Bellian analysis is irrelevant to Einstein-Podolsky-Rosen-Bohm

Abstract Using elementary algebra to refute Bell's famous inequality in the context of the Einstein-Podolsky-Rosen-Bohm experiment (EPRB), we show that Bellian analysis is self-defeating and irrelevant to EPRB. Then, as part of a program to update our prior refutations of Bell's theorem—via truly-local and truly-realistic explanations of EPRB—another note will identify Bell's false assumption. Calling it 'Bell's first error', there we will show it to be the contagious source of Bell's half-expected silliness and much Bell-based confusion.

1. Introduction

1.1. Seeking to provide a more complete specification of the EPR-Bohm experiment (EPRB), Bell (1964) leads to inequalities that are experimentally false:[1] a fact that surprises many; eg, see Aspect (2004:2). So in this note—without mystery or surprise—we use elementary algebra to derive an EPRB-based inequality that refutes Bell's famous 1964 inequality and identifies Bell's error conclusively.

1.2. nb: our inequality shows that Bell's first error moves Bellian analysis to contexts less-correlated than EPRB. In thus refuting Bell's misstep, we show that Bellian analysis is irrelevant to any study of EPRB: for the *not-to-be-avoided* common-cause physical significance of EPRB is that it involves

> 'a kind of correlation of the properties of distant noninteracting systems, which is quite different from previously known kinds of correlation,' Bohm & Aharonov (1957:1070).

1.3. Hence Bell's dilemma and half-expected silliness re the relevance of his unsuccessful specification:

> (i). 'And that is the dilemma. We are led by analysing this [EPRB] situation to admit that in somehow distant things are connected, or at least not disconnected.' (ii) 'Maybe someone will just point out that we were being rather silly .... But anyway, I believe the questions will be resolved.' (iii) 'I think somebody will find a way of saying that [relativity and QM] are compatible. But I haven't seen it yet. For me it's very hard to put them together, but I think somebody will put them together, and we'll just see that my imagination was too limited.' (iv) 'I say only that you cannot get away with locality': after Bell (1990:7,9,10,13).

1.4. Thus, in resolving Bell's dilemma, our later updates will confirm *Einstein-locality* via our truly local and truly realistic specification of EPRB—at one with quantum theory and experiment—eg, see the draft in Watson 2017D. We thereby refute any analysis that produces false conclusions like these:

> "In a theory in which parameters are added to quantum mechanics to determine the results of individual measurements, without changing the statistical predictions, there must be a mechanism whereby the setting of one measuring device can influence the reading of another instrument, however remote. Moreover, the signal involved must propagate instantaneously, so that such a theory could not be Lorentz invariant," Bell (1964:199).

1.5. So, progressing via unequivocal elementary facts to irrefutable anti-Bellian conclusions, let's see:

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[1] Bell (1964) is freely-available online, see References. Based on EPR (1935), Bell uses additional variables $\boldsymbol{\lambda}$ with Bohm & Aharonov's (1957) example of EPRB. For a related inequality/experiment see CHSH (1969)/Aspect (2004).

2. Analysis

2.1. The context is EPRB—the basis for much Bellian theorizing—as in Bell (1964). We use E for expectations (not P, which we reserve for probabilities), and a, b, c for Bell's unit-vectors $\vec{a}, \vec{b}, \vec{c}$.

2.2. Thus, from Bell 1964:(1) and anticipating his further needs (p.198), we have the expectations

$$-1 \leq E(a,b) \leq 1, \; -1 \leq E(a,c) \leq 1, \; -1 \leq E(b,c) \leq 1. \tag{1}$$

$$\therefore E(a,b)[1 + E(a,c)] \leq 1 + E(a,c);\text{ ie, if } V \leq 1, \text{ and } 0 \leq W, \text{ then } VW \leq W. \tag{2}$$

$$\therefore E(a,b) - E(a,c) \leq 1 - E(a,b)E(a,c). \tag{3}$$

$$\text{Similarly: } E(a,c) - E(a,b) \leq 1 - E(a,b)E(a,c). \tag{4}$$

$$\therefore \pm [E(a,b) - E(a,c)] \leq 1 - E(a,b)E(a,c). \tag{5}$$

$$\therefore |E(a,b) - E(a,c)| + E(a,b)E(a,c) \leq 1; \blacksquare \tag{6}$$

2.3. ie, deriving the key term $|E(a,b) - E(a,c)|$ in Bell's famous inequality—Bell 1964:(15)—via (1) alone, we deliver irrefutable inequality (6): which, unlike Bell's inequality, is consistent with EPRB.

