Is the subjective interpretation of quantum probabilities really inconsistent?[1]

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ABSTRACT: Christopher Fuchs has recently offered a provocative version of quantum mechanical realism, which is based on the suggestion that quantum probabilities merit a subjective interpretation. His proposal, however, has been charged with inconsistency by Amit Hagar (2003), who argues that interpreting quantum probabilities subjectively is inconsistent with the realist claims Fuchs wants to maintain for the quantum system and the dimensionality of the Hilbert space that accompanies it. In this paper I first outline the fundamentals of Fuchs's approach and then take up the task of rebutting Hagar's charge by demonstrating the internal coherence of Fuchs's realism.

Keywords: Bayesianism, measurement problem, incompleteness of the quantum formalism, wave-function, collapse postulate, realism.

1. Introduction

One of the few things in the foundations of Quantum Mechanics (QM) that is generally agreed upon is that quantum probabilities require an *objective* interpretation. Recently, however, Christopher Fuchs and his collaborators (cf. Caves et al. 2002a, 2002b, 2007, Fuchs 2003) have presented an account according to which the probabilities of QM are best understood as *subjective degrees of belief*. As I explain in the first part of the paper, Fuchs does not deny that QM describes some objective features of the world but rather intends to integrate his proposal within a more general programme, which is supposed to draw a clear-cut line between the subjective and the objective elements of QM. Thus Fuchs's proposal can be described as a broadly realistic one, with the qualification that not all elements of the formalism of current non-relativistic QM can be assumed to correspond to elements of reality.

Fuchs's argument has been recently criticised by Amit Hagar, who claims that it is impossible to accept a subjective interpretation of quantum probabilities and at the same time offer a realistic account, however qualified, of QM. More specifically he argues that the use of subjective probabilities forces us to ignore the measurement problem of QM and thus commits us to instrumentalism. In the second part of this paper I

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investigate and assess the legitimacy of Hagar's claim. More specifically, I argue that one need not be an instrumentalist *in general* about QM if one chooses to interpret quantum probabilities subjectively. If I am correct, it follows that Fuchs's minimal realist position is internally perfectly consistent and, hence, cannot be challenged in the way Hagar claims.

2. Quantum probabilities as subjective degrees of belief

Fuchs's general orientation is to provide a reformulation of all the axioms of QM in information-theoretic terms. This demand stems from his belief that "quantum mechanics has always been about information" (Fuchs 2003, p. 989) and, Fuchs thinks, if satisfied, will clarify the persistent conceptual problems in the foundations of QM. At the same time, once we acquire a grasp of the subjective elements of QM, we should be able to draw the line between the subjective and the objective and thereby maintain a *realistic* stance towards those elements of the theory that merit this treatment.

The link of QM with information and the proposal that we should seek to understand QM in information-theoretic terms is traced by Fuchs back to Einstein and the famous EPR paradox.[2] EPR allegedly established the *incompleteness* of the quantum formalism, i.e. that the wave function does *not* give us a full description of reality. This result is consistent with an *epistemic* interpretation of the probabilities derived via Born's rule. Epistemic interpretations of the probability calculus construe probabilities as a measure of our *degrees of belief*. This is in contrast to *objective* interpretations, which take probabilities to reflect objective features of the physical world.[3] Regardless of whether Einstein himself subscribed to an epistemic view of quantum probabilities, Fuchs is more than willing to do so. Sharing with Einstein the conclusion that the quantum formalism is incomplete, he goes on to endorse an epistemic interpretation of quantum probabilities in the particular form of *Subjective Bayesianism*.

Fuchs, however, is careful *not* to endorse Einstein's hopes about the possibility of a fuller description of physical reality, now commonly referred to as a 'hidden-variables approach'. The reasons for doing so have to do with the advantage of time: if one is willing to accept locality as a reasonable constraint, as Fuchs is, then Bell's no-go theorem, which proves that all hidden-variables theories have to be non-local, is a serious predicament. Furthermore the Kochen-Specker no-go theorem, which precludes the possibility of assigning values to all observables in all states, is an even greater problem for a hidden-variables approach. In the face of these difficulties Fuchs proceeds to a most contentious point: he claims that QM is incomplete, given the way the world is (cf. ibid. pp. 994-995).

