Science and Inner Experience

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In the fall of 1964, a group of eminent neuroscientists met under most unusual auspices to consider the material basis of mental activity. The meeting—the proceedings of which have now been published in **Brain and Conscious Experience**, edited by John C. Eccles (Springer-Verlag, New York, 1966. 613 pp. $16.80)—was held at the Vatican as a Study Week of the Pontifical Academy of Sciences. Planning for the conference began under the pontificate of the late Pope John as part of his program for *aggiornamento*, or up-dating of the Catholic Church. One of the purposes of such updating, it may be surmised, is ecumenism in the broadest sense: the Church's aim of bringing about an understanding not only with other faiths but also with science, as a step toward realizing its mission of universal stewardship.

The time may have seemed ripe for a rapprochement with science, since mutual distrust and disrespect have subsided. In the modern era, the Catholic Church has not shared in the fundamentalist antagonism to science (for example, it remained neutral in the controversy over biological evolution). It also discerns a more receptive attitude to moral considerations among scientists in their horror over the military and political uses which have been and may be made of their discoveries. The waning influence of behaviorism and logical positivism in psychology and related fields likewise contributes to the propitious climate. A revival of interest among some scientists in mentalistic concepts—awareness, attention, thinking, feeling, decision-making, voluntary action—brings science and religion much closer together in their fundamental view of the nature of man. As H.-L. Teuber notes in the concluding chapter, 10 or 15 years ago neuroscientists would probably not have considered consciousness a fit topic for scientific discussion; yet the very fact that the conference was held indicates that they are now willing to admit it to their lexicon, to make hypotheses about its material basis, and to bring empirical evidence to bear upon it.

The term "consciousness" as used by the participants in this symposium is of course not identical with the moral conscience of theologians, as Pope Paul emphasizes in his address, although he believes it to be closely related. Indeed, the participants were warned not to extrapolate the meaning of "consciousness" into the extrascientific domain, but to use it strictly to designate "the psychophysiological concept of perceptual capacity, of awareness of perception, and the ability to act and react accordingly," a proscription of which Eccles, the organizer, was unaware prior to the meeting. Eccles does mention in the preface, however, that he was not able to invite any professional philosophers because he was instructed that "the discussion of philosophical questions is excluded." One can guess that the central philosophical question thus meant to be avoided concerns the problem of individual responsibility: free will versus determinism and predictability of behavior. The one is no less the keystone of religion than the other is the keystone of scientific psychology. Apparently, to further the cause of reconciliation, the Church sought to discourage any controversy over these concepts at the conference and to restrict the scientists to what it regards as their proper domain. This staking out of territorial claims suggests that the Church subscribes to the adage "Good fences make good neighbors," with the reservation that it clearly wishes its own all-embracing world view to be seen as subsuming that of science.

If the foregoing indicates what the Church expected of the conference, how did the participants interpret their task of searching for new insights into the neural basis of conscious experience, as they were asked to do by Eccles? The papers presented can be divided into three main groups: first, those which did not deal directly with consciousness at all, but discussed the minute anatomy and physiology of the higher nervous system; second, those which conformed rather closely to the Church's wish that they should report empirical relations between neural and conscious activities; and third, those which went beyond this limit to theorize about the cerebral basis of consciousness and freedom of choice, some of them providing ways in which the scientific and the religious philosophies might be reconciled.

I have included eight papers in the first group. M. L. Colonnier and P. O. Andersen describe the cellular structure of the neocortex and the archicortex, respectively, each placing strong emphasis on structural-functional relationships. Cerebral synaptic mechanisms are discussed by Eccles from the point of view of neurophysiology, and by C. Heymans and A. de Schaepdryver from that of neurochemistry. Three papers are concerned with neurophysiological analyses of sensory systems: V. B. Mountcastle dealing with first-order mechanoreceptive fibers; O. Creutzfeldt *et al.*, with information transforms at different levels of the visual system; and R. Granit, with the relation of anatomical characteristics of afferent systems to their efficiency as analyzers. The remaining paper in this group is an admirable review by C. G. Phillips of what is known about the corticofugal system of the precentral motor area.

Mechanisms of Consciousness

The first group of papers thus sets the stage for a more specific consideration of data and hypotheses concerning the neural correlates of a variety of conscious experiences. One of the themes running through the contributions I have placed in the second group is the role of the nonspecific systems of the brain stem and diencephalon in processes indispensable to consciousness. B. Libet discusses the long latency of a reportable sensation, a result taken to reflect the importance of the late components of the evoked potential, now known to be sensitive to influences from the nonspecific midline structures. The contributions of W. Penfield and of H. H. Jasper emphasize the special importance of the "centrencephalic

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system," which unites the diencephalon with the forebrain hemispheres above and the mesencephalon below. In their view, perceptual awareness depends crucially on elaboration of the sensory influx in the circuits of this integrated system, Jasper further suggesting that its synapses are anatomically and chemically distinct from those mediating specific sensory input. F. Bremer, discussing mental unity, implicates essentially the same system as one of several mechanisms promoting interhemispheric liaison. R. W. Sperry likewise expresses the view that midline brain-stem structures provide a unifying influence when forebrain commissures are sectioned. He describes two cases of brain bisection where special tests showed striking defects in interhemispheric communication, yet the patients in ordinary life apparently perceived the world as one and acted with normal bilateral synergy.

