cortisone-treated animals can at the present time be only a matter of conjecture.

HENRY GROSSFELD
*Departments of Medicine and Orthopedic Surgery, College of Physicians and Surgeons, Columbia University, and Edward Daniels Faulkner Arthritis Clinic, Presbyterian Hospital, New York*

### References and Notes

1. H. Grossfeld and C. Ragan, *Proc. Soc. Exptl. Biol. Med.* 86, 63 (1954); G. Lenti *et al.*, *Folia Endocrinol.* (*Pisa*) 4, 743 (1956).
2. This work was supported in part by grants A-21 and A-817 from the U.S. Public Health Service to the College of Physicians and Surgeons, Columbia University. I thank John V. Taggart and LaRoy S. Dietrich for very helpful advice.
3. K. K. Sanford *et al.*, *J. Natl. Cancer Inst.* 11, 4, 773 (1951).
4. W. W. Umbreit, R. H. Burris, J. F. Stauffer, *Manometric Techniques and Tissue Metabolism* (Burgess, Minneapolis, Minn., 1951).
5. M. Woods, J. Hunter, D. Burk, *J. Natl. Cancer Inst.* 16, 351 (1955).

11 October 1957

## Effects of Stimulation of Brain Stem on Tachistoscopic Perception

This report concerns part of a study (*1*) conducted on rhesus monkeys to investigate the effects of electrical stimulation of different sites in the brain on tachistoscopic perception.

For this investigation the animals were first trained to discriminate between stereometric objects presented in pairs, by placing food reward under one of the objects of each pair. After this preliminary training without restriction of exposure duration, each animal was subjected to several series of trials at different exposures; the number of correct responses was noted, and the reaction time was automatically measured. The testing apparatus was a modification of that used by Harlow, which for our purposes was transformed into a tachistoscope (Fig. 1). Its main feature was an argon-mercury bulb which was used to flash briefly a light of controllable duration and constant intensity upon the objects. The pairs of white objects (for example, a cone and a 12-sided pyramid of similar proportions) were placed in a dark field in front of the animal. A brief acoustic signal preceded by 2 seconds the illumination of the objects; this signal was in no case concomitant with the visual stimulus. Selection of the correct member of each pair was always followed by a food reward. The position of the correct member was changed randomly from trial to trial.

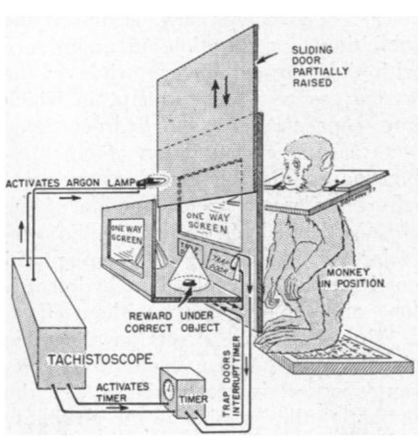


Fig. 1. Testing apparatus for visual discrimination. The monkey is shown in one of the plastic collars (schematically represented) by which the animals were permanently held to protect the electrode mount from their hands and to restrict them partially for performing the experimental task.

Electrodes were implanted in the animals' brains so that the effects of electrical stimulation could be studied. To date, six animals have been used in the investigation. The electrode placements were histologically verified. As a rule, currents were always used that did not cause any apparent effect on the normal behavior of the awake animal, regardless of the placement of the electrodes. A biphasic square wave current, of 300 cy/sec and intensities between 100 and 300 μa, was used as a norm. Each animal was used as its own control. In the experimental series, the electrical stimulation was applied during each trial period, starting 2 seconds in advance of the flash and persisting until the animal had made its choice.

Stimulation of the core of the brain stem at the level of the mesencephalon consistently increased the animals' efficiency at discrimination, as indicated by significantly higher percentages of correct responses and shorter reaction times as compared with the controls (Fig. 2). Stimulation through the same electrodes with intensities higher than the threshold for the elicitation of observable motor effects, such as generalized muscular jerks (startle reaction), eye movements, pupillary oscillations, vocalization, and so forth, had a deleterious effect on the performance of the animals, as indicated by the diminution of correct responses at all exposure durations and prolongation of reaction time. These effects were consistent and reproducible from animal to animal.

The same areas which upon mild stimulation facilitated tachistoscopic discrimination have previously been shown to evoke electroencephalographic and behavioral arousal in the sleeping or relaxed animal (*2, 3*). These areas are in the rostral part of the brain stem activating system, which is mostly composed of the reticular formation of the midbrain tegmentum. Evoked potentials of long latency to sensory stimuli are also picked up in these areas (*4*). This was verified in the present investigation, by using the same electrodes for recording.

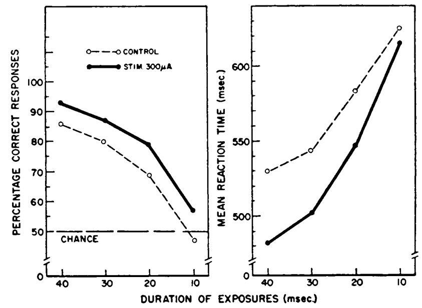


Fig. 2. Effects of stimulation of the brain stem on tachistoscopic discrimination. Each plotted point is based on 100 trials.

Both perceptual and motor processes involved in tachistoscopic discrimination appear to be facilitated by stimulation of the reticular activating system. It is difficult to determine whether the effects on reaction time are a direct consequence of the facilitatory effect on perception or independent of it. However, it seems likely that the reticular facilitation is primarily upon "central integrative time," rather than upon peripheral transmission time.

These findings give support to the hypothesis that the reticular activating system, whose primary role has been demonstrated to be that of central mediator for the achievement and maintenance of wakefulness by means of activation of the cortex, extends its function to the alert state as a further manifestation of the same physiological role, subserving basic attentive behavior. Its different degrees of excitation underlie the gradation of this function from deep sleep to extreme alertness. Excitation of this brain stem system induces general activity of the cortex (arousal), presumably facilitating its receptivity to the sensory impulses ascending over the classic sensory paths. The facilitation of tachistoscopic discrimination by electrical stimulation of the same system may be considered as an example of such an effect on visual perception.

JOAQUIN M. FUSTER*
*Department of Psychiatry, School of Medicine, University of California, Los Angeles*

### References and Notes

1. This work was aided by grants from the following sources: Carnegie Corporation of New York; Office of Naval Research contract NR-144-102, Nonr 233(32); U.S. Public Health Service, grant B-611; Ford Foundation. I am especially indebted, also, to Robert B. Livingston, H. W. Magoun, Donald B. Lindsley, and K. F. Killam for their help and advice throughout the course of this investigation.
2. G. Moruzzi and H. W. Magoun, *Electroencephalog. and Clin. Neurophysiol.* 1, 455 (1949).
3. J. P. Segundo, R. Arana, J. D. French, *J. Neurosurg.* 6, 601 (1955).
4. J. D. French, M. Verzeano, H. W. Magoun, *A.M.A. Arch. Neurol. Psychiat.* 69, 505 (1953).
* Del Amo fellow.

25 November 1957