RES MEDICA
Journal of the Royal Medical Society

Brain Mechanisms and Social Problems

W. Ritchie Russell
C.B.E ., M.D.(Edin.). D.Sc.(Oxon.). F.R.C.P.(Edin. and Lond.)
Director. Department of Neurology. United Oxford Hospitals

Abstract
Knowledge with regard to the Central Nervous System (C.N.S.) is increasing so quickly that it is difficult to adjust one's ideas to the ever-changing scene. When we turn for help to the ideas of great thinkers in the past, it becomes apparent that these are now of limited importance for the simple reason that they were building castles with bricks which are now known to be inadequate. It seems desirable therefore that we should from time to time stand back and view the whole problem of how we use our brains or of how our brains use us.

The neurologist is constantly studying the effect of lesions of the C.N.S. on functions and behaviour, so that he is forced to consider the physiological mechanisms involved.

ISSN: 2051-7580 (Online) ISSN: 0482-3206 (Print)
Res Medica is published by the Royal Medical Society, 5/5 Bristo Square, Edinburgh, EH8 9AL

Res Medica, Summer 1960, 2(2): 7-12
doi:10.2218/resmedica.v2i2.336

BRAIN MECHANISMS AND SOCIAL PROBLEMS

By W. RITCHIE RUSSELL

C.B.E., M.D.(Edin.), D.Sc.(Oxon.), F.R.C.P.(Edin. and Lond.)*
Director, Department of Neurology, United Oxford Hospitals

Based on an Address delivered to the Royal Medical Society on 4th December 1959.

Knowledge with regard to the Central Nervous System (C.N.S.) is increasing so quickly that it is difficult to adjust one's ideas to the ever-changing scene. When we turn for help to the ideas of great thinkers in the past, it becomes apparent that these are now of limited importance for the simple reason that they were building castles with bricks which are now known to be inadequate. It seems desirable therefore that we should from time to time stand back and view the whole problem of how we use our brains or of how our brains use us.

The neurologist is constantly studying the effect of lesions of the C.N.S. on functions and behaviour, so that he is forced to consider the physiological mechanisms involved.

It was Hughlings Jackson who realised more than anyone in his time, how much may be learned by studying what he called dissolution of the various levels of the nervous system, but it is just as important to study the development during infancy and childhood of the patterns of behaviour. I think that the work of psycho-analysts is of the greatest importance in this regard, for they have shown how the features of an adult's behaviour can be traced back to the earliest reactions of that individual in infancy. This is so striking a phenomenon that those interested in education are paying more and more attention to the importance of the infant-parent relationship, for it is in infancy that the earliest seeds of future behaviour are sown. This all-important aspect of the development of behaviour patterns is becoming much easier to appreciate as a physiological matter than was possible even a few years ago.

I should like in the first place to stress what is really obvious, namely that nearly all our reactions are based on the repetition of previous responses. This affects all aspects of C.N.S. activity so that the way we learn to walk, speak, play or think becomes so strongly fixed that our friends know us by our posture or gesture, and our banker recognizes our signature as being something unique to us.

These same features of C.N.S. activity are apparent in the higher forms of activity, and we can often tell what our colleagues or friends are going to say in advance, for they react to the same situation each time in much the same way. I am not suggesting that we need be entirely controlled by habit, that is by repetitions, but the first tendency is always to do what was done before, and a special effort is needed to change the pattern. Some people make this effort to avoid getting in a rut more than others, and a few people make a special habit of reacting differently on each occasion, but this trait, though it adds much to the pleasure of social contacts, is in itself a repetition. Our so-called characters seem to be concerned with what particular type of repetition we favour.

* Dr Ritchie Russell is a former Senior President of the Society.

It is difficult to realize that the neuronal structure of the brain has been known about for little more than half a century. Before that it was not surprising that ancient philosophers paid little attention to the C.N.S., for the brain provides a very "Silent Service" which produces sensations referred mostly to other parts of the body. However, having discovered that we each possess about 10,000,000,000 neurones it is naturally important to study the behaviour of these separate units, and it is fair to say that the more we learn about them the more astonished must we become by the complexity of the mechanisms involved. At the same time it is disconcerting to learn that nerve cells, after the age of 20 years, probably disappear at the rate of about 50,000 a day.

