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Conscious Experience and the Human Brain

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I have chosen the expression " conscious experience " in preference to the simple term " consciousness " in order to stress the experienced character of consciousness in all its aspects. In recent decades the word " mind " or the term " concept of mind " has been philosophically unfashionable. Philosophers of great influence, such as Ryle and Ayer, have claimed that the problem of brain and mind is illusory and due to verbal confusions or category mistakes. Nevertheless neurophysiologists and neurologists have continued to wrestle with the problem of brain and mind, regarding it as the most difficult and fundamental problem confronting man; and now we can be encouraged by a recent book " The Existence of Mind " (Beloff, 1962) that certainly re-establishes the philosophical status of the brain-mind problem. In addition, I give two quotations from a recent lecture " Two Kinds of Reality " by Eugene Wigner, Nobel Laureate in Physics, in order to illustrate how important and urgent the problem of consciousness is to a theoretical physicist.

> . . . " There are two kinds of reality or existence: the existence of my consciousness and the reality or existence of everything else. This latter reality is not absolute but only relative. . . . Excepting immediate sensations, the content of my consciousness, everything is a construct. . . . but some constructs are closer, some farther, from the direct sensations."

These constructs are, of course, the physical world.

> . . . "As I said, our inability to describe our consciousness adequately, to give a satisfactory picture of it, is the greatest obstacle to our acquiring a rounded picture of the world."

Because conscious experience is the immediate and absolute reality, it is necessary that I base my account of it on my own experience, adopting a purely personal or egocentric method of presentation, which may be called methodological solipsism. My conscious experience is all that is given to me in my task of trying to understand myself; and it is only because of and through my experience that I come to know of a world of things and events and so to embark on the attempt to understand it. Furthermore, I have to consider the totality of my conscious experiences, not only here and now, but of all my past. Because of the experiences that can be recalled in memory, and so re-experienced, I recognise my unity and identity through all past vicissitudes; it is memory that gives me that continuity of inner experience which belongs to me as a self; and this inner experience comprises not only my memories,

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but all the sequences of imagery, ideas, desires, volitions and emotional feelings that characterize my waking life, and in addition it includes my dreams and hallucinations.

In contrast to this inner experience I have experiences or perceptions that are derived from activation of my sensory receptors. It is solely from such perceptual experiences that I derive the concept of an external world of things and events, which is a world other than the world of my inner experience and which even includes my body, the "body image" of neurology. I would agree with Wigner that this external world has the status of a second-order or derivative reality. How, it may be asked, can my perceptual experiences give me such an effective knowledge of the external world that I can find my way round in it and even manipulate it with such success? So effective is this practical operation that I am not conscious of this problem in my whole experience of practical living; my body and its environment appear to be directly known to me. This attitude towards perceptual experiences can be termed naive or direct realism, which has of course been rendered untenable by modern neurophysiology.

We can of course look at man from the outside, just as perforce we must do with all other animals; and this outlook has been dominant for at least a century. The study of his brain gives clues to his intelligence as evidenced by the appropriateness of reaction to the most diverse and extreme changes in environment. Man's brain is much larger even than that of his nearest relatives, the apes. It is greatly convoluted so that there is a maximum surface area of the all-important grey matter of the cerebral cortex, which has a total area of about 2,000 square centimetres and a thickness of about 3 millimetres. Both the structural and functional studies of the vertebrate brain have established that the cerebral cortex plays the key role in all the subtlety of brain control. We find the specialised cortical areas of input from sense organs—eye, ears, skin, etc.—and also the area for muscle control. It is therefore reassuring to find that man's cerebral cortex is so impressive relative to other mammals. But man has not the largest brain—the whale has a brain up to five times heavier; and it also is greatly convoluted so that the area of cortex must be proportionally greater than the human cortex. No doubt we can be comforted by arithmetical calculations showing that, relative to body weight, man's brain is pre-eminent; however, we can derive more comfort from the belief that mere mass is a crude criterion.

