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Mental Activity and Physical Reality

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Recent experiments in physics have demonstrated strong support for the existence of a non-local influence on physical events (i.e., an influence with a velocity greater than that of light). As the coherence of special relativity depends on the stipulation that light is the fastest physical existent, the question arises as to the nature of this influence. This paper addresses the basic design and results of the recent experiments, proposes an experiment that will provide indications as to whether this influence has a mental component, and discusses some already existing evidence of the influence of mental activity in the very development of physical reality.

In 1935, in response to the limitation in the knowledge of physical events proposed by the proponents of the Copenhagen interpretation of quantum mechanics (as expressed in the principle of uncertainty), Einstein, Podolsky, and Rosen published a theoretical paper attempting to demonstrate that quantum mechanics is not a complete theory of physical reality. According to the principle of uncertainty, the accuracy with which the position and momentum of an electron, for example, can be known is limited in accord with a small, positive quantitative value (Planck's constant). In their argument, Einstein et al. first proposed what they believed was a reasonable criterion for the adequate accounting for an element of physical reality in a theory. They then proposed a necessary requirement for a complete theory of physical reality. For the reasonable criterion, Einstein et al. wrote:

> If, without in any way disturbing a system, we can predict with certainty (i.e., with probability equal to unity) the value of a physical quantity, then there exists an element of physical reality corresponding to this physical quantity. (p. 777)

For the necessary requirement for a complete theory, they wrote: "Every element of the physical reality must have a counterpart in the physical theory" (p. 777). Based upon these premises, Einstein et al. developed an argument that first attempted to demonstrate that quantum mechanics is: (1) either incomplete in its description of physical reality, or (2) that two matched quantities (e.g., the position and momentum of a particle) cannot have

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simultaneous reality. Specifically, they argued that according to quantum mechanics either the position or momentum of a particle could be predicted with certainty (but not both) and without disturbing the particle. Thus, according to their premises listed above, the conclusion of the first part of their argument was drawn. Then, in part two, granting the condition of completeness to quantum mechanics, Einstein et al. demonstrated to their satisfaction that two matched quantities can have simultaneous reality. They wrote:

> Thus the negation of (1) [just as noted above] leads to the negation of the only other alternative (2) [just as noted above]. We are thus forced to conclude that the quantum-mechanical description of physical reality given by wave functions is not complete. (p. 780)

Nils Bohr (1935), one of the chief proponents of the Copenhagen interpretation, responded to Einstein et al. by noting that their criterion for the adequate handling of an element of physical reality by a theory was ambiguous. Bohr noted that the basis of quantum mechanics is the intrinsic relationship between the experimental arrangement used to study a physical existent and this existent. Einstein et al. seemed to have proposed a criterion for an element of physical reality based on the lack of this relationship between the system studied and the experimental arrangement. According to Bohr, this proposal is impossible if one wishes to use quantum mechanical theory. Once this intrinsic relationship is accepted, quantum mechanics is complete for it provides a framework for all knowledge regarding a system that is possible within the boundaries of this relationship.

David Bohm (1951) presented a concrete formulation of the problem presented in part two of the Einstein et al. paper that emphasized the centrality to their argument of the velocity limitation imposed by special relativity that no physical influence can travel faster than the speed of light. Further, he proposed an alternative interpretation (classical in nature) that accepts the velocity limitation of special relativity to that of quantum mechanics of the experiment presented by Einstein et al. Bohm's formulations, though, did not develop differing quantitative predictions for the various alternatives. J.S. Bell (1964) provided such predictions. Mermin (1981) provided an excellent non-technical explanation of the Einstein et al. problem as interpreted first by Bohm and then by Bell.

The description in the next paragraph is a modification of Mermin's explanation. The particles in this description could be, for example, either photons or protons. In the case of photons, the relevant measurement would be of polarization. For protons, the measurement would be of spin. The description also refers to spacelike separated events. A physical event is an occurrence at a point in spacetime. Spacelike separated events are physical events separated such that the absolute value of the quotient obtained by dividing the spatial distance between the events by the temporal interval between the events is greater than the velocity of light. They are physical events which light cannot causally relate.

Consider a device with three parts. Two parts are detectors, with each detector having a switch capable of being set in one of three positions. Each detector also has a green and a red light. When set off, either the green or red light of the detector flashes. Between the two detectors, a box is placed from which two particles emerge and move in opposite directions towards the detectors when a button on the box is pushed. In the experiment, the button is repeatedly pushed, and many such pairs emerge. Further, the detectors are randomly set. The detectors are situated such that the random setting and the detection of a particle in one detector is spacelike separated from the random setting and the detection of the other particle in the other detector. As these events are spacelike separated and if the velocity limitation central to special relativity is valid, the only basis for any correlation between the flashes at the two detectors is due to properties of the particles imbued prior to their departure from the box. Given these experimental conditions and assuming the validity of the velocity limitation in special relativity, Bell developed predictions assuming these properties were indeed imbued prior to their departure from the box and found that these predictions differ from the predictions of quantum mechanics for the above experimental conditions. Thus, the theoretical framework for an experimental test of the problem posed by Einstein et al. was developed, specifically that portion concerning whether influences travel faster than the velocity of light. If such non-local influences were found, the argument of Einstein et al. regarding the completeness of quantum mechanics would be invalidated—for their argument depends on the velocity limitation of special relativity.

