Meetings

Attention as a Concept in Neurophysiology

The psychological, behavioral concept of attention as used in the interpretation of neurophysiological phenomena was examined critically and intensively at the International Conference on the Concept of Attention in Neurophysiology held at the National Physical Laboratory, Teddington, England, 3 to 5 October, 1967, with Lord Adrian as guest of honor.

Certain problems concerning attention that kept recurring throughout the conference included the definition of attention, or rather, the multiplicity of definitions, behavioral and physiological; the lack of valid and comprehensive evidence concerning the origin of the recorded electrophysiological activity assumed to be related to attention; the sheer complexity and diversity of physiological and biochemical processes, required for behavioral attention, which showed the oversimplification of concepts such as "activation," "arousal," and "attention."

In his exposition of the development of the concept of attention in psychology, D. Berlyne (Toronto) showed the complexity of the process of attention and defined differentially phenomena which had been lumped under a single concept, "attention."

Five participants raised the issue of the relation of the visual control systems to the electroencephalographic (EEG) occipital alpha rhythm. In his studies on the effect of eye deviation on alpha rhythm, P. Fenwick (London) confirmed and extended the original results by Mulholland and Evans that occipital alpha can be facilitated by elevation of the eyes. Alpha was consistently increased in these subjects by upward, lateral, and downward deviations of the eyes in 30 to 50 percent of untrained subjects. This effect was dubbed the "improper alpha rhythm" by C. R. Evans (Teddington) who showed a film illustrating the facilitation of alpha by eye elevation despite the extremely bright lights required for filming.

T. Mulholland (Bedford) presented results concerning eye position and alpha, and interpreted these and other experiments in terms of the hypothesis that the occipital alpha-activation cycle reflected the visual control systems. These systems, grouped under the term "triad of accommodation," include pupillary control, lens-accommodation control, and eye-position control. When the triad of accommodation was unstable, alpha occurred; when the triad was stable, alpha occurred much less or not at all.

M. Bender (New York) pointed out that when the brainstem is stimulated, many systems are activated including the oculomotor, invariably causing alterations in eye movements. Oculomotor pathways and reticular-activation systems are located in the same zone of the brainstem tegmentum. He concludes "since it is claimed that alpha rhythm becomes more evident during upward rolling of the eyes with partial eyelid closure and since such an ocular syndrome could be activated in the brainstem it is conceivable that some of the electrical activity in the occipital lobe may originate in the brainstem."

V. Zikmund (Bratislava) discussed the oculomotor component of the orienting response. He showed that orienting to auditory stimuli included a series of rapid eye movements supplanted by slower undulatory movements during intervals of no stimulation.

Electroencephalography is used to determine the level of attention for diagnosis and the evaluation of the alertness of astronauts in orbital flight. A. Mirsky (Boston) reported on a study with humans suffering from petit mal epilepsy who looked at a recurring visual pattern. Every now and then a different pattern was presented. He found that the probability of not detecting the different pattern was closely correlated with the occurrence of a change in the EEG, characteristic of petit mal, the so-called spike-and-wave episode. The episodic impairment of performance began and ended a brief time before the recorded spike-and-wave episode began and ended. In other studies of background EEG in relation to performance, monkeys were trained to respond to, for example, one color and to withold response to another. Performance was best with theta (4 to 7 hz) low and beta (21 to 32 hz) high, worst with theta high and beta low. Mirsky did not find rhythms of 8 to 13 hz a useful index in these studies.

O. Creutzfeldt (Munich) described EEG recordings obtained by radio telemetry while subjects were performing mental and visuomotor tasks. Occipital alpha was present in all subjects with eyes open, though less than for eyes closed. During various tasks alpha increased for some and decreased for others. Creutzfeldt's results offered little support to the idea that alpha occurrence is a useful measure of attention during performance of complex tasks or a measure of the rated difficulty or complexity of the tasks.

Despite wide individual differences in basic EEG patterns, R. Adey (Los Angeles) reported that spectral-density distributions have characteristic features in a wide gamut of waking and sleeping states. These measures have proved valuable not only in establishing norms, but have stimulated the use of multivariate pattern recognition of the EEG signatures that characterize, in an individual way, the performance of subjects on a standard set of tasks graded in difficulty.

E. Dewan (Bedford) discussed "entrainment" and "adaptive control" and related them to electrophysiological activity associated with activity of the central nervous system that relates to attention. In addition, the Wiener optimum filter as extended by Kalman and Bucy (for use in computerized space technology) was compared with models for attention, orientation, and habituation. In the past, G. Walter and N. Wiener noted that "mutual entrainment" whereby linked oscillations converge to a common frequency may play a role in normal and abnormal EEG rhythms. "Adaptive control" is an extension of the feedback control to increase the range of situations in which a control system can continue to perform adequately. This is achieved by regulating the control system itself by means of an additional control system. This additional control system constantly monitors input and output of the main control system and alters the latter's internal structure so that it will be best suited for ongoing tasks. A

crucial aspect of such a system is the procedure of "identification" of the main control system's potential response. This is often done by means of "testing signals" which can consist of sinusoidal waves and, often, pure noise. Since both forms of electrical activity are found in large amounts in the central nervous system, and since adaptive control is to be expected in biology, it was suggested that perhaps some of the observed signals, for example noise and 10-hz rhythms, might serve the purpose of testing signals. Finally, optimum filtering was compared to attention processes and it provided a suggestive computer analogy to some important aspects of attention.