Although not entirely clear, Fuchs's basic argument seems to be that the incompleteness of QM shows us that the quantum state is best seen as representing incomplete information and quantum probabilities as being subjective degrees of belief. Had we been able to complete this information, we would arrive at the Einsteinian ideal of

[2] In fact, Fuchs (2003, p. 993) acknowledges that this line of thought "had a long pre-history with Einstein alone", yet he still takes EPR to contain its 'paradigmatic' explication.

[3] For more details on the distinction between epistemic vs. objective probability see Gillies (2000).

a hidden-variables theory. Yet the various no-go theorems suggest the untenability of this aim and one plausible explanation for this is that "there is something about the world that keeps us from ever getting more information than can be captured through the formal structure of quantum mechanics" (ibid. p. 995). This is a radical ontological claim, one that allows Fuchs to declare all quantum probabilities as *indispensable* subjective degrees of belief, in the sense that probabilistic statements are unavoidable given the above constraint on our epistemology. According to this interpretation then — though Fuchs denies the term 'interpretation'— "quantum theory does not describe physical reality. What it does is provide an algorithm for computing *probabilities* for the macroscopic events … that are the consequences of our experimental interventions" (Fuchs and Peres 2000, p. 70).

What, then, remains from QM that can be given a realistic interpretation? First of all, it is important to be clear as to what it means to be realist about QM. Along with most contemporary scientific realists, I take it that a quantum mechanical realist holds the following two theses: A) the *semantic* thesis that QM should be taken at face value, i.e. as capable of being genuinely true or false about its domain of description, and not as a mere algorithm for prediction, and B) the *epistemic* thesis that we have good reasons to think QM is actually a true, or at least approximately true, description of its domain and that the unobservable entities it postulates (or at least most of them) do exist in the world.[4] According to Fuchs, the only concepts that can be reasonably believed to correspond to elements of reality are the *quantum system* and the *dimension of the Hilbert space* associated with that system (Fuchs 2003, pp. 989, 1018-1021).[5] The quantum states are considered to be states of belief without any objective ontological significance, mere algorithms for predicting the usual macroscopic experimental phenomena. In other words, Fuchs's account is a *minimal realist* one, allowing for very few elements of QM to be taken at face value and correspond to real entities in the world. The rest are just instruments for prediction. Consequently, Fuchs's position is an interesting blend of realism and instrumentalism, with some parts of QM meriting a realistic interpretation and others only an instrumentalist one.

3. Reconstructing Hagar's challenge

In a recent paper Amit Hagar has challenged Fuchs's claim that one can adopt a subjective account of quantum probabilities and still maintain some form of realism about some parts of QM. Instead he suggested that "the epistemic view can be rendered

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[4] Incidentally this formulation of the realist thesis shows why a hidden-variables theory is *not* the only candidate for a realistic approach to QM. No matter how complicated or strange a theory is, one can maintain a realistic stance about it as long as one holds some kind of correspondence thesis between that theory and the entities it postulates and the world. What makes hidden-variables theories more appealing as realist candidates is their kinship with our common-sense ontology rather than any argument establishing that they should be the *only* candidates.

[5] I think that Fuchs's realism would remain an interesting position, even if it turned out that all real-world systems have infinite dimensional Hilbert spaces. This is because it would still contribute an interesting insight into the nature of reality, no matter how complicated the latter might end up being (I am grateful to an anonymous referee for bringing this point to my attention).

consistent only at the price of denying *even the weakest form of realism* Fuchs alludes to" (Hagar 2003, p. 763; my emphasis). Hagar's argument though is quite cryptic so it needs some spelling out.

Hagar claims that ignoring or rather sidestepping the well-known measurement problem of QM, as Fuchs in effect proposes to by means of his epistemic interpretation of quantum probabilities, is tantamount to endorsing instrumentalism. By using a thought experiment, which he attributes to Meir Hemmo and which is a standard 'Wigner's friend' scenario, Hagar's challenge can be reconstructed as a dilemma: *either (i) the epistemic account of probabilities is inconsistent or, (ii) if rendered consistent, it commits us to instrumentalism*. Furthermore, he implicitly makes the more general claim that (iii) a subjectivist approach to quantum probabilities, even if consistent in the first place, implies some form of metaphysical anti-realism.

