objects and definite measurement results consistent with the Born rule. Then, as a result of the ontology and dynamics, the theory ensures that observers' mental states will supervene on well localized physical states and thus it can also explain the definite perceptions of observers. Therefore, the measurement problem will be solved by these theories without caring about the minds of observers. He said, "Bohmian mechanics and GRW theories provide clear explanations of the physical processes responsible for the definite localization of macroscopic objects and, *consequently*, for well-defined perceptions of measurement outcomes by conscious observers... these theories *guarantee*, in virtue of their Primitive Ontology (PO) and dynamical laws, that observers' mental states will supervene on well localized physical states representing measurement outcomes" (Oldofredi, 2019, italics added).

However, this common line of reasoning is problematic. Why assume such ontology and dynamics in the first place? Obviously such assumptions are made in order to account for our definite experience. Thus the actual line of reasoning should be that these theories first assume *implicitly* that observers' mental states supervene on the well localized physical states representing measurement outcomes, and then they assume certain ontology and dynamics so that the measurement outcomes predicted by them can be consistent with the Born rule. This means that in order to solve the measurement problem, these theories still need to care about the minds of observers by assuming a certain form of psychophysical connection.

Furthermore, as argued by Gao (2019), the form of psychophysical connection in a theory cannot be simply posited, and it is restricted by our understanding of minds. For example, the form of psychophysical connection assumed by Bohm's theory is inconsistent with the popular functionalism in the philosophy of mind when including the wave function in the ontology of the theory (Brown and Wallace, 2005; Lewis, 2019).[1] If functionalism

[1]Note that "Functionalism in one version or another remains the dominant view of mind among philosopers" (McLaughlin et al, 2009, p.149). In particular, "virtually all current major theories of mental content are in one way or another functionalist" (McLaughlin et al, 2009, p.8). Moreover, in philosophy of mind, it is widely thought that although qualitative properties of consciousness, or qualia, may be not reducible, other mental phenomena are physically reducible, i.e., reducible to how physical matter moves and interacts (see, e.g. Kim, 2005). Thus, if this kind of physicalism is true, then the form of

is correct, for the mental state to supervene on the Bohmian particles but not on the wave function, the Bohmian particles must have some functional property that the wave function do not share. However, in a human brain, where the wave functions are decohered due to the hot, wet and noisy environment and thus they are effective wave functions in Bohm's theory, the functional behaviour of the Bohmian particles is arguably identical to that of the effective wave function in which they reside (when coarse-grained at the level relevant to the mental functions of the brain).

Finally, even if the form of psychophysical connection assumed by a theory is valid, there are still unsolved issues that are closely related to the minds of observers. Take collapse theories as an example. In these theories, the mental state of an observer supervenes on her wave function. Since these theories can explain definite localization of macroscopic objects and definite measurement results, and observers' mental states also supervene on these well localized physical states, it seems that they can readily explain the definite perceptions of observers. However, due to the imperfectness of wave-function collapse, the post-measurement state of an observer is an entangled superposition of brain states with different records, although the modulus squared of the amplitude of one state is close to one in general. This leads to the well-known tails problem (Lewis, 1995; Albert and Loewer, 1996; McQueen, 2015). Moreover, even though the tails problem can be solved, we still need to analyze how the mental state of an observer supervenes on her wave function in general. Since the collapse time of a single superposed state is an essentially random variable, whose value can range between zero and infinity, there always exist certain measurements with a tiny probability, for which the collapse time is longer than the normal conscious time and the observer after the measurements is in a general entangled superposition of brain states with different records. Then, an intriguing question arises: What is it like to be such a quantum observer?[2] The answer to this question may help solve the tails problem (Gao, 2019).

To sum up, I have explained why mind matters in quantum mechanics, and in particular, why the mentalistic formulation of the measurement problem is helpful to understand and solve the problem. I hope these explanations may answer Oldofredi's criticisms in a satisfactory way.

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psychophysical connection assumed by Bohm's theory will be problematic (when including the wave function in the ontology of the theory).

[2]A similar question has been asked in the bare theory (Albert, 1992, p.124; Barrett, 1999).

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