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Br. J. Psychol. (1967), **58**, 3 *and* 4, *pp.* 222–333
Printed in Great Britain

BRAIN AND CONSCIOUS EXPERIENCE: A CRITICAL NOTICE FROM THE U.S.S.R. OF THE SYMPOSIUM EDITED BY J. C. ECCLES (1966)*

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In recent years there has been an upsurge of interest in the problem of the relation of consciousness to the brain and to underlying brain mechanisms. At least four large international symposia have been devoted to this problem since 1953 (Adrian, Bremer & Jasper, 1954; Jasper *et al.* 1958; Wolstenholme & O'Connor, 1960; Moruzzi, Fessard & Jasper, 1960).† This paper is dedicated to the fifth and latest in the series (Eccles, 1966).

There are many reasons for such an interest in this problem. It is partly due to recent developments in brain morphology connected with the discovery of the non-specific reticular formation of the brain and to the rapid development of physiological research at the neuronal level. It is also due to recent successes in neurosurgery which have made it possible to conduct experiments in which the human cerebral cortex is stimulated while the subject is at the same time being questioned. There is again the recent development in the study of memory and its analysis at the molecular level. Finally, there are the recent achievements in psychopharmacology which have made it possible to follow the changes in consciousness brought about by different centrally acting drugs. But perhaps the basic reason for such a lively interest in the relation of the brain to conscious activity is the effort in natural science to do away with the 'isolation' of the mental and the attempt to try to understand the material basis of conscious activity.

The symposium on *Brain and Conscious Experience* occupies a special place in the efforts to discuss this problem. It is distinguished by two characteristics. First, perhaps no other symposium dedicated to the problem of the relation of brain to mind has brought together such a large number of outstanding participants, including such scholars as Adrian, Bremer, Eccles, Granit, Jasper, Mackay, Moruzzi, Mountcastle, Phillips, Penfield, Sperry, Teuber, and Thorpe. These scholars represent the fields of neurophysiology, morphology, psychology, ethology, information theory and cybernetics. This character of the symposium facilitated a broad and many-sided discussion of the problems.

A second characteristic of the symposium was the fact that it was called by the Vatican Academy of Sciences and took place in one of the Vatican palaces. Pope Paul VI addressed the participants, pointing out the significance which the Roman Catholic Church attaches to scientific research on the brain and its relation to consciousness.

The symposium was preceded by a correspondence between its organizer, Sir John

* *Brain and Conscious Experience.* Edited by J. C. Eccles. Berlin, Heidelberg and New York: Springer Verlag. 1966. Pp. xxi + 591. $00.00.

† A symposium on the problems of consciousness was also held in Moscow in the spring of 1966.

Eccles, and the President of the Vatican Academy of Sciences. In this correspondence the President of the Academy asked that a purely scientific character be attached to the symposium and that discussion of philosophical questions be excluded. In reply Eccles declared that in his opinion all science has a philosophical basis, that 'there is a philosophy of science which is in fact basic to all scientific investigations' and that 'it is not possible to exclude relations with philosophy' (p. viii).* The outcome was that philosophers were not invited to participate, but that philosophical questions nevertheless continued in fact to be very important.

Basic philosophical positions

Almost every participant in the symposium began with a theoretical definition of consciousness and the characteristics of his attitude to the philosophical problem of its relation to the brain. Hence it is of serious interest to analyse the basic philosophical positions of these representatives of modern science.

A careful study of the material from the symposium clearly shows the position which has developed in the natural sciences in modern capitalistic countries. The real achievements of modern science and those scientific findings which objectively are essentially materialistic differ sharply from the philosophical positions of the researchers themselves. Although their factual work is armed with the most up-to-date of techniques and is conducted on the highest and most modern level, their initial philosophical positions remain behind the factual work and display the typically theoretical helplessness of idealistic philosophy. This is why, in accordance with Wundt's 'principle of the heterogony of ends', the factual achievements of these scholars go far beyond the boundaries of their formulated aims and enrich science in spite of the fact that the philosophical problems they set before themselves lead them nowhere.

The philosophical positions of a significant number of the participants in the symposium (Adrian, Eccles, Granit, Penfield and others) are not distinguished by anything novel or original. They define consciousness as a primary, directly given reality and consider the objective world as being a secondary reality produced from consciousness. Basing themselves on this dualistic principle (in which they repeat the position of the classical physiologist, Charles Sherrington), they set themselves the basic task of precisely defining the relation of consciousness to brain, of finding those brain mechanisms in which 'consciousness enters the brain' or in which brain units begin 'to generate consciousness.'