Hemmo's thought experiment, as expounded by Hagar (cf. ibid. pp. 763-764), runs as follows: consider two people, Eve and Adam. Eve is in the laboratory and performs a measurement of a spin-1/2 electron, while Adam is outside of it. Before the measurement they both have the *same knowledge* of the situation in the lab, namely the superposition of the possible states of the spin of the electron $|\Psi_1\rangle = 1/\sqrt{2}\,|\uparrow\rangle + 1/\sqrt{2}\,|\downarrow\rangle$ (1), the arrows standing for the possible spin outcomes, up and down respectively. The measurement problem suggests that *after the measurement has taken place* the measuring device gets infected by the initial superposition. The result is a new superposition $|\Psi_2\rangle = 1/\sqrt{2}\,|\uparrow\rangle|\uparrow_M\rangle + 1/\sqrt{2}\,|\downarrow\rangle|\downarrow_M\rangle$ (2), with the subscript M indicating the reading of the measuring device.

Eve, however, is inside the lab and, in order to resolve the problem, she employs the collapse postulate, which, from the standpoint of the epistemic view, is now understood in an *instrumentalist* fashion as a mere updating rule. Having experienced the outcome of the experiment, her new degree of belief for, say, spin up changes from 0.5 to 1. Adam, on the other hand, is outside the lab. Being unable to see what the outcome of the experiment is, his knowledge of the situation remains the same as before and is described by the superposition (2). Clearly, Adam's prediction for spin up is probabilistic, with probability 0.5.

Hagar (cf. ibid. p. 763) realises that this incompatibility between the two predictions need not worry the subjectivist. As is well known, when a Subjective Bayesian acquires new evidence, she updates by means of well-defined rules her assignment of prior probabilities to the hypotheses under consideration. Eve is inside the laboratory, so after the measurement she knows what she has measured and she updates her beliefs accordingly. Adam, on the other hand, is outside of it and, not knowing the outcome of the measurement, has got no new evidence to use in order to update his own degrees of belief. Clearly our two agents do not update their (common) initial beliefs under the light of the same data. Consequently, it is perfectly natural that they reach different results.

The trouble for the subjectivist however, claims Hagar, comes from another direction. He believes that QM can give rise to other kinds of incompatible descriptions of the same situation, which do *not* admit of an epistemic interpretation. Demonstrating the possibility of such an event would prove the epistemic view *inconsistent*.

Such a case, he argues, arises from the, admittedly physically implausible, possibility of *Adam* performing operations in the lab. As we saw earlier, after the measurement Eve's state is either $|U\rangle = |\uparrow\rangle|\uparrow_M\rangle$ or $|D\rangle = |\downarrow\rangle|\downarrow_M\rangle$, depending on the outcome of the experiment. Let's assume she got spin up. Adam's on the other hand is the superposition

$$|\Phi\rangle = 1/\sqrt{2}\ |\uparrow\rangle\,|\uparrow_M\rangle + 1/\sqrt{2}\ |\downarrow\rangle\,|\downarrow_M\rangle = 1/\sqrt{2}\ \left(|U\rangle + |D\rangle\right). \qquad (3)$$

Now let Adam perform an operation in the lab in the form of a unitary transformation as follows:

$$|U\rangle \rightarrow 1/\sqrt{2}\ \left(|U\rangle + |D\rangle\right) \qquad (4)$$

$$|D\rangle \rightarrow 1/\sqrt{2}\ \left(|U\rangle - |D\rangle\right) \qquad (5)$$

In that case, (3) reduces to $|U\rangle$ for *Adam*, who now assigns his prediction for spin up probability 1, while Eve's description for spin up, formerly given by $|U\rangle$, is now given by (4) and her prediction is probabilistic with probability 0.5.[6] The claim here is that this divergence of predictions *cannot* be given an information-theoretic interpretation. If this last claim is correct, then, assuming the legitimacy of the formalism, the epistemic view of quantum probabilities is *inconsistent*.

