

02 M2, M-DP
02a 400859
02b McGill Univ (can)
30c
Reprinted from SLEEP AND ALTERED STATES OF CONSCIOUSNESS
Association for Research in Nervous and Mental Disease, Vol. XLV
Baltimore, The Williams & Wilkins Company
Copyright © 1967, Association for Research in Nervous and Mental Disease, Inc.
Printed in the United States of America

412 422

30c

02c Dept of Psychology 2nd Montreal Que
Chapter I

30a p 1-7

04 CEREBRAL ORGANIZATION AND CONSCIOUSNESS¹

D. O. HEBB²

46 1968?

What we are to discuss is the problem of cerebral organization in its diurnal cycle and in its other fluctuations. In conformity with the honorable traditions of this Association, the present symposium brings together the clinical and the experimental in a unified discussion, sits the behavioral scientist down with the anatomist and the physiologist, and finds no difficulty about combining evidence obtained from the beast, the infrahuman animal, with that from man—in other words, it happily combines the bestial and the humane.

I follow my great teacher K. S. Lashley in saying that the problem of cerebral organization is the problem of *mind*—a word that is sometimes taboo in behavioral circles—and I follow him also in supposing that there is no hope of success in the study of mind without studying both brain and behavior. It is consequently good to find in this Association none of the isolationism that has on occasion afflicted psychiatrist and psychologist, or for that matter the comparable isolationism sometimes apparent in the neurophysiologist or neuroanatomist who sees no need, in his study of the brain, to inform himself of modern developments in the field of behavior. It is true that today there is hardly any hope of keeping up with all the papers in one's own field, but we need not conclude that this rules out reading in other fields; after all, many of the papers in one's own field are trivial, and the boundary between fields is artificial. A little smuggling over the border now and then is a good thing, and I hope the Officers and Trustees will not be hurt if I commend them as honorable smugglers—or commend this Association for its honorable and valiant bootlegging, past and present.

09 7
09a 10

When you cross the behavioral border, however, you must watch your step. Verbal traps are common, and the meaning of some apparently simple terms becomes important. In the title of our symposium there are two words, "sleep" and "consciousness," that need at least some passing mention. I know of no sufficient definition of sleep; English and English (3) in their *Dictionary* list two or three of its properties, but say these are also to be found in other states. Then they go on to say, "But sleep is nonetheless a distinct, if as yet

¹ Preparation of this paper was aided in part by Public Health Service Research Grant MH-02455 and by the Defence Research Board Grant 9401-11.

² From the Department of Psychology, McGill University, Montreal, Canada.

38 PHS MH-02455

35 (D) - 94-01-11

98

ill-described, phenomenon." In other words, I know what sleep is but I can't define it. That's psychology for you.

Dorland's Medical Dictionary (2) says sleep is a period of rest with bodily and mental functions partially suspended: hardly a more definitive statement but one with a more positive tone—in line with medical practice when in doubt. Sleeping is an astonishing phenomenon, obviously instinctive if any behavior ever was, and a characteristic of all higher animals. It is so characteristic that we do not wonder at it and even, most of the time, forget it. The psychological textbooks make little reference to it, and research has neglected it. Kleitman's great work (6) stood almost alone in the field for years, while important aspects of the problem remained untouched; for example, the striking familial differences in sleep pattern or dependence on sleep. The new activity in research, to which the present symposium bears witness, is welcome indeed.

As for the second word, "consciousness," everyone knows that this one is booby-trapped and approaches it cautiously. Let me see if I can identify one of the traps and make it harmless. It consists in the two different senses which the word has, two meanings that are used without, apparently, realization that the meanings are different.

For Lashley, mind or consciousness was an organized activity of the cerebrum. How then could he (7) say as he did to this Association that "no activity of mind is ever conscious"? He went on to explain what he meant by this—namely, that mind is not conscious of its own processes—but did not explain what he himself called the paradox of saying what he did. The explanation lies in recognizing two meanings of the term conscious. The first meaning is a reference to a state of the brain, one phase of the diurnal cycle: the state of the normal, waking, alert, adult human being or higher animal, as contrasted with one that is comatose. The other meaning refers not to the whole organized activity of the cerebrum, nor to the whole activity of mind, but to those parts of the activity of which the mind itself is conscious. It is one thing to say that I am conscious—of the world about me. It is another to say that some of my ideas are conscious—and mean by this that I am conscious of them. One must question this latter usage. There is reason to believe that there are no ideas of which we are conscious, that introspection does not exist (as a direct awareness, that is, rather than complex inference (1, 5)). In that case the second meaning of conscious is illusory and might be avoided; however, if it is to be used, along with its corollary of an unconscious mind, I would urge that the user should always make clear that he means it in this second and now somewhat doubtful sense.

