Bell's inequality refuted irrefutably on Bell's own terms

Gordon Watson[1]

Abstract Consistent with claims that we've advanced since 1989, we refute Bell's 1964 inequality on Bell's own terms. In sum, in the context of the EPR-Bohm experiment: Bell-(14b) $\neq$ Bell-(14a).

1. Introduction

(i) Bell's theorem has been described as one of the most profound discoveries of science. (ii) Yet, despite this fame, Bell (1990:7) lived on the horns of a dilemma wrt the significance of his theorem. (iii) Here, using elementary mathematics as an introduction to its further use in Watson (2018e),[2] we refute Bell's inequality on Bell's own terms and respond to an interesting objection.

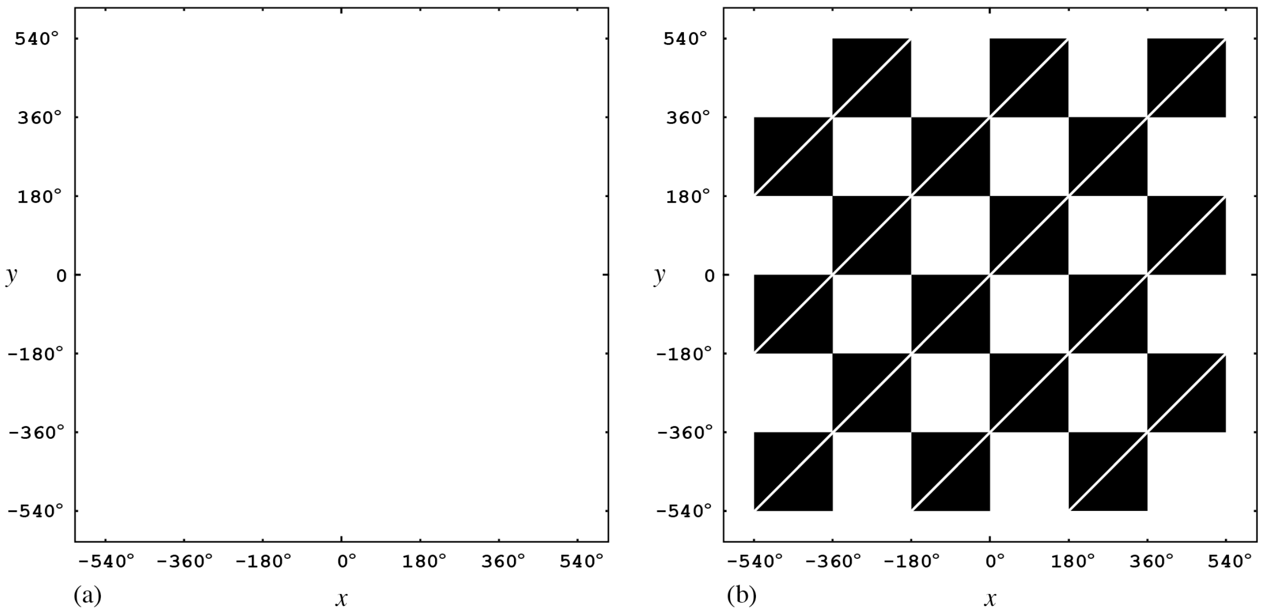

Fig.1. With $x = (\vec{a}, \vec{b})$, $y = (\vec{a}, \vec{c})$, simplified[3] screen-shots compare the irrefutable upper bound of the variables in (7) with Bell's similar claim re (8), his famous inequality B(15). (a) shows (7) to be 100% true, its upper bound of 1 not exceeded. (b) shows (8) to be 50% true, its similarly-claimed Bellian upper bound of 1 exceeded regularly; see (20). White lines show $\cos(\vec{a}, \vec{b}) = \cos(\vec{a}, \vec{c})$ and thus (8) is true there via the equality noted in (7).

(iv). Bell (1964) is available free-online, see References: it will pay to have it on hand. Let B(1) be short for Bell 1964:(1); etc. Let B(14a)-B(14c) identify the three relations between B(14) and B(15). nb: when we refer to a relation number, say (7), we are generally referring to the core relation, not the related commentary; as should be clear from the context. Further, our upper and lower bounds are defined by the *variables* in each relation. So the *claimed* upper bounds are the starting constants in each relation; here that is 1. And, to be clear: the lower bounds (for which no claims arise initially) are determined by those same *variables*.

[1] Correspondence welcome. email: eprb@me.com Ex: (2018d)-14. Ref: Watson (2018d)-15. Date: 20180820.

[2] All results here are independent of Watson (2018e), which simply delivers new results with similar mathematics.

