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Does Physics Allow for Free Will?

Proposing a Novel Type of Psychophysical Experiments Testing the Multiverse Interpretation of Quantum Mechanics

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Biography

Christian D. Schade is a full professor at Humboldt University and holds the chair of Entrepreneurial and Behavioral Decision Making. His research mainly spans three fields: behavioral decision making and game theory, gender differences in decision making, and quantum decision making - including philosophical considerations on the existence of free will. He contributes to a better understanding of decision making in general (and what that actually is), of entrepreneurial as well as innovative decision making, as well as to a philosophical understanding of innovations. He is currently working on novel foundations and perspectives for the decision sciences. His research is mainly based on laboratory experiments, economic psychology and mathematical psychology, as well as quantum mechanics.

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Abstract

This contribution proposes a novel type of experiments that might be able to (a) test the multiverse interpretation of quantum mechanics against the standard interpretation, and (b) together with the theory of the clustered-minds multiverse (Schade 2018), might offer a proof of the existence of free will. The experiments are psychophysical in a novel sense, because, via top-down entanglement, consciousness is at the core of the measurement problem and influences the physical. At the core of the experiments are quantum-optical setups, together with a manipulation of the number, preferences, and state of information of the observers.

Keywords

Interpretation of Quantum Mechanics, Measurement Problem, Free Will, Consciousness, Top-down Entanglement, Clustered-minds Multiverse, Novel Psychophysical Experimentation, Quantum-optical Setups, Wave-particle Inequalities

Justifying Free Will via the Multiverse – And the Multiverse via Experimentation

Within the JCN special issue on free will (2015, vol. 3, issue 1), a plethora of diverging positions on free will have been presented, based on a conference held back in 2014 in Flint, MI. The papers are offering a great collection of contemporary treatments of the matter. Oftentimes, it becomes quite clear how essential the physical basis chosen or discussed by the respective author(s) is for the line of arguments presented by them.[1] Specifically, the physical basis chosen is often associated with the *opportunity* that is offered for free will. E.g., Cogley (2015) is defending current libertarianism against the potential problems arising from the assumed *indeterminism* – resulting from the standard interpretation of quantum mechanics – and Vihvelin (2015) makes the strong argument

1. This may partially be routed in the fact that the understanding of a concept that is more general than free will, i.e., decisions, may also be routed in physics (e.g., Schade and Sunder 2020).

that (singular universe) *determinism* – the basic premise of classical physics – does not matter for the free will debate, but clearly assuming that determinism might be correct – and opting for a compatibilist account.[2,3]

A somewhat special position has been introduced by Schade (2015) who not only justified the existence of free will via *quantum mechanics* (such as the above-mentioned libertarians; e.g., Kane 1985; Cogley 2015); but other than within libertarianism, an actual free will in the sense of being able to 'choose otherwise' was argued to be justifiable *without* indeterminism, within a framework offered by the multiverse interpretation of quantum mechanics, along with parallel times (for a more detailed treatment of the matter see the monograph by Schade 2018; see also Schade 2020). Other than in the Copenhagen (or 'standard') interpretation of quantum mechanics underlying libertarianism, there is no problem of randomness or 'luck' (see, e.g., the discussion in Cogley 2015) or other problems arising from an indeterminist notion of free will in a singular universe (see Schade 2020 and the discussion section of this paper) because the Schrödinger equation underlying the multiverse is *deterministic* (there are no random collapses of the wave function leading to indeterminism); and at the same time a *multiplicity of possibilities* exists given the *superposition* principle so that 'choosing otherwise' is in principle possible[4] in a more fundamental way than within compatibilist accounts.

Also, a set of arguments has been crafted within Schade (2015, 2018, 2020) suggesting that the multiverse might be the most *compelling* interpretation of quantum mechanics (see also the earlier, related thoughts on this by Menski 2000, 2005, 2007,

2. A more complete treatment of the many JCN-contributions on free will and their respective physical basis is beyond the scope of this paper.

