molecules (7). Presumably there are units in these molecules which may be represented by α_1 α_1 and β_1 β_1 in chick hemoglobin 1, and α_2 α_2 and β_2 β_2 in chick hemoglobin 2. Since only three components are detected electrophoretically, it seems that either $\alpha_1\alpha_1$- and $\alpha_2\alpha_2$-, or $\beta_1\beta_1$- and $\beta_2\beta_2$-units of polypeptide chains are identical. One may wonder, however, whether these dissociations and recombinations are possible in the animal system. Results obtained on the in vitro and in vivo biosyntheses of chick hemoglobins suggest the possibility of the transfer of one of the subunits from one of the hemoglobins to the other. On the other hand, the rate of production of these three subunits may be genetically so controlled that they lead to results like those demonstrated here. However, mutations in any one of these genes would give rise to numerous hemoglobins in the avian species which have been experimentally observed earlier (1, 8, 9).

ANIL SAHA*
Department of Applied Chemistry, University of Calcutta, India
JHARNA GHOSH
Institute of Biochemistry, University of Uppsala, Sweden

References and Notes

1. A. Saha, R. Dutta, J. Ghosh, *Science* **125**, 447 (1957).
2. A. Saha, *Science and Culture, Calcutta* **21**, 756 (1956).
3. A. Saha, *Indian J. Physiol. and Allied Sci.* **10**, 87 (1956).
4. H. Borsook, "Conference on Hemoglobin," *Publ. 557, National Academy of Sciences–National Research Council* (1958), p. 111.
5. H. J. van der Helm and T. H. J. Huisman, *Science* **127**, 762 (1958).
6. H. A. Itano and S. J. Singer, *Proc. Natl. Acad. Sci. U.S.* **45**, 174 (1959).
7. A. Saha, *Indian Council of Med. Research, Tech. Rept.* p. 286 (1954).
8. R. Datta, J. Ghosh, B. C. Guha, *Nature* **181**, 1204 (1958); J. Ghosh, in preparation.
9. We are grateful to Prof. B. C. Guha and Prof. A. Tiselius for their kind interest.
* Present address: California Institute of Technology, Pasadena.

8 July 1960

Simultaneous Study of Behavior and Brain Waves

Abstract. A technique for the simultaneous audiovisual recording of behavior and brain waves is described. The absence of muscle movement artifact, despite unlimited activity of the patient, suggests that telemetering may be adaptable for routine electroencephalography.

This preliminary report describes our development of an audiovisual technique for the simultaneous study of a patient's behavior and electroencephalogram (EEG).

In the Children's Service of the Langley Porter Neuropsychiatric Institute, where research is primarily concerned with defining the etiologic role of experiential factors in childhood schizophrenia (1), the possible contribution of any organic factor in all children seen is studied with all the facilities and skills available, since the differentiation between schizophrenic children and emotionally disturbed children with mental deficiency or organic brain disease may be initially difficult. We occasionally find EEG dysrhythmias in children of varied diagnoses without any historical or clinical evidence of a convulsive disorder. For such cases we were particularly interested in devising a technique for the more precise study of the correlation, if any, between behavior and dysrhythmias.

In 1951 Berlin and Yeager (2) noted that the level of emotional tension in epileptic children may be correlated with the frequency and severity of seizures as well as the degree of EEG dysrhythmia and, in 1956, Yeager and Guerrant (3) reported that a patient's performance, as measured by finger tapping, was altered sometimes during a paroxysmal burst on the electroencephalogram without any other apparent clinical evidence suggesting seizure activity.

In 1958 (4), a transistorized telemeter about the size of a "king-size" package of cigarettes was developed by the Research and Development Laboratory of the University of California Medical Center, San Francisco. The telemeter shown in operation on a child in Fig. 1 uses a circuit, previously described in detail (4), which consists of a four-stage transistor amplifier, a reactance modulator, and a 30-Mcy/sec oscillator which produces signals frequency-modulated by the patient's scalp voltages. The brain waves may be telemetered to an antenna within a radius of 40 feet and then coupled by a frequency-modulated receiver to a conventional electroencephalograph. Either needle or disk scalp electrodes may be used. Thus a trace can be made while the child, unencumbered by leads, is able to move about freely.

Preliminary trials with the telemeter produced traces *with a surprising absence of muscle movement artifact* (Fig. 1 includes such a trace). We then considered how a 16 mm motion picture camera might be utilized to photograph the child and the telemetered electroencephalogram on the same film.

