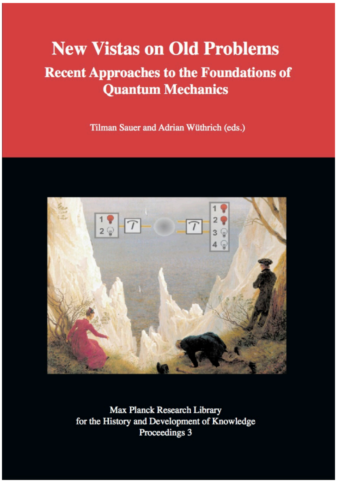
Max Planck Research Library for the History and Development of Knowledge
Proceedings 3

Iñaki San Pedro:

On Free Will and No-Conspiracy



In: Tilman Sauer and Adrian Wüthrich (eds.): *New Vistas on Old Problems : Recent Approaches to the Foundations of Quantum Mechanics*
Online version at http://edition-open-access.de/proceedings/3/

ISBN 9783844242843
First published 2013 by Edition Open Access, Max Planck Institute for the History of Science under

Printed and distributed by:
Neopubli GmbH, Berlin
http://www.epubli.de/shop/buch/26987

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de

On Free Will and No-Conspiracy

Iñaki San Pedro

Abstract. *In this paper, I challenge the widespread view that* Measurement Independence *adequately represents the requirement that EPR experimenters have free will.* Measurement Independence *is most commonly taken as a necessary condition for free will. A number of implicit assumptions can be identified in this regard, all of which can be challenged on their own grounds. As a result, I conclude that* Measurement Independence-*type conditions are not to be justified by appealing to the preservation of the EPR experimenters' free will.*

1 Introduction

This paper is concerned with a particular aspect of the usual derivations of the Bell inequalities. It is the idea that the inequalities follow partly from the requirement that the EPR experimenters are able to and do make free choices at the moment of setting up the EPR measurement apparatus. In other words, this is the idea that free will is a necessary requirement to be implemented in any physically possible hidden variable theory and therefore necessary for the derivation of Bell's theorem. I do not take this to be a controversial claim. It is less clear however how this requirement for free will is to be actually implemented.

Typical derivations of the Bell inequalities presuppose a common cause—as a hidden variable—onto which several constraints and restrictions are set. Constraints on the postulated common causes are intended to reflect standard requirements of a generic physical system, including temporal order of causal relations or locality considerations. As a result, some version of Bell's *factorizability*—and therefore of a Bell-type inequality—is derived. The strength of such arguments relies on the plausibility of the conditions imposed on the common causes. There is, for instance, an extensive literature regarding the idea of locality, particularly concerning the intuitions leading to the concept of physical locality, the character-

T. Sauer, A. Wüthrich (eds.), *New Vistas on Old Problems. Recent Approaches to the Foundations of Quantum Mechanics*, Edition Open Access, 2013.

isation of the concept itself, its implications and whether it may be appropriately captured and characterised in terms of probabilistic relations.

Less attention has been paid to the requirement that the EPR experimenters do take free independent decisions at the moment of setting up the EPR apparatus for measurement. Roughly, this idea of the EPR experimenters being able to act freely when setting up measurement apparatus is usually taken to entail that the events representing their decisions, and the foregoing corresponding free acts, be causally independent of the hidden variables. This is usually expressed by means of the so-called *No-conspiracy* condition—I shall later refer to this condition, more neutrally, as *Measurement Independence*—, a probabilistic expression which is taken to be necessary for free will.

The aim of this paper is to reassess and ultimately challenge this particular claim. I shall suggest that the fact that the EPR experimenters have free will does not provide a justification for the requirement of *No-conspiracy*. This is not to say that it cannot be justified otherwise. But I shall not pay attention to such issues here since, as pointed out, this paper concerns exclusively the very specific claim connecting free will and *No-conspiracy*.

The paper is divided in two parts. First, I shall motivate that it is indeed commonplace, in the usual arguments for the derivation of the Bell inequalities, to think of free will as being behind the justification of the requirement of *No-conspiracy*. This is done in Sections 2 and 3, where the logical structure of the actual claim I shall later challenge is also made precise. The second part of the paper looks at the various presuppositions involved when invoking *Measurement Independence* as a requirement of free will. In Section 4, I comment on the more general presuppositions so as to be able to later identify more specific (causal) assumptions. These are discussed in detail in Sections 5, 6, and 7, respectively. The paper closes with some brief remarks on some of the implications of the discussion on the previous sections.