3. It is important to note that the free will theorem in its strong form by Conway and Kochen (2009) shows that a couple of desirable conditions is inconsistent with determinism or, if two experimenters are free to choose certain measurements, then the outcomes of their measurements cannot be determined by the past. Let me note four things here. (1) It might not exactly be free will (in the philosophical sense) that this theorem is about, rather non-determinism, since the potential sources of freedom are not addressed. (2) The theorem clearly rejects classical physics in its idea of a clockwork universe. (3) Beyond the latter, it is not clear whether this theorem would imply any specific interpretation of quantum mechanics; indeed, one would expect that it rather does not, since it is often applauded for not leading to or requiring any specific theory of physics. (4) According to my view, past and future might be seen as problematic categories, if there is no linear flow of time (DeWitt 1967; Barbour 1999; Schade 2015 and 2018, chap. 3). For all those reasons, and although the theorem might suggest a clear "yes" to the answer raised in the title of this paper, this paper is *not* dealing in more detail with the free will theorem.

4. For more details/further conditions see the development in Schade 2018, chaps. 2, 3 and 4.

2010 or, e.g., by Deutsch 1997) and that there are good arguments existing in physics for parallel times (e.g., DeWitt 1967; Barbour 1999; Schade 2015, 2018, chap. 3).[5] Even though the line of arguments suggested by these authors – a review would be beyond the scope of this paper – might be seen as compelling by some, however, others might argue that the only way to convince them of that set of arguments would be *experimental*, and that only if at least the multiverse interpretation has been proven experimentally, they might perhaps consider the free-will argument presented by Schade (2015, 2018, 2020).

But can the multiverse be proven experimentally? This question has made its way into TV comedy, even. In *The Big Bang Theory*,[6] Dr. Sheldon Cooper asks his (only) prospective student Howard Wolowitz: "What is the correct interpretation of quantum mechanics"? And since Howard wants to be accepted as Sheldon's student, he answers: "As every interpretation gives exactly the same answer to every measurement they are all equally correct. However, I know you believe in the many-worlds interpretation, so I'll say that." This conversation states a well-known puzzle. In all standard physical experiments, we expect the same outcome no matter which interpretation is true, the standard or von Neumann (1932 [1996]) interpretation assuming a collapse of the wave function during measurement (leading to a singular reality but quantum indeterminism), or the many-worlds interpretation (Everett 1957), often called the quantum multiverse or theory of the universal wave function.[7]

In this paper, I am going to challenge the notion of the 'untestable multiverse,' even without presenting any experimental evidence. Instead, I am going to craft a type of experiment that is novel and that I suppose should actually be run, a type of experiment that might, in fact, discriminate between different interpretations of quantum mechanics. This type of experiment might be called 'psychophysical' (see Schade 2018; chaps. 12 and 13) and is based upon the understanding that there is a close connection between

5. Generally, the interpretation problem of quantum mechanics might be viewed as unsettled. The two most prominent interpretations are, indeed, collapse or 'standard' interpretation (von Neumann 1932 [1996]) and theory of the universal wave function (Everett 1957, building on Schrödinger 1926), also called 'many-worlds' or multiverse interpretation. However, the latter interpretation 'needs interpretation' (Albert and Loewer 1988). A novel proposal to this effect has been made by Schade (2018): the clustered-minds multiverse (CMM). The experiments suggested in this paper are imbued by the CMM and its top-down entanglement starting in consciousness, an idea refining Wigner's (1961) idea of measurement starting in consciousness and translating it to the multiverse, i.e., abandoning any collapse postulate (see also below).