When we look at the detailed structure of the cerebral cortex, we find a most confused close packing of nerve cells that are the unitary structures of the nervous system. There are about 50,000 cells in one square mm of human cortex, which gives a total population of about ten thousand million neurones. No such count has been made for the whale's brain, but Professor Jansen of Oslo tells me that the neuronal density appears to be much lower, so that a whale may have only a fraction of the human neuronal population.

At the next degree of refinement of examination we would have to study the synaptic connections between these individual nerve cells, for by this means the nerve cells are arranged in functional patterns. In this way some pattern of activation of nerve cells spreads in some organized manner giving a specific spatio-temporal pattern of activation. There is general agreement that these specific patterns of activation provide all the variety and subtlety of reaction, and that the development of conditioned reflexes is due to changes that usage produces in the spatio-temporal patterns of neural activation. Such changes have been demonstrated by the relatively crude methods of leading the electrical potentials generated in the cortex, the electroencephalogram. For example the potential evoked by some input, such as a brief sound or a flash of light is modified by the conditioning process.

It cannot be too strongly emphasized that this investigation is still at an extremely primitive stage and hence gives but some dim and shadowy picture of the amazing intricacy of pattern woven in space and time by the sequential activation of neurones in multi-lane traffice over the ten thousand million components in the cortical slab of cells. It has been surmised that many millions of cells take part in the simplest cortical response. We can further speculate that the human cerebral cortex surpasses that of all other animals in its potentiality to develop subtle and complex neuronal patterns of the utmost variety, for from this would stem the richness of human performance as compared with even the most intelligent animal.

Physiological investigation reveals that all perception depends on very complex processes of detection by sense organs and of transmission of signals (nerve impulses) in a coded pattern thence to the brain. There is much neurophysiological evidence that a conscious experience arises only when there is some specific cerebral activity. For every experience we would postulate that there is a specific spatio-temporal pattern of neronal activity in the brain. Thus with perception the sequence of events is that some stimulus to a sense organ causes the discharge of impulses along afferent nerve-fibres, which, after various synaptic relays, eventually evoke specific spatio-temporal patterns of impulses in the neuronal network of the cerebral cortex. The transmission from sense organ to cerebral cortex is by a coded pattern of nerve impulses that is quite unlike the original stimulus to that organ, and the spatio-temporal pattern of neuronal activity that is evoked in the cerebral cortex would be again different. Yet, as a consequence of these cerebral patterns of activity, I experience sensations (more properly the complex constructs called percepts) which in my private perceptual world are "projected" to somewhere outside the cortex; it may be to the surface of the body or even within it, or, as with sight, hearing or smell, to the outside world. However, as succinctly expressed by Russell Brain:

> "the only necessary condition of the observer's seeing colours, hearing sounds, and experiencing his own body is that the appropriate physiological events shall occur in the appropriate areas of the brain".

This direct relationship of brain activity to perception was first clearly seen by Descartes. It is immaterial whether these events are caused by local stimulation of the cerebral cortex or of some part of the afferent nervous pathway, or whether they are, as is usual, generated by impulses discharged by sense organs. However, electrical stimuli applied to the sensory zones of the cerebral cortex evoke only chaotic sensations: tingling or numbness in the skin zones; lights and colours in the visual zone; noises in the auditory zone. Such chaotic responses are to be expected since electrical stimulation of the cortex must directly excite tens of thousands of neurones regardless of their functional relationships, and so initiate a widely spreading amorphous field of neuronal activation quite unlike the fine and specific patterns that must be set up by the input to the cortex from the sense organs. A familiar chaotic sensation, involving elements of touch, heat, cold and pain, arises from similar reasons when a sensory nerve is directly stimulated, as when the ulnar nerve in the elbow (the "funny bone") is mechanically stimulated.

