CL

December 14, 1994

LBL-36559

Answers to Shimony's Queries *

Henry P. Stapp
Theoretical Physics Group
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

sw 9504

*This work was supported by the Director, Office of Energy Research, Office of High Energy and Nuclear Physics, Division of High Energy Physics of the U.S. Department of Energy under Contract DE-AC03-76SF00098.

Disclaimer

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor The Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial products process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or The Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or The Regents of the University of California and shall not be used for advertising or product endorsement purposes.

Lawrence Berkeley Laboratory is an equal opportunity employer.

Professor Shimony ended his recent review¹ of my book *Mind, Matter, and Quantum Mechanics* with eight queries that were “intended to evoke clarifications from Stapp”. His questions, followed by my answers, are:

(i) Does the reduction of the wave packet, as understood by Stapp, entail a non-linear or stochastic modification of the time-dependent Schroedinger equation? If so, what is the detailed form that he envisages? Would the modification have any implications at the microlevel, where the Schroedinger equation has been tested?

(i*) For a relativistic formulation I use the Heisenberg picture. Then the analog of the Schroedinger equation is the set of Heisenberg equations for the operators. These equations are not modified in any way: jumps change only the state, not the operators. There is a sequence of random jumps, and the n th jump projects the state Ψ_n prior to this jump to $\Psi_{n+1} = P_n \Psi_n$, where P_n is a projection operator built from Heisenberg operators associated with a macroscopic spacetime region R_n , such as Tom’s brain now. Where classical ideas would lead to several top-level attractors in the brain, quantum dynamics will necessarily lead to a superposition of the quantum analogs of these attractors. My hypothesis is that each quantum jump projects onto a subspace that can be characterized as the quantum analog of one of these top-level attractors. Micro-processes are largely unaffected by these jumps, because the projection operators are specified in terms of the collective variables that characterize the top-level process: each jump merely selects a macroscopically characterized branch, leaving its micro-structure largely intact.

(ii) Is a Schroedinger cat physically possible at the level of a biologically important macromolecule—e.g., the superposition of two configuration states of an inhibitor protein which corresponds to switching “on” and “off”? If so, would the superposition be disruptive of the biological functioning of the cell unless it were rapidly reduced? And if reduction occurs, what experimental and theoretical estimates can be given of the speed of reduction? A similar question can be posed concerning the firing or nonfiring of a neuron.

(ii*) Micro-processing is virtually unaffected, for the reasons just stated. Even without any collapses at the molecular level a superposition of two states of an inhibitor protein causes no problem because these states correspond to different branches of the wave function that, for all practical purposes, will not interfere

with each other, because they are correlated to very different states of their immediate environment.

(iii) Aside from the desideratum of mirroring the unity of consciousness by a holistic brain state, what physical evidence is there for such a brain state? After all, there are many good scenarios of chemical cybernetics of the cell (see Jacques Monod, *Chance and Necessity*) which use quantum mechanical holism only for explaining the steric properties of individual protein, RNA, and DNA molecules, but dispense with holism above the molecular level. Might not the integration of the brain also rest partly upon quantum mechanical holism and partly upon cybernetically correlated product states of neurons?

(iii*) Following the dictum 'Desist from needless proliferation of entities', I introduce only those violations of the Schroedinger equations (jumps) that are needed to explain the structure of human experience: middle-level collapses are excluded because they either yield no empirical consequences that go beyond the purely quantum-theoretical predictions or produce violations of those predictions. Scientific theories should be parsimonious: I do not adhere to the philosophy that asserts that if a low-level event cannot be empirically proved to be absent then it must be assumed to be present.

(iv) Is it necessarily the case that the actualization of a distinct metastable configuration of a macroscopic system entails an entangled state? According to N.F. Mott's famous analysis, each cloud chamber track is a product state of ionized and unionized molecules, and there would be an entangled state of the contents of the chamber only if no wave packet reduction occurred, leaving a superposition of very many different track configurations.

(iv*) It is entanglement *before* the collapse that leads to the need for nonlocality. This necessary occurrence of nonlocal influences in any (non-Everett-type) ontological theory makes the introduction of ontological quantum jumps—which automatically induce nonlocal influences—a reasonable possibility. Each such jump actualizes as a unit the values selected by a nonlocal projection operator P_n : it actualizes together values pertaining fields at spacelike separated points, in spite of the fact that these values are logically independent quantities within the general framework of quantum field theory.