With a motor-driven 16 mm camera with masks behind the lens which allowed exposure of either two-thirds or one-third of each film frame, we photographed the child, notching the film at a landmark in the camera before starting the motor. The instant the camera motor was started the EEG trace was marked. The upper third of

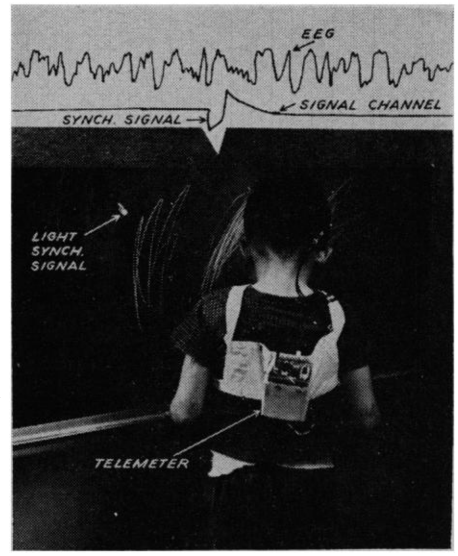

Fig. 1. Effect achieved in a frame of the motion picture film. The composite photograph was prepared because of technical difficulties involved in enlarging directly from the film.

the film was masked for this first exposure.

After 100 feet of film were exposed without interruption, the film was rewound in a darkroom, replaced in the camera, and the notch in the film was aligned with the same landmark as before. The EEG trace was also rewound to the mark made when the camera motor was started, and the lens mask was changed to expose the remaining third of each film frame. The camera and EEG motors were then started simultaneously.

Although our first film was satisfactory photographically, we had no demonstrable proof that synchronization of the child's behavior and the electroencephalogram was either initially correct or was maintained.

We then decided to use a sound camera and a system to check synchronization.

Using this system, we modulated the electroenecephalogram into an audible frequency directly recorded on the sound track at the first filming. We also devised a signal system in which pressing a button flashed a light on the wall of the playroom, produced an audible click in the modulated electroencephalogram, and marked the EEG trace on a second channel. This signal was triggered by one of us each time a paroxysmal burst occurred on the electroencephalogram (a frequent occurrence with the patient studied, who manifested a hypsarhythmic record).

Our technique of marking the film and the electroencephalogram, masking the film and rewinding it and the EEG trace after the initial exposure, and then rephotographing the trace was otherwise unchanged.

Synchronization was insured on the projected film if the light flashed when a portion of film exposed at the first run coincided with the mark on the EEG trace exposed after the film was rewound and the mask changed. Figure 1 illustrates the appearance of the movie during a synchronization check. By this technique, synchronization was maintained throughout 1200 feet of film.

A telemetering system may be adaptable for routine electroencephalography because of the absence of muscle movement artifact despite the patient's unrestricted activity. We are currently developing a miniaturization of the telemeter and increasing the channels to achieve such a system.

ALFRED J. GIANASCOL
CHARLES L. YEAGER

Langley Porter Neuropsychiatric Institute and *University of California School of Medicine, Psychiatry, San Francisco*

References

1. S. A. Szurek and I. N. Berlin, *Psychiatry* **10**, 1 (1956).
2. I. N. Berlin and C. L. Yeager, *A.M.A. J. Diseases Children* **81**, 664 (1951).
3. C. L. Yeager and J. S. Guerrant, *Calif. Med.* **86**, 242 (1957).
4. R. W. Vreeland, L. A. Williams, C. L. Yeager, J. Henderson, Jr., *Electronics* **31**, 86 (1958).

20 May 1960

Relating a Component of Physiological Nystagmus to Visual Display

Abstract. A transactional position suggests the hypothesis that there should be changes in the fine eye movements of a fixating subject if the fixated visual display is altered. It is shown that the mean saccadic eye movements are unequivocally different with different positions of the stimulus within the visual field.

This report resulted from interest in the transactional concepts of perception elaborated by Mead (*1*) and Dewey (*2*) wherein an alteration of the receptor by a motor or centrifugal component of the perceptual act is an implicit necessity. These concepts are the equivalent of saying that at any given instant in the perceptual act the perceptual system has used the data taken in so as to be able to change the state of the receptor suitably for taking in the next increment of data. This implies that if the stimulus changes then the cumulative centrifugal actions taken would change. Livingston (*3*) has recently presented the evidence for centrifugal control mechanisms in the optic nerve, the auditory nerve, the olfactory bulb, and the stretch receptors, but no attempt has yet been made to study the involuntary fine eye movements of fixation (physiological nystagmus) with transactionally derived hypotheses.