6. Season 8, episode 2, "The Junior Professor Solution," CBS, Monday, September 22, 2014.

7. In this publication, I am only dealing with those two, not with other interpretations or modifications of quantum mechanics such as the Bohmian interpretation or the Penrose modification etc.

consciousness and free will on the one hand, and consciousness and the measurement problem on the other hand.[8] It is not psychophysical in the sense of, e.g., the Weber–Fechner laws of the relationship between physical stimuli and human perception. Instead, in the type of experiment that I am going to suggest, psychophysical is meant in a kind of reversed manner, as quantum optical experiments are supposed to be modified via specific manipulations of actual conscious observation.[9] The theoretical underpinning of the experiments is idealist in the sense of Plato (~ 360 B.C., 2000) or, based on quantum mechanics, Wigner (1961), but without running into any logical paradoxes (at least in conjunction with the idea of free will) as singular-universe approaches such as Wigner's typically do (Schade 2018, 2020 and the discussion section of this paper). The experiments will be idealist in a multiverse fashion as proposed within the *clustered-minds multiverse* (Schade 2018; for first thoughts on this, introducing the notion of weak and strong universes[10] as well as using the example of a torchlight[11], see also Schade 2015). At the same time, the type of experiment will be quite practical in nature, it can be implemented in a joint effort of experimental physicists and psychologists (or experimental economists, for that matter). It will also be fairly explicit and unambiguous, testing behavior of a quantum system against predictions based on a mathematical formula.

The contribution of the current paper is, thus, potentially large. It might form the basis of a new type of experiments that, in turn, help addressing the interpretation problem of quantum mechanics. It moreover, gives explicit directions as to how such experiments might practically be set up. It therefore helps advancing the issue as to how free will might be justified, if, (a) the line of arguments in Schade (2015, 2018, 2020) will be accepted as compelling and, within the proposed experiments, (b) the multiverse interpretation will turn out to be supported.[12] Some might be tempted to see

8. A novel type of experiments combining quantum mechanics and psychology has also been postulated by Mensky (2000; 2005).

9. A look at an exciting paper from Fedrizzi's work group (Proietti et al. 2019) shows that the general idea of observer dependence of quantum systems underlying also the experiments suggested in this paper is experimentally supported. However, the 'observers' in Proietti are photons, no actual, conscious observers.

10. This idea has been suggested to me in a discussion by Tanja Schade-Strohm.

11. This idea has been suggested to me in a discussion by Adam P. Taylor.

12. I am not dealing with the question, here, how parallel times might be tested. In a way, this question already has been positively tested (see the line of reasoning in Schade 2015 as well as 2018, chap. 3), even though some might debate this.

the type of experiments suggested, given their psychophysical nature and the test of an active role of consciousness, as a, potentially, direct proof of the existence of free will, circumventing the, perhaps 'inadmissible,' multiverse somehow, but in fact matters are fairly complicated and such a direct proof of free will is not feasible (see the discussion section).

The paper is organized as follows. In the next section, the most famous quantum optical experiment, the double-slit experiment and its most typical extension (eliciting so-called which-way information), will be introduced (including some historical information). The basic premises of the psychophysical experiments suggested in this paper are also outlined. The subsequent section specifies one of those psychophysical experiments in more detail, i.e., a double-slit experiment varying the *number of observers* as well as containing other treatments and provides a formula that is supposed to be tested within those experiments. The final section briefly extends the line of thoughts to related quantum-optical experiments that might be used for robustness checks of findings potentially generated at the double slit, dismisses singular-universe free will via the necessity of parallel times, and concludes.

Standard Quantum Optics versus 'Psychophysical' Experiments

The pre-version of the double-slit experiment is more than two hundred years old: Young let regular light pass through two parallel, vertical slits and demonstrated an interference pattern consistent with the wave nature of light. Thought experiments employing some fictitious versions of a double-slit experiment, typically having photons pass through the double slit and asking the question as to where the photon(s) passed through, i.e., so-called *which-way* experiments,[13] are about eighty years old. *Actual* double-slit experiments *with photons* are from the early sixties (Jönsson 1961). And smart *actual* which-way experiments have been carried out since more than thirty years (e.g., Mittelstaed et al. 1987; Menzel et al. 2012).