The charge of instrumentalism comes about once we try to respond to the alleged paradox from the standpoint of the epistemic account of probabilities. Hagar considers two ways out, both of which would lead to instrumentalism. The first (cf. ibid. p. 765) would be to suggest that due to decoherence, Eve's superposition, given by (4), would vanish. Thus *for all practical purposes* (FAPP) we would face no real threat of inconsistency. Strictly speaking, however, decoherence only allows for the usual observable macroscopic phenomena to be recovered. What actually happens in the world is explicitly left out of its domain, usually on pragmatic grounds. Such a stance though is very congenial to instrumentalism, since all we have in our hands is (at best) a good predictive device, which need not be taken at face value.

The second possible way out is the so-called *Erasure Objection* (cf. ibid. pp. 765-767). On the basis of the time-reversal-invariant character of orthodox QM it might be claimed that such an experiment would allow Adam to 'erase' Eve's memory. This would lead to the erasure of the collapse of the spin measurement from her memory, which gives rise to the incompatible predictions after Adam's operations in the lab, and thereby consistency would be restored. Hagar argues that this line of reasoning leads to the subordination of one's ontology to one's epistemology. This is because the Erasure Objection appears to relativise quantum probabilities to the observer and in this way introduce "an arbitrary cut between the observer and Nature" (ibid. p.

[6] Of course Eve's prediction for spin up would be the same even if she had measured 'spin-down' because of the nature of the transformations.

767). And although this last point sounds more like idealism rather than instrumentalism, it is certainly unacceptable for a realist.

The final point of Hagar's, namely that a subjectivist approach to quantum probabilities implies some form of metaphysical anti-realism is not explicit in his paper but can be read off his comments regarding the Erasure Objection. It becomes evident once we consider what follows his comment I just mentioned above. Stated more fully, Hagar claims that

> relativising quantum probabilities to the observer …is tantamount to stipulating an arbitrary cut between the observer and Nature. …[A]ccording to the epistemic view what counts as real, i.e. as having definite properties, is now dependent on where this cut is made. (Ibid., p. 767)

Although these remarks are intended to explicate the implications of the Erasure Objection, they mostly serve to present a general charge against subjectivism in the context of QM. Hagar seems to be drawing attention to the main message of 'Wigner's friend' scenario, namely that there appears to be no non-arbitrary way to distinguish between the classical and the quantum realms. The subjectivist wishes to maintain that the quantum state is only an algorithm, an instrument for predicting the usual macroscopic experimental phenomena. At the same time, however, she must accept that it is always possible to assign a quantum state to macroscopic objects and situations, including the macroscopic phenomena that she takes for granted. But then, the argument goes, what is the rationale for denying reality only to certain properties of objects belonging to the micro-world and not to the corresponding properties of other objects belonging to the macro-world? It appears, that is, that Fuchs's subjectivist still needs to defend more adequately the 'cut' between the quantum and the classical realms if his minimalist version of realism is to be tenable.[7]

4. Tackling the Challenge

In the rest of the paper I will try to show that Hagar's criticism is unsuccessful. I will advance and support the following two main theses for this purpose: (a) Like in the case before the operations have taken place, similarly no real inconsistency arises for the Bayesian due to the divergence of opinions about the predictions of our two agents after the operations. The reason is that it is very easy for her to accommodate this divergence within her framework. (b) The issue of inconsistency aside, it is mistaken to suggest that adhering to a subjective account of quantum probabilities commits one to any form of metaphysical anti-realism. It should be clear that (a) is intended to neutralise Hagar's dilemma, by denying point (i), while (b) aims at rebutting Hagar's general charge (iii). In concluding, I will also briefly indicate a possible direction for a more fruitful criticism of Fuchs's realism.

4.1. Resisting the dilemma

Recall the main claim Hagar makes in presenting Hemmo's thought experiment. Although the initial incompatibility after Eve's measurement but *without* Adam's opera-

[7] I am indebted to an anonymous referee for pointing out the importance of this dimension of Hagar's critique.

tions in the lab need pose no problems to the subjectivist, this is not so for the situation that ensues after *both* Eve's measurement *and* Adam's operations. This means that there is an alleged difference in kind between the first and the second case of divergent results, such that the first can and the second cannot be given an information-theoretic interpretation.