[3] More complex shots can compare lower bounds and combinations of both; see (20). Fig.1(b) is adequate for present purposes, with (8)'s true upper bound at $\frac{3}{2}$ against B(15)'s claim of 1. The upper bound for our irrefutable (7) is also 1.

(v) Then Fig.1 introduces our results graphically upon two opaque-white screens. Akin to archeological sieves screening for mathematical relations that breach a *claimed* upper bound—which is 1 here—each screen is here set to catch real numbers $\mathbb{R} > 1, \forall \vec{a}, \vec{b}, \vec{c}$. Thus all $\mathbb{R} \leq 1$ pass through and settle beneath a screen, hidden from view. On screen (a), white-space shows our irrefutable[4] (7) 100% true. On screen (b), white-space shows where (8) is true; (7), per (a), being true over all of screen (b).

(vi) Here's the key: irrefutable (7) can match all valid values of (8)—ie, of B(15), that famous inequality—but B(15) exceeds the irrefutable limits of (7); see (20). Therein, B(15) is refuted irrefutably.

2. Analysis

(i) Via B(1) and LHS B(2), there are (for us) two key relations in Bell's work: result A, given by $A(\vec{a}, \boldsymbol{\lambda}) = \pm 1$, etc; expectation value $P(\vec{a}, \vec{b})$, the average over the product of paired-results $A(\vec{a}, \boldsymbol{\lambda})$ and $B(\vec{b}, \boldsymbol{\lambda})$, etc. (ii) Thus—using facts at one with mathematics,[5] quantum theory (QT), observation and true local realism (as in Watson 2018e)—we have the Bellian result functions

$$A(\vec{a}, \boldsymbol{\lambda}) = \pm 1, \quad B(\vec{b}, \boldsymbol{\lambda}) = \pm 1, C(\vec{c}, \boldsymbol{\lambda}) = \pm 1, \text{ and the related expectations} \tag{1}$$

$$-1 \leq P(\vec{a}, \vec{b}) \leq 1, \quad -1 \leq P(\vec{a}, \vec{c}) \leq 1, -1 \leq P(\vec{b}, \vec{c}) \leq 1; \text{ all irrefutably linkable} \tag{2}$$

$$\text{like this: } 1 + P(\vec{a}, \vec{c}) \geq P(\vec{a}, \vec{b})[1 + P(\vec{a}, \vec{c})] \text{ for all } \vec{a}, \vec{b}, \vec{c}, \text{ and so on. For it's irrefutable} \tag{3}$$

$$\text{that } q \geq pq \text{ if } p \leq 1 \text{ and } 0 \leq q, \text{ with } p \,\&\, q \text{ here coming naturally from (2).} \tag{4}$$

$$\text{So too: } 1 + P(\vec{a}, \vec{b}) \geq P(\vec{a}, \vec{c})[1 + P(\vec{a}, \vec{b})] \text{ for all } \vec{a}, \vec{b}, \vec{c}. \text{ So now, from this and (3):} \tag{5}$$

$$1 - P(\vec{a}, \vec{b})P(\vec{a}, \vec{c}) \geq P(\vec{a}, \vec{b}) - P(\vec{a}, \vec{c}) \text{ and } 1 - P(\vec{a}, \vec{b})P(\vec{a}, \vec{c}) \geq P(\vec{a}, \vec{c}) - P(\vec{a}, \vec{b}). \text{ So} \tag{6}$$

$$1 - |P(\vec{a}, \vec{c}) - P(\vec{a}, \vec{b})| \geq P(\vec{a}, \vec{b})P(\vec{a}, \vec{c}). \text{ Clearly true when } P(\vec{a}, \vec{c}) = P(\vec{a}, \vec{b}), \text{ as is} \tag{7}$$

$$1 - |P(\vec{a}, \vec{c}) - P(\vec{a}, \vec{b})| \geq -P(\vec{b}, \vec{c}); \text{ ie, B(15), delivering its QT-problem on Bell's behalf.} \tag{8}$$

$$\text{For via Bell at B(15)} : \ 'P(\vec{b}, \vec{c}) \text{ cannot equal the QT value of } -\cos(\vec{b}, \vec{c}), \text{ from B(3).}' \tag{9}$$

$$\text{However, please note} : \ \textit{independent of any theory}, \text{ B(15) -- as in (8) -- will fail if} \tag{10}$$

$$P(\vec{a}, \vec{b})P(\vec{a}, \vec{c}) + P(\vec{b}, \vec{c}) < 0 \text{ and } P(\vec{a}, \vec{c}) \neq P(\vec{a}, \vec{b}). \text{ For B(15) then exceeds RHS (7),} \tag{11}$$