In response to sensory stimulation, I experience a private perceptual world which is an interpretation of specific events in my brain. Hence I am confronted by the problem: how can this cerebral pattern of activity give me a valid picture of the external world? Usually this problem is discussed in relation to visual perception. There seems to be an extraordinary problem in explaining how impulses from the retina when relayed to the cerebral cortex give rise to a picture of the external world with all its various objects in three dimensional array and endowed with brightness and colour. However, this epistemological problem has led to much

philosophical confusion because it has been discussed on the assumption that visual perception is an inborn property of the nervous system. On the contrary it is an interpretation of retinal data that has been learned through association with sensory information from muscles, joints and skin. The three-dimensional world pictures which result from my visual experience are primarily based on perceptual data derived from movements and touch, and are the end product of a long effort of progressive learning by trial and error. As a well-trained adult it is difficult for me to realize that my earliest learning occurred in a cot with movement of limbs under visual observation; and thereafter the field of visual education was extended by crawling, walking and still other modes of locomotion so that my sphere of observation was progressively further extended. I judge distance and space as distance and direction that could be travelled, if I so wish; and so I orientate the world around myself. Thus my three-dimensional perceptual world is essentially a "kinaesthetic world"; it is initially bounded by the cot, but has thereafter been enormously extended in range and subtlety.

The learning processes of early childhood are largely unremembered, but I can remember many early efforts to evaluate distance and size, as well as the errors of judgment that I made when confronted by strange environments where familiar clues were lacking. Fortunately, I do not have to rely on memories from infancy, for there are well documented accounts by Senden of adults who were given patterned vision for the first time by the removal of congenital cataracts from their eyes. They reported that their initial visual experiences were meaningless and quite unrelated to the spatial world that had been built up from touch and movement. It took many weeks and even months of continual effort to derive from visual experiences a perceptual world that was congruous with their "kinaesthetic world" and in which as a consequence they could move with assurance. Similar evidence is provided by Riesen's experiments on chimpanzees that were reared in darkness and then transferred to an illuminated world. It took many months of training before they could skilfully use visual experience in guiding movement. A further illustration of the way in which learning can transform the interpretation of visual information is provided by Stratton's experiences when a system of lenses was placed in front of one of his eyes (the other being covered), so that the image on the retina was inverted with respect to its usual orientation. For several days the visual world was hopelessly disordered. Since it was inverted, it gave an impression of unreality and was useless for the purpose of apprehending or manipulating objects. But as a result of eight days of continual effort the visual world could be sensed correctly and then became a reliable guide for manipulation and movement.

Further problems are involved in attempting to understand how the brain events derived from the various sensory inputs can give me not only my own private perceptual world, but also experiences that are shared by other observers and which as a consequence I have come to regard as manifestations of an external world. Communication between observers serves to establish the existence of a world that is virtually identical to many observers. Its manner of operation is best illustrated by giving instances where there are differences between observers. For example, it is easily established that many observers differ in their perception of colours; and we have come to resolve this discrepancy not by rejecting colour as an attribute of an external world common to all observers, but by classifying some observers as defective in colour preception, i.e., as colour blind to a varying degree. Rushton has demonstrated the phsiological basis of colour blindness by showing that it is attributable to deficiency of a retinal pigment. Similarly, there are subjects with defects of taste or hearing to varying degree. Again, a subject under the influence of an hallucinogenic drug, such as mescaline, experiences a wealth of

imagery that is not shared by other observers close by. It is readily appreciated that such a discrepancy does not cast doubt on the validity of the external world that is derived from the perceptual world; instead, the exceptional experiences that occur under the influence of mescaline or in disordered cerebral function are classified as hallucinations. It will be realized that, when observers report one or other of these exceptional features of their perceptual worlds, the situation is customarily handled in a "common sense" way so that the concept of a real external world independent of observers is preserved. It suffices merely to mention our attitude to such perceptual experiences as dreams and day-dreams.

The conclusion is that every observation of the so-called objective world depends in the first instance on an experience which is just as private as the so-called subjective experiences. The public status of an observation is given by symbolic communication between observers, in particular through the medium of language. By means of this same method of communication, our inner or subjective experiences can likewise achieve a public status. We report such experiences to others and discover that they have like experiences to report to us. A large proportion of our literature is concerned with such verbal communications of inner experiences, either of the author himself or of the characters that he so creates.