I shall not attempt to explain what is known of the mixture of the physical and chemical which constitute neuronal activity, but it does seem important to emphasize that nerve cells are extremely active units, which discharge as an infinite variety of "strengths" and this is determined by the rate of discharge—a phenomenon which is associated with depolarization of the cell membrane. The rate of discharge may be anything up to 500 per second for some of the most active cells.

It seems probable that the brain cells are seldom waiting idly for something to do for even when we think they are idle, they are probably discharging at a slow rate and are exercising as it were, through the neuronal circuits they have formed. In this way the spontaneous repetition of activity in a particular direction strengthens the previously established neuronal connections, and probably provides a physiological explanation of the great strength of the repetition-systems which constitute our habits.

In order to study further the behaviour of separate cells, we have to turn to the brilliant researches of physiologists such as Eccles (1957), Granit (1955) and Charles Phillips (1956), for they have been able to record from individual cells in the spinal cord and brain and to analyse many aspects of their behaviour. In addition to the spontaneous activity which they have studied they have shown that the occurrence of central synaptic transmission is followed by a state of reduced threshold which facilitates a repetition of the same reaction. This is a most important matter, for it provides a physiological basis for the repetitive action which is such a vital feature of all C.N.S. activity. The exact mechanism of this encouragement of repetition is not very clear, but the change seems to take place in the synaptic terminals, and it seems to provide a physiological clue to the fact that repetition is one of the most striking features of all C.N.S. activity.

Now it is obvious that if all our nerve cells are discharging night and day throughout life, this constant activity provides much of what is needed to maintain various patterns of neuronal activity. This is probably the physiological basis of a capacity to repeat a skill such as writing, in our own inimitable way.

Further, the suggestion that the brain is always strengthening its patterns, provides some explanation of our remarkable capacity to remember, say, how to swim or ride a bicycle after many years of neglect of these skills. This I think is easier to understand if we imagine that the spontaneous activity of these neurones concerned with bicycling is to some extent practising bicycling throughout life *via* its spontaneous activity.

If this view is correct then the capacity to repeat seems to be a basis of remembering how to swim, and the physical changes relevant to this achievement are probably situated in the synaptic apparatus rather than the cell body; at least it is here that physiological observations have demonstrated a mechanism which would encourage repetitions to occur.

The next question is concerned with whether what we call the psycho-

logical forms of memory demand a separate physical explanation, or whether they can be explained as an elaboration of the mechanism involved in remembering how to swim.

It seems that there is much to suggest that both depend on similar mechanisms. Thus the study of organic amnesic states shows not only an incapacity to establish new memories, but an astonishing strength of certain remote memories which can have been of no special importance to the individual. I have been specially interested in recovery from concussion in which remote memories recover first so that a gradual shrinkage of the retrograde amnesia is often a remarkable feature (Russell, 1959).

It seems that certain remote memories strengthen themselves with the passage of time regardless of their importance to the individual while recent memories of the greatest importance are very vulnerable to the effects of concussion. These characteristics of remote and recent memories may to some extent be explained on the basis of constant neuronal activity strengthening memories automatically. In other words our memories may depend not on molecular changes within the nerve cells but on changes at the synaptic part of cell systems, and these changes are always being maintained by the active and spontaneous discharges of neurones.

On the other hand all severe head injuries after recovery demonstrate the phenomenon of retrograde amnesia, and this must surely mean that a repetitive system must operate some hundreds of times before it will withstand the paralysing effect of concussion. Retrograde amnesia often only covers a period of a few seconds but that is a long time for a neurone that may discharge at up to 500 times per second.

I would suggest therefore that these aspects of remembering are consistent with the mechanism I have just put forward.

There is another aspect of C.N.S. activity that must be given some consideration. It is obvious that our sense organs, especially our eyes, are bombarded continually with impulses which we never notice at all. Almost everything going to the brain seems to be automatically extinguished, but then of course the inhibitory system in the C.N.S. is probably even more important than that concerned with excitation. Psychologists have sometimes thought that everything seen is remembered except what we want to forget, but this approach is inacceptable in the light of current physiological knowedge. Recent work however suggests a previously unsuspected effect on peripheral thresholds of sense organs such as the retina which is exerted by the brain. The centrifugal effect on the sense organs seems to have the power to control peripheral thresholds to a remarkable degree.