Several of the leading participants in the symposium (for example, Eccles), basing themselves on the principle that 'the primary reality is our consciousness—everything else is a derivative and has a second-order reality (p. 327)—took the position of 'methodology solpsism' (p. 315). Others (for example, Granit), 'belong to the people who were brought up in the Machian philosophy' (p. 255). Many cited Sherrington, Addington and such modern representatives of idealistic philosophy as Beloff (1962), Kneale (1962) and Wiegner,* in whose statements they see the basis for the indisputable admission of dualistic philosophy and refer to the idea that 'we

* The page references throughout are to *Brain and Conscious Experience*, the work under review.

* E. Wiegner, 'Two kinds of reality', unpublished lecture, 1964.

must retain the Platonic notion of mental events which are distinct from anything in the physical world' (p. 472).

It is quite natural that such positions led many of the participants to consider as fundamental the question posed by Sherrington, namely in which formations of the brain does the 'physical give rise to the mental' and in what way does active volition which can result in our hands shading our eyes from the sun produce the influence of the mental on the physical? (See for example, pp. xv, 315, 446–7).

One can only be thankful that the factual work of these participants goes well beyond the limits of these questions. Being guided by the logic of objective scientific research, they have enriched science with many facts of outstanding scientific value. There were also participants, MacKay, Moruzzi, Teuber and others, who were distinguished from the others by theoretical positions which have nothing in common with the above conceptions of subjective idealism.

Two scientific positions

In spite of the fact that the definitions of consciousness given by the participants were varied, not one of them understood consciousness as the reflection of objective reality, as 'conscious being' or as complex activity which has a semantic and systemic structure. In what way then do these investigators approach the analysis of the material substrate or brain mechanisms of consciousness? In their approach to this basic question the participants were clearly divided into two groups.

Some of the participants consider that one should look for the material basis of consciousness *inside the brain* and that careful search will lead to the discovery of formations in the neural structure of the brain which give rise to consciousness. Among these is Penfield who, on the basis of observations made at the operating table when he has stimulated the human cortex electrically, has come to the conclusion that, in addition to the sensory and motor zones of the cortex, there exists a region which when stimulated calls forth experiences and thoughts. This area, limited to the temporal zone, he considers to be the 'interpretative' cortex which in its earlier stages of development was neutral (see 'The uncommitted cortex', pp. 217–36). There are also those neurophysiologists like Eccles who do not consider it possible to be limited to a crude macroscopic level in the search for the mechanisms of consciousness. They believe that these mechanisms can only be found on the neuronal and synaptic level. Following this idea, Eccles returned to the notion he expressed earlier (cf. Eccles, 1952): that the elementary forms of the phenomenon of consciousness ought to be sought by the methods of quantum physics, by seeking out the smallest synaptic units at a level where the Heisenberg–Eddington 'uncertainty principle' can be replaced by a principle of harmonic organization; he again repeated the idea that the basis is the synaptic unit, the mass of which is expressed by the figure 10^{-16}g (p. 467). Such explorations of the nervous basis of a non-qualitative consciousness are far removed from the study of the mechanisms of consciousness understood as the complex meaningful reflexion of reality.

Among the researchers who were trying to solve the problem of the material basis of consciousness in the above way were neurophysiologists working on the neuronal and molecular level. However, the representtives of the schools of information theory and cybernetics had a completely different position on the question of the

mechanisms of consciousness. MacKay claimed with justice that it was unlikely that the problem of consciousness could be solved by the study of isolated neurons. In this he received support from researchers who claim that neurons in any part of the nervous system have an identical structure (see Eccles, p. 50) and that, consequently, it is not possible to obtain facts which will lead to the mechanisms of consciousness from the study of separate neurons.

Consciousness according to MacKay is a form of organization of a whole system concerned with the processing of information, and its mechanisms should be sought in the properties of organizations of this system. Regarding the transfer of information as something 'psychophysically neutral', and repeating in this a well-known contention of idealistic philosophy, he sees in the study of the structure of the system which transmits information 'the bridge which connects the data of physiology with conscious experience'. On this basis he considers it possible to explain not only the phenomenon of consciousness but also 'free will' without disturbing the principles of the structure of physical systems (pp. 427–9, 433–5). The position of the biophysicist, Gomes, was similar; from an analogous position he attempted to approach a solution to the problem of how one should understand the possibility of transforming the uncertainty which reigns at the quantum level into the certainty characteristic of conscious activity (pp. 449–59).