Whereas the behavior of particles[14] at the double slit, containing which-way information, has been interpreted by David Deutsch (1997, chapter 2) already as clear evidence in favor of the multiverse interpretation of quantum mechanics ('shadows'),

13. For more details see Feynman et al. (1965).

14. Some disagree that there are even particles and, instead, employ the notion of narrow wave packets (Zeh 2016).

others have disagreed. Indeed, the which-way thought experiments have originally been brought up within the paradigm of the Copenhagen interpretation of quantum mechanics. They have been an instrument of debate between Einstein, Heisenberg, Bohr etc. And although the novel findings in some actual which-way experiments at the double slit *seem* to undermine the complementary principle because they allow a high visibility of the interference pattern together with accurate which-way information (e.g., Menzel et al. 2012), an alternative view to David Deutsch's by researchers with a strong belief in the complementarity principle is justified by the fact that violations could always theoretically be justified somehow within the framework of the Copenhagen interpretation (even though the explanations gain more and more complexity). An example for this are theory and experiments on the *postselection principle* (Leach et al. 2014), to be discussed with a slightly different purpose below.

One thing has never been changed. There is only *one actual observer* in all those experiments.[15] And whereas the changes induced by such conscious observation have already had some argue that something 'special' is going on, that conscious observation is the final answer to the question as to where the 'Heisenberg cut' between the measurement and the 'to-be-measured' is supposed to be located, no one has actually 'played' with conscious observation in a more explicit way. That is the radical change in experimentation to be suggested in this paper. A psychophysical double-slit experiment is supposed to make measurements at the double slit with the number of observers and the type of feedback/information provided to them being experimentally manipulated.

It is *not* assumed that the manipulation of conscious observation will change the frequencies of photons flying through one slit or the other; but instead it is assumed that the *tension* between the strength of the interference pattern on the one hand and the precision of information regarding the 'which-way' question can be manipulated via the type of conscious observation. This is captured within a formula, to be introduced in the next section, against which the experimental treatments are testing.

The type of experiments to be suggested is also inspired by a set of experiments published by Radin et al. (2012). Radin et al. demonstrate that asking individuals to direct their *attention* more or less to the double slit has an influence on the strength of the observed *interference pattern*. Or in other words, these authors' findings indeed suggest that it is *consciousness* that matters with respect to the results that are observed at the double slit. However, their results do not serve to answer the question as to which

15. In Proietti et al. (2019) there seems to be more than one observer, but only the final observer, the experimental scientist, is 'real,' the others are photons, in the role of 'observers.'

interpretation of quantum mechanics might be correct. And therefore, following the set of arguments as well as the literature presented in the introduction, their results do not allow to answer the question whether physics is consistent with free will or not.

Also, whereas the approach to be introduced below in this article might be labelled psychophysical, Radin et al.'s (2012) approach might rather be labelled 'para-psychophysical'[16] as will be shown. Anyway, in the experiments carried out by Radin et al. (2012, 159), the dependent variable that was supposed to reflect changes due to the experimental treatments was defined in the following way:

> To measure perturbations in the wavefunction, the interference pattern recorded by the line camera was analyzed with a fast Fourier transform to quantify the power associated with the two dominant spatial wave-lengths: a shorter wavelength associated with the double-slit interference pattern (call this power P_D) and a longer wavelength associated with the diffraction pattern produced by each slit (P_S) (…). The fraction of (log)spectral power associated with the interference pattern was $D=[P_D/(P_D+P_S)]$, and that with the diffraction pattern was $S=[P_S/(P_D+P_S)]$. The ratio of these fractions, $R=D/S$, was the preplanned variable of interest.

The definition of those variables is reported in detail here for the sake of comparison with formula (1) that I am below suggesting should be tested to support (an idealist version of) the multiverse interpretation of quantum mechanics.[17] It will also be a test integrating the interference pattern, but in a different way and in conjunction with other information (see the next section).