2 Free Will in Bell's Theorem

The requirement for free will in itself does not seem to spark off any controversies. In particular, it seems desirable that any theory we propose that aims at a description of nature and that may include or refer to our (human) interaction with it, is to be consistent with the idea of free will; unless, of course, we discard the possibility of free agents from the very start. A more interesting issue concerns the need to represent appropriately the idea of free will within the theory, be it as a piece of mathematical formalism, as some set of background assumptions or presuppositions, etc.

In the context of the derivation of the Bell inequalities the requirement of free will is usually represented by means of a probabilistic expression demanding that the postulated hidden variable must not influence the probabilities of the actual settings of the EPR measurement apparatus. This is the so-called *No-conspiracy* condition:

$$p(m_i|C) = p(m_i), \tag{1}$$

where C stands for the postulated (hidden) common cause and m_i for any of the different possible measurement settings in (both wings of) an EPR experiment.

Since in the following sections, I shall argue against this kind of justification of *No-conspiracy*-type conditions —that is, against the view that *No-conspiracy*-type conditions are reasonable, and indeed necessary, conditions to be required in the derivation of the Bell inequalities *because* they reflect the fact that free will is preserved—, I shall first show that, as matter of fact, these ideas are quite widely endorsed by philosophers and physicists alike, including Bell himself. Let us start precisely with Bell's own reflections on the issue:

> [I]t may be that it is not permissible to regard the experimental settings a and b in the analyzers as independent variables, as we did. We supposed them in particular to be independent of the supplementary variables λ, in that a and b could be changed without changing the probability distribution $p(\lambda)$. Now even if we have arranged that a and b are generated by apparently random radioactive devices, housed in separate boxes and thickly shielded, or by Swiss national lottery machines, or by elaborate computer programmes, or by apparently free willed experimental physicists, or by some combination of all of these, we cannot be *sure* that a and b are not significantly influenced by the same factors λ that influence A and B. But this way of arranging quantum mechanical correlations would be even more mind boggling than one in which causal chains go faster than light. Apparently separate parts of the world would be deeply and conspiratorially entangled, and our apparent free will would be entangled with them. (Bell, 1981, C2 57)

Reading the quotation above, one might not be completely convinced that Bell's thoughts as regards probabilistic independence assumptions such as *No-conspiracy* are just thoughts about free will. Indeed, one may note that in the quotation free will is only one among other mechanisms behind the requirement that the experimental settings are regarded as independent variables. So, perhaps, one might argue Bell did not suggest free will was an essential part of the picture, after all. If the EPR measurement apparatus is set exclusively by some computer routine involving random numbers, for instance, with no human action involved at all (not even to run the routine), the argument would go, there would be no reason to appeal to free will.

Despite the reference to mechanisms of this kind however, i.e. random radioactive devices, lottery boxes, etc., it seems clear to me that it was Bell's conviction that the justification of *No-conspiracy*-type conditions by means of random number generators, or other non-human resources, still involves an assumption (hidden or implicit, perhaps) about free will. This is indeed what the final part of the quotation above seems to endorse. Bell concludes there that the deep conspiratorial entanglement in the world as a consequence of the influence of the hidden variable on the measurement settings in turn involves an entanglement as regards our (apparent) free will.

For Bell thus, world conspiracies and the lack of free will seem to go hand in hand. This has also been stressed by several other authors. An example is Huw Price, who provides the following analysis on Bell's thoughts with respect to these issues:

> Bell's Theorem requires the assumption that the properties of a quantum system are independent of the nature of any measurements that might be made on that system in the future—"hidden variables are independent of later measurement settings," to put it in the jargon.
>
> Bell saw that in principle quantum mechanics could be both realist […] and local […], by giving up this *independence assumption*. But he found this solution even less attractive than that of challenging special relativity, for he took it to entail that there could be no free will. (Price, 1996, 231)

Also, in a more recent treatment of the problem, there is a clear sense in which both philosophers and physicists endorse the idea that free will and the kind of independence required by Bell are tightly connected. For instance, Conway and

Kochen's so-called "Free Will Theorem" revolves around the idea that free will is behind such independence of measurement settings, and ultimately behind the fact that there are not world conspiracies of the type described above.[1] As Tumulka (2007) points out in commenting on (Conway and Kochen, 2006):

> [...] we should require a physical theory to be non-conspirational, which means here that it can cope with arbitrary choices of the experimenters, as if they had free will (no matter whether or not there exists "genuine" free will). (Tumulka, 2007, 194)

In sum, the claims about probabilistic independence regarding the setting of the EPR measurement apparatus found in the usual arguments for the derivation of the Bell inequalities are made in virtue of us (or perhaps nature, more generally) being capable to act under our (or its) freedom of will.

