

BRAIN MECHANISMS AND CONSCIOUSNESS

A SYMPOSIUM
organized by
THE COUNCIL FOR INTERNATIONAL
ORGANIZATIONS OF MEDICAL SCIENCES

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August 23rd-28th, 1953

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* Dr. W. R. Hess was prevented at the last minute from attending the meeting. He was represented by Dr. R. Hess, Jr.

FOREWORD

By

J. F. DELAFRESNAYE

Executive Secretary, C.I.O.M.S.

Each year the Council for International Organizations of Medical Sciences sponsors an international symposium in connection with certain selected international congresses. The conjunction of the Third International Congress of EEG and Clinical Neurophysiology and the Nineteenth International Physiological Congress afforded a rare opportunity for holding such a meeting on the North American Continent. A chalet in the Laurentian Mountains provided an ideal setting for an informal meeting where each member would have unrestricted opportunities to give expression to his views. The meeting was purposely kept small and no audience was invited.

The symposium was planned around the general theme of 'Brain Mechanisms and Consciousness'. Research workers in the fields of neuroanatomy, neurophysiology, neurosurgery, psychology and psychiatry were invited to review present-day thinking regarding the functional significance of the brain stem reticular system about which so much has been written during recent years.

The attempt to bring together individuals from so many fields to discuss a subject at the focal point of so many disciplines was a challenge in itself. Credit for organizing a select international team which worked in complete harmony must go to Dr. H. H. Jasper who presided over the meeting and spared no effort to make it a success.

To the distinguished group of research workers were added younger men who willingly undertook certain tasks to help the meeting along.

The discussions were transcribed immediately with the assistance of Drs. Green, Livingston, Courtois and Ajmone-Marsan who also compiled the index. Dr. Buser supervised the

recording of the discussions while Dr. Ingvar acted as projectionist. On behalf of the Council, I would like to thank them all.

This monograph is the record of the conference held at Ste-Marguerite, Quebec, Canada, August 23rd-28th, 1953. I would like to express my indebtedness to the Consulting Editors and especially to Dr. H. H. Jasper. My thanks also go to Dr. A. Fessard who advised me on many points. It is our hope that these proceedings will be helpful to those who are interested in the problem of cerebral integration and the neurological basis for conscious mental processes and behaviour with special reference to the brain stem reticular system.

INTRODUCTION

by

HERBERT H. JASPER

It was with Dr. Henri Gastaut and Dr. J. F. Delafresnaye at Unesco House in Paris, during the month of June 1952, that the plans were laid for this Symposium on Brain Mechanisms and Consciousness. It was first known as 'The Laurentian Symposium on the Electrical Activity of the Cortex as Affected by the Brain Stem Reticular System in Relation to States of Consciousness'. Prejudiced perhaps by our own interests, we could think of no development in neuro-physiology during recent years of such far-reaching significance.

Discovery of the remarkable functional properties of the extensive core of grey matter lying adjacent to the principal afferent and efferent pathways in the brain stem and diencephalon has stimulated new conceptions of the integrative action of the brain as a whole. Curiously, at the very start, in the natural history of this development, relationships were found between the activity of this 'reticular system' and states of consciousness, sleep or wakefulness. We are thus plunged immediately into the most complex problems of brain and mind: fields of thought and research into which only the naive or the tough-minded scientist dare enter. You may find examples of both in the pages that follow.

Selection of contributors to this Symposium was guided somewhat by the desire for international representation. More important was the need to bring together a small group of outstanding workers who would approach the problem of brain mechanisms underlying conscious mental processes and behaviour from different points of view; representatives of different scientific disciplines who could help to establish our discussion upon firm foundations of objective data derived from various methods of observation. In addition we have been particularly fortunate in being able to stimulate these same scientists to speculate well beyond available facts, to reconsider traditional viewpoints with

open minds, and to propose new hypotheses which may serve as a guide to research in this field for years to come.

The enthusiastic co-operation of the contributors to this Symposium has made the task of organization an easy one. The problem was not one of finding sufficient material but rather one of trying to restrict the programme within reasonable limits. In doing so I regret that it was not possible to invite many who would have made equally important contributions if time and space had allowed. We hope that our many colleagues who should have joined us will profit by this rather complete account of our proceedings.