Modern thought has come a long way from the time, in the 1920's, when it was possible to debate whether consciousness was the result of impulses crossing synapses with high resistance, or low resistance—consciousness being like a kind of juice squeezed out of the neuron. The modern period is mainly

marked by emphasis on the brain-stem control of level of consciousness and might be dated from a suggestion of Penfield's (9) in 1938—a suggestion that, I regret to say, I failed to appreciate at the time. He concluded that consciousness must be more closely correlated with some discrete subcortical region than with any specific cortical activity and that “the indispensable substratum of consciousness lies outside the cerebral cortex.” With hindsight, one can see this pointing directly to the epochal paper of Moruzzi and Magoun (8) on the brain-stem activating system, one of the focal points of our present discussion.

Lashley and Penfield are the two outstanding names when one discusses the problem of cerebral organization and consciousness, and I want to take a moment to put their contributions in perspective before going on. Lashley's weakness was an over-reaction from his own early simpleminded Watsonian connectionism, which in effect ended up as an opposition to any form of theory. His theoretical contribution was thus negative and destructive only, but it was at the same time enormously clarifying, and it is to him more than to any other man, I believe, that our understanding of theoretical issues in this field is due. As for Penfield, his great contributions are empirical, in the demonstration of fundamentally important phenomena of brain function. His theory of memory is unsatisfactory, I think, because of not having a behavioristic foundation, of not being an outgrowth of that simpleminded S-R formulation that we all disavow in its cruder forms but that nonetheless is the starting point, the germ from which the theory of learning springs, even for those whose purpose seems to be to destroy S-R theory—but to destroy only by modifying and elaborating and making it grow into something more flexible and powerful. But whatever difficulties there may be for the theory, Penfield has made discoveries that are truly fundamental for psychology and the theory of cerebral organization: the astonishing lack of apparent importance of prefrontal lobe in that organization (compared, *e.g.*, to temporal lobe), the major significance of dysfunction for psychological processes, and the special relation, at least, of temporal lobe to memory. These discoveries must have lasting significance. Finally, Penfield's (10) delineation of the speech areas in conscious patients, of first importance in itself, has a special significance for our understanding of cerebral organization.

The significance lies in the fact that electrical stimulation of speech-area cortex does not produce speech but impairs or prevents it. This is in contrast to stimulation of primary sensory or motor cortex, which mimics the normal function of the tissue instead of being directly opposed. It draws attention to a property of neural transmission in higher centers, and an aspect of cerebral function, that has been little regarded by the neurophysiologist although it appears to be related to the much regarded function of ARAS, the “ascending reticular activating system” or arousal system.

Fundamentally the role of the cerebrum like that of the rest of the central nervous system must be to act as a communications system, a transmitter of excitations. If so, how or why should so much of the cortex consist of the so-called silent areas where electrical stimulation is not transmitted or has only a negative effect? As I see it, the answer has much to tell us about cerebral organization and consciousness—why the activating system is needed for consciousness, as well as the nature of the conscious activities themselves.

The answer (as I see it) is that transmission in the cerebrum is largely via divergent pathways with no automatic provision of summation at the synapse, such as is provided by the overlapping axon collaterals at each synaptic junction in the great afferent and efferent tracts, which are organized in parallel. In divergent pathways, the summation necessary for reliable excitation of the postsynaptic neuron, therefore, must be provided elsewhere; hence, the necessity of bombardment from ARAS, to provide that summation. With it, synaptic transmission in the "silent" regions—which I think would be better known as regions of divergent conduction—becomes possible. It is clear that organized activity in these regions must depend on a concordance of neurons at a distance from each other; firing all the neurons in one small region, by electrical stimulation, must negate their normal function, whereas a similar stimulation in a region of parallel conduction would reproduce normal function: for here the neurons that lie side by side are normally excited together.