3 No-Conspiracy and Free Will

I will argue in the following sections that the idea of free will involves, at different levels, a number of causal presuppositions, which I will try to make precise. Causation will then be a central notion in the discussion to follow so it seems convenient to specify further some of the ideas in the previous section in terms of causal notions.

It is not new at all to think of the issues discussed above causally. Van Fraassen (1982) constituted a turning point in this respect, in that he suggested for the first time that the notion of "hidden variable" that appears in Bell's work plays the role of a "cause"—more particularly a "common cause." There is thus in (van Fraassen, 1982) an explicit identification of Bell's "hidden variables" with the notion of "common cause." Therefore the derivation in this context of the Bell inequalities follows by appealing to causal statements. Interestingly enough, van Fraassen (1982) also assumes in his derivation of the Bell inequalities a condition which is equivalent to the independence assumption suggested by Bell himself, which we saw in the previous section. This is the so-called *Hidden Autonomy*. But van Fraassen's *Hidden Autonomy* is different from Bell's original assumption in two respects. First, as pointed out, *Hidden*

[1] It is worth pointing out that the idea of free will in (Conway and Kochen, 2006) does not refer exclusively to humans but is extensible to every particle that could be involved in an EPR experiment, i.e. electrons, photons, etc.

Autonomy is the result of a causal assessment of the EPR scenario and therefore has an explicit causal reading. Second, van Fraassen (1982) does not make any clear reference to the notion of free will, nor to conspiracies, as a motivation of *Hidden Autonomy*. Van Fraassen's justification of *Hidden Autonomy* points rather to the idea that the condition needs to be assumed in order to make sure that the EPR correlations are caused exclusively by the postulated common cause (van Fraassen, 1982, 32).

Despite the fact that van Fraassen (1982) does not make any clear reference to the idea of free will, his *Hidden Autonomy* is, as pointed out, an expression which is equivalent to Bell's independence requirements, or seamlessly to *No-conspiracy*. And, as I have argued above, even if the idea of *No-conspiracy* can be spelled out making no explicit reference at all to (human) experimenters taking free decisions, there is a clear sense in which the notion of free will seems to be behind it. I suggested, more precisely, that requiring *No-conspiracy* is usually justified by appealing, even if not always explicitly, to the notion of free will.

This is the very claim I will be challenging in the remainder of the paper. Before proceeding however, a terminological but in my view important point needs to be made. It has to do with the actual expression used to refer to probabilistic independence conditions such as equation (1), i. e. the expression "no-conspiracy." By making use of this terminology we seem to be tacitly endorsing the view, once more, that violations of such probabilistic independence conditions do indeed entail in some sense or another a conspiracy on the part of nature. Since my aim is to show that this is not so, i. e., that there being free will needs not be expressed by means of a probabilistic independence assumption, I shall refer from now on to expression (1) just as *Measurement Independence*. This is definitively a less prejudiced and more neutral way to refer to such probabilistic independence conditions, the violations of which need not, I will argue, involve any sort of world conspiracy.

To be more precise, what I shall challenge is what I take to be the general agreement that *Measurement Independence* is necessary for *free will*, i.e.

$$\text{Free will} \rightarrow p(m_i|C) = p(m_i). \tag{2}$$

4 What the Idea of Free Will Presupposes

There are a number of presuppositions behind the claim that *Measurement Independence* is necessary for free will but most of them are hardly made explicit in the usual derivations of the Bell inequalities. They can be divided in two classes. We find on the one hand a number of general assumptions, usually in relation to the connection between the experimenters' free decisions and the corresponding actual free acts. In particular, if free will is to be at the origin of the EPR experimenters' decisions to act, it seems a reasonable assumption that there be a robust (one to one) correspondence between the willing of an experimenter to act so and so and the actual act she later commits.[2] Moreover, a "faithful correspondence" of this sort seems to be necessary if we are to make sense at all of free acts—or acts of free will, understood as actual physical events taking place in space and time—and not just free decisions.

