A contagious error voids Bell (1964), etc.

 2018K.v1

Abstract Elementary instance-tracking identifies a contagious error in Bell (1964). To wit, against his own advice: in failing to match instances, Bell voids his own conclusions. The contagion extends to CHSH (1969), Griffiths (1995), Peres (1995), Aspect (2004), etc.

1. Introduction

1.1. Bell (1964) and Watson 2018J.v3 (or later) provide the preamble to this essay; they are freely available, see ¶4-References. After Bell 1964:(14), we label the unnumbered math-expressions (14a)-(14c). And we put the crucial line[1] before Bell 1964:(1) into a convenient mathematical form:

> Discrete result A_i is determined by a and $\boldsymbol{\lambda}_i$, so $A_i = A(a, \boldsymbol{\lambda}_i)$. And the *paired result* B_i [ie, *the result obtained in the same instance*] is determined by b and $-\boldsymbol{\lambda}_i$. So $B_i = B(b, -\boldsymbol{\lambda}_i)$ [$= -A(b, \boldsymbol{\lambda}_i)$ consistent with Bell 1964:(13)]. We therefore work with subscript instance-identifiers (using n tests per test-setting for convenience in analysis):

$$A_iB_i : i = 1, 2, ..., n.\ A_jC_j : j = n + 1, ..., 2n.\ B_kC_k : k = 2n + 1, ..., 3n. \tag{1}$$

$$\therefore A_iA_i = B_iB_i = A_iA_iB_iB_i = 1; A_iB_j = \pm 1; B_iB_j = \pm 1;\ \text{etc.} \tag{2}$$

1.2. Thus, via fn.2: $n\,i$-indexed randomly-generated particle-pairs define the $n\,i$-indexed instances that deliver the n paired A_iB_i results from which the expectation $E(a, b)$ is derived; etc. [With $n \to \infty$, if required.]

1.3. Now from Watson 2018J we know that Bell's famous inequality—Bell 1964:(15)—is false. And since Bell 1964:(15) is correctly derived from Bell 1964:(14b), we consequently know that (14b) is false. Thus, since Bell 1964:(14a) is true (by definition), it follows (with certainty) that:

$$\text{Bell 1964:(14b)} \neq \text{ Bell 1964:(14a)}. \tag{3}$$

1.4. Then, since Bell arrives at (14b) using 1964:(1), it follows (with certainty) that this usage is the source of his error. Indeed, comparing (14b) with (14a), we see that Bell uses 1964:(1) absurdly[2] via

$$A(b, \boldsymbol{\lambda})A(b, \boldsymbol{\lambda}) = 1\text{: whereas instance-tracking (as we'll show) requires } A_i(b, \boldsymbol{\lambda}_i)A_j(b, \boldsymbol{\lambda}_j) = \pm 1; \tag{4}$$

hence the utility of instance-tracking subscripts [here: i, j] when correcting false Bellian theorizing.

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[1] *Crucial* in that EPRB correlations and expectation values only arise from paired-results obtained in *the same instance*, and not at all by pairing two results from two *different instances*. So [except when presenting Bellian analyses] each instance here is uniquely [and systematically; see (1)] identified by a subscript *instance-identifier*: which is thus nothing but the unique identifier that we have historically allocated to each particle-pair under the same system.

[2] Bellians may claim that this is Bell's way of providing 'the more complete specification of EPRB via parameters $\boldsymbol{\lambda}$' that he seeks (p.195). But this leaves Bell's false 1964:(15) standing, which leads to other Bellian errors; see Watson 2018J:¶1.2 for now. Further, the CHSH (1969) inequality—false on the same grounds—is one of the clearest examples of instance-matching errors. For four sets of subscripts [say: i, j, k, l] are required to conveniently track all the instances, as in (1); each set built from randomly generated particle-pairs. For now, see Watson 2017d:(34)-(41) for the general idea.