In any event it is clear that some alerting system has to operate before the images on the retina are noticed at all. Whether they are suppressed before or after reaching the calcarine cortex is difficult to be sure of but it should be appreciated that the striate area is but a receiving station for the visual system. It is what happens beyond the calcarine area that is of such great interest and we may infer the presence of some simple features.

In the first place, as regards looking at things, the familiar must be distinguished from the unfamiliar. The familiar is often associated with a contented type of feeling response while the unfamiliar is potentially dangerous and may alert aggressive or fear responses. There is plenty of evidence to indicate that the hippocampal mechanism is very much concerned with both establishing a memory (visual in this example), and also in enabling a memory to re-arouse the feelings which were previously associated with the same thing. The recognition of the familiar seems to be a very fundamental aspect of all afferent mechanisms and seems to form an essential part of memory mechanisms.

The feeling of familiarity in temporal lobe fits is probably highly significant in this connection as also is the capacity of abnormal activity in temporal lobe lesions to lead to hallucinations of almost any of the senses. Hallucinations are presumably distorted memories and are sometimes concerned with memories from early childhood: these however may be mixed with more recently acquired images as in the case of a friend of mine, a consultant neurologist, who when ill with bulbar poliomyelitis had an hallucination of himself curled up in one of the brain stem nuclei!

The remarkable effects of excising both temporal lobes support this conception of the importance of the hippocampal system, (Scoville and Milner, 1957), for it evidently leads to loss of recent memory and indifference to sights and sounds which formerly caused emotional responses.

However we must turn to an even more primitive part of the brain in order to study the beginnings of behaviour patterns. Perhaps we might begin with the foetal opossums which about ten days after conception climb out of their mother's womb up her abdominal wall into her pouch where they remain for many weeks. When they make this remarkable trip their nervous system seems to consist of little more than a fifth nerve nucleus; the upper limbs consist of what amount to two hooks and the lower limb buds are hardly visible. The automatic movements of the head and upper limbs enable the mouth to find a rudimentary nipple in the pouch. The whole affair provides a wonderful example of the importance of the mouth and the trigeminal nerve in relation to the earliest reactions of the body.

From the point of view of behaviour patterns it is necessary to emphasize that all organisms facilitate reactions which seem to the organism to be desirable, and inhibit those which are harmful. This can be demonstrated in very primitive forms of life, and in animals which have a well-developed central nervous system it seems that the pituitary-hypothalamic system is responsible for these all-important aspects of development.

There have been many experiments of the electrical stimulation of these hypothalamic centres in mature animals, and very dramatic emotional responses have been demonstrated. The most astonishing development I think is that of Olds and Milner (1954) who implanted electrodes in a rat's brain in such a way that the animal could stimulate a certain area of his own brain by pushing a small lever. These workers found that from certain areas of the rhinencephalon forebrain and cephalic brain stem the animal would repeatedly stimulate his own brain over long periods of time to the exclusion of other activity, at rates of up to 8000 times an hour. The cingulate and hippocampal cortex also had some effect in this direction.

Here then we have abundant evidence of facilitating and inhibiting mechanisms which in the adult animal, and no doubt the human being also, are inexorably mixed up with the well-known feeling of fear, pleasure, anger, etc. We can but conclude that these powerful feelings tend to dictate the pattern of behaviour, and if we realise that all responses tend to repeat themselves with ever increasing constancy, we come to appreciate the overwhelming importance of the earliest feeling responses. Here we return to the same view that has been arrived at by psychoanalysts from a different approach.

It seems that the individual's ultimate capacity and behaviour depend so much on his earliest feeling responses that they become the most important steps in the development of the adult behaviour patterns. If this is a sound argument then the parent assumes an importance which is so great that his or her education becomes the most important aspect of national education!

Thus it seems reasonable to maintain that you might first decide what

you want your children to be like and then work out the optimum feeling response and keep encouraging it in relation to what you want.

Many studies of neglected children demonstrate the astonishing improvement in intelligence which results if the feeling environment is improved, and we all know the remarkable influence exerted by what we call "a good mother." The importance of early parental love is all too well recognized by social workers in preventing strong anti-social traits, for the infant's feeling reaction to his parent seems to establish to a large extent his future reaction to his fellow men.