On the other hand, there seems to be a general agreement that the notion of free will has some causal import, and that it can therefore be expressed to some extent by means of causal terms. We don't need to review the different proposals to characterise human free will in detail, or the role that causality plays in them. This would take us into a deep metaphysical discussion, away from the purpose of this work. It will be enough, for the sake of the argument, to assume that causation plays in fact a central role when it comes to a description or characterisation of acts of free will. It seems intuitively right to say, for instance, that human free acts are actually free in that they are not *causally* determined or simply influenced by other events we might not even be aware of. Also, it is from a causal perspective that we seem warranted to make claims such as that free will guarantees humans to be able to decide and act freely, or to be able to act differently under changing circumstances, i.e. to revise our decisions to act after reassessment of a situation. These general considerations are, to my mind, rather uncontroversial. It is more intricate, though, how to make more precise and sharp more specific causal assumptions which are behind those considerations.

I would like to pay attention here to three specific presuppositions, all related to some sort of causal view or picture, that the idea of free will, as characterised above, demands. First, if *Measurement Independence*, i.e. expression (1), is to represent some causal statement at all, we need to assume that there is indeed a (faithful) correspondence between causal statements of the interesting kind to us and probabilistic relations.[3] I will refer to such an assumption as the *Cause-*

[2]Whether the (one to one) relation between human free decisions and corresponding free acts needs to be of a causal nature or not is not completely clear. Issues concerning the specific form of such relations will not play any role in the argument here and will therefore be put aside.

[3]There is the issue as to how a proper probabilistic theory of free will would actually look like. We shall not pay attention to such issues here, but it goes without saying that this is a deep and

statistics Link. Second, the specific independence pattern expressed by equation (1) seems to make sense only if a particular event time order as well as a fixed causal order are assumed. This can be made explicit by what I will call the *Time Order* presupposition. Finally, equation (1) is the result of demanding, not only the lack of *some* causal influence between the postulated common cause and the events representing the setting of the experiments (and therefore between the common cause and the experimenters' decisions), but the lack of *all* causal influences between these. This I will refer to as the *No-cause* presupposition.

Note that the three presuppositions above may not be the only assumptions in relation to free will when it comes to *Measurement Independence*. I do take however these presuppositions to be sustaining the intuitive core of *Measurement Independence* as an assumption about free will.

5 Cause-Statistics Link and Causal Explanation

If we endorse the idea that free will can be characterised, perhaps at a basic level, by the presence or lack of certain causal relations we will need to provide a minimal definition at least of what is to be a cause (or, alternatively, what it is for a certain event to be causally influenced). We need, for instance, to be able to tell how a certain event is to causally influence or not the EPR experimenters' free acts (to choose such and such setting for measurement). A common option is to identify, at least to some extent and under certain circumstances, causal dependence (independence) with statistical dependence (independence).

As a first observation thus, and as far as we endorse a probabilistic characterization of causation, we seem to be in need of a robust correspondence between causal relations and probabilistic expressions. In particular, we need to assume that the "translation" of our causal claims into probabilistic expressions are not only sensible but also adequate—at least in the cases we are interested in. This is to say, we need to make sure that the proposed probabilistic relations express unambiguously the actual causal claims they are intended for, and no others. Let us call this the *Cause-statistics Link* assumption.

---

interesting open problem. Miklós Rédei, for instance, has suggested (private conversation) that, if "acts of will" are defined as elements in a Boolean algebra, there could be at least three possible probabilistic conditions that one could claim would express in some sense the idea of us having free will. It would all depend on whether the required independence between the common cause C and the measurement settings m_i is of a logical character, refers to the corresponding probability distributions, or is simply statistical independence.

The *Cause-statistics Link* assumption is not a presupposition about free will *per se*. But, as pointed out, it is needed if we are to make sense of a probabilistic expression (such as *Measurement Independence*) as representing the notion of free will, as far as we take free will to be characterised, if not actually defined, causally.