The nonspecific systems are known to be crucial in sleep regulation, and G. Moruzzi suggests that sleep involves the synchronization by these systems of slow recuperative processes required by the cells and synapses concerned with conscious activities. Since the nonspecific systems are phylogenetically old, their role in consciousness suggests that at least the rudiments of awareness should exist in subhuman forms. Such an assumption is supported by the observations of ethologists, presented by Thorpe, on animal behaviors suggestive of abstraction, expectancy, and the like. Such capacities must depend largely on learning and memory, and Moruzzi's notion that the responsible cells and synapses require prolonged recuperative periods suggests only one of their possible distinguishing characteristics. In contrasting neural mechanisms at cerebral and spinal levels, Eccles suggests several other features of possible significance.

Teuber deals not only with perceptual-cognitive processes but also with voluntary movement. His suggestion that the frontal lobes compensate for self-produced movement by a motor-to-sensory "corollary discharge" may account for the stability of spatial perception. In suggesting that a "corollary discharge" is the hallmark of *voluntary* movement, Teuber takes a first step toward consideration of the will. The paper of Eccles, referred to above, also contains a hypothesis about the cerebral basis of consciousness which is relevant to freedom of action; since the awake brain is in a state of intense activity, a large proportion of neurons must be passing through levels of excitation at which discharge of an impulse would be problematical; consciousness, perceiving, and willing are possible only when there are a sufficient number of such "critically poised" neurons.

The Experience of Free Will

Eccles's conception clearly includes an element of indeterminacy in brain activity. Since the advent of the uncertainty principle in physics, such an element is not uncommon in attempts to reconcile the scientific point of view with our inner conviction that we are free causal agents. Among the papers of the third group, which I have characterized as being philosophically oriented, the contribution of A. O. Gomes is an illustration of a theory along these lines. He supposes that in living organisms behavior is governed by a number of controls, some of which are microphysically indeterminate. He shows that a machine could be designed in which the output, though indeterminate also, could exhibit a high degree of order by being filtered according to a set of rules, which can be as complex as one wishes. In the nervous system, he says, the interaction of innate and fortuitously acquired patterns provides an even ampler random variation than that resulting from microphysical uncertainty. Yet "order-from-disorder" can be created by experience, which sets up the rules for filtering the output. A theory of mind and action must therefore be derived from sciences dealing with experience. The importance of studies dealing with the development of intelligent behavior—in particular, the differentiation of the self from the external world—is also stressed by Adrian as one means of bridging the gap between mind and body which exists in current behavioral science. From the point of view of psychosomatic disease, H. Schaefer likewise looks to experience, especially of an emotional kind, as the initiator of a chain of bodily events. Espousing a theory of psychophysical parallelism, he finds the apparent mental-physical linkage not at all mysterious, since emotions are somatic as well as psychic phenomena.

The contribution of D. M. MacKay, which to me is the pièce de résistance of the whole collection, remains to be considered. MacKay rejects indeterminacy as providing a reasonable basis for the experience of making a noncapricious decision, and he likewise rejects the notion that the freedom we feel in choosing between alternatives is illusory. He presents an information flow model of an organizing system to account for goal-directed activity in the external field of action, and on this superimposes a similar system for control of the internal field, that is, the elements and structures of the organizing system itself. This "metaorganizing system" takes its data from the whole internal field, including its own activities, and it is this part of the model that MacKay considers to be the correlate of conscious experience. Some interesting consequences of this treatment follow: since it is assumed that what the agent believes is rigorously reflected in the state of his brain, *he* is not correct to believe any prediction about his choice—even though this prediction might be correct for an observer with complete data—because the belief itself would alter the grounds on which the prediction was made. It is only when the belief would *not* alter such grounds (for example, in uninhibitable seizures) that the agent could validly believe a prediction of his actions, and it is only when this condition is fulfilled that we should absolve him of responsibility for what he does. MacKay's formal model, therefore, achieves the feat of retaining free will for the agent and providing a criterion for individual responsibility within a completely deterministic system. The sponsors of the conference must have been pleased by this generous gift.

Gains and Hurdles

I have not attempted to comment on the scientific merit of the separate papers in this volume, not only because of space limitations, but especially because it seemed more appropriate to attempt an assessment of the conference as a whole in terms of its purpose. Many of the papers are scientifically excellent and would reflect credit on any journal in which they might appear. The extensive group discussions (which are published in full) are valuable, expressing as they do the opinions of some of the most productive thinkers of our time on the problem of subjective experience. Undoubtedly, the stated theme of the conference prompted them to speculate more freely than they ordinarily would. In evaluating the success of such an undertaking, then, it may be best to suspend the critical attitude and to consider the conference

a venture in "brainstorming." It amply illustrated the obstacles to a scientific treatment of consciousness, and its most important results were suggestions and hypotheses rather than solutions. In the present "state of the art," however, the fulfillment of a heuristic function is the very best outcome that could be expected.