When I re-examine the nature of my sensory perception, it is evident that these give me the so-called facts of immediate experience and that the so-called "objective world" is a derivative or representation of certain types of this private and direct experience. But this must not be interpreted as a purely idealist attitude, for the implication is that the perceptual world is my symbolic picture of the "objective world" and thus resembles a map. This map or symbolic picture is essential so that I can act appropriately within this "objective world"; and, as we have seen, it is synthesized from sensory data so as to be effective for this very purpose. It is built upon spatial relations, but also gives symbolic information in terms of secondary qualities. For example, colours, sounds, smells, heat and cold as such belong only to the perceptual world. Furthermore, it is part of my interpretation of my perceptual experience that my "self" is associated with a body that is in the objective world; and I find innumerable other bodies that appear to be of like nature. I can exchange communications with them by bodily movements that give rise to perceptual changes in the observer, for example by gestures or, at a more sophisticated level, by speech that is heard or by writing that is read, and thus discover by reciprocal communication that they too have conscious experiences resembling mine. Solipsism becomes for me no longer a tenable belief. There is a world of selves, each with the experience of inhabiting a body that is in an objective world comprising innumerable bodies of like nature and a tremendous variety of other living forms and an immensity of apparently non-living matter.

It is imperative when speculating on the whole range of the problem of mind and matter to avoid making apparently profound and compelling statements that in fact are merely wishful thinking. On the basis of evolutionary theory it is frequently stated by scientists that the association of mind and matter in the human brain must imply that there is a mental attribute latent in all matter; and that, as the organization of matter gradually became perfected in the evolutionary process, there was a parellel development of the mental attribute from its extremely primordial state in inorganic matter or in the simplest living forms through successive states until it reached full fruition in the human brain. This statement is often expressed as if it were scientifically established, which is certainly not true. It is a purely gratuitous assumption that inorganic matter or that the simplest organism has some mental attribute that is refined and developed in the evolutionary process. There is in fact, much evidence against the belief that there is a mental attribute in

all matter, even in the organized matter of the central nervous system. As clearly stated by Adrian, our conscious experience arises in only one part of our body—the highest levels of the brain—and even then only when the brain is in the right state of dynamic activity. Sentience of any part of my body is dependent on its functional nervous connection with my brain.

The key problem in perception can be stated in the question: how can some specific spatio-temporal pattern of neuronal activity in the cerebral cortex evoke a particular sensory experience? We can dimly perceive a relationship between brain states and consciousness when we consider the neuronal activity of the cortex in states of unconsciousness, i.e., when stimulation of sense organs fails to evoke a sensory experience. The electro-encephalogram reveals that in such states there may be either a very low level of neuronal activity as in coma, concussion, anaesthesia and deep sleep, or a very high level of stereotyped and driven activity as in convulsions. On the contrary the electrical activity of the waking brain indicates that a large proportion of the neurones is occupied in an intense dynamic activity of great variety. Under such conditions it has been postulated that at any instant a considerable proportion of the neurones would be passing through levels of excitation at which the discharge of an impulse would be problematical, such neurones being "critically poised" with respect to the generation of impulses. It has further been postulated that consciousness is dependent on the existence of a sufficient number of such critically poised neurones, and consequently only in such conditions are willing and perceiving possible. However, it is not necessary for the whole cortex to be in this special dynamic state. There is clinical evidence that excision of a large part of the cerebral cortex does not interrupt consciousness; and in convulsions unconsciousness does not supervene until the convulsive activity has invaded a large part of the cortex. Furthermore, I would suggest that the transcendent performance of the central nervous system is a consequence of its amazing complexity, which is of a much higher order than any other organized system in the universe.