Of special interest must be the probable effect of early influences on intelligence, for if this can be profoundly influenced by an early favourable feeling-response to acquiring new knowledge and a general wish to explore the unknown, then our whole national plan for education may prove to be partly misdirected. The family tradition of learning may yet prove to be the most important factor in acquiring intelligence. It is perhaps particularly unfortunate that the highly intelligent child from an uninterested home may have developed intelligence as a rebellion against his environment so that students with this background are most likely also to be anti-social in their behaviour.

I would like to suggest therefore that the modern educationalist should pay less attention to the avoidance-of-trauma aspect of psychology, and should engage in much research on the positive aspect of education from the earliest months of life. The fronto-hypothalamic system may have the last word as far as the individual's behaviour is concerned and the great emotional drive from this physiological mechanism has possibilities which have been little studied in the educational field.

We must also give full due and regard to the far-reaching value of group or tribe loyalties, traditions, religions, creeds and customs. These all introduce a regulating discipline into life which is obviously of the greatest importance.

As far as man is concerned the feeling response to his environment and his activities develops a highly complex mechanism for which the integrity of the prefrontal lobes seem to be important. This prefronto-hypothalamic mechanism seems to provide a highly developed elaboration of what begins in hypothalamic mechanisms, and this is therefore a vital anatomical region as far as the development of behaviour patterns are concerned. The development of these patterns occurs to a large extent during childhood and I suggested some years ago (Russell, 1948) that the integrity of this system is of special importance to the infant and young child, so much so that loss of the prefrontal lobes in infancy must make education impossible and also render very difficult the establishment of satisfactory behaviour patterns.

In adults on the other hand behaviour patterns and educational levels are already established, and it seems that for this reason we can do without the prefrontal lobes without necessarily any very noticeable change in our behaviour patterns. In adult life, however, if the frontal mechanism has to work very hard to control some strongly distorted behaviour pattern, then loss of frontal control may lead to the so-called frontal lobe syndrome in its florid form. A study of soldiers with frontal brain wounds led to the conclusion that the subsequent clinical picture depended largely on the type of previous personality (Jarvie, 1954).

I should like again to emphasize that from the physiological point of view the individual's behaviour pattern seems to be formed by the nature of his feeling responses to his environment, and the earliest aspect of this must be closely connected with the infant-mother relationship.

Young mothers of today are in general unaware of their very special

importance in education and it seems to me that in general they would benefit from some education in this direction.

It is worth while also to consider from the physiological point of view how to deal with the individual whose anti-social or psychopathic behaviour leads him to be a nuisance to the community.

From this point of view we would not expect much advantage from attempts to reform his attitude by education or argument. There is much more sense in a policy of introducing discipline of some kind which involves making it obviously no longer worth while to be unconventional or anti-social. This is the only type of reforming that is likely to succeed with psychopaths, and indeed disciplines seem to be advantageous to most forms of education.

Finally, may I point out that although it is fashionable nowadays to belittle traditional customs and religions, we must surely continue to support what has proved itself of value to the community. It may be impossible for the scientist to swallow much of what he is asked to believe, yet I feel that we should encourage any organization which concerns itself with improving standards of human behaviour.

On the other hand it seems important that ancient beliefs should be modified intelligently in the light of new knowledge, and it should be recognized that modern thought is much more attracted by action than by beliefs. Indeed new knowledge suggests that there are fresh fields for activity for those who devote their lives to problems of human welfare.

In conclusion, I hope that with these few remarks I have succeeded in showing that ideas regarding brain mechanisms must be considered in relation to problems facing mankind, and in particular that a more positive and physiological approach to the development of the individual's personal characteristics is a matter of considerable importance.

REFERENCES

Eccles, J. C. (1957) *The Physiology of Nerve Cells.* Baltimore. John Hopkins Press.

Granit, R. (1955) *Receptors and Sensory Perception.* New Haven. Yale University Press.

Jarvie, H. F. (1954) *J. Neurol. Neurosurg. Psychiat.* **17,** 14.

Olds, J. and Milner, P. (1954). *J. Comp. and Physiol. Psychol.* **47,** 419.

Phillips C. G. (1956). *Quart. J. Exp. Physiol.* **41,** 58.

Russell, W. Ritchie. (1948). *Lancet.* **1,** 356.

Russell, W. Ritchie. (1959). *Brain: Memory: Learning. A Neurologist's View.* Oxford. Clarendon Press.

Scoville, W. B. and Milner, B. (1957). *J. Neurol. Neurosurg. Psychiat.* **20,** 11.