6. The Jibu-Yasue Approach.

The preceding sections are both very conservative and very general. They are very conservative because: (1), they adhere to the underlying philosophical idea of orthodox quantum theory, which is that science, like every human endeavor, is built on the fact thathuman beings make choices about how they will act, and then experience responses to their actions; and (2), they exploit those equations of quantum theory that *inject the effects of this interaction with human agents* into the mathematical structure. The effect of the choice is represented by von Neumann's Process **1**, and the effect of the feedback is represented by Process **3**.

The *generality* of the earlier sections stems from the fact nothing has been said about the nature of the brain states specified by the P(e). These operators define the neural correlates of conscious experiences. But it has not been specified whether these operators P(e) act on the variables that describe the possible motions of particles in the brain, or, alternatively, on the electromagnetic fields in the brain. Do the P(e) act in the coordinate domain or the frequency domain, or in some other domain? These question are not answered by von Neumann's general framework: they constitute key problems for future work. On the other hand, the general theory does provide a methodological handle on these questions by allowing the physical consequences of a choice about how to act to be separated, theoretically, from the issue of what causes the choice to be what it is.

There is a related question of how memories are stored. Karl Pribram has suggested (Pribram 1966, 1991) that consciousness operates on principles similar to that of a hologram, in which tiny variations of a myriad of physical variables, dispersed over a large region, combine to modulate a carrier wave. These physical variables might be the strengths of the synaptic junctions. Pribram identifies the dendritic network (a dense set of neural fibers) as the likely substrate of such a brain process.

This holographic model would seem to be implementable within quantum electrodynamics, which is the naturally appropriate physical theory for brain dynamics. However, Umezawa and co-workers

(Riccardi, 1967: Stuart 1978, 1979) suggested that perhaps an exotic physical process is involved, namely one similar to the one that appears in the theory of superconductively. That theory is characterized by the existence of a continuum of states of the same (lowest) energy, and Umezawa suggested that long-term memory is connected to breaking the symmetry of these ground (hence stable) states instead of, for example, enduring changes in the physical structures of nerve cells.

Jibu and Yasue (Jibu 1995) have attempted to weave these ideas of Pribram and Umezawa into a unified quantum theory of brain dynamics (QBD). Their theory takes the substrate associated with Umezawa's ideas to be the water that pervades the brain. Excitations of certain states of the water system are called corticons, and they interact with photons in the electromagnetic fields of, for example, the dendritic network. They say:

"With the help of quantum field theory, we have found that the creation and annihilation dynamics of corticons and photons in the QBD system in the sub-microscopic world of the brain to be the entity we call consciousness or mind."

It is not clear why "the creation and annihilation dynamics of corticon and photons" should enjoy or entail the defining characteristic of conscious process, namely a way that it "feels," nor what feature of this physically described process *can actually be* a conscious feeling, nor how *particular definite thoughts* emerge from this essentially quantum process, with its rampant inherent quantum uncertainties. The structure described by QBD must apparently be placed within the general von Neumann framework in order to be adequately tied to human experience. Whether we actually need the immense theoretical richness of QBD, as contrasted to normal QED (quantum electrodynamics), in order to accommodate the empirical data of psychology and neuroscience, remains to be seen. The projection operators P(e) can introduce the pertinent nonlocal structure. Surplus degrees of freedom will bring ambiguities into the structure. Hence the more restrictive QED – which is both well defined and massively validated – would appear to be the most promising initial candidate.

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