The closest Hagar gets into providing the rationale for this claim is in the following quote:

> For these special observables, if Eve and Adam compute the probabilities for subsequent measurements to be carried out at some time on the information that is available to them *now*, they will inevitably come up with *different* predictions.

He continues saying that

> Hemmo concludes that this indicates that the epistemic view is inconsistent, since it yields two different predictions for one and the same experiment, no matter how complicated and difficult the actual performance of the experiment will be. (Ibid., p. 764)

Now, this allusion to 'Hemmo's conclusion' might give the impression that Hagar intends to distance himself from it. This appearance, nonetheless, is deceptive. Hagar's very starting point is Hemmo's charge of incoherence. Furthermore, Hagar himself makes it abundantly clear that the charge of instrumentalism arises out of the need to oppose Hemmo's argument (cf. ibid., 764).[8] This means, however, that, if anything, Hagar must believe that Hemmo's thought experiment is *at least* a *prima facie* problem for the epistemic view. Indeed, if it is not, then one is left wondering why Hagar thinks it is so important to come up with an answer to it that runs the danger of contradicting Fuchs's realist aspirations.

In effect, Hagar seems to be thinking as follows: in the first case of incompatibility, which arose after Eve applied the collapse postulate, it was easy for the subjectivist to interpret the divergence of opinions as the result of updating common initial knowledge on *different* data, i.e. knowledge of the outcome of the experiment in the case of Eve and no new knowledge at all in the case of Adam. In the second case, however, no such interpretation is possible, since both Adam and Eve have *the same information*, yet they reach different results. At any rate, it is this last claim which has to be substantiated in order to demonstrate the inconsistency of the epistemic view; namely that two agents, starting with the *same* degrees of belief and updating in the light of the *same* data end up with incompatible predictions.

Is, however, the story between Adam and Eve such a case? I don't think so for the following reason. In the first case of divergence, Adam and Eve started with the same information, i.e. the initial superposition, and then updated their knowledge in the light of different data. This is why it was natural for their predictions to diverge. Now Adam conducts his operations in the lab only *after* Eve's measurement has taken place, i.e. only after both himself and Eve have reached different predictions. To be sure, the operations are the *same* for both of them, which means that if they are to be interpreted in information-theoretic terms, they have to be considered as evidence (or information of some sort) *common* to both agents. Yet, as we just noted, old prior beliefs

[8] Hagar repeats this point in the concluding summary of his argument (see Hagar 2003, p. 767).

have already been updated once, resulting in the first *innocuous* case of incompatibility. Whatever happens from here onwards will take place on the basis of the new prior beliefs, which are the *old posterior beliefs* on a Bayesian account. This means though that Adam's operations will affect *in the same way different prior beliefs* resulting, once again naturally, in different results. Once more, though, this is no inconsistency at all, since different prior beliefs updated on the same evidence quite trivially result in different posterior ones.

Furthermore, this conclusion also holds for the following possible modification of the thought experiments' interpretation.[9] It might be countered that the crux of the thought experiment becomes apparent if we consider not Eve and Adam, but Eve and *her own would-be thoughts* had she contemplated herself in Adam's place. In this case we would end up not with two individuals having different degrees of belief but with one and the same person holding differing degrees of belief under different circumstances.

Despite the air of paradox that this interpretation introduces, there is no inconsistency in this case either. The following sentence is surely a truism for a Bayesian, if not for everyone: 'I can have certain beliefs now and also quite consistently contemplate myself *justifiably* holding different beliefs in a counterfactual situation in which I would be differently informed'. Yet this very truism applies in the case of Eve contemplating herself in the shoes of Adam. Inside the lab, Eve knows certain things and after the transformations she updates her beliefs and reaches a probabilistic prediction. Now, upon contemplating the counterfactual state of her being outside the lab and updating different initial beliefs in the light of the same information (i.e. the transformations), it is very natural for her to conclude that she would have reached different results. There is nothing whatsoever in the subjectivist conception that forces her to entertain the same beliefs across the board of possible information circumstances.

