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THE NEUROLOGICAL BASIS OF THOUGHT

GABRIEL HORN

MANY attempts have been made in the present century to remove from our language the misleading dichotomy of knowledge which derives from acceptance of the Cartesian Dualism. Aristotelian authoritarianism certainly helped to retard intellectual progress for some 1800 years, but during that time few people were particularly interested in advancing the boundaries of knowledge. And of those who were, the threat of punishment that hung over their heads for any attempted deviation from the accepted dogma, was usually sufficient to quell even the most intrepid intellectual from actively pursuing his independent ideas and thoughts. During the latter part of the Renaissance, however, when the shackles of Scholasticism had been finally broken, there arose a school of thought which attempted to reconcile the old ways of thinking with the new. This School, founded by Descartes, first enunciated the doctrine of Dualism—which was to lead to such absurdities as psycho-physical parallelism—and which was to permeate Occidental thought to the twentieth century. It is all the more lamentable that this should be so, since whereas the Aristotelian doctrine was predominantly extant during a period in Western history when most men were willing to accept religious dogma without question, Cartesian Dualism arose at a time when men were at last free to think as they desired. In spite of this, however, and because of the inability of science to explain all natural phenomena, the new intellectuals were willing to incorporate into their thoughts whatever facets of Scholasticism they were able. If this led to inconsistencies, it was convenient to ignore them.

The time has more than come, however, when these linguistic confusions should be removed. The logical positivists have attempted to do this, although they have probably taken the matter too far in the opposite direction.

If we are ever to understand man, we must study him without any preconceived, unverifiable notions of what our conclusions are going to be; and this is precisely what is not done today. When biologists study the brain of man, most of them do so with the qualification that, however much they study the tissues of that organ, the apparatus which they use will never enable them to investigate the mind. The mind they consider (although they do not usually say) is a mystical entity the nature of which cannot be rendered comprehensible by the scientific method. Some (it is hoped few) who accept Descartes' legacy, still believe the mind to be contained in a small organ, the pineal gland (which, incidentally, undergoes calcification with advancing years). Let us get the matter quite clear. The mind has

not a separate existence within the individual's body; it *is* the individual's body in every aspect of his complex structure and in every facet of the infinitely large number of ways in which the parts of that structure interact.

Ryle (1950) succinctly stated the case when he wrote of a stranger who visited this country, having only the slightest knowledge of our language, being shown round a University. After a most exhaustive tour of the buildings and after being told of the University's students, dons, constitution, purpose and traditions, he eventually remarked that he had been very impressed by what he had seen and heard, but could he please see the University. Evidently the stranger thought that the " University " was the name of something that was locked away in a safe in one of the buildings he had seen. But this is not so. The University is all that he had seen and been told about. The foreign visitor was guilty of a " category mistake " in that he had assumed the University to be a piece of paper, rather like the University's Constitution. Similarly, those who consider the mind of man to have its own existence within and separate from the individual, are like Ryle's stranger, guilty of a category mistake.

If the process of thinking is to be rendered potentially soluble, then it must be defined in scientific terms, If, and only if, scientific investigation proves fruitless to this end, are we justified in seeking a metaphysical solution to the problem.

Thoughts may be considered the product of the interaction of the parts of a highly specialised structure, the brain. This part of the central nervous system is incredibly complex and, although much of its anatomical structure is known, a great deal is still veiled in obscurity. This is even more true in that branch of physiology which studies the function of the central nervous system. But it is nevertheless possible, even at this stage of knowledge, to attempt an explanation of the neurological processes which constitute thought. Subsequent investigation may prove the following hypothesis hopelessly inadequate or even wildly wrong, but it is nevertheless a step in the right direction.

Before we are able to consider thought, in its generally understood connotation, we must initially consider the meaning of memory—which bears the same relation to thought as bricks do to the house.

It is necessary at this point to define certain expressions which will be used. The unit of the Central Nervous System is the neurone. The neurone is a small cell which has many processes ~~of~~ limbs. One of these, which is often very long, is known as the axon. These processes are linked with other cells at junctions known as synapses. In this way one cell may be connected to a very large number of other cells. In and beneath the skin, tongue, eye, nose and in the ear are certain structures known as sense organs, each of which receives a nerve supply. Stimulation of a sense receptor initiates an impulse in the nerve which is usually conveyed to a highly specialised area in the base of the brain known as the thalamus. From the thalamus, other nerve fibres convey the impulse to the cerebral cortex.

