ultraviolet light. No counts were made, but we have the impression that neutrophils from positive skin reactors had a greater affinity for the antigen than the neutrophils from negative reactors (*5*).

Neither neutrophils nor lymphocytes from cord blood showed affinity for the antigen. This suggests the possibility that the polymorphonuclear neutrophil, as well as the lymphocyte, may in some way take part in the response to tuberculin skin testing.

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Bilateral Differences in the Human Occipital Electroencephalogram with Unilateral Photic Driving

Abstract. *Differential activity was induced in the electroencephalograms of the occipital lobes by limiting intermittent photic stimulation to the right or left halves of the two retinas. The results indicate that the driving of one hemisphere also affects the opposite hemisphere and that the amount and pattern of the effect is determined by the hemisphere being directly stimulated.*

Lindsley (*1*) was the first to suggest an independence of the alpha activity of the two hemispheres. Regions of synchronous, in phase, activity in the resting state were interpreted as reflecting a focus of alpha activity. Lindsley found eight such foci, two in each occipital area, one in each parietal area, and one in each temporal area of the two hemispheres. Because he found differences in the frequencies of the foci, the independent variation of their patterns and magnitudes, and blocking in one region and not in others, Lindsley concluded that the origins of the alpha waves were independent in these bilaterally homologous areas of the brain.

Sperry (*2*) and Myers (*3*) have been more directly concerned with independent functioning of the two hemispheres. Myers found that animals with optic chiasms sectioned in the midline performed discriminations learned with one eye equally well with input to the other eye. In other words, with a lateralized input, the information or engram is presumably laid down in both hemispheres of the animal if the corpus callosum is intact. Thus, the higher functions such as learning and memory do not occur in one hemisphere independently of the other.

The independent action of Lindsley was based upon observations of the human electroencephalogram (EEG) in the passive normal resting state. The dependent action of the two hemispheres found by Myers and Sperry was based on operated animals actively engaged in learning and transfer. Although the two studies are not directly comparable, they do suggest an interesting set of questions. Can differential activity be stimulus-induced in the two hemispheres of the intact human by driving the electrical activity of one hemisphere with intermittent light while the other hemisphere remains unstimulated? If this differential electrical activity is achieved, do both hemispheres show stimulus following or does only the hemisphere stimulated? If, as inferred from the work of Lindsley and Myers and Sperry, active hemispheres act dependently upon each other, while passive resting hemispheres are independent of each other, what would happen to the independence of the resting hemisphere if the other were made active through the use of photic stimulation?

In an investigation of these questions, subjects were exposed to a stroboscopic light (*4*), flashing at a rate of 8 flashes per second through the translucent portion of a pair of goggles, specially designed to achieve differential stimulation. The goggles were made out of halves of table-tennis balls, cut to fit snuggly over each eye socket. They were nearly equidistant from the pupil at all points. Slightly more than half of each eyepiece was painted inside and out with a flat black paint. Thus, either the temporal or the nasal hemiretinas could be shielded from light exposure, depending upon where the painted side was placed. A small fixation hole was drilled 4 mm inside the opaque portion and a "grain-of-wheat" light bulb was cemented over the hole so that the subject would have a constant fixation point. The outside of the bulb was painted black to prevent a field lighting of the translucent portion. With the subject gazing at the fixation point, intermittent photic stimulation through the translucent portion of the goggles fell onto the retina in a wide arc from the peripheral limit of the retina to a point about 19° short of the fovea. Thus, with the translucent portion of the goggles toward the subject's right, the stroboscope persumably stimulates the left hemiretinas and is "reported" on the left occipital lobe.

The EEG's of four subjects were recorded (*4*) from two bipolar scalp parieto-occipital pairs of leads. Eye movements were recorded on a third channel in order to monitor fixation. The signals from the three channels were simultaneously recorded on magnetic tape (*4*), from which representative 10-second epochs were selected on the basis of good fixation. The analysis of the taped EEG epochs was by means of a type of baseline crossover system sometimes called the zero-crossing technique. Thus, EEG potentials were analyzed in terms of their wavelength, wave by wave, by means of an electronic tachometer circuit arranged to trigger as the wave crossed the zero voltage point in the positive direction. The height of a zero-crossing readout was directly proportional to the wavelength and therefore inversely proportional to the frequency. A count was subsequently made of the number of waves having a wavelength in a class interval between 7.5 and 8.5 cy/sec, since an 8-flashes-per-second stimulus was the driving frequency.

Three conditions of stimulation were investigated. The unstimulated condition, (I), was a control condition in which the subject was resting with his eyes open, wearing unpainted goggles, and in the presence of a steady, full-field light source. Since the frequencies of the EEG in the two hemispheres may differ within a given subject in the resting state, the difference in the amount of 8-cy/sec waves may then be used as a correction factor for the subsequent driving conditions at that frequency. In another control condition (II), the stimulated condition, the entire visual field was stimulated at 8 flashes per second while the subject wore the unpainted goggles. The experimental or differential driving condition, (III), consisted of driving one or the other hemisphere at 8 flashes per second while the subject wore the half-opaque goggles. For all subjects the first day was concerned only with the stimulated condition (II). On each of the remaining two days the unstimulated condition (I) was presented first. This was followed by a counterbalanced presentation of the right and left differential driving conditions (III).