Coming back to the para-psychology label that I have used above for Radin et al.'s work, this might be evidenced by the following quote, enriched by insertions in italics by myself (Radin et al. 2012, 160):

> The consciousness collapse hypothesis predicted that the act of focusing attention toward the double-slit *without any direct connection*

16. One might also call those experiments psychokinetic. Although effects of consciousness on the quantum might be considered part of 'normal' physics, depending on the interpretation of quantum mechanics chosen, the mechanism that Radin et al. (2012) are focusing on is psychokinetic because only attention of consciousness directed at the double slit (and no direct observation of the quantum system) is analyzed.

17. Such a proof will be *general* with respect to the multiverse interpretation, but it will also show that an idealist version of it will be the appropriate framework.

> *between observer and quantum system* would cause *R (the spectral-ratio value)* recorded during attention-toward epochs to decrease as compared to during attention-away epochs.

In contrast, the role of the observer that I am proposing to be analyzed will turn out to be 'conservative,' bearing the potential of a higher acceptability by mainstream physics (see the next section). Naturally, given the somewhat para-psychological nature of Radin et al.'s experiments, they have been criticized by some realists on various grounds. Also quite naturally, Radin et al. have refuted their criticism. It is beyond the scope of this study to report on this discussion in detail; also, as said, the type of observation suggested in the experiments propsed here will be more traditional in nature, so that the criticism and its discussion are simply not relevant here.

Specifying a Double-slit Experiment with Dual Observers and Other Experimental Conditions

Basic Premises

If one starts with measurement – i.e., finally *locates* the measurement problem – in consciousness, one gets to the concept of top-down decoherence (see Schade 2018, chap. 2; see also Bacciagaluppi 2020), or, more neutral, to *top-down entanglement*.[18] What is meant with this is that (the in principle) non-directional quantum correlations actually *start* in consciousness, so that consciousness is not the end of the chain of quantum correlations (some epiphenomenon upon the workings of physics) but its source. With top-down entanglement in a multiverse, quantum systems with two real, concurrent observers might, especially under conditions of diverging goals, differ in their physical consequences from single-observer systems (note that this idea is somewhat related to that of Wigner's friend (Wigner 1961; Proietti et al. 2019), but within a different interpretation of quantum mechanics and using a different implementation). Note that

18. 'Neutrality' means absence of operations leading to a *reduced density matrix*. This operation, typically the second stage in decoherence analysis, is sometimes 'accused' to introduce collapse through the 'backdoor,' and would hence not be 'neutral' anymore with respect to the interpretation problem of quantum mechanics. For a critical discussion of not just staying with quantum correlations (entanglement) but also calculating a reduced density matrix see Zeh (2012, 77–84); see also Schade (2018, chap. 2).

showing this divergence would be a *general* proof of the multiverse, not only a special version of it.

Proposing the Type of Experiment To Be Run

Let me now describe a version of the experiment that I propose should be run, based on the double-slit experiment. The basic setup is as usual, photons are fired at some plate, pierced in the form of two parallel slits (with a certain, critical distance), and there is a measurement of where the photons pass through: left slit *or* right slit?, as well as of the interference pattern at some screen, located in appropriate distance from the plate. Within that framework, however, and this is the novelty, the following six treatments (= experimental conditions) are to be implemented:

Treatment basic (*b*) will be run without anyone observing which-way observation, treatment *so* with single observers and rewards, coupled to one of two outcomes of the quantum experiment, i.e., whether the photon passes through the right or the left slit. Another four treatments will implement two concurrent observers (i.e., observer pairs) that both observe the *same* quantum experiment. This part of the experiment will implement a 2 x 2 design with the first factor (preferences) involving the two steps: (1) aligned (*do-ai*) versus (2) conflicting rewards (*do-di*), i.e., observers getting rewards for the same or for different outcomes of the quantum experiment. The second factor (information) will implement the following two steps: (i) no information on the outcomes that the other has observed, and (ii) information on the observed outcomes by the other player; in light of the below discussion on postselection and given the fact that postselection might be seen as equivalent to communication, the interpretation of that factor, however, will have to be carefully pondered.[19]

