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FROM THEORY TO EXPERIMENTS AND BACK AGAIN ... AND BACK AGAIN ... COMMENTS ON PATRICK SUPPES

"The picture of theory often presented by philosophers of science is too austere, abstract and self-contained" Professor Suppes writes. While, as it turns out from the two substantive examples considered in the paper, a closer analysis of the experimental details, the method of data processing and the most important features of the measuring equipments can be fruitful in understanding the basic concepts and the metaphysical conclusions drawn from the theoretical description of the experimental scenario.

Since my field of interest is closer to quantum mechanics, I would like to focus on Suppes' second example based on de Barros and Suppes (2000) general analysis of the realistic GHZ experiments, where experimental error reduces the perfect correlations of the ideal GHZ case. The following important question motivated their analysis: "How *can one verify experimentally predictions based on correlation-one statements, since experimentally one cannot obtain events perfectly correlated?*" De Barros and Suppes' analysis makes use of inequalities which are said to be "*both necessary and sufficient for the existence of a local hidden variable*" for the experimentally realizable GHZ correlations. In applying their analysis to the Innsbruck experiment, however, they only count events in which all the detectors fire. While necessary for the analysis of that experiment, they recognize that this selective procedure weakens the argument for the nonexistence of local hidden variables.

In Szabó and Fine (2002) we pointed out that their analysis does not rule out a whole class of local hidden variable models in which the detection inefficiency is not (only) the effect of the random errors in the detector equipment, but it is a more fundamental phenomenon, the manifestation of a predetermined hidden property of the particles. This conception of local hidden variables was first suggested in Fine's *prism model* (1982) and, arguably, goes back to Einstein.

M.C. Galavotti (ed.), Observation and Experiment in the Natural and Social Sciences, 57–62.

Both, de Barros and Suppes' analysis and our polemics, confirm, however, Suppes' thesis about the continuing interaction in science between theory and experiment.

Theory => Experiment

De Barros and Suppes approach the problem in the following way. Without loss of generality, the space of hidden variable can be identified with $O = \{+, -\}^6$, the set of the $2^6 = 64$ different 6-tuples of possible combinations of the values of $\sigma_{1x}, \sigma_{1y}, \ldots \sigma_{3y}$. Then the GHZ contradiction amounts to the assertion that no probability measure over O reproduces the expectation values.

De Barros and Suppes demonstrate this by concentrating on the product observables *(A, B, C* and *ABC)* for which they derive a system of inequalities that play the same role for GHZ that the general form of the Bell inequalities do for EPR-Bohm type experiments; namely, they provide necessary and sufficient conditions for a certain class of local hidden vaxiable models. Their inequalities axe just

$$-2 \leq E(A) + E(B) + E(C) - E(ABC) \leq 2$$
$$-2 \leq E(A) + E(B) - E(C) + E(ABC) \leq 2$$
$$-2 \leq E(A) - E(B) + E(C) + E(ABC) \leq 2$$
$$-2 \leq E(A) + E(B) + E(C) + E(ABC) \leq 2$$

and clearly this is violated by

$$E(A) = E(B) = E(C) = 1$$
$$E(ABC) = -1$$

Experiment => Theory

In the realistic experiments, due to inefficiencies in the detectors or to dark photon detection, the observed correlations were reduced by some factor e; that is:

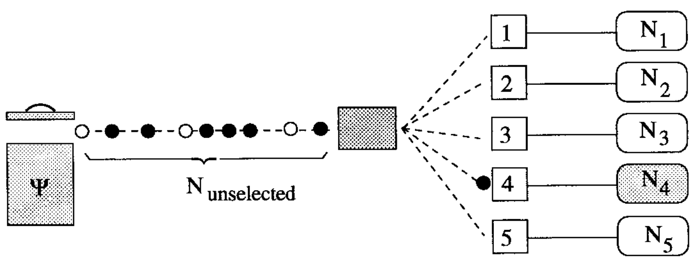
$$E(A) = E(B) = E(C) = 1 - \varepsilon$$
$$E(ABC) = -1 + \varepsilon$$

Theory => Experiment

Then, it follows immediately from the inequalities that, "*the observed correlations are only compatible with a local hidden variable theory*" if $\varepsilon > 1/2$. De Barros and Suppes (2000) translated this condition into the language of the dark-count rate and the detector efficiency.

Experiment => Theory

Estimating the realistic values of the dark-count rate and the detector efficiency, they found that the Innsbruck experiment is not compatible with a local hidden variable theory.



$$N_{\text{unselected}} \neq \sum_i N_i$$
$$tr\,(WP_i) = \frac{N_i}{\sum_i N_i}$$

Figure 1: *In a typical quantum measurement, quantum mechanical "probabilities" are equal to the relative frequencies taken on a* sub-ensemble of *objects producing any outcome.*

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