(v) Isn't the two-aspect theory of the mind-brain relation a postulate over and above the quantum mechanical description of the brain, rather than a deriva-

tion from this description? After all, the usual treatment of a holistic state of a many-body system consists only in the establishment of correlations among the observables of the individual bodies composing the system, and there is nothing mental about correlations among ordinary physical observables unless further structure is postulated.

(v*) The dual character of reality is an intrinsic characteristic of nature within the quantum framework, as interpreted ontologically according to Heisenberg: there is the quantum-propensity field, and there are the actual events that these propensities are propensities *for*. The dual character of mind/brain is also a given: there are the inner thoughts and feelings felt by the individual mind/brain itself; and there are the outer aspects that are parts of a shared world. These two dualities are similar: both the quantum propensities and the outer aspects of the mind/brain can be represented as deterministically evolving structures in spacetime (i.e., by the matter-like characteristic of nature); and both the quantum jumps and the inner aspects of mind/brain implement decisions between alternative possibilities. In view of the similarity of these two dualities I *hypothesize* a concordant ontology. Since all matter-like properties can be parimoniously represented by quantum propensities, what is left besides mind for these propensities to refer to?. And should not mind have such a logically necessary place in the basic dynamical process?

(vi) If the two-aspect postulate is made (to which I am not averse), should it not be done in a general way, so as to apply also to nervous systems much less complex than those of human beings, or even to systems commonly considered to be inorganic? Were the postulate assumed only for organisms endowed with high level consciousness, there would be a danger of anthropocentrism, or at least of a natural philosophy tailored to the character of later arrivals in the evolution of the biosphere. Generalizing the dual-aspect postulate would lead to a position like that of A.N. Whitehead's *Process and Reality* and *Adventures of Ideas* (Part III). Stapp acknowledges an affinity to Whitehead's doctrine of creative acts (p. 79), but he does not highlight Whitehead's idea that a kind of mentality is the ultimate stuff of all actual entities, including those at the level of elementary particles. How far does Stapp agree with Whitehead's pan-mentalism, and if there is a cut-off in agreement, where is it and what is its rationale?

(vi*) To hypothesize collapses other than the ones I postulate is to bring unnecessary elements into the theory: other jumps have, at present, no empirical support or basis. They can be brought in later, if they are needed to fit some empirical data. But first we should develop a theory that adequately explains human thoughts, without introducing superfluous entities that have no apparent affect on the form or content of human experience². This postulated form of the theory is the one best suited to the present empirical state of science: it is not something written in stone. Its great virtue is that the quantum events, which are otherwise virtually outside the reach of empirical science, become the very basis of the connection of the theory to empirical phenomena: they become the counterparts within the theory of precisely the human experiences that it is the job of human science to explain. Although my ideas do have an affinity to Whitehead's (see ³), I take all jumps to be consciousness-related brain events because this postulate coverts a flabby theoretical structure into a framework that can be the basis of a coherent and tight-knit science in which human thoughts have a rational place.

(vii) If Stapp does endorse Whitehead's pan-mentalism for the purpose of explaining the evolutionary continuity from primitive physical entities to high level organisms, how does he propose to solve certain problems that confront Whitehead: What evidence is there for protomentality other than its utility for the Great Chain of Being? And what is the meaning of terms like "feeling" when applied to entities utterly remote from human mentality?

(vii*) I do not follow Whitehead's pan-mentalism precisely because there is no empirical evidence for it: it lies outside science.

(viii) How is the choice—as contrasted with mere chance outcome—among the terms in a superposition of brain states to be explained in terms of "enduring complex macroscopic form," if every term in the superposition already satisfies this description? I continue to be baffled by the apparent phenomenon of free will, which seems to be intermediate between deterministic behavior and sheer stochasticity.

(viii*) I stay with contemporary quantum theory and accept, at least tentatively, the randomness of the quantum choice. Some empirical evidence indicating a failure of this assumption is needed if we are to go beyond this position, yet remain within science. Of course, the 'physical person', represented by his

evolving brain-body, greatly influences the flow of his thoughts by influencing, though his deterministically evolving wave function, the propensities for the various possibilities. But quantum theory entails that something else also enters: the non-mechanical and nonlocally implemented choices between these quantum mechanically generated weighted possibilities .

References

1. Abner Shimony, Amer. Journ. Phys. **62**,956 (1994)
2. Henry P. Stapp, *The Integration of Mind Into Physics* in Fundamental Problems in Quantum Theory, Annals of the New York Academy of Sciences (1995)
3. Henry P. Stapp, Nouvo Cimento **29**, 270 (1975); Found.Phys. **9**, 1 (1979); *Einstein Time and Process Time*, in Physics and the Ultimate Significance of Time, SUNY Press (1985)