Now, the *Cause-statistics Link* is a presupposition that can be easily challenged. In fact, there are many counter-examples that show that probabilistic dependence/independence is not necessary for causation, and certainly not sufficient either.[4] Only in some cases and under certain "good" conditions can the *Cause-statistics Link* assumption be considered adequate. So we could conclude that *Measurement Independence*, at least as defined in the context above, is not necessary for free will just by rejecting the idea that causal relations are adequately expressed in terms of probabilistic relations. This move would have however undesired consequences. For instance, if our analysis is motivated to some extent by the desire of explaining the EPR correlations causally—making use for example of the Principle of the Common Cause—we could not afford rejecting the necessity claim (2) on the grounds above. For if common cause explanations are to make sense at all then the *Cause-statistics Link* presupposition needs to be in place. Thus, while rejecting the *Cause-statistics Link* would undermine the claim that *Measurement Independence* is necessary for free will, it would also eliminate any possibility of explaining the EPR correlations in terms of common causes (or any other causal explanation based on the idea that causal relations are captured by probabilistic expressions).

6 Temporal Order of Events and the Direction of Causation

The requirement of *Measurement Independence* in the EPR picture presupposes as well a certain temporal time ordering of the events involved. Common causes, in particular, are assumed to take place *before* measurement operations do—and therefore *before* the corresponding outcomes have been recorded. Let us call that the *Time Order* presupposition.

As a side remark, it needs to be noted that *Measurement Independence* is a relation about *types* of events which are not, strictly speaking, defined as actual spacetime events. Thus, in principle, the notion *before* (*after*) should not apply to them. There is not, to my knowledge, an appropriate and detailed spacetime

[4] The literature on the subject is huge. A classic reference is for instance (Salmon, 1984).

description of event types. A simple way to avoid such problems is to consider type events as constituted by sets or collections of the corresponding tokens. In this view one can then refer to event types spatio-temporally in virtue of them being collections of token events. This should allow us in turn to consider common cause (type) events in *Measurement Independence* as located in the causal past of measurement (type) events.

In any case, the *Time Order* presupposition is very often assumed only implicitly, and with no further justification. The common view seems to be that presupposing this particular time order of events is just as natural—how could it be otherwise?—, so there is really no need for a proper justification. I will suggest however that there are conceivable causal pictures of the EPR experiment in which this time order is altered.

First, note that the presupposed time arrangement that the *Time Order* presupposition demands makes sense only in the context of a further causal assumption, namely that *cause events are in the past of their effects*. In other words, the usual EPR picture involved in the derivation of the Bell inequalities takes it that, if there were some causal story to explain the correlations, causes would take place prior in time to the corresponding effects, i.e. the EPR outcome events. (Again, this seems an intuitively correct, straightforward and innocuous assumption, which may not need further justification.) Thus requiring *Measurement Independence* in the usual derivations of the Bell inequalities involves a combination of an assumption about the *temporal order* of events as well as an assumption about the correct *causal order* to be taken. Both these two presuppositions can be contested independently. This leads to at least three different (causal) pictures, depending on which of the two assumptions above is dropped.

One may want to keep in the first place the temporal arrangement of events initially assumed. That is, one may want to stick to the idea that the postulated common cause is to take place before *both* the measurement operation events (in both wings) and the outcome events. Let me point out that I see no particular reason one must assume this specific time order of events—rejecting it however, would take us to a different causal picture (causal pictures 2 and 3 below). But if we do insist in keeping this specific temporal order the intuition is that, if violations of *Measurement Independence* are not to be tantamount to a world conspiracy (e.g. in the form of a lack of free will), the causal picture should involve backwards in time causation. In particular, the setting of the apparatus for measurement m_i (and perhaps the actual measurement operations) can be thought to be a (future) cause of the postulated common cause C, which would cause in turn the measured

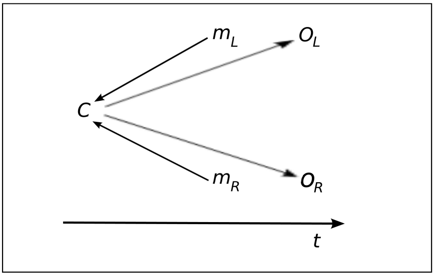


Figure 1: Backwards causation (version 1). Time order of events is preserved but causes propagate backwards in time (causal picture 1).

outcomes O_i (see Figure 1). If the common cause C is located in a sufficiently distant past, this picture turns out to be completely local, hence avoiding the usual conflicts with special relativity. Needless to say that the appeal to backwards causation is taken by many as a highly counterintuitive option. A good argument in favour of such a causal picture however has been made by Price (1994, 1996).