In five papers the relation between evoked responses and concepts of attention was directly considered. W. A. Cobb (London) described the effect on the visual-evoked potential of binocular rivalry considered as a special case of alternations in attention. Flicker presented to an eye when it is dominant or when it is suppressed does not produce any differences in the waveform of the resulting evoked response. With patterns, there was a difference depending on whether the dominant or suppressed eye was stimulated. E. Garcia-Austt (Montevideo) reported changes in visual-evoked responses which co-vary with the processing of visual information. The results suggest that the critical determinant of the waveform of a visual-evoked response is the attitude of the subject toward the stimuli presented. W. G. Walter (Bristol) asked whether attention can be defined physiologically. The results of evoked-response recording from multiple electrodes implanted on the human cortex in the frontal area suggests that this supposedly nonspecific area of the brain is an integral part of the sensory system that receives signals in all modalities and produces many evoked-response patterns to incoming signals. Even closely adjacent points on the cortex show markedly different evoked-response waveforms and individual specificity to different stimulus parameters.

E. C. Beck (Salt Lake City) reviewed experiments on the function of the reticular activating system in the acquisition of conditioned responses. Abrupt, acute interruption of the function of this system disrupts a conditioned response in the behaving animal. However, if the animal is subjected to long-term deprivation of the reticular system conditioned responses can still be acquired. Resolution of this seeming paradox may lie in the dynamic nature of brain function which permits the development and utilization of auxiliary functional systems. Another series of experiments was designed to test the possibility that the reticular system's role in attention is to stabilize selectively the ongoing electrical activity in certain areas of the brain thereby improving the signal-to-noise ratio and facilitating sensory perception. By a final series of experiments, changes in human evoked responses were investigated during changes in attentiveness, and the apparent importance of the right parietal area to the neurophysiology of attention was indicated. W. Goff (West Haven) evaluated the concept of attention in evoked-response studies. He reviewed selected recent experiments and suggested the implication of the results for methodology and concepts in future attention experiments. Recent evidence suggesting the necessity for revision of previous theories as to the neural pathways mediating the late components of evoked responses, which are most often studies in attention experiments, was described.

The work of the Bristol group on the contingent negative variation (CNV) in normal children, adults, and psychiatric patients was reviewed by C. McCallum. He concluded that various distractions reduce the CNV, and that this reduction was related to the degree of attention focused on the distracting stimuli.

C. Lombroso (Boston) raised questions concerning the hypotheses that the CNV (i) is coincidental with psychological and behavioral processes; (ii) forms an integral part of the bioelectric activity of the underlying cortex; and (iii) measurement may provide information on the functional state of the cortex. Lombroso's results were not consistent with the hypothesis that the CNV reflects a cortical "priming" in frontal cortex for discharge of motor neurons.

In a discussion of the habituation of response from single cells in brain and behavioral reactions, G. Horn (Cambridge) speculated that some of these may function as novelty detectors, exerting an influence on command systems underlying perceptual and behavioral activity. With reference to the elevation of visual threshold occurring in conjunction with all saccadic eye movements, L. Stark (Chicago) postulated that saccadic suppression is a functionless consequence of the recomputation of the visual frame of reference initiated by a saccadic anticipatory signal sent to the visual control system by a brain-stem controller for eye movements. R. Jung and J. Dichgans (Freiburg) discussed optokinetic nystagmus in relation to attention and the constancy of space perception during the rapid phase of optokinetic nystagmus.

Reporting on experimental research on neurochemical mediation of neural processes related to sleep and waking, H. H. Jasper (Montreal) concluded that significant changes do occur in the chemistry of the cerebral cortex during different states of behavioral responsiveness in sleep and wakefulness, and that similar changes might occur, though perhaps more localized during the process of focal vigilance called attention or attentive behavior.

The late R. Hernandez-Peon (Mexico City) provided the conference with neurophysiological and evolutionary models of attention, concluding that attention has a superreptilian origin, evolving in birds and reaching higher development in mammals; in *Homo sapiens* it reaches a glorified culmination.

A relation of attention and arousal to cardiac function was shown by I. Ruttkay-Nedecky (Bratislava), who pointed out that though there is evidence for a reflex facilitation of sensory intake during attention arousal via central and peripheral threshold variations, autonomic changes occurring much later seem to be instrumental in preparing the subject for action, following as a consequence of sensory intake. He also supported the idea that the conceptualization of the orienting reaction should be in terms of the probability of occurrence of its components.

H. P. Koepchen (Munich) warned against oversimplified identification of brainstem neurons. He showed that criteria for discriminating between these classes of neurons are not sufficient. The multisensory connections commonly ascribed to neurons of the unspecific activating brainstem system also exist in neurons responding to the respiratory and circulatory changes and vice versa.

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