Although the approach of the first group of researchers leads far away from the analysis of those large and complex structures permitting complex forms of reflexion of reality, it still retains the possibility of concrete physiological research. The approach used by the representatives of the second group of scholars, while retaining whole complex systems as a subject of analysis, radically departs from any concrete research and replaces the analysis of real physiological mechanisms by the 'black box' principle of description. There are obvious dangers connected with this approach in which scientific research is replaced by logical systems.

Thus two scientific positions were presented at the symposium; they are characteristic of modern science and potentially they contain the rudiments of a serious crisis in the future.

New tendencies in research on brain systems

Discussions of fundamental theoretical positions did not, however, constitute the major part of the symposium. The larger part was devoted to the analysis of material reflecting essential progress in science. This material was very varied. There were papers reflecting the current state of morphological and morphophysiological studies of the cortex and the brain stem (Kolonier, Eccles and Anderson); papers on the analysis of the physiological mechanisms lying at the basis of sensory and perceptual processes (Mountcastle, Granit, Creutzfeldt, Libet and Teuber); and papers dealing directly with the problem of brain mechanisms of consciousness and wakefulness (Penfield, Adrian, Jasper, Eccles and Moruzzi). There were also papers containing new facts about brain mechanisms involved in the unity of the personality and reports of experiments in which different regions of the brain have been separated (Bremer and Sperry), on the cerebral control of movement (Phillips), and papers concerned with attempts to approach cerebral organization in the light of contemporary cybernetics (Mackay and Gomes), as well as papers in the field of ethology (Thorpe).

It is not possible to consider each of these topics separately or to reflect the richness of all the factual information contained in these reports. Only some basic questions are considered, therefore, and some of the trends in brain research which are reflected in the symposium.

Specific and non-specific systems of the brain

The central problem of the conference on 'Brain mechanisms and consciousness' in 1953 was the question of the role played by the non-specific system of the brain stem in providing an active and waking state for the cerebral hemispheres (Adrian, *et al.* 1954). The discovery of the reticular formation of the brain stem and the optic thalamus made by Magoun, Moruzzi and Jasper, and the neurological analysis of brain-stem mechanisms by Penfield attracted widespread attention. One might say that the 1950s were to a significant extent years of research in neurophysiology on the non-specific systems of the brain, and that research on modally specific cortical systems was set aside for the time being.

Now the situation is essentially different. The analysis of the neuronal structures of the cortex and their vertical connexions, and neurophysiological investigations of the functions of separate neurons, connected with the development of microelectrode techniques and the introduction of computers, have brought about fundamental changes. The work of Hubel and Wiesel, Jung, Evarts and many others has shown the variety of ways in which neurons differ from one another, and what highly specific functions neurons have for perceptual processes. After Jung (1900) had shown that there are neurons which respond to stimuli of various modalities, as well as neurons which regulate only one modality, a group of investigators has shown that there are neurons in the cortex and in the corresponding nuclei of the thalamus which respond exclusively to such specific stimuli as smooth or broken, vertical or inclined lines, movement from the centre of the field of vision to the periphery and from the periphery to the centre, and so on. Thus it has been established that information reaching the sensory cortex is broken down into many thousands of component elements in order to be synthesized dynamically in the more complex areas of the cortex. It has also been established that, together with the cortical neurons (or subcortical nuclei) which react to different aspects of a stimulus, there are neurons which react only to a *change* in the perceptual field (the 'novelty neurons' of Jasper, 1900, or 'attention neurons' of Hubel, 1900 and of Sokolov, 1900). Furthermore, it has been established that the populations of these neurons have a sufficiently clear topographical distribution within the cerebral hemispheres, forming well-defined zones in which neurons of a particular type predominate in vertically organized 'colonies' (Mountcastle and others). These zones form distinct structures within the cortical and subcortical apparatus of the brain. Other new evidence shows that formations can be distinguished in the cortex in which 'novelty neurons' predominate (e.g. hippocampus) and which evidently are connected with such complex functions as 'memory'. Finally there is the careful research which has correlated the character and density of cell populations in different regions of the cortex with their functional characteristics and their 'graded accessibility' to different stimuli, for instance (Phillips and others).