For the purpose of this hypothesis a permanent memory will be considered to have been established if it is capable of recall at least two hours after the original event. There will consequently be degrees of " permanency ". It is not possible to discuss memory patterns which are not capable of recall after two hours, but J. Z. Young (1951) has adduced evidence which indicates them to be of the nature of reverberating electrical circuits, that is circuits, which, when once initiated, are capable of self-propagation for a limited period of time (see fig. 1).

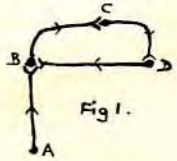


Fig. 1.—Impulses which arrive along AB from the surface of the body continue in circuit BCDB. When the impulses arrive at B again, the circuit is fired once more, and so on.

A threshold stimulus is that stimulus which effects the propagation of an impulse along a nerve fibre. Finally, the term " central feed-back mechanism " will be introduced. The underlying principle is the same as that of the thermostat, an instrument which is used to maintain a constant temperature in a boiler. When the water reaches a certain temperature, the thermostat automatically breaks the electric circuit supplying the boiler. Conversely, when the temperature of the water falls below that required, the circuit is completed and the electricity once again heats the water.

PERMANENT MEMORY.

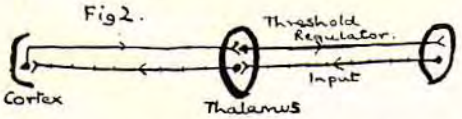
The part played by a neurone in establishing a permanent memory may be compared to the action of a condenser which is capable of storing electrical energy. This energy may be discharged at any time in the future, provided the circuit in which the condenser is contained is activated. In the case of a permanent memory, an electrical sequence causally associated with a specific pattern in the external environment, is probably converted into a physico-chemical event of a permanent nature. The energy associated with this chemical change may be discharged, like the energy in the condenser, when the circuit, of which the cell is a part, is activated.

Perhaps the first problem which requires clarification is the process which induces some memories to remain in the form of a purely dynamic electrical system and that which renders a memory permanent.

It may well be that all memory patterns commence as electrical reverberating systems, but whether such a system will induce permanent intra-cellular changes will depend on the intensity of the circuit. The intensity will in turn be determined by the "innate" behaviour patterns and previous experi-

ence of the individual. Thus, if an event is occurring to the individual, such that its future recall may be advantageous in reaching a consummation of his drive, it is necessary that this event be permanently recorded. If, however, the happenings of the present would be of no assistance to the future fulfilment of drives, there is no necessity for them to be permanently recorded and only a transient, rapidly disintegrating memory pattern will be established.

The following is an account of what probably occurs when a particular pattern of events is presented to an individual. Electrical disturbances are propagated along various nerve tracts to the terminal neurone pool in the cerebral cortex. A reverberating system is established. This system is linked by pathways which lead to other cortical areas and to an integrating centre in the thalamus (Jasper, 1949). Certain events are then precipitated. Comparison occurs between the system immediately initiated and those previously established: if similarity (and therefore, it may be assumed, compatibility) exists, facilitation of the new system occurs activating the central feed-back mechanism in the thalamus, which, by direct or indirect activity, lowers the threshold of the sensory end-organs receiving the external pattern. (See fig. 2.)



The electrical intensity of the newly-established system is increased, and probably it is extended to embrace other neurones and, therefore, to be associated (by contiguity) with other neural representations of behaviour. This raising of intensity has manifest effects at the cell surface. Intra-cellular changes may be postulated as occurring when the electrical activity impinging on the cell surface reaches a limiting level. As Monne (1949) pertinently observes, any intra-cellular change must take place by activating or modifying certain intra-cellular enzyme systems. Haddow (1944) has presented evidence which indicates that contained within certain intra-cellular structures, the cytoplasmic chromidia, are cytoplasmic genes which are liable to mutate. The chromidia are also believed to be a centre of protein synthesis. As a result of the intense electrical activity at the cell surface, mutation of the cytoplasmic genes occurs, as a result of which protein is synthesised with a specific configuration. Thus a permanent memory is laid down. The cell may be considered a type of condenser, as previously suggested. When the circuit of which it is an integral part is activated, the stored information is discharged. However, the templates of protein have already been laid down and resynthesis after the original pattern occurs. The memory is thus a permanent one in spite of the fact that it may be discharged at times of memory recall.