If the fine eye movements were part of a centrifugal control process it should follow that they would not occur at random but would be determined in some manner related to the visual stimulus. The operational hypothesis derived was that if the position of the stimulus within the visual display were changed then the saccadic component of the fine eye movements would change.

The fixation eye movements (physiological nystagmus) of a subject (myself) were measured photoelectrically from light reflected by a small mirror mounted on a tight-fitting scleral contact lens worn by the subject while his head was immobilized on a bite board. The apparatus (*4*) and its use were similar to that described by Nachmias (*5*) but differed in that the change in amount of light incident on a photoelectric tube was recorded on a polygraph instead of the movement of a light beam being recorded photographically. The apparatus was sensitive to less than a minute of arc of eye movement. Both the horizontal and vertical components of the eye movements were recorded, and, since the mirror mounted on the contact lens was normal to the visual axis, the torsional eye movements and most head movements were canceled out. Separate runs were made under the four different conditions of having the visual stimulus (Fig. 1) in each of the four visual quadrants, designated clockwise as shown, while the other three quadrants were empty. The display was projected from a slide projector on a white background to cover 14 degrees of visual angle horizontally and vertically, 48 inches from the subject's eye. The runs lasted 45 seconds each and contained an average of 39 saccades (flicks, or small rapid eye movements of a range of 1 to 30 minutes of arc magnitude). There were 20 runs, 5 for each quadrant.

Each saccade was measured horizontally and vertically and a mean saccade was calculated for each run by adding all of the saccadic vectors algebraically and dividing by the number of saccades. Figure 2 shows the distribution of the mean saccades under the four conditions. As can be seen, there is a striking separation of the four groups with only one area of overlap, that between the mean saccades of quadrants 1 and 2. If the grand mean of all mean saccades is taken arbitrarily as a zero point, it can also be seen that there is a tendency for the mean saccades to be in a quadrant diametrically opposite to that of the stimulus.

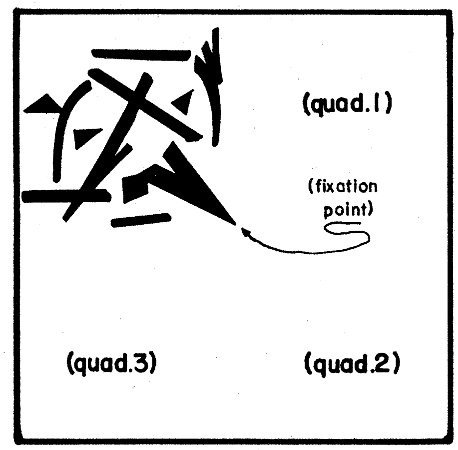

Fig. 1. The visual display. The stimulus is in quadrant 4 in this diagram. The fixation point is always at the center of the field.

Cornsweet (*6*) has postulated that the function of saccades is to recenter the eye after a random drift which results from the instability of the oculomotor system. Nachmias (*5*) has felt his work consistent with Cornsweet's hypothesis. It now seems justified to go considerably further and suspect that saccades are part of a central ocular control mechanism which functions in a determined manner related to the nature of the stimulus. When this hypothesis is combined with the observations of Ditchburn *et al.* (*7*) and Riggs *et al.* (*8*), which show that perception is affected by eye movements,

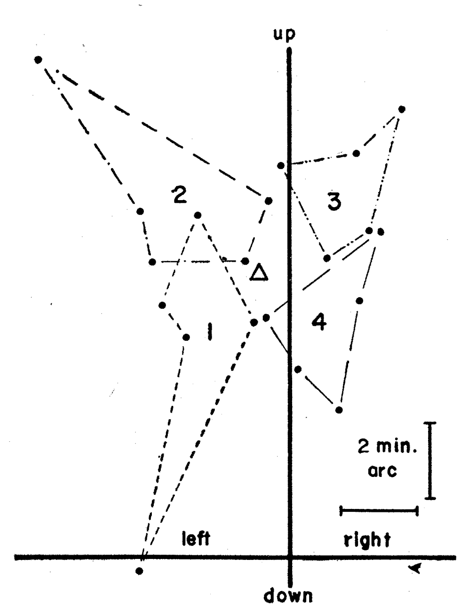

Fig. 2. Distribution of the mean saccades of the four positions. Dotted lines connect the five mean saccades of the same quadrant. Quadrant indicated by number, grand mean of means by Δ.