All these facts have stimulated a growth of interest during the past decade in

'specific' formations of the brain and in a return to a new level of what Mountcastle calls the 'geographic principle' in brain study (p. 86). Granit (p. 122–3), Jasper (p. 272) and several other participants in the symposium supported this view. It led the participants categorically to reject Lashley's idea of the equivalence of different regions of the cortex, an idea which has been shown to be the result of imperfect experimental technique on Lashley's part (see Thorpe, pl 552; Teuber, p. 553; and others). They emphasized that the non-specific reticular system itself acts in close connexion with the specific systems of the brain stimulating them and receiving stimulation from them. (P. K. Anokhin has also worked on this problem in the U.S.S.R., although his work was not reported at the symposium.) They emphasized that it is more realistic always to have in mind the inter-relations of the non-specific (brain-system) and specific (cortical) formations which together are responsible for the real forms of regulation of behaviour (Jasper, p. 272). This rebirth of the 'geographic principle' of brain analysis, on a new plane, is one of the basic features of the symposium.

Selectivity in the work of brain systems

The positions formulated above reflect current approaches to the morphology or 'statics' of the brain; but there was also great interest in new approaches to the *dynamics* of the brain system.

Recent decades have seen a rejection of the idea of simple transmission of information along nerve tracts leading to the central nervous apparatus and the storage of new and rich facts. Instead it seems that the reception of information by the nervous system is an *active* process and that at practically all levels there is a *selection* of 'useful' information, accompanied by inhibition and blocking of unnecessary, non-essential stimulation. This increased interest in ideas which were formulated in their day by I. P. Pavlov in his theory of 'analysers', and of analysis and synthesis as the basic function of the cortex, is very apparent in the symposium, although Pavlov's ideas were not themselves mentioned.

A group of participants put the view that the essential function of the nervous apparatus is not so much the transmission of excitation due to external stimulation as the *limitation* of the exictation transmitted, the selection of the essential and the inhibition of the superfluous (Mountcastle, p. 89; Moruzzi, p. 556; Granit, p. 117; and others). This process is connected with the independently operating processes of continuous excitation in the cortex and with synaptic inhibition (Eccles, p. 24). All these facts have turned up in the observations of ethologists, who have shown that animals react only to a relatively limited number of signals which have been selected in the history of the species and retained genetically in the form of 'innate releasing mechanisms' (Thorpe, p. 475), or which have been selected by experience in the lifetime of an individual. These facts have turned up as well in a series of neurophysiological investigations which show that even separate neurons can be activated only in the presence of conditions corresponding to a specific 'aim' (Granit, pp. 129–32; Moruzzi, P. 354) and that, to quote Moruzzi, 'in life we receive only those impressions which can be utilized' (p. 557).

Facts concerning the state of continuous excitation of neurons in regions of the brain (Jasper, pp. 260–1) do not say anything about 'the spontaneous work of the cortex' as some of the theoreticians feared. Rather, these facts show that in the

nervous apparatus there can develop continuous dominating foci which participate in the selection of needed information. The emergence of such foci brings us closer to the analysis of memory mechanisms. Jasper (p. 562) states that with the development of an epileptic focus there arises in the symmetrical region of the other hemisphere a 'mirror focus' which can be retained for months after the expiration of the basic epileptic zone. It is of interest that, as Moruzzi suggests (pp. 349–53) 'these slow continuous processes appear first of all in the most complex neurons of the cortex which participate directly in the digestion of information and the elaboration of new forms of experience.' Their establishment requires the long sleep which is necsssary for complex neurons but which is completely unnecessary for more simple motorneurons. In this way sleep spreads throughout the cortex in a highly selective fashion (p. 439). The analysis of the mechanisms of this selective activity naturally drew the attention of researchers to the results of synaptic studies, and Eccles' report (pp. 24–54, 321 ff.) reflects accomplishments in this area of investigation.

The recognition of the active selective character of the central nervous apparatus is one of the most significant features of modern neurophysiology and it receives much attention in the symposium.

Functional systems of the brain

Classical physiology as a rule was characterized by investigations of sensory and motor functions in isolation and by the analysis of the morphology of receptor and motor zones. The methods used were stimulation of the cortex and recording of potentials in the cortical regions corresponding to the sensory or motor periphery. Such investigations of have created serious doubts. One of the basic tendencies of current psychophysiology is to develop the study of whole functional (sensory-motor) systems. This tendency is clearly in evidence in the symposium.