If, on the other hand, dissimilarity (and, therefore, incom-

patibility) between the new electrical system and the previously established systems exists, inhibition of the former occurs, which, acting back on the thalamus, raises the threshold of the sense receptors. The new system thus ceases to receive peripheral augmentation, its intensity remains low, and no permanent intracellular modifications occur. The memory is of a transient nature.

THE MEANING OF " COMPARISON " IN MEMORY.

The developing infant, as every astute observer will know, initially becomes acquainted with itself before its external* environment becomes meaningful. This it does by touching its body with its hands, correlating its sense of touch with visual sense, by watching what its hands are doing. When the child opens and closes its hands, sense receptors in the muscles involved are fired and impulses are signalled to the cerebral cortex. By the constant repetition of this exercise a circumscribed area in the cortex becomes associated with that part of the body " hand ". Permanent cellular alterations in this part of the cortex occur, probably after the manner already described. The impact of the hand on the big toe results in a discharge of impulses in the seeking hand and in the toe. The above sequence of events will again be initiated. And so on, until the infant becomes fully acquainted with itself. When, and only when, this " body image " is formed will objects in its environment commence to have meaning. The body image is a definite concept, and its presence is dramatically illustrated by the adult patient, who, after having a limb amputated, still feels sensations which appear to arise from the missing part.

As the infant develops, certain sounds become associated with certain visual patterns. The word " table ", with its particular sound, becomes associated with the object " table " with its particular spatial configuration. In a similar way, all the senses become correlated.

Soon after the child has been weaned, it is taught the elements of social etiquette—which means that there is a special way in which it must satisfy its fundamental requirements. This teaching is done by the infliction of punishment or the promise of reward. In this way a painful stimulus, usually located on the back of its hand, or on another vulnerable part of its anatomy, becomes associated with belching—or some other such unsophisticated behaviour.

By this mechanism certain protein patterns are formed in the neurones of the cerebral cortex (memory) and certain cortical areas become linked up (association). It has already been pointed out that some memories are less, and some more, " permanent " than others. The subjective elements determining the " permanency " have been described, and it was said that comparison occurred between the system immediately initiated

* The division of environment into internal and external in relation to the organism is both neurologically and epistemologically objectionable, but in order to retain some modicum of simplicity, it is used here in its generally accepted sense.

and those previously established. Obviously, the latter are constituted by the body image together with the associations. How the comparison occurs is not at all clear. It may happen in a manner analogous to that which occurs when two similar sound waves are initiated, one of which is out of phase by half a wave length of the other. Silence results. If both waves are in phase the sound is reinforced, with varying effects between these two extremes (Fig. 3).

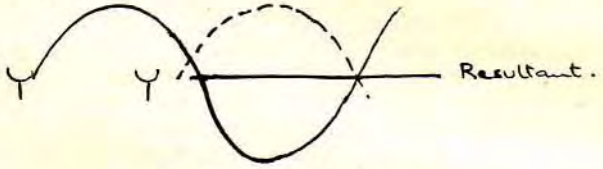


Fig 3a Extinction.

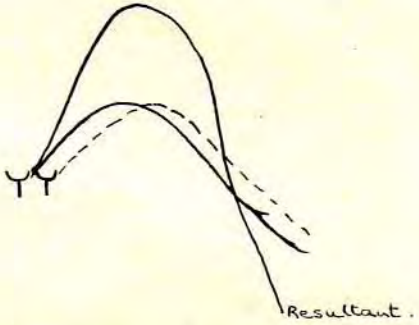


Fig 3b Reinforcement.

The analogue in the central nervous system of reinforcement would be the facilitation of the new impulse sequence by increasing the intensity of input and establishing a permanent memory, whilst the analogue of extinction would be to lower the input intensity inducing transient memory formation.

THE NATURE OF SELF.

Man is what he is because of his ability to communicate with fellow men. Without this power he would have been just another animal—which he likes to believe he is not. Thus speech undoubtedly played a major part in determining which group of early human or sub-human primates were selected to be the ancestors of modern man. The first attempts at communication in these groups were probably of an imitative character whereby the hunter informed fellow hunters of the presence of certain animals by mimicking their sounds. Much later " I " came to be a way of saying something about the self and hence to be equated with the self.