A second causal picture results from rejecting the initially presupposed temporal arrangement of events while keeping the assumption that causes propagate forward in time to cause their effects (San Pedro, 2012). The resulting causal structure is depicted in Figure 2. In this case, the postulated common cause C can be thought to take place sometime in between the actual measurement operations m_i and the occurrence of the observed (correlated) outcomes O_i. That is to say, C is postulated to be in the future of the measurement operations in both wings (and thus after the events representing the experimenters' measurement choices) but in the past of the EPR outcomes. Moreover, measurement is taken to be in this view an explicit causal factor (of both C and the outcomes), hence implying that *Measurement Independence* is violated. As pointed out, the above causal picture retains the most accepted intuition that causes propagate forward in time. This comes at a price nevertheless. Namely, a common cause model built along these lines seems to forcefully involve some sort of (explicit) non-locality.[5]

Finally, a third causal picture would result form the rejection of both the initially presupposed time order of the events involved as well as the intuition that causa-

[5] See (San Pedro, 2012) for details.

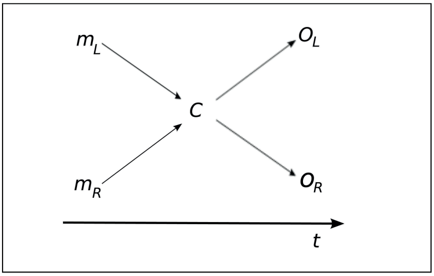


Figure 2: Time order of events is *not* preserved and causes propagate, as usual, forward in time (causal picture 2).

tion propagates forward in time. If backwards causation is again brought into the picture, the time order of events can be easily rearranged such that the postulated common cause C is in the future of the EPR outcome events (and thus, of course, in the future of the events representing the experimenters' choices and/or the actual measurement operations). The common cause may be thought indeed to be situated far enough in the future so as to guarantee that the causal interactions be completely local. (The corresponding causal structure is represented in Figure 3.) Then again, once we consider violations of *Measurement Independence*, the issue of locality seems to be tightly bound to whether or not we allow for backwards causation.[6]

It is not my intention here to discuss how appealing, likely or unlikely any of the above options are.[7] My aim is rather to suggest that in revising the presuppositions of a certain fixed time order of events and/or whether causation propagates forward in time, one can provide sensible causal pictures in which *Measurement Independence* is violated. Violations of *Measurement Independence* do not involve in any of these cases a lack of freedom of will on the part of the EPR experimenters, nor a world conspiracy in the form of an entanglement of "apparently separate parts of the world," to use Bell's terminology. Thus, what

[6]Locality issues are complex and deserve more attention than what we can afford here. See (San Pedro, 2012) for a brief discussion of the implications to the idea of locality due to violations of *measurement independence*.

[7]I point the reader to (Price, 1994, 1996) and to (San Pedro, 2012) for a defense of causal pictures 1 and 2 respectively.

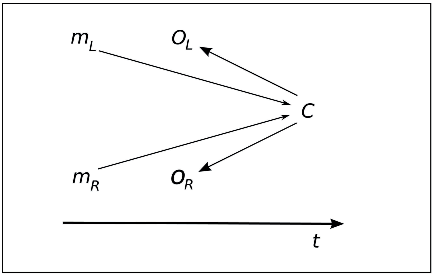


Figure 3: Backwards causation (version 2). Time order of events is *not* preserved and causes propagate backwards in time (causal picture 3).

the above already suggests is that the requirement of *Measurement Independence* in the derivation of the Bell inequalities is *independent* of whether EPR experimenters have free will or not.

7 No Causal Influence at All

In addition to the two assumptions discussed above, for the necessary connection between *Measurement Independence* and free will to stand, it is required that there be no causal influence *at all* from the common cause on the experimenters' free acts when setting the apparatus in such and such direction for measurement.

This *No-cause* presupposition, as we may call it, may turn out to be however too strong a requirement. For demanding no causal influence *at all* seems to suggest either a deterministic causal view as regards the (hidden) common cause events, or at least an idea of cause that exhausts all possible causal factors of a given effect, i.e. a *total* cause. In particular, *No-cause* may be taken to be reasonable in a deterministic context or, alternatively, in the case common causes were thought to be *total* causes of measurement settings. These two are, of course, not the only available options.