Mountcastle and Teuber on the one hand, and Phillips on the other, show in their papers that both the sensory and the motor apparatus of the cortex work in much more intricate dynamic complexes than had been assumed, and that they operate according to much more complex laws than had been previously described. As Phillips has shown (pp. 391–2) the stimulation of one isolated point of the sensory cortex never leads to a whole sensation nor stimulation of an isolated point of the motor cortex to a whole action. The effects of such stimulation always have an artificial character and it gives rise only to parts of the corresponding sensory or motor process. Actually, motor processes are affected by much broader systems of cortical zones, the significant part of which goes far beyond the limits of the 'motor' cortex. Thus there is new support for the idea that afferentation widely distributed across the cortex participates in the organization of movements. (This idea has been advanced by L. A. Orbeli, P. K. Anokhin, N. A. Bernshtein and others in the U.S.S.R.)

Investigation by Phillips has uncovered interesting new facts concerning the intimate organization of the motor zones of the cortex. It has been known for a long time that stimulation of separate points in the cortex leads to results which change greatly depending on the intensity of the stimulus and the preceding state of the cortex.

Phillips (pp. 401 ff.) has succeeded in showing the presence in the motor cortex of 'optimal points' of excitation corresponding to places of densest population of motor

cells and in formulating a principle of the selective accessibility of separate muscle groups. According to this principle, the muscles of those zones which possess the greatest mobility and directability (fingers of the hand, lips, tongue) have not only the greatest representation in the motor zone of the cortex (which has been convincingly shown by Penfield, but also have the densest population of motor cells in the cortex, and thus the greatest 'selective accessibility' of directable impulses from the periphery (pp. 339–402). This fact requires a re-evaluation of the brain mechanisms of the cortex which make them possible.

Phillips and other participants introduced the especially interesting idea that among those types of structures which can provide the directability of movements there are also structures created by internal 'efferent patterns' which permit great regulation of a single efferent impulse, even when it is isolated from sensory systems (pp. 408–9). Such facts greatly change the customary understanding of the role of afferent systems in the regulation of movements and they deserve intensive study.

Teuber is among those who have thought it necessary to investigate whole functional systems underlying perception and movement. His paper is concerned with perceptual disturbances in brain lesions. Facts about perceptual disturbances in local brain lesions, and disturbances of constancy in particular, led him to conclude that human perception cannot be considered to be the result of the work of a sharply delineated zone of the cortex. The whole system of brain zones participates in every perception—visual perceptions for instance—and each zone makes its contribution in coding visual information. Some zones are concerned with the reception of visual information; others are concerned with the spatial organization of that information; and a third group is concerned with constancy. Of great interest is the fact that, according to Teuber, in perceptual constancy which is retained independently of 'groping' movements of the perceiving organs (in particular the eyes), an active part is played by those returning impulses which come from the movements to the perceiving apparatus. When analysing functional systems therefore, one ought not to go not only from sensory to motor, as is usually done, but also from motor to sensory (pp. 198 ff.). This principle, which was supported by MacKay (pp. 429–31), provides a new approach to the formation of active reflexion which was outlined by I. M. Sechenov in his day and which has been developed in the U.S.S.R. by N. A. Bernstein.

Bremer (pp. 283–95) and Sperry (pp. 298–308) introduced new material on the study of functional systems of the brain which make possible the unity of personality. These papers present new facts concerning the various mechanisms which make possible the joint working of both hemispheres and describe in detail those amazing forms of disturbances of the unity of psychological activity which were seen in Sperry's widely known experiments. Fibres of the *corpus callosum* in monkeys (and now also in man) were completely severed, isolating one hemisphere from the other and transforming them (both the dominant one concerned with speech and the subdominant one which is not concerned with speech) into two completely independently working organs. These observtions are of great interest to psychology and merit intensive study.

The change from isolated studies of the function of separate apparati of the brain to the careful study of functional systems, of kinds which have been carried out in

the U.S.S.R. by the physiologist P. K. Anokhin and the psychologist L. S. Vygotsky, represents an important tendency in the development of current psychophysiology which was clearly reflected in this symposium.

Conclusion

This symposium is one of the most significant that has been dedicated to the problem of the relation of the brain to conscious experience. Physiological science, having rid itself of its one-sidedness, has begun to arrive at a synthesized understanding of nervous processes underlying psychological activity and has brought out facts concerning the wholeness of the relations between the specific and non-specific systems of the brain, the selective nature of brain activity and the reflexion of reality; it is now approaching an objective analysis of the workings of functional systems.

The author gratefully acknowledges the help of Dr Norman Segalowitz, who translated the typescript into English.

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(*Manuscript accepted* 20 *May* 1967)