The results of the control conditions (I and II) are summarized in Fig. 1. When the subject is resting with his eyes open, a treatment-by-subjects analysis of variance (*5*) showed there is a significantly greater ($p < .05$) number of 8-cy/sec waves in the right hemisphere than in the left on the first day, the second day, and both days of experimentation combined. The number of 8-cy/sec waves in the left and right hemispheres does not differ significantly when the entire visual field is stimulated with the stroboscope flashing at 8 flashes per second. The obviously greater number of 8-cy/sec waves in the stimulated condition than in the unstimulated condition indicates that photic driving had occurred when the two hemiretinas were equally stimulated at 8 flashes per second.

The raw data for the differential driving condition (III) are shown in Fig. 2. It should be noted that driving, shown by 1½ to 2½ times the amount of 8-cy/sec activity in the normal resting state, is present in both hemispheres though only one is being stimulated. Multiple comparisons by use of Duncan's Multiple Range test (*5*) gave confirmation that when the right hemisphere is driven at 8 flashes per second there are significantly more ($p < .05$) 8-cy/sec waves in the right hemisphere than in the left. Paradoxically, when the left hemisphere is driven there are also significantly more ($p < .05$) 8-cy/sec waves in the right hemisphere. The difference between the number of 8-cy/sec waves in the two hemispheres is greater for every subject when the right hemisphere is stimulated than the difference between the two when the left hemisphere is stimulated. A subsequent *t*-test for correlated means (*6*) showed that the values of the differences under these two conditions differed significantly ($p < .01$). It was felt that these

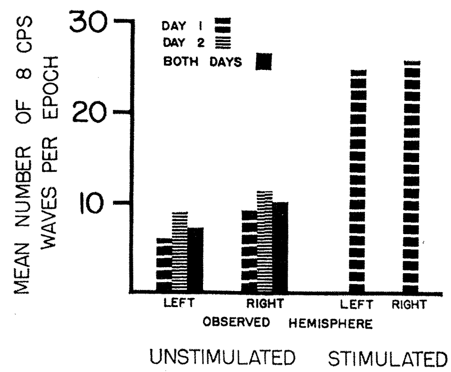

Fig. 1. Conditions I and II: mean numbers of 8-cy/sec waves from six selected 10-second epochs in the two hemispheres under unstimulated and full-field stimulated conditions.

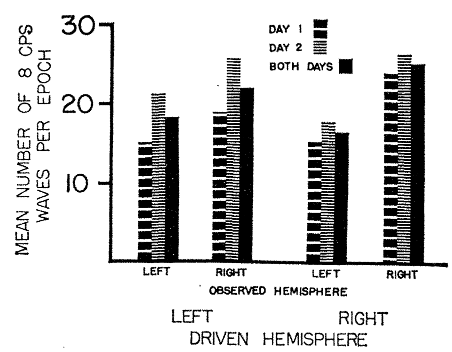

Fig. 2. Condition III: mean number of 8-cy/sec waves from six selected 10-second epochs present in each hemisphere for the two differential conditions of stimulation.

unusual results could be due either to differences in frequency in the normal resting state of the two hemispheres or to those differences occurring as a result of an asymmetry when the whole field is stimulated. However, exactly the same pattern of 8-cy/sec activity was found when the data were adjusted by (i) linear subtraction for unstimulated hemispheric differences (I), and (ii) whole-field stimulated conditions (II). Two subjects were run at a stimulation frequency of 12 flashes per second to check whether the phenomenon was only specific to frequencies below that of the normal resting state. Data collected at this stimulation frequency likewise indicate a pattern similar to that for the 8-flashes-per-second data, as far as direction is concerned. However, no adequate statistical test could be performed to confirm the significance of these results on such a small number of subjects.

Thus, we see that differential activity did occur. There were significant differences in the two hemispheres during differential stimulation not occurring during the stimulated condition (II). Nevertheless, electrical activity in one hemisphere was not independent of the activity in the other, since both hemispheres showed photic driving though only one was stimulated.

The anatomical connections from the left hemiretinas lead one to assume that nerve impulses initiated here will terminate upon the occipital cortex of the left hemisphere. Uncontaminated one-sided hemispheric input was not expected, because of possible light spread in the eye and neural communication between the two sides within the retinas and all along the visual pathways. On the other hand, it was assumed that the technique employed would result in a substantial hemispheric input differential.

There is no known anatomical or physiological differential between the two hemispheres which can account for the fact that the right hemisphere always showed greater following no matter which hemisphere had been stimulated. Likewise, the EEG frequency differences which normally occur between the two hemispheres in the resting state (I) and the whole-field stimulated state (II) cannot account for this surprising finding, since significant differences were still present even though these differences are used to adjust the data. The greater following of the right hemisphere or the lack of symmetry of the unilateral driving effect suggests a classical dominance interpretation. The ad hoc fact that all subjects were right-handed gives some weight to this proposition (*7*).

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