Experimental Treatments and Mathematical Ordering

The theoretical idea behind those manipulations is *not* to find any differences in the frequency of the two outcomes (i.e., the photons passing more through either the right slit or the left slit) of the respective quantum-optical experiments, e.g., depending on

19. Given the discussion in the next but the following subsection, the most interesting results regarding the factor information might materialize in the form of *interaction effects* with the factor preferences. It is beyond the scope of this contribution to explore this in more detail.

some characteristics of the observers – this would be a parapsychological prediction – but, as already mentioned, to put the quantum system under more or less 'stress.'

What is exactly meant with putting the quantum system under 'stress?' In the clustered-minds multiverse, overall consciousness (i.e., the total of consciousness across all versions of an individual) will have to 'split attention' between different realities, in our case 'marked' by different passing of the photon through either the left or the right slit.[20] But since rewards are coupled to either the *same* observation (left slit *or* right slit) being preferred by *both* observers or to *two different ones*, realities with more or less tension regarding consciousness to be allocated between realities will emerge (see, for the basis of this idea, Schade 2018, chap. 8, page 139-141, especially formulas 8.1 and 8.2). What are the implications of these thoughts? High fringe visibility (interference) is expected in treatment *b*; in the *so* treatment, the sum of V^2 (visibility of the interference, squared) and P^2 (which-alternative information, squared) should be similar to the respective sum in *b* (duality principle in its up-to-date form: e.g., Greenberger and Yasin 1988). If there are two observers with the same goals, the stress on the system should be larger than with singular observers, but smaller than with conflicting goals; i.e., regarding the latter, the 'stress' put on the quantum system to keep an intact interference structure on the one hand (e.g., quite figural, 'shadows of other realities' in David Deutsch's not undebated view; Deutsch 1997, chap. 2, see above), but 'having to provide' two different realities to the two observers on the other hand, might considerably enhance the sum of V^2 and P^2. For the sake of brevity and to reduce complexity, the second factor (information provision) will not be discussed here in more detail (and might, anyway, require a deeper analysis; see the next subsection) and will thus not be integrated into the following, preliminary formula. (Think of it, for now, as this factor being fixed at "no information on the outcomes of the other player" for formula (1)). It will also be left open here whether (in any of the treatments) $V^2 + P^2$ might become larger than one or not (typically: = 1, for pure states, < 1, for mixed states, but also > 1 under special conditions; see the discussion in the next subsection) (e.g., Leach et al. 2016). Given those simplifications, the suggested experiment is going to test the following set of conditions:

$$\mathcal{V}_b^2 + \mathcal{P}_b^2 \approx \mathcal{V}_{so}^2 + \mathcal{P}_{so}^2 < \mathcal{V}_{do-ai}^2 + \mathcal{P}_{do-ai}^2 \ll \mathcal{V}_{do-di}^2 + \mathcal{P}_{do-di}^2 \qquad (1)$$

20. It should be noted that observing a photon flying through either the right slit or the left slit in a quantum apparatus is sufficient to generate two different realities. Everett (1957) would associate this event with a splitting of the universe.

Avoiding the Relevance of Alternative Explanations: Postselection and the Like

In a paper by Menzel et al. (2012), clear interference fringes are observed together with sharp which-way information. Leach et al. (2016) discuss (and experimentally show) as to *how* the sum of V^2 (visibility of the interference, squared) and P^2 (which-alternative information, squared) may reach values up to two, specifically (3):