The complete manuscripts of each of the principal contributions were circulated to all members of the Symposium before the meeting at Ste. Marguerite. Consequently, presentation of additional material and discussion occupied most of our time during the week-long sessions in this inspiring mountain setting. All discussions were recorded verbatim. Those following each communication were considerably condensed for publication though, we hope, without omitting important questions raised and points of view expressed. The final general discussion is presented in full, with very little editing, so that the considered views of many of the participants could be fully recorded after they had benefited from preceding presentations and discussion. We hope that, in this manner, our readers may share in some measure the exciting spontaneity and sincerity of the interchange of ideas which made this Conference most memorable to all of us privileged to attend in person.

The formal presentations are published, with a few exceptions, as they were prepared before the Conference, and in many instances before the authors had received the communications of others. This has resulted in a certain amount of repetition which, we hope, will only serve to clarify the rather difficult subjects under review. The same facts, expressed in a different way, often gain new meaning. One exception is the treatise of Dr. Fessard which has been revised somewhat to provide a critical and comprehensive statement of the basic issues of this Conference. This paper might be recommended to the readers either as an introduction to the whole Symposium, as a summary, or perhaps as both.

The order of presentation is also the same as given in the Conference. This may not provide the most logical sequence but it was necessary for the continuity of the discussion.

On behalf of all those who took part in this stimulating adventure as guests of C.I.O.M.S., I wish to express our most sincere appreciation to Dr. J. F. Delafresnaye and his Committee who, with the support of W.H.O. and Unesco, have organized this meeting in such an efficient manner, and who have undertaken its publication.

Though few problems have been solved, the record of progress marked by this Conference is a significant advance, more important for the guidance it may give to future work. New conceptions of brain function have been put forward, supported by a wealth of new data, which serve, at least, to clarify that ever-intriguing problem of how conscious experience may be related to neuronal mechanisms in the intricate circuits of the brain.

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THE ASCENDING RETICULAR SYSTEM AND WAKEFULNESS

By

H. W. MAGOUN*

When the history of neurophysiology is examined, it can be noted to have passed through periods when investigations of reflex and of sensorimotor functions were of paramount concern. Added to these today is increasing study of neural activity associated with behaviour and with related mental activity. Although the present symposium on consciousness is doubtless something of a milestone in this development, enthusiasm may well be tempered by appreciation of the head-shaking sympathy with which future investigators will probably look back upon the groping efforts of the mid-twentieth century, for there is every indication that the neural basis of consciousness is a problem that will not be solved quickly.

It is not easy, in 1953, for the physiologist to put his finger upon consciousness, though it is present abundantly and for long periods. The present investigative programme has capitalized upon its characteristic periodic interruption, in exploring the contrasting features of central neural activity, common to animals and man, in the cerebral mutation between wakefulness and sleep. Pronounced alterations in consciousness obviously accompany the transition from sleep to wakefulness and records of the electrical activity of the brain provide objective data which are at least associated with this change.

Without further acknowledgment of the obliquity of approach, it can be said that this work began with the chance observation that direct electrical excitation of the reticular formation of the brain stem induced changes in the EEG seemingly identical with those observed in awakening from sleep, or alerting to attention, and which have been referred to variously as activation, desynchronization, EEG arousal or the blocking reaction (Moruzzi

* Aided by grants from the Commonwealth Fund, the National Institute for Neurological Diseases and Blindness, United States Public Health Service and the Eli Lilly Company.

and Magoun, 1949; Moruzzi, 1952b; Magoun, 1950, 1952a, 1953; French *et al.*, 1952; Ingram *et al.*, 1951, 1952, 1953). The effect was most pronounced against a background of EEG synchrony (Fig. 1, middle record) and little added influence was apparent in the already aroused electrocorticogram (Fig. 1, upper record). The alteration was generalized over the cortex and persisted for long periods after cessation of the stimulus initiating it,