It is almost certainly true that all mammals at least, if not all vertebrates, have a " body image " culminating in complexity

in man. But it is certainly not true that other animals are capable of the profundity and diversity of thought, which characterises man. If the self is closely related to the body image, as the thesis of this argument claims, how can this apparent anomaly be explained? The answer lies quite simply in the acquisition of the power of speech. In this way the individual could communicate experiences which were occurring to him to his fellow man. By this means enormous possibilities were opened up to primitive man, possibilities which are still in the process of being realised.

It is usual for the protagonist of Cartesian Dualism to ask certain questions of any biologist who professes to have established a physical basis of thought. The questions usually ask how he can account for such things as " knowing " and " loving ". The phrase " I know this to be right " is readily explicable. When a situation is presented, a particular message is transmitted to the cortex. Comparison between the new system and an experientially verified memory pattern occurs, and if compatibility is established, vocalisation of the compatibility ensues and the person states that " I know this to be right ".

The experience of loving is also explicable. Associations occur between the appearance of persons and their effect on the individual. This is particularly true during childhood, when the child is protected and fed by someone else. That specific form which is most always associated with satisfaction of the child's needs, becomes the template against which potential lovers are compared. The girl almost invariably sees many of the characteristics of her father in her prospective spouse. The new form (the lover) evokes a similar intense satisfaction (and thus contentment) which the original form (the father) previously induced—commensurate, of course, with the degree of maturity of the individual. And the phrase " I love . . . . is merely a vocalisation of this state.

Conclusion.

An attempt has been made to indicate briefly the neurological basis of thought. Although most of what has been written has an experimentally established basis, many of the conclusions have been of a speculative nature. This has necessarily had to be so because of the limitations of contemporary knowledge.

We are living in the era of the scientific method, but that does not mean that all human activities, hopes, desires and pleasure will succumb to a materialistic interpretation. The scientific method merely seeks an evaluation of observable phenomena. What has been said of the mind of men neither affirms the materialistic, nor denies the idealistic doctrine, it does not confirm nor deny the existence of God; it is simply not relevant to the solution of either of these problems, however much the theist and atheist may wrangle.

In the past there seems to have been what may only be described as an innate fear of lifting the shroud of metaphysical obscurantism which has encompassed the brain, in case a real physical basis of mind should exist. Why this should be so is

inexplicable. But the time has come when the problem of human activity and thought must be clearly understood if man is to survive.

Instead of marshaling huge military forces for slaughtering our fellow men—in defence or aggression—let us marshal an army of men and women whose work will lead to a bloodless solution of Society's problems.

Since it is a fundamental axiom that we must understand ourselves before we can begin to understand our fellow beings, our first task must be an intensive study of man and his society. This cannot be done by one branch of knowledge alone. Man is a biological system, but the key to the understanding of that system does not lie in the hands of the biologist. Like all other systems such physical concepts as entropy and electrostatic fields are fundamental to this comprehension, and here the physicist may make valuable contributions; the chemist must accelerate his search for new means of elucidating the processes of protein synthesis and the many other vital processes occurring in cells, whose activity, as has been pointed out lies at the very seat of thought. The communication engineer must come forward to show us how we can improve the process of learning, just as he has shown how we may transmit many messages in one telephone wire contemporaneously. Anthropologists must make an exhaustive study of the environment and structure of primitive groups so that we may benefit by understanding the operative factors which are common to all human groups; the sociologist should make a more careful analysis of the structure and faults of contemporary society. Students of the Arts must join hands with the Scientists; no source of knowledge may remain untapped. The social and economic forces which were extant during the bursts of intellectual activity which occurred in the Renaissance and Industrial Revolution must be analysed by the historian, whilst the philologist should tell us not only why the world is a Tower of Babel, but how we may satisfactorily overcome the linguistic barriers.

The work of clarification and co-ordination must fall to the lot of the mathematician and philosopher.

What has been written is not meant to be a dynamic conclusion to a scientific paper. It is an attempt to stimulate those who are interested in the survival of the human race to take some action—in my opinion, the only action—to prevent its extinction.

And we are all interested in the human race.

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