In an excellent paper, d'Espagnat (1979) reviewed the results of the experiments conducted and concluded that the evidence obtained supported quantum mechanics. In the experiments cited by d'Espagnat, though, the random detector settings were not spacelike separated. It was thought that though the detections were spacelike separated, the possibility existed of some influence allowed by special relativity between the detectors if the random settings of the detectors were not spacelike separated. Perhaps some influence was transmitted between the detectors which subsequently affected the detections. In 1982, Aspect, Dalibard, and Roger reported an experiment in which the random settings were spacelike separated. Their results strongly supported the quantum mechanical predictions, not the predictions developed by Bell and others assuming the relevant properties had been imbued in the particles prior to their departure from one another. In general, physicists believe quantum mechanics has been well supported by these experiments. Rohrlich (1983), for example, began his paper in *Science* entitled "Facing Quantum Mechanical Reality" with the statement: "Local hidden variables theory is dead. It received its coup de grace by two precision experiments carried out last year in Paris" (p. 1251). Local hidden variables theory refers to the classical theoretical framework allowed by special relativity.

Thus, physicists confront a dilemma in which results have been obtained that support a theory which allows for an influence with a velocity greater than that of light on physical events. The question arises as to the nature of this influence. Is it strictly a physical influence, or is it an influence that has a mental component? The latter possibility becomes distinctly plausible because any physical influence would violate special relativity. A test of the possible influence of mental activity on the measurements of physical events is theoretically possible and is a simple extrapolation of the experimental design previously discussed. In the Aspect et al. experiment, machines were used to randomly determine the setting of each detector. One reason for the use of machines is that their use made what had been a *gedankenexperiment* practical to conduct. These machines must operate extremely fast in order to overcome the obstacle to achieving spacelike separation presented by the very great velocity of light. Physicists assumed that the use of random selection by the machines would be equivalent to the free choice of the settings by human experimenters, the latter emphasized by Bohr as being at the foundation of quantum mechanical theory. It is just this assumption that is now called into question. If the results of an experiment using machines to determine the detector settings differ from the results obtained when people freely choose the detector settings, the thesis that this influence has a mental component would be supported. Specifically, as the Aspect et al. results support quantum mechanical predictions, a violation of the expected quantum mechanical pattern in the experiment using human experimenters to freely set the detectors would provide evidence for a mental component.

In fact, the Aspect et al. experiment already provides significant evidence to support such an influence. The key element in special relativity is time. It is so important that Einstein (1905/1952) devoted the first section of the body of his monumental paper on special relativity to developing a valid concept of simultaneity and time. A Newtonian frame of reference is a set of spatial coordinates for which the classical laws of motion are valid. In special relativity, the common time of clocks at different spatial locations in a Newtonian frame of reference is formulated in terms of the motion of light.

Essentially, in special relativity, simultaneity (or the common time of clocks) for a Newtonian frame of reference is defined as the time required by a ray of light to travel from a spatial point A to a spatial point B being equal to the time required for a ray of light to travel from point B to point A. It is this formulation of time, rather than the instantaneous nature of common time in Newtonian physics that leads to the conclusions of special relativity. As previously noted, spacelike separated events are partially defined in terms of the difference in their temporal coordinates, *this definition presupposing a* *common time of the clocks involved so that these temporal coordinates can be meaningfully compared.* Thus, when physicists consider spacelike separated events (events without the possibility of being related by light), they are unclear regarding the nature of time. The theoretical framework of special relativity just does not support their consideration of these events. It is proposed that when physicists discuss spacelike separated events and obtain experimental evidence to support hypotheses in which such events are thought to be involved, physicists have engaged in a mental, or theoretical, development of physical reality (including conceptions of time and simultaneity) that is confirmed by their experimental work. The only other alternative for establishing a temporal basis for the consideration of these events is for the common time to have the instantaneous nature found in Newtonian mechanics. This alternative is just what special relativity has so completely refuted.

Thus, the ambiguity in the phrase, "without in any way disturbing a system," in Einstein et al.'s criterion of physical reality reflects a point of even greater depth than that noted by Bohr. This point concerns the possibility of a mental, or theoretical, influence on physical systems. In their 1935 paper, Einstein et. al. attempted to provide support for the viability of a classical means (including special relativity) for understanding physical events in the face of the success of quantum mechanics. Instead, it appears that Einstein et al. provided the theoretical foundation for a conception of physical reality that includes a mental, or theoretical, component. The key to this foundation is found in the nature of time. The underlying structure of part two of Einstein et al.'s argument lies in the juxtaposition of the time of the special theory of relativity (that is independent of mental activity) with a time that involves a mental component. Einstein was unaware of this point for he wrote (1954), "the eternal mystery of the world is its comprehensibility" (p. 292). It appears that this mystery is on the path to being resolved.

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