It seems also that transmission in these divergent-pathway regions of the cerebrum needs the further summation coming from activities that are already going on in the cerebrum, so that only those messages that are related to the concurrent activity tend to be transmitted and have their effect on behavior. These regions have an essential screening function. This is strictly an inference from the behavioral evidence of the selectivity of attention, and of thought generally, so I will not expand on it here. But I cannot speak on the topic of cerebral organization and consciousness without saying at least that I believe consciousness to consist in the activity of the closed or re-entrant circuits of Lorente de Nó, and transmission of excitations from circuit to circuit, with a constant motor outflow as well as constantly varying sensory input to the system. The importance of divergent conduction in the higher centers of the central nervous system is that it does that screening that I have referred to, in addition to permitting a semiautonomous activity in the system. Without it, man would be an automaton-like stimulus-response animal, programmed by his environment—whereas, in fact, he programs himself to a very large extent in what we call voluntary behavior (4).

All this refers to only one phase of the diurnal cycle. When one speaks of

the alternate phase, sleep, one finds oneself saying mostly negative things—sleep is the absence of this or that property of the waking state—which is hardly a satisfactory position in which to find oneself concerning such an important phenomenon. It is of course desirable to define the state from which sleep is a variation, even if the definition is speculative, but it is very desirable not to stop there. The research to be reported in this symposium, as it allows us increasingly to make positive statements and to say what sleep *is* rather than list the things that it is not, makes a fundamentally significant contribution to the understanding of man and the nature of conscious organization in the cerebrum.

REFERENCES

1. Boring, E. G.: A history of introspection. *Psychol. Bull.*, 50: 169, 1953.
2. *Dorland's Illustrated Medical Dictionary*, Ed. 24. W. B. Saunders Company, Philadelphia, 1965.
3. English, H. B., and English, A. C.: *A Comprehensive Dictionary of Psychological and Psycho-analytical Terms*. Longmans, Green & Co., Inc., New York, 1958.
4. Hebb, D. O.: *A Textbook of Psychology*, Ed. 2. W. B. Saunders Company, Philadelphia, 1966.
5. Humphrey, G.: *Thinking*. Methuen & Co., Ltd., London, 1951.
6. Kleitman, N.: *Sleep and Wakefulness*. University of Chicago Press, Chicago, 1939.
7. Lashley, K. S.: Cerebral organization and behavior. *Res. Publ., A. Nerv. & Ment. Dis.*, 36: 1, 1958.
8. Moruzzi, G., and Magoun, H. W.: Brain stem reticular formation and activation of the EEG. *Electroencephalog. Clin. & Neurophysiol.*, 1: 455, 1949.
9. Penfield, W.: The cerebral cortex in man. I. The cerebral cortex and consciousness. *Arch. Neurol. & Psychiat.*, 40: 417, 1938.
10. Penfield, W., and Roberts, L.: *Speech and Brain-Mechanisms*. Princeton University Press, Princeton, 1959.

DISCUSSION

DR. LAWRENCE C. KOLB: Dr. Hebb has given us a neat distinction between several meanings of consciousness. First of all, he refers to a state of the brain in the normal, waking organism. I assume by this he is speaking of an organism which is attentive and perceptive to its immediate environment relating that to events recalled in the immediate past but, at the same time, interrelating it with a stream of experiences of which there is no ongoing or immediate awareness.

As to the second definition—those parts of the activity of the mind of which one is conscious—I find myself much less disturbed than he is in accepting the fact that one may be unconscious of certain ideas. While we may agree that we are not conscious of our ideas (if Dr. Hebb defines an idea as all those perceptions, experiences, associations and interrelations assembled by the brain as a mediating system which would form an idea), yet shall we spend time arguing over the fact that we may be consciously aware of the endproduct of that mediating process stipulated as an idea?

I would like to inquire of Dr. Hebb whether he feels that the concept of the un-

conscious has been at all useful. There are some who might suggest that this concept is the central force leading to the work which will be reported here today.

