Review of: "On the Bell Experiment and Quantum Foundation"

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Bell experiments are still an exciting topic for foundational questions in quantum mechanics and beyond. Ideas that can shed a new light on the lessons that can be learned from the experimentally observed violations of Bell inequalities should therefore generally be approached with an open mind.

Reading Helland's article with this mind-set I have struggled to find a clearly understandable line of reasoning that would lead from Bell experiments to the mind of an observer and its limitations. While some elements of the article seem to offer glimpses of a new view, as posited by the author, others may just add to existing confusion around Bell experiments. The mathematics around accessible / inaccessible conceptual variables as stated in the Lemma and in Helland (2023b) could be interesting in the sense of a purely abstract framework, the philosophical references to the mind and its alleged limitations seem, however, unconnected and unfounded.

The derivation of Bell inequalities has nothing to do with quantum theory, it rests on a realist assumption about the world, i.e. it is assumed that unperformed experiments may be assigned an outcome (i.e. a counterfactual value). This assumption, together with other more specific assumptions, like Bell locality, free choice, no retro-causality, allows the derivation of Inequality (3). Assumptions about the mind and its capacity do not enter the derivation of Bell inequalities. As a statistician, the author knows how statistical uncertainties can be dealt with, e.g. by introducing confidence intervals. However, on this basis Bell experiments can clearly be automated so that the human scientist just gets a single bit of information: the scientist predefines a number of measurements to be made on entangled particles as well as a desired confidence level and inputs this to a machine. The machine runs the experiment generating pairs of entangled particles, setting the measurement directions a vs. a' and b vs. b' automatically at random* and recording the outcomes. After all measurement rounds are complete the machine computes the amount by which Inequality (3) was violated and then gives the human scientist a simple yes/no answer based on the desired confidence level for a violation.

On this basis all references to human observers, their mind and its limitations seem unfounded. It is completely unclear how a conceptual jump from a Bell experiment to statements about the "mind of an observer" could be accomplished. Additionally, when quantum theory is viewed as essentially epistemic by the author, then how could it provide conclusions about limitations of the mind?

The author's claim on p.6 "*This points at a new foundation of quantum theory, and it also suggests a general epistemic interpretation of the theory: Quantum theory is not directly a theory about the world, but a theory about an actor's*

knowledge of the world" is rather strong. If he wants to attempt something like this, then his line of reasoning connecting his mathematics to philosophy and epistemology needs to be much clearer.

He additionally writes "*From the discussion above, it seems that it is the assumption of realism which must be abandoned*" in the conclusion on p.9. This is a less conventional angle as the debate usually focusses on violations of locality as very few people are prepared to give up realism. While giving up realism would prevent the derivation of Bell inequalities, it is a very strong ask. Looking at Corollary 1 I am starting to wonder if the philosophical point that the author wants to make is about limitations for simultaneous perception, i.e. the question why superpositions are never observed directly? If so, a different wording and a clear link to his mathematics would be interesting.

[*] Assuming that an automated choice at random, e.g. resulting from another quantum experiment, satisfies the free choice assumption. This is the standard Bell experiment, although adherents of super-determinism may say that random choices are not really possible.