Hence, the alleged inconsistency is *no inconsistency* after all. There is *no* difference in kind between the two cases such that the second, unlike the first, does not admit of an information-theoretic interpretation. Consequently, Hagar's initial dilemma has been taken by its first horn and given an answer. This means, however, that one need not trouble oneself with the issue of instrumentalism and/or anti-realism at this stage. Since the charge of instrumentalism follows from our attempts to *restore* consistency (namely, FAAP and the Erasure Objection), showing that there is no inconsistency in the first place relieves us from the need to resort to solutions with such implications.

4.2. Quantum Bayesianism, Anti-realism and the Quantum/Classical 'Cut'

The only remaining way one might take in order to undermine Fuch's minimalist realism is Hagar's implicit charge that a subjectivist account of quantum probabilities, even if internally consistent in the first place, commits one to metaphysical anti-realism. Recall that the danger here stems from the main message of Hagar's 'Wigner's friend' scenario rather than the details of his thought-experiment, namely that there seems to be no natural dividing line by which to distinguish between the classical and the quantum realms. Fuchs's realist maintains that quantum states are merely an in-

[9] I am grateful to Guido Bacciagalupi for suggesting to me this possibility.

strument for prediction, an algorithm that allows us to compute probabilities about empirical facts without any physical significance whatsoever. Hence, when there is a superposition there is no fact about, for example, where a microscopic object is located. All that we have at our disposal is certain degrees of belief regarding certain experimental results, whose reality is, *prima facie* at least, not questioned. Since it is always possible, however, to assign a quantum state to macroscopic objects too, the subjectivist's presumption appears arbitrary. If the quantum state is to have no physical significance, this should be so irrespective of whether it refers to the micro-world or the macro-world. But, then, don't superpositions for macroscopic objects imply that there is equally no fact regarding certain, seemingly unquestionable, properties of those objects too (like location)?[10] Surely, if this were the case, the end result would be general metaphysical anti-realism and, of course, no talk of QM being interpreted realistically could be raised.

The answer to this more general conundrum is, I think, twofold. First of all, the absence of sound first principles, from which a distinction between the classical and the quantum realms can be shown to follow naturally, does not imply that all attempts to draw such a dividing line are entirely unmotivated. In fact, a number of considerations are available to the subjectivist in her quest to motivate an answer to this problem. To start with, due to their non-negligible size, ordinary macroscopic objects are *observable*, either directly through our unaided senses or with the use of relatively simple instruments.[11] Furthermore, subjectivism has traditionally been associated with a brand of empiricism. On the subjectivist's view, experience is a reliable source of knowledge regarding the nature and basic properties of all observable objects. Hence, she appears to be able to claim some sort of 'privileged access' to the usual classical properties of macroscopic objects (cf. Fuchs and Peres 2000, p. 70). The same, however, cannot be said with respect to microscopic objects. The latter fall outside the scope of experience due to their negligible size, which is why we lack any independent access to their fundamental properties.

Consequently, and in stark contrast with Hagar's claim that "one can shift [the cut between the observer and Nature] according to whim" (Hagar 2003, p. 767), there seems to exist a natural dividing line between the classical and the quantum realms that the subjectivist can defend. This line coincides with the observable vs. unobservable distinction. The latter, coupled with an empiricist epistemological presumption, allows the subjectivist to assert the independent and unquestionable existence of all basic properties of observable macroscopic objects. That those objects can also be as-

[10] For a more detailed statement of this line of argument see Leggett (2002, R422).