There is no answer to such questions as: How does the information that my sense organs relay to my brain give me perceptual experiences which of their very nature are to me more directly known than the matter-energy world, which is in fact merely a derivative from such experiences? Again, is any reconciliation possible between the direct experience that an act of will can call forth a muscular movement, and on the other hand the scientific account whereby such a muscular movement, results from an activity of nerve cells in the brain, which in turn is relayed by nerve impulses to motoneurones and so to muscles? It is my contention that these questions concerning the problem of brain-mind liaison have been wrongly posed.

I have a direct experience that my thought can lead to action. I can decide on a particular action, perhaps of the most trivial nature, and my muscular movements can be directed towards accomplishing that act. I have no experience of the manner in which my willing leads to action. Naturally, scientific investigation can be applied to study the sequence of events leading to movement, though such investigations are necessarily restricted to the material events: the response of nerve cells, the synaptic transmission, the propagation of nerve impulses, the muscular activation and eventual contraction. There would be no evidence supporting my belief that my body does carry out my willed movements. Curiously enough, the most compelling evidence for this belief comes when there is some failure in the control of movement. If I find that I cannot direct my muscular movements in some willed manner, I would immediately recognize this as due to some disorder in my neuro-muscular apparatus. I would consult a neurologist or a psychiatrist; and this

would be the reaction of all normal human beings in a civilised society. The belief that it is possible to exert a conscious control of movement is usually demonstrated by the response to any untoward limitation of this so-called " freedom of the will ".

" Freedom of the will " is a primary fact of experience, and the formation of the problem arising from this experience, should be the inverse of its usual statement. The problem is to discover in the brain the functional properties that give it the requisite responsiveness so that, when I consciously will an action, I call forth responses that lead to the desired muscular movements. So far there have been merely initial tentative probings in relation to this hitherto intractable problem. It seems that both physics and physiology are too primitive to allow even the proper formulation of the problem, let alone its solution. One can surmise from the extreme complexity and refinement of its organization that there must be an unimagined richness of properties in the active cerebral cortex. Meanwhile, belief in the freedom of the will is not impugned, though its mode of operation cannot at present be explained scientifically.

On the basis of the concept of the unimaginable complexity of the brain we can face up anew to the extraordinary problems inherent in a strong dualism. Interaction of brain and conscious mind, brain receiving from conscious mind in a willed action and in turn transmitting to mind in a conscious experience. But let us be quite clear that for each of us the primary reality is our consciousness—everything else is a derivative and is a second-order reality. We have tremendous intellectual tasks in our efforts to understand baffling problems that lie right at the centre of our being; but as Wigner asks: " Have we any right to expect a solution to such fundamental problems when the efforts made have been trivial relative to the extreme nature of the problem?"

Conclusions

This brief survey of the relationship between neuronal activity on the one hand and conscious experience on the other has impinged on many philosophical problems. The principal problems, those of brain-mind liaison in perceiving and willing remain unsolved, though their reformulation will serve to challenge all varieties of materialists, mechanists and behaviourists. It is important for philosophers to realize that scientific knowledge is still in a very primitive state, and unfitted for the development of precise hypotheses on brain-mind liaison. But this present failure must not be interpreted as indicating that the problems are either meaningless or forever insoluble. We have to await developments in physics and physiology, but at the same time it is important that there should be speculations within the existing framework of knowledge in the hope that at least some insight will be achieved.

It can be claimed that the philosophical position here outlined has the merit of encompassing in principle all experience. Admittedly these philosophical speculations are at a very elementary level, but I believe that they are consistent within themselves and that the metaphysical suppositions are adequate for the conceptual developments. Such features have been conspicuously lacking in all of the materialist and behaviourist philosophies, which arbitrarily reject much of experience and which are based on initial metaphysical assumptions, though metaphysics is later repudiated. Their basic suppositions are planned so that they lead to some caricature of man, to robot man or computer man or cybernetic man, not the

spiritual being or self that I apprehend myself to be. To many, such philosophies provide satisfactory explanations of man as viewed from the outside, but they fail abysmally when applied to man as seen from the inside, which is the privileged position each of us has in respect of his own self.

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