In an indeterministic context it is indeed a possibility to conceive the postulated common cause C to be not a total but just a *partial* cause of the measurement setting events m_i. Obviously *Measurement Independence* would not hold in this case. But, would that picture constitute a violation of free will? I don't think so. It is to me very sensible to think that free will would still be preserved even in the case our range of choices, or acts, had been somehow limited. (It seems in fact difficult to think of a situation where we are completely or "unboundedly" free to act.) And this is precisely what seems to be behind the idea of *partial* cause. So in this view free will is again completely compatible with the violation of *Measurement Independence*.

As for deterministic contexts, there is no need to distinguish between *total* and *partial* causes since the presence of *any* cause entails (with probability one) the occurrence of the corresponding effect. In this particular case it does seem intuitively correct to demand no causal influence of any sort if free will is to be preserved. But this may turn out not to be so, after all. In particular, one may want to endorse for instance a *compatibilist* position, and claim that free will is perfectly compatible with a fully deterministic universe.[8] There is no need to revise the *compatibilism-incompatibilism* debate here. I just would like to stress the fact that there are several options available, also in deterministic contexts, where *No-cause* is just too strong an assumption. Under such circumstances then the necessity claim (2) is to be put into question.

In sum, as suggested above, the *No-cause* presupposition may very well be seen to be too strong a condition on the requirement of *Measurement Independence* as a necessary condition for free will. Relaxing it then, opens for the possibility of non-conspiratorial—or free will compatible—violations of *Measurement Independence*.

8 Discussion

I have shown in the discussion above that the commonplace claim by which *Measurement Independence* is taken to be necessary for the whole idea of free will in causal explanations of the EPR correlation is, although apparently correct according to certain intuitions, ultimately mistaken.

The three underlying assumptions I have identified here are all revisable and can be challenged each in its own grounds. As a result, the notion of free will is shown to be compatible with the violation of *Measurement Independence* in different fashions, depending on which of the assumptions is rejected, and with diverse implications in each case. For instance, while it is difficult to make sense of common cause models of EPR if *Cause-statistics Link* is rejected, it seems

[8] Very roughly, *compatibilism* reconciles the idea of free will within deterministic contexts by reducing it somehow to a psychological subjective feature of ours.

plausible to conceive violations of *Measurement Independence* as long as one takes (hidden) common causes to be events that only *partially* cause or influence the EPR experimenters' (partially) free decisions and acts. Most interesting are perhaps the three common cause models that one may conceive in the context of a violation of *Measurement Independence* due to the rejection of either the fixed time order of events usually presupposed in the EPR scenario or the idea that causes propagate forward in time to cause their effects, or both. In discussing them, we saw that whether the models turned out to be local or not depended on which of these two assumptions was dropped. Locality issues, then, can be seen in these three models to be related to considerations about the temporal order of events, or the direction of causation. It would be valuable to know precisely how these are related, but this work needs to be left for further research.

Acknowledgment

Some of the ideas presented in this work were developed during discussion in the context of a broader project, also on the relation between free will and *No-conspiracy*, in collaboration with Miklós Rédei. I thank him for his dedication and generosity. Research supported by the Spanish Ministry of Science and Innovation research project FFI2008-06418-C01-03.

References

Bell, J. (1981). Bertlmann's socks and the nature of reality. *Journal de Physique*, Colloque C2, suppl. au numero 3, Tome 42:41–61.

Conway, J. and Kochen, S. (2006). The free will theorem. *Foundations of Physics*, 36:1441–1473.

Price, H. (1994). A neglected route to realism about quantum mechanics. *Mind*, 103:303–306.

Price, H. (1996). *Time's Arrow and Archimedes' Point*. Oxford University Press.

Salmon, W. (1984). *Scientific Explanation and the Causal Structure of the World*. Princeton University Press.

San Pedro, I. (2012). Causation, measurement relevance and no-conspiracy in EPR. *European Journal for Philosophy of Science*, 2:137–156.

Tumulka, R. (2007). Comment on ‘The free will theorem’. *Foundations of Physics*, 37:186–197.

van Fraassen, B. (1982). The charybdis of realism: Epistemological implications of Bell’s inequality. *Synthese*, 52:25–38.