$$\text{an irrefutable limit} : \ \text{one to test any theory, like Bell's choice of QT or any other.} \tag{12}$$

$$\text{So, given (11), B(3), QT} : \ \text{B(15) fails for } \cos(\vec{a}, \vec{c}) \neq \cos(\vec{a}, \vec{b}) \text{ and } 0 < \sin(\vec{a}, \vec{b}) \sin(\vec{a}, \vec{c}) \tag{13}$$

$$[\text{from } -\sin(\vec{a}, \vec{b}) \sin(\vec{a}, \vec{c}) = P(\vec{a}, \vec{b})P(\vec{a}, \vec{c}) + P(\vec{b}, \vec{c}) < 0 \text{ as required in (11)] see Fig.1(b).} \tag{14}$$

$$\text{So, as claimed in 1989} : \ \text{Bell's theorem is false. And B(15) fails at its source:} \quad \textit{QED.}\blacksquare \tag{15}$$

$$\text{for B(14b)} = (8) \neq (7) = \text{B(14a) via (6); ie, B(14b)} \neq \text{B(14a).} \quad \text{QED.}\blacksquare \tag{16}$$

$$[\text{nb: LHS B(14a)} = P(\vec{a}, \vec{b}) - P(\vec{a}, \vec{c}) \text{ which, via (3), gives (6).] So} \tag{17}$$

$$\text{Bell's (1964:196-7)} : \ \text{"not possible" and "contradiction" are unjustified;} \quad \textit{QED.}\blacksquare \tag{18}$$

$$\text{Bell's conclusion too} - \text{Bell (1964:199) -- see Watson 2018e:¶5 also.} \quad \textit{QED.}\blacksquare \tag{19}$$

$$\text{Finally, } \forall \vec{a}, \vec{b}, \vec{c} : 0 \leq (7) \leq 1, \text{ whereas } -1 \leq (8) \leq \tfrac{3}{2}, \text{ as surmised at (11).} \quad \textit{QED.}\blacksquare \tag{20}$$

(iii) Now some academics say that our use of QT in (13) is invalid—despite it being triggered by Bell—because Bell (against QT) wanted to keep open the possibility that the "quantum correlation B(3)" was false. We find merit in this suggestion: for it allows an inference to the best explanation for Bell's acceptance of a result that is clearly QT-false. However, consistent with our acceptance of QT: at Watson 2018e:(19) we derive this "quantum correlation B(3)" without QT: with both that derivation and QT valid here. So, while some say QT was unavailable to Bell under his belief-system—despite Bell's frequent invocations—QT is clearly available to us: with QT's endorsement (and via that alone if necessary—to allow our focus on B(15) to continue—see next).

[4] Our use of this adjective reflects the absolute certainty of our claim against Bell since 4 June 1989.
[5] Note that the result in (7) emerges from the fact that the LHS of each relation in (6) is positive.

(iv) For yet again—equaling all the QT values—we again beat Bell's QT comparison. For our (6)—and thus our (7)—reduces to an observationally-significant fact (worked for one example only):

$$\cos(\vec{a},\vec{b}) - \cos(\vec{a},\vec{c}) + \cos(\vec{a},\vec{b})\cos(\vec{a},\vec{c}) = 1 - 4\sin^2\frac{(\vec{a},\vec{b})}{2}\cos^2\frac{(\vec{a},\vec{c})}{2} \leq 1,\ \forall\, \vec{a},\vec{b},\vec{c};\ \text{etc. } QED.\blacksquare \quad (21)$$

(v) With other Bellian errors corrected in Watson (2018e), we rest our analysis here and conclude.

3. Conclusions

(i) Whatever the justification for Bell's (14b), it is mathematically false: for, given another fact here—that our matters of fact may generally be confirmed by observation—it leads to Fig.1(b). Moreover, on this point please note: point-by-point, the performance of each screen may be audited with low-cost hand-held calculators—or via Web2.0Calc—and the relevant relation, (7) or (8).

(ii) Further, whatever triggered Bell's assumption, B(14b) is also unwarranted. For, against Bell here, Watson (2018e) delivers—via true local realism—the same results as QT and observation. Thus showing, independently, that B(2) equals B(3): at the same time dismissing the famous Bellian "impossibility" claim below B(3).

(iii) Not only that, but under EPRB, Bell's (14b) is also unphysical: akin, see Watson 2018e:¶7, to falsely and naively inferring that naive-realism might succeed in Bohm's highly-correlated EPR-quantum setting: and not then dropping naive-realism when it failed.

(iv) So, in the context of our elementary mathematics, and on Bell's own terms, we rest our case:

Via irrefutable (7), Bell's famous Bell-(15) is refuted irrefutably. *QED.*■ (22)

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