[11] We must carefully distinguish at this point between two related, yet distinct issues regarding the observable vs. unobservable distinction. The first is the tenability of the distinction itself, which appears to be relatively uncontroversial to assert. Indeed, the distinction is both intuitively plausible and also psychologically difficult to evade. The second, and more controversial issue, is whether the observable vs. unobservable distinction can ground the fundamental epistemological distinction between believing that a theory is a true description of the world and 'accepting' the theory as empirically adequate while at the same time suspending judgement regarding its truth (cf. van Fraassen 1980, 8-19). The controversy surrounding this second issue notwithstanding, Fuchs's subjectivist need only be concerned with the tenability of the distinction in order to motivate her stance.

signed quantum states besides their standard classical description, then, can be treated by the subjectivist as a peculiarity of the quantum formalism, which nonetheless does not suffice to cast doubt on the underlying reality of their basic classical properties.[12]

Suppose, however, that the answer sketched in the previous two paragraphs does not suffice to alleviate all worries of arbitrariness with respect to the subjectivist's 'quantum/classical cut'. Still —and this is the second part of the answer— we need to ask whether the situation is any better even with those theories which allege to have gotten rid of the need for a principled quantum vs. classical distinction, like the GRW theory that Hagar himself favours (cf. Hagar 2003, pp. 769-772). It turns out that the answer to this last question is not trivial at all.

As is well known, the GRW theory construes the collapse of the wave function as a physical process. It was hoped that in this way the distinction between the quantum and the classical world would follow naturally from the theory without the need for an *ad hoc* stipulation. There is strong dissent, however, as to whether GRW *strictly speaking* saves ordinary observable phenomena and, hence, provides a natural classical vs. quantum distinction. This is because a GRW-collapse generally produces a *strongly localised* wave function around one of the possible eigen-states rather than a proper collapse in one of those eigen-states. There is, however, no non-arbitrary way to determine 'how much' of the wave function has to be within an antecedently specified narrow interval around the eigen-state for the system to be classically localised. This problem is now known as the 'tails problem'.[13] Consequently, it is by no means uncontroversial that even GRW has managed to offer an entirely non-arbitrary account of the 'quantum/classical cut'.

It seems fair to conclude, then, that Fuchs's project neither reduces to thoroughgoing metaphysical anti-realism nor postulates the 'quantum/classical cut' any more arbitrarily than other realist theories of QM. All that Fuchs argues for is that some parts of QM yield results, which are best understood as reflecting degrees of belief and, hence, deserve an instrumentalist reading. This need not imply that he should also be an instrumentalist or anti-realist about *all* parts of QM, the way Hagar wants it. Consequently, Fuchs can perfectly consistently maintain an instrumentalist view of the quantum state and a minimal realist view of the quantum system and the dimensionality of the Hilbert space that accompanies it.

5. *Conclusion*

To sum up then: in the course of this paper I examined the validity of Hagar's claims against Fuchs that a subjectivist interpretation of quantum probabilities is inconsistent even with a minimal account of quantum mechanical realism and concluded that they do not stand up to close scrutiny. It seems to me that Fuchs's account is perfectly consistent and quite immune from the challenge Hagar poses.

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[12] This seems to be the position that Fuchs and Peres (2000, p. 71) assume in their discussion of the question whether QM applies to the observer.

[13] For a discussion of the 'tails problem' see Frigg (2003, pp. 43-48).

To be sure, I have not argued in this paper for the more general thesis that no 'Wigner's friend'-type experiment is capable of demonstrating the inconsistency of Fuchs's project. Indeed, *a priori* it is conceivable that an experiment of this kind might eventually succeed. Until such an argument is forthcoming, however, there is another strand open to the realist as a way of reaction, deriving from the fact that talk of consistency does not reveal much about a theory's plausibility. Hence, if one wants to attack Fuchs' interpretation of quantum probabilities, another option is to focus on plausibility rather than possibility issues. Hagar hints at this approach when he characterises Fuchs's minimalist version of realism "a Pyrrhic victory" (ibid., p. 760), yet he does not pursue the argument further. One might object to Fuchs, then, on the grounds that his subjectivist account of quantum probabilities implies such an impoverished version of realism that any reasonable realist should not be content with. More precisely, one might want to suggest that attributing reality only to the two elements Fuchs allows fails to capture our realist intuitions underlying the predictive and explanatory success of QM, usually expressed by means of the No-Miracles Argument, and is thus an unacceptable form of realism, or, at any rate, not a form of realism inspired by what is really distinctive about QM *per se*. Such an attack, although inevitably by no means conclusive given that it does not aim at establishing a contradiction, might fare better than Hagar's unconvincing points.

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