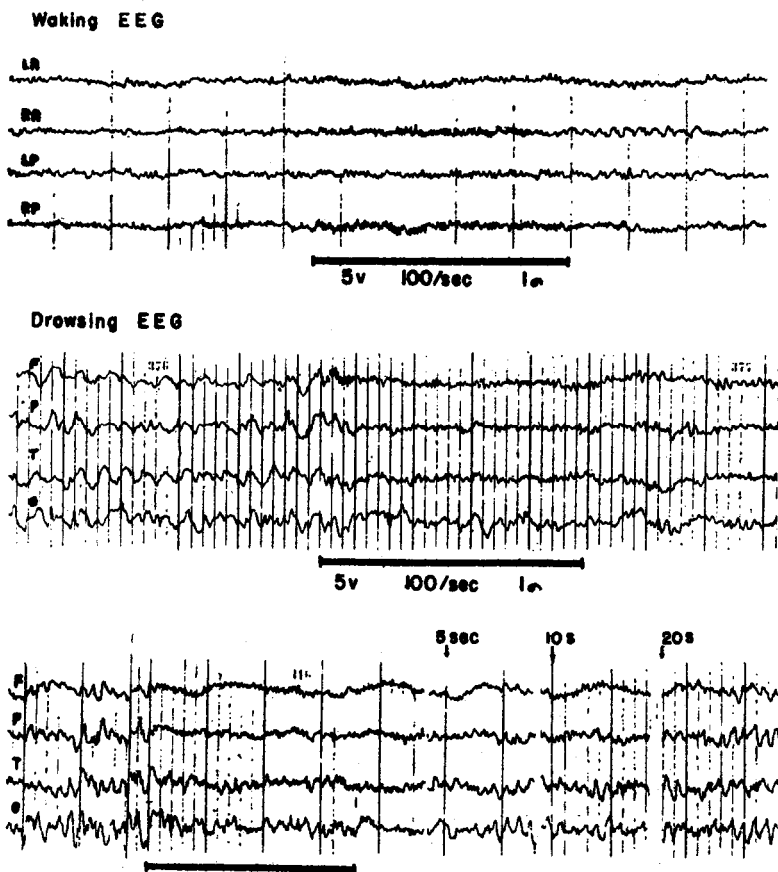


FIG. 1

Effect of stimulating the brain stem reticular formation (heavy line) upon the electrocorticogram of the monkey. Channels are: F, frontal; P, parietal; T, temporal; O, occipital. From French *et al.*, 1952, *AMA Arch. Neurol. Psychiat.* 68: 577.

being most pronounced and enduring longest in the anterior part of the hemisphere (Fig. 1, lower record).

The regions of the brain stem from which such EEG arousal could be induced included the reticular formation and tegmentum of the lower brain stem and, in the diencephalon, the subthalamus together with the dorsal hypothalamus and ventromedial thalamus (Fig. 4). There is indication that influences leading to desynchronization are transmitted to the cortex both by way of an extra-thalamic route from the subthalamus to the

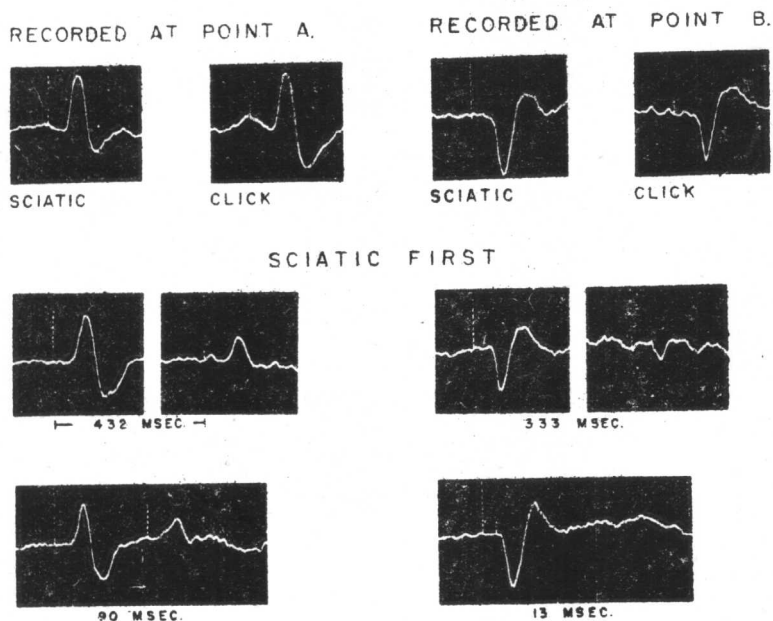


FIG. 2

Records of potentials evoked in the reticular formation of the monkey's brain stem by sciatic and auditory stimuli. Point B was 2 mm. below point A. From French *et al.*, 1953, *AMA Arch. Neurol. Psychiat.* 69: 505.

internal capsule, as well as through the non-specific and possibly other thalamic nuclei which, for the most part, however, lie dorsal and lateral to the most excitable zone (Starzl *et al.*, 1951a, b).