DR. D. O. HEBB: Obviously mine is an extreme view, which I can afford since I have no responsibility for patients. "The unconscious" has certainly been of value in communicating with patients, a conception helping to make them realize that they have thoughts they do not know about. I do not mean that the psychiatrist need stop using the term in dealing with the layman; and Dr. Kolb is certainly right in suggesting that the conception has been a stimulant to research in the past. But it may have outlived its usefulness as a theoretical tool. The evidence is now strong that this dichotomy between two regions of mind or two kinds of mental process is unsatisfactory; continuing to make it may stop us from asking a question that is important for understanding psychotherapy; namely, how do we know some of our thoughts inferentially? But if one does continue to use the terms "conscious" and "unconscious" in this way, it seems that for clarity at least it is important to be explicit in which of the two senses the term conscious or unconscious is used.

Let me point out something else. Objective behavior theory may seem unpalatable to the analytical psychiatrist, but he must realize that psychoanalysis itself is the great forerunner of objectivism. The whole theory of the unconscious tells us that verbal report is unreliable as an index of mental content, and that one can learn more about the presence of hostility or anxiety as an inference from a person's non-verbal behavior (and some of his verbal behavior) than one can by simply asking for a subjective report. Freud anticipated Watson as a behaviorist.

DR. WALLE J. H. NAUTA: Dr. Hebb made a plea, and I believe a most appropriate one, to restrict the connotation of the term "consciousness" as used by the animal physiologist to that particular functional state of the central nervous system that corresponds to behavioral vigilance. It seems certain that this state, when compared with sleep, cannot be characterized as one of more intensive overall central nervous activity. In searching for another interpretation one is almost forced to think of a "gating" process, the manifestation of an at least dualistically organized functional system the subsets of which each promote one particular form of systemic and inter-systemic integration. A strong indication of such gating is found in Evarts' impressive evidence that the segmental motor level is "uncoupled" from the cortical level during sleep. Recent findings by Jouviet suggest that this uncoupling results from an active influence of certain brain-stem regions upon the neuronal mechanisms at the lower motor level. Comparable active dissociations are almost certain to occur at the level of the forebrain, even though it may not be possible to describe the net results in simple terms.

I was intrigued by Dr. Hebb's characterization of the so-called silent or associative cortical fields as "regions of divergent conduction," in contrast with the parallel and inherently more summative organization of the great afferent systems. It would be of great interest to learn whether, and to what extent, the neural processes in the sensory and associative thalamocortical organizations, respectively, are differentially affected by the cyclic "gate-setting" mechanisms of the upper brain stem. The striking heterogeneity of afferents to the associative thalamocortical organizations (including, for example, connections from various limbic forebrain structures to the mediodorsal and lateral thalamic nuclei) could conceivably be a determining factor

in this respect. As elsewhere in the brain, so also at the level of the associative cortex it is likely that sleep corresponds to a shift in relative dominance of one conduction pattern over another. Certainly it appears that extensive intersystemic forebrain connections are functional during paradoxical sleep at least, allowing ideational processes with corresponding affective concomitants and limited possibilities at least for storage and recall.

DR. HEBB: Dr. Nauta's theoretical suggestions seem entirely reasonable to me. I am really in the dark about the extent to which there may be a complete uncoupling at times during sleep, and in the past we have had so little positive information about sleep that I have just been obliged to think of it as the absence of the waking state of consciousness. Kleitman and Dement and Jouviet are changing that, and now we can develop positive theories. As for the gating function of the arousal system (or systems), I have felt obliged in the past to make theoretical formulations as a basis of experiment, aware at the time that they were bound to be wrong, and the kinds of analysis that Dr. Nauta has suggested should be of immense clarifying value for behavior when we learn how to carry them out.

ABSTRACTED BY
MJM

JUL 4 1969

MJM

DEFENCE RESEARCH BOARD	
DEFENCE SCIENTIFIC INFORMATION SERVICE	
NATIONAL DEFENCE HEADQUARTERS 125 Elgin Street OTTAWA 4, ONT., CANADA	
Date	JUN 26 1969
From	<i>McLellan</i> 2/6/69
Copy No.	1 of 1
Acc. No.	69-07285

enc: Dr. Hoyle, SSO 7/17/69 RM
DR E T Dr. A. Smith
AMS
24/7/69