2. Analysis

2.1. In the preamble to Bell 1964:(1), evidently implying significant generality for his theorizing, Bell is indifferent to the nature of the parameters $\boldsymbol{\lambda}$ that he invokes to provide a more complete specification of EPRB. So, independent of $\boldsymbol{\lambda}$ for now, we prove the validity of our inequality—Watson 2018J:(7); and thus of (3)—using subscripted outcomes like $A_i = \pm 1$ and $B_i = \pm 1$:

$$\begin{aligned}
\text{Bell 1964:(14a)} &\equiv E(a,b) - E(a,c) && (5)\\
&\equiv \frac{1}{n}\sum_{i=1}^{n} A_i B_i - \frac{1}{n}\sum_{j=n+1}^{2n} A_j C_j && (6)\\
&= \frac{1}{n}\sum_{i=1}^{n} A_i B_i \left[1 - A_i B_i \cdot \frac{1}{n}\sum_{j=n+1}^{2n} A_j C_j\right] && (7)\\
&\qquad\qquad \because\ \frac{1}{n}\sum_{i=1}^{n} A_i B_i A_i B_i = 1,\ \text{since} A_i B_i A_i B_i = 1: && (8)\\
&\neq \text{Bell 1964:(14b)}.\ \blacksquare && (9)
\end{aligned}$$

2.2. That is, comparing Bell 1964:(14b) with our (7), (3) is confirmed. Then, continuing via (7):

$$\begin{aligned}
\therefore |E(a,b) - E(a,c)| &= \left|\frac{1}{n}\sum_{i=1}^{n} A_i B_i \left[1 - A_i B_i \cdot \frac{1}{n}\sum_{j=n+1}^{2n} A_j C_j\right]\right| && (10)\\
&\qquad\qquad \because\ |X| = |Y|\ \text{ if } X = Y: && (11)\\
&\leq \left|\frac{1}{n}\sum_{i=1}^{n} 1 \left[1 - A_i B_i \cdot \frac{1}{n}\sum_{j=n+1}^{2n} A_j C_j\right]\right| && (12)\\
&\qquad\qquad \because\ \frac{1}{n}\sum_{i=1}^{n} A_i B_i \leq \frac{1}{n}\sum_{i=1}^{n} 1 = 1: && (13)\\
&\leq \left|\frac{1}{n}\sum_{i=1}^{n} 1 - \frac{1}{n}\sum_{i=1}^{2n} A_i B_i \cdot \frac{1}{n}\sum_{j=n+1}^{2n} A_j C_j\right| && (14)\\
&\qquad\qquad \because\ \text{inner brackets removed:} && (15)\\
&\leq \left|1 - \frac{1}{n}\sum_{i=1}^{n} A_i B_i \cdot \frac{1}{n}\sum_{j=n+1}^{2n} A_j C_j\right| && (16)\\
&\qquad\qquad \because\ \frac{1}{n}\sum_{i=1}^{n} 1 = 1;\ \text{and now using (5)-(6):} && (17)\\
&\leq 1 - E(a,b)E(a,c);\ \blacksquare && (18)
\end{aligned}$$

confirming the irrefutable algebraic result at Watson 2018J:(7) in a physically significant way.

2.3. We now provide[3] a physically significant exposure of Bell's error. That is, we work with uniquely-subscripted $\boldsymbol{\lambda}$-pairs—no two pairs the same; consistent with (1)—where each subscripted-$\boldsymbol{\lambda}$ (pairwise anti-correlated via the pairwise conservation of total angular momentum) denotes the orientation of a particle's total angular momentum.

[3] For the record: this provision is consistent with true local realism and our own more complete specification of EPRB; as drafted in Watson (2017d), which is now being improved.