Since the EEG changes evoked by stimulating this reticular system resembled so closely those of arousing peripheral stimuli,

it became of interest to determine whether afferent paths made connections with the reticular mechanism in the brain stem. When, in the unanaesthetized brain, recording electrodes probed the central region, marked responses were evoked by clicks and sciatic shocks (Figs. 2, 4). This discharge had a long latency and a wave-like rather than a spike-like form, suggesting multi-neuronal organization (Starzl *et al.*, 1951a, b; French *et al.*,

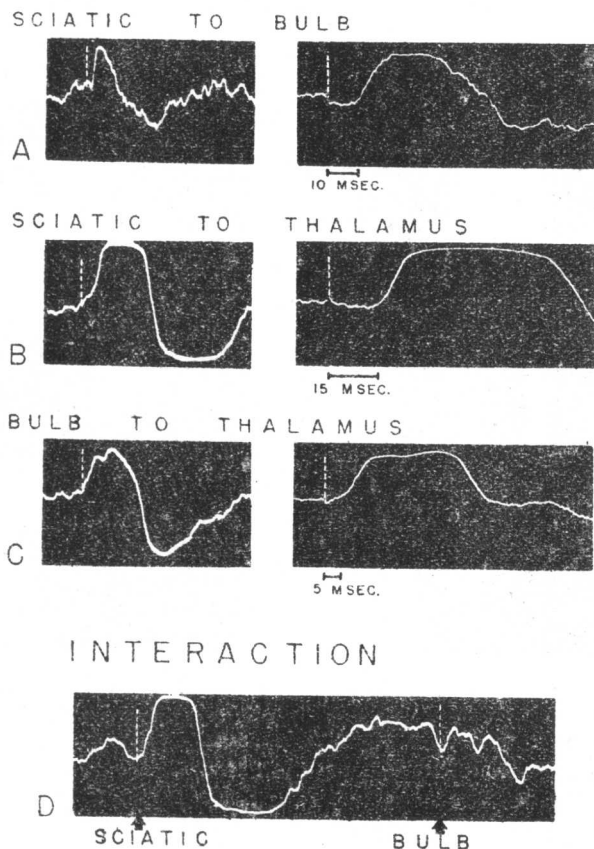
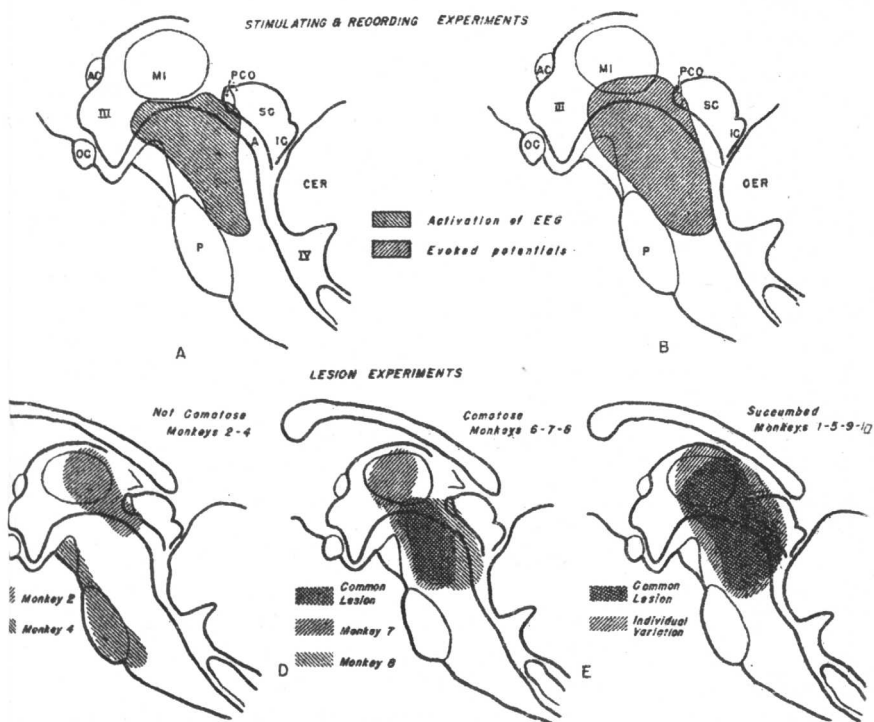


FIG. 3

Records of potentials evoked in the monkey's bulbar reticular formation and thalamus (centre median) by sciatic stimuli. The thalamic response to bulbar stimulation is also shown. From French *et al.*, 1953, *AMA Arch. Neurol. Psychiat.* 69: 505.