$$\mathcal{V}_{\hat{\pi}1}^2 + \mathcal{P}_{\hat{\pi}2}^2 \leq 2 \tag{2}$$

Surpassing the sum of 1 may be feasible when "measuring visibility and predictability are conditioned on different postselections $\hat{\pi}1$ and $\hat{\pi}2$" (4), with the most extreme case occurring when the two are orthogonal to each other, then leading to a sum of 2.[21] So potentially, such effects could be alternative explanations for the results to be expected in the proposed experiment, to claiming the effects of a manipulation of the number of observers etc. (see above) and thus a potential, alternative explanation to the one suggested: the existence of a quantum multiverse. So this alternative explanation for the experimental results would be a serious threat to the theoretical development suggested in this paper, including the idea of constructing the basis for the existence of an actual free will. Even more plausible, and as already mentioned, they could be an explanation for the potential effect of exchanging information on the observed state of the system between the dual observers (in some of the treatments proposed above). Indeed, as Leach et al. (2016, 5) note,

> We show that if a qubit is coupled to its environment, it becomes possible to obtain simultaneous high values for conditional measures of visibility and predictability. (…) We note that although our experimental procedure allowed us to *purposely* obtain simultaneous high values which lead to an obvious violation of an algebraic bound, there can be realistic experimental cases where an *inadvertent* postselection could be performed without necessarily obtaining a clear violation. In these cases, detecting the loophole might be much more difficult. [Italicizing by the author of the current article]

21. A structurally similar approach, requiring the same ingredients and leading to qualitatively comparable outcomes is direct measurement relying on weak values (see Lundeen et al., 2011; Salvail et al., 2013).

When running the test of the multiverse suggested above, one thus has to avoid this problem, keeping an eye on *inadvertent cases* of postselection. One safeguard arises from avoiding experimental manipulations implementing *any* apparent changes of the physical environment relevant within the quantum-mechanical calculus (this is fully avoided, I insist, in the variation of the number of observers suggested in the current paper). Another safeguard, most naturally, is taking changes explicitly into account such as the change of information regime in some of the experimental treatments and *modelling* them in terms of postselection.

Discussion, Further Steps, and Conclusions

Running the proposed experiment and avoiding (or explicitly modelling) postselection and other potential threats of internal validity potentially leads to a 'proof' of the multiverse and this, in turn, to a theoretical basis for an actual free will. Let me assume that the results are perfectly in tune with the conditions specified in formula (1) (leaving out, once more, the information conditions or assuming that they, indeed, be explicitly modelled). Quite naturally, nevertheless, such farfetched consequences would not be applauded unless some robustness checks, some related experiments have been run. One might, therefore, not only carry out double-slit experiments but also other quantum-optical experiments, e.g., *interferometer* experiments; implementing the same *type* of treatments described above, but with technical modifications appropriate for the different optical setup at hand (details are beyond the scope of this contribution).

Moreover, I have mentioned that some might view the type of experiments suggested as a direct proof of free will (if they generate the predicted results), perhaps hoping to 'circumvent' the multiverse, somehow. Besides the fact that those experimental results would, anyway, *be* a proof of the multiverse, seeing them as a direct proof of free will abstracts from some complexities that have to be taken into account. Just a few words on this. Let me assume that two observers, depending on whether their preferences are aligned or divergent, are indeed able to produce more or less tension within a quantum system. Then this will be interpreted as a proof of the multiverse and will generate the planned, indirect proof of free will, if, in addition, the framework presented in Schade (2015; 2018; 2020) is seen as compelling.

But clearly, the experimental results would tell us more: a story of an idealist version of the world (*Maja*, in Indian philosophy), of 'mind over matter,' without (other than in Radin et al. 2012) any necessary recurrence to parapsychology and with real observers rather than photons (other than in Proietti et al. 2012). And, if it is accepted that mind is ruling matter rather than the other way around, wouldn't free will arise as a natural consequence? Moreover, wouldn't the active role of consciousness proven within such experiments hint in a similar directions as the implications derived from the strong free-will theorem (Conway and Kochen 2009)? According to that version of the free-will theorem, *if* decisions *what* to measure can freely be implemented by observers, the future is non-determined by the past. But there are a few problem with this, part of them already specified in footnote 3. One of them was not mentioned there: Our observers are *not* free to choose what to measure. Another had been mentioned: At least the *notion of a regular flow of time* (past and future being integral parts of the theorem) is quite problematic in the context of free will (see below). So at least, and as already conjectured in footnote 3, the free-will theorem is not terribly helpful, here.