2.4. Further, exhausting (1) unconditionally—and thereby embracing EPRB unconditionally; which, see §1, is the supposed focus of Bell (1964)—our irrefutable inequality (6) becomes irrefutable

$$0 \leq |E(a,b) - E(a,c)| + E(a,b)E(a,c) \leq 1. \blacksquare \tag{7}$$

2.5. Note that (7) holds for any pair of expectations that are consistent with (1), whatever their form. In particular, it holds for Aspect's (2004) experiment with photons (spin-1) and for the EPRB experiment with spin-$\frac{1}{2}$ particles.[2] Moreover, under EPRB and QM—and thus in the context of this note and Bell (1964)—expectations are of this form:[3]

$$E(a,b) = -\cos(a,b), \; E(a,c) = -\cos(a,c), \; E(b,c) = -\cos(b,c). \tag{8}$$

2.6. So—as is well-known, and as we now confirm—Bell's inequality is not consistent with EPRB under QM. For, in a format matching our (6), here—from Bell 1964:(15)—is Bell's famous inequality:

$$|E(a,b) - E(a,c)| - E(b,c) \leq \; 1 \; [\textbf{sic}]. \blacktriangle \tag{9}$$

2.7. Thus, in Bell's chosen context of EPRB, and using (8) in (9) for proof by exhaustion, we find:

$$-1 \leq |E(a,b) - E(a,c)| - E(b,c) \leq \tfrac{3}{2}. \blacksquare \tag{10}$$

2.8. That is, under EPRB: via (10), Bell's upper-bound of 1 [**sic**] in (9) is false, being exceeded by 50%. Moreover, comparing Bellian (9) with our irrefutable (6), Bell's error[4] under EPRB is clear. Our rigorous term $+E(a,b)E(a,c)$ cannot lead to a breach (6)'s upper-bound of 1: while Bell's comparable term $-E(b,c)$ is false because it does lead to breaches of his upper-bound of 1 in (9).

2.9. So, supposedly bound by EPRB: Bell's primary error moves Bellian analysis to contexts less-correlated than EPRB; ie, to non-EPRB contexts which do not breach (9)'s erroneous upper-bound. Thus, with certainty, Bellian analysis and Bell's famous (9) are irrelevant to EPRB and QM.[5]

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[2] As we'll show in our next note 2018K.v4, Bell derives a different inequality for each experiment: and each is false.

[3] Via LHS Bell 1964:(2) and RHS Bell 1964:(3), and in agreement with QM: $E(a,b) = -a{\cdot}b = -cos(a,b)$; etc.

[4] Coming notes will refer to several Bellian errors whose particulars should be clear from the context. When added clarity is required: (i) the error leading to Bell's famous (9) is Bell's first error. (ii) Bell's second error—the basis for his famous theorem—is independent of his first. (iii) His third error—Bell locality/factorizability—is independent of both.

[5] Agreeing with Peres 1995:162—'Bell's theorem is *not* a property of QM'—the above refutes Peres' claim that 'Bell's theorem applies to any physical system with dichotomic variables, whose values are arbitrarily called 1 and -1'.

3. Conclusions and the next step

3.1. Compounding the magnitude of Bell's error—ie, Bell's false upper-bound of 1 [**sic**] in (9) needs to be $\frac{3}{2}$ under EPRB per (10)—there is also the consequent range of Bell's error. Thus—under a typical Bellian/planar angular-relation; eg, from Peres (1995:Fig.6.7)—let

$$(b,c) = (a,c) - (a,b)\colon \text{and let } (a,c) = 3(a,b);\ \text{so } (b,c) = 2(a,b). \tag{11}$$

3.2. Then, in this antecedent/consequent example: If Bell's inequality is (9) under EPRB, then it is false over $\frac{2}{3}$ of the range $-\pi < (a,b) < \pi$; ie, in this example, Bell's inequality is EPRB-false for

$$-\pi < (a,b) < \tfrac{2\pi}{3}, \tfrac{\pi}{3} < (a,b) < 0, 0 < (a,b) < \tfrac{\pi}{3}, \tfrac{2\pi}{3} < (a,b) < \pi; \text{ etc.} \tag{12}$$

3.3. So, confirming the certainty expressed in ¶2.9: Bell's inequality (9) and Bell-based analysis are irrelevant to EPRB. For—as we show in the next step, Watson 2018K.v4—Bell's first error is the assumption that led him to his invalid $-E(b,c)$ in (9) instead of our irrefutable $E(a,b)E(a,c)$ in (6).

3.4. Thus, against Bell's conclusions in ¶1.4 and as later notes will show, we use additional variables—consistent with Watson 2017D—to deliver a more complete (truly local and truly realistic) specification of EPRB. One like Bell sought in 1964; one that Bell's first error precludes.

4. References

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