2.4. We begin with the way that Bell equates his (14b) to his (14a):

$$\text{Bell 1964:(14a)} \equiv E(a,b) - E(a,c) \tag{19}$$
$$\equiv -\int d\lambda\, \rho(\boldsymbol{\lambda})\, [A(a,\boldsymbol{\lambda})A(b,\boldsymbol{\lambda}) - A(a,\boldsymbol{\lambda})A(c,\boldsymbol{\lambda})] \tag{20}$$
$$= \int d\lambda\, \rho(\boldsymbol{\lambda}) A(a,\boldsymbol{\lambda})A(b,\boldsymbol{\lambda})[A(b,\boldsymbol{\lambda})A(c,\boldsymbol{\lambda}) - 1] = \text{Bell 1964:(14b):[sic]}\blacktriangle \tag{21}$$
$$\text{with Bell using 1964:(1) and } A(b,\boldsymbol{\lambda})A(b,\boldsymbol{\lambda}) = 1 \text{ as in our (1);}\blacktriangle \tag{22}$$

ie, the move from (20) to (21) is absurd, as is the justification(22): (i) such correlation applies only to outcomes obtained *in the same instance,* per (Bell 1964:195) and our (1); (ii) Bell 1964:(14a), as in (19)-(20), is a valid formulation in which no two subsidiary instances are the same [see also (23)-(24)]; (iii) moreover, because many miss this absurdity, it is contagious: eg, CHSH 1969:(first math expression; unnumbered), Griffiths (1995:378), Peres 1995:(6.25, 6.29), Aspect 2004:(17), etc.

2.5. So, in rebuttal, we now restart with (19): respecting our subscript instance-identifiers, per (4).

$$\text{Bell 1964:(14a)} \equiv E(a,b) - E(a,c) \tag{23}$$
$$\equiv -\int d\lambda\, \rho(\boldsymbol{\lambda})\, [A_i(a,\boldsymbol{\lambda}_i)A_i(b,\boldsymbol{\lambda}_i) - A_j(a,\boldsymbol{\lambda}_j)A_j(c,\boldsymbol{\lambda}_j)] \tag{24}$$
$$= \int d\lambda\, \rho(\boldsymbol{\lambda}) A_i(a,\boldsymbol{\lambda}_i)A_i(b,\boldsymbol{\lambda}_i)[A_i(a,\boldsymbol{\lambda}_i)A_i(b,\boldsymbol{\lambda}_i)A_j(b,\boldsymbol{\lambda}_j)A_j(c,\boldsymbol{\lambda}_j) - 1] \tag{25}$$
$$\therefore |E(a,b) - E(a,c)| \leq \int d\lambda\, \rho(\boldsymbol{\lambda})[1 - A_i(a,\boldsymbol{\lambda}_i)A_i(b,\boldsymbol{\lambda}_i)A_j(b,\boldsymbol{\lambda}_j)A_j(c,\boldsymbol{\lambda}_j)] \tag{26}$$
$$\because \int d\lambda\, \rho(\boldsymbol{\lambda}) A_i(a,\boldsymbol{\lambda}_i)A_i(b,\boldsymbol{\lambda}_i) \leq 1 \tag{27}$$
$$\leq 1 - E(a,b)E(a,c) = (18),\ \text{our inequality (as it should):}\ \blacksquare \tag{28}$$

for the expectation over the product of $A_i(a,\boldsymbol{\lambda}_i)A_i(b,\boldsymbol{\lambda}_i)$ and $A_j(b,\boldsymbol{\lambda}_j)A_j(c,\boldsymbol{\lambda}_j)$—two independent and uncorrelated random variables; representing two sets of systematically specified instances, per (1)—is the product of their individual expectations. Hence the utility of our subscript instance-identifiers.

3. Conclusions

3.1. Our analysis identifies a telling contagious error in Bell (1964); see ¶2.4(i)-(iii).

3.2. The basis for Bell's 1964 inequality (and his consequent theorem) is widely discussed up to the present day. We show that there is no basis for either.

3.3. It follows that Bell (1964) is no bar to our proof[4] of Einstein's argument that EPR correlations "can be made intelligible only by completing the quantum mechanical account in a classical way," Bell (2004:86). For *grossly non-local structures* (Bell 1964:195) are characteristic of Bell-style theory-voiding instance-matching errors: not a failure of the *vital* [locality] *assumption* below Bell 1964:(1).

4. References

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[4] Drafted in Watson (2017d), and now being improved.

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