But still, the temptation to directly 'leap' to free will, not taking any 'detour' via the multiverse and a somewhat complex theoretical development, might be large. So, again, why is the multiverse so important to justify free will, why couldn't we just stay with the comfortable, well-known idea of a singular universe? The reason is that singular-universe free will may not be seen as even possible. Let me reference my own work, here (Schade 2020, 324-325) (insertions in brackets are added within this contribution):

> Many changes in the weltanschauung [compared to classical, deterministic physics] are already realized within the standard, singular-universe interpretation of quantum mechanics (collapse theory/reduction postulate). And some researchers indeed use this interpretation as a basis of free will (e.g., Kane 1985; Stapp 2017; Laskey 2018). Of the singular-universe approaches, I regard Laskey's (2018), built on Stapp (who points for inspiration to von Neumann), to be the most creative and advanced. According to this theory, free will is related to the choice of what to measure and to the quantum Zeno effect (Misra and Sudarshan 1977). The anti-free will evidence presented by Libet and coauthors (e.g., Libet et al. 1982) as well as his neuroscience followers (e.g., Soon et al., 2008) is my main reason for suggesting a novel, multiverse-based alternative to the various collapse/singular-universe versions of free will.

Specifically, in all the experiments by Libet and coauthors as well as in Soon et al. *consciousness is running after the fact*, apparently an obstacle for most individuals' common-sense idea of free will somehow being related to some choices made in consciousness and then 'executed' (note that many sophisticated versions of free will do not differ much from this notion, whereas, indeed, matters are getting slightly less straightforward in the multiverse). Interestingly, this obstacle can be circumvented, but, in my opinion, *only* in the multiverse, not within any singular-universe theories. Here is a fairly condensed version of the argument that could be made (Schade 2020, 325; see also Schade 2015):

> (…) singular-universe quantum theories, with their implied irreversibility of actions, cannot rule out the inference that free will is a mere illusion. (…) ruling out no-free will inference from the Libet et al. data, one needs parallel times, or times as special cases of parallel universes (…). The basis for this, in turn, is provided within the Wheeler/ DeWitt equation (DeWitt 1967) linking general relativity and the Schrödinger equation, where time as a variable disappears. In the same way in which the—unaltered and unaccompanied—Schrödinger equation is a multiverse equation, the Wheeler/ DeWitt equation also is. Thus, it is the multiverse perspective that rules out the Libet evidence against free will.

So is it really necessary to take a view into cosmology and cosmological equations (such as the Wheeler/DeWitt equation) and into the problem of time (a philosophical term crafted to address the problem that the time variable disappears in the Wheeler/DeWitt equation), into the multiverse, anyway, to be able to justify free will? And are we really prompted to run the experiments suggested in this article to first prove the existence of a quantum multiverse and then, using the line of arguments suggested in Schade (2015, 2018, 2020), are able to provide a framework, the clustered-minds multiverse, that accommodates for free will?

Well, a pure theorist could perhaps save on the experiments suggested here, and just buy into the free-will arguments crafted in connection with the clustered-minds multiverse. Whereas I am personally sympathetic to this position, because with respect to free will and the multiverse, theories from different areas fit together like the pieces of a puzzle (see Figure 1 in Schade 2015), I also clearly understand that some would require an empirical proof, and I would personally love to be able to deliver one.[22] Therefore, I

22. Actually, when I am not writing about quantum decision making and free will, I do run many laboratory experiments on decision making or analyze large datasets and publish the results in Journals on Economic Psychology, so that I need not to be convinced of the beauty of experimentation.

suppose that for most people the answer to the above questions would be: “yes”, and I very much hope that the suggested experiments will finally be run.

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