CORRELATION "WAVES" IN BRAIN-LIKE STRUCTURES

R. Bernhard*
Grumman Aircraft Engineering Corporation,
Bethpage, New York

A correspondence is established between a tangible model of brain structure (and function) and a system of observer-observed interactions. The observed quantities are "stimuli" in the form of signal amplitude distributions in a mass of neuron-like units; the observer is a set of neurons (not circumscribed in a local region) in which a distributed parameter mirrors the stimulus history of the set, i.e., represents a "memory". Utilizing the theory of the Perceptron, a contemporary brain model, it is demonstrated that large systems composed of many observer-observed interactions exhibit quantum mechanical behavior on a "macroscopic" scale. This behavior entails wave-like phenomena and the need of applying the superposition mechanics to system information content calculations.

1. Introduction. Rosenblatt (1962) has discussed in some detail the history of significant approaches to the "brain model" problem, categorizing them either as "analytic", "logical", or "statistical" in their fundamental methodology. It is not our intention to dwell more than momentarily on these distinctions; this should be sufficient time to point to the nature of the neural cell assembly, or "brain-like structure", which is the subject of the subsequent discussions. Crudely speaking, the statistical type of model may be said to depart most significantly from the logical or analytic model in the sense that the properties of the latter may be derived from deterministic mathematicophysical reasoning, whereas the character of the former follows from probabilistic analyses, perhaps

* Present Address: Department of Molecular Biology, Albert Einstein College of Medicine, Bronx, New York.
more typically encountered in particle physics. Rosenblath (1959) has pointed to the possibility that the mathematics of the neural assembly may be required to resemble more the mathematics of large populations, involving statistically distributed parameters rather than the logical characterizations (Boolean algebra, etc.) of completely describable systems such as the digital computer (or other deterministic machine). There is, indeed, a quite widespread manifestation of similar feelings in the literature of neurophysiology and cybernetics, e.g., Fessard (1962), Farley and Clark (1954), Rochester (1956), Beurle (1962), Lashley (1929), Rapaport (1950), Shimbel (1950), Uttley (1958), Rosenblatt (1962), etc. These authors employ concepts of neural network structure and function-utilizing statistical methods to describe the connectivity patterns, threshold distributions, and relations between the network's "responses" to "stimulations". While Gerard (1960) and Minsky (1962), among others, have noted that a randomly associated population of neurons is a weak postulate, such models seem to be rather imperative, since the opposite properties—more precisely organized networks with their necessary synchronization requirements—appear unlike conditions usually observed in the nervous system.

Of course probabilistic models describing physical systems are not unusual in classical physics, particularly in statistical thermodynamics, kinetic theory, etc. In these instances the statistical approach follows either from insufficient data concerning the state of a system consisting of a large number of particles (lacking information about the condition of every particle in the system), from the mathematical intractibility of descriptions containing large numbers of variables related nonlinearly, or simply from the inconvenience of a very large number of variables, "the curse of dimensionality" (Bellman, 1961). In these systems, however, there is no difficulty, in principle, of attaining a complete, deterministic picture of the system's conditions at any time. On the other hand, as is well-known, the statistical model of quantum physical systems does not entertain, in principle, the possibility of complete description; this is because the quantum theoretical formulation contains the relationship between the "observer" and the "observed", whereas classical physics demonstrates no appreciation of this relationship and its dramatic consequences. Indeed, the interaction of the "observed" with an "observer" (the fundamental, irreducible nature of all measurement) has been shown to be the origin of the wave-like phenomena and superposition laws associated with quantum systems (Landé, 1955, 1956, 1957).

In the light of the foregoing remarks, the contemporary statistical models of neural assemblies or networks contain the viewpoint of classical statistical physics insofar as these models regard the network as remote from the level and laws of quantum mechanical ensembles (except perhaps at a level below that of