Having read the book, I look at the problem of conscious experience in ways that are new and interesting to me. Although the following statements are not to be construed as representing the consensus of the conference (since the members reached no explicit consensus), they may illustrate the thought-provoking character of the volume. For example, it now seems to me (i) that conscious processes are slow and likely to be mediated in part by small cells and fibers; (ii) that such processes are probably not more complex than unconscious functional systems and may well be less complex; (iii) that consciousness must be a kind of supersystem, one that "knows that it knows," to use MacKay's phrase; (iv) that the function of consciousness is likely to be in acquiring new nervous connections, that is, in speeding up and enlarging the scope of learning. A list of the same kind constructed by another reader would surely differ in its particulars, but I think it likely that he would find the new notions he came away with provocative, even though they may lack a solid foundation.

One must keep in mind the difficulties the conference faced. There is no general agreement on what "consciousness" means, what it entails, what behaviors it is essential for, whether or not it has biological survival value, whether it is one or many different processes, and so forth. Inner experiences traditionally fall within the domain of psychology, yet in this century psychology has been trying to divorce itself from its historical underpinnings and to become a science like physics. It has therefore been proceeding rapidly away from introspection, taking its data solely from observable behavior and eschewing mentalistic constructs as meaningless and valueless. Yet, perhaps because of increased self-confidence, there is a growing body of opinion, even within experimental psychology, that there should be no territory immune to scientific investigation, not even the private data of the mind. The distinction between public and private fades when we consider the abundant evidence from both verbal and nonverbal communication that no inner experience of an individual is unique. If experimental psychology is to enter this hitherto tabooed realm, however, it will probably have to be helped over the threshold by philosophy and physiology. Philosophy can help by clearly explicating the kind of logic that applies to investigations of ourselves. And physiology can help, through the tremendous prestige it enjoys among psychologists, by actively searching for neural correlates of conscious processes; if such correlates are found, psychology will be encouraged to recover its lost subject matter. The conference broke new ground along both these lines.

Women's Place in the Russian Work Force

It has long been axiomatic in the study of labor force trends that the proportion of women among the gainfully employed declines in the course of industrialization. The uniqueness of the Soviet case lies in the fact that, contrary to the experience of previously industralized countries, the participation of women continues at a high rate—indeed, higher in 1959 than in 1939—despite the declining importance of the agricultural sector as a source of employment. Norton T. Dodge's study of this phenomenon, **Women in the Soviet Economy: Their Role in Economic, Scientific, and Technical Development** (Johns Hopkins Press, Baltimore, 1966. 351 pp. $10), was underwritten by the Office of Economic and Manpower Studies of the National Science Foundation and in addition was "prepared under the supervision of the Department of Economics, University of Maryland." It therefore probably documents the situation in greater detail than would otherwise have been possible.

Consistent, however, with the "hard line" currently being pursued in the "manpower field," the book virtually denies that the uniqueness of the Russian experience has anything to do with the social structure of the Soviet Union, except insofar as Marxist ideology has been useful in persuading Russian women to undergo the necessary training and to remain in the labor force throughout the critical child-bearing years. Rather, it is Dodge's essential thesis that the sustained high rate of female participation in the labor force is largely a function of the shortage of males in the population that has resulted from some 40 years of civil strife, famine, political purges, and world wars.

Among semiprofessionals and professionals, of whom half were women in 1959, the effect of this demographic imbalance was compounded, according to Dodge, by the fact that during the war years only women were available for most specialized secondary and higher education. But since the majority of these women—about 60 percent in 1959—were medical personnel, teachers, librarians, and the like, there will undoubtedly be those who will attribute at least some significance to the classic combination of relatively high social status and low wages prevailing in these occupations until recently. By the same token, the recent decline in this proportion may well be attributed to increasing salaries in some of these occupations, a hypothesis Dodge does not even entertain.

Instead, he contends that the recent and impending decline in the proportion of professional and semiprofessional women in the Soviet labor force is a reflection of the increase in the number of men available and of a tacit recognition on the part of Soviet planners that women are, in the last analysis, less productive than men in view of an inherent conflict between the obligations of "family and work." Yet the fact remains that this second conclusion is *ad hoc* and largely after the fact. Moreover, most of the evidence adduced in support of it—the underrepresentation of Russian women in administrative positions, their failure to achieve eminence on an appreciable scale, and their lack of creativity—consists of sociological and psychological considerations which as such are not indices of productivity in the rigorous economic sense in which Dodge clearly intends that the term be understood.

In addition, Dodge's conviction that Soviet planners are now proceeding on the assumption that women have been shown to be less productive than men is an inference from the outcome of their planning rather than from any knowledge of their intentions. To be sure, the Soviet economy is a planned economy, and the supply of labor is no less subject to planning than is any