1953b). Equivalent potentials were induced at the same recording site by these contrasting modalities, reversing in phase as the focus was traversed (Fig. 2, upper records). When paired shocks were delivered, one to each of the two peripheral sources, attenuation and occlusion occurred in the brain stem, as the second stimulus approached the first, demonstrating further that common reticular elements were fired (Fig. 2, lower records). In agreement, potentials evoked at cephalic levels of the central brain stem by afferent stimuli could be shown to interact with those induced by direct excitation of the bulbar reticular formation (Fig. 3). From the additional studies of Amassian (1951, 1952b), Dell (1952), Arduini and Moruzzi (1953a) and Livingston, Haugen and Brookhart (1953) it is now clear that afferent paths subserving all sensory modalities make connections with the central reticular activating system. These connections have been designated collateral, in the sense that they are diverticula from direct paths to receiving areas of the cortex and without morphological connotations.

The great functional importance of this non-specific reticular system in the brain stem is indicated by the consequences of lesions in its cephalic part (Fig. 4). Monkeys with such experimental injury remained throughout survival in a comatose state, in which the absence of all behaviour associated with wakefulness contrasted sharply with the alertness and activity which this animal normally displays (Fig. 5). The EEGs of such preparations were chronically hypersynchronous and could no longer be affected by peripheral stimuli (Fig. 6), emphasizing the importance of collateral over direct corticopetal paths in EEG arousal induced by afferent stimulation (French and Magoun, 1952). Results in general similar to these have followed injury to the cephalic brain stem in the cat (Lindsley *et al.*, 1949, 1950) and man (Penfield, 1938; Jefferson, 1944; Thompson and Nielsen, 1948; Jefferson and Johnson, 1950; French, 1952; Cairns, 1952; Jefferson, 1952) and the findings are in good agreement with Bremer's fundamental observations that transection of the upper brain stem leaves the cerebral hemisphere in a state of sleep, with which current investigations of this problem may be said to have begun (Bremer, 1935, 1936, 1937, 1938b, 1951a, 1953c).

The chronic loss of wakefulness following injury to the central

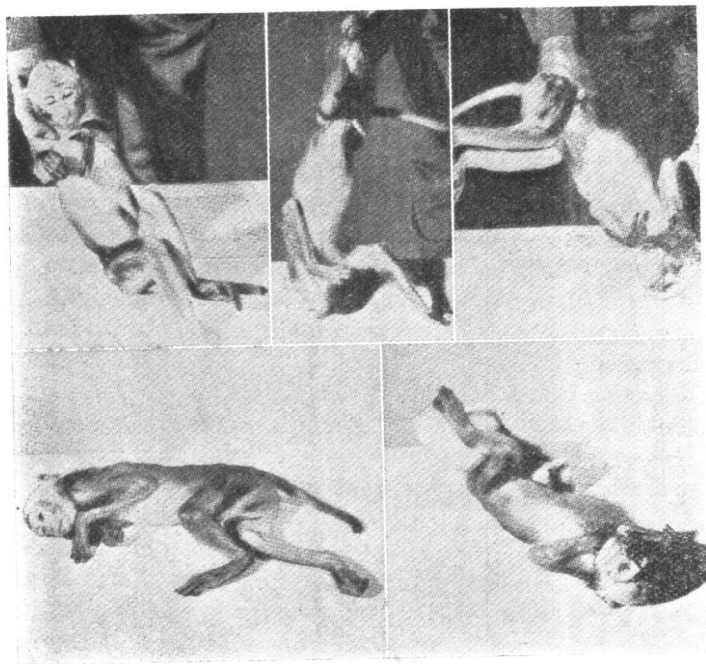


FIG. 5

Photographs of monkey with extensive injury to the central cephalic brain stem. From French *et al.*, 1952, *AMA Arch. Neurol. Psychiat.* 68: 591.

