convulsed at 90.9 ± 18.7 seconds ($P < .0005$). Furthermore, 65 seconds after the administration of Metrazol, brain ATP in 25 untreated rats, killed before convulsion, was 70.9 ± 16.6 percent of normal values, in contrast to a value of 90.7 ± 12.3 percent observed in 24 rats given prior treatment with succinate ($P < .0005$). Thus, the relation between onset of seizure and ATP concentration in the brain is unaltered under these conditions. These data support the proposal that decreased brain ATP concentrations precede the onset of convulsions.

The fact that the concentration of ATP in the brain decreases before the onset of seizures in these animals does not imply that decreased brain ATP is the cause of seizures. It does imply that decreased ATP in the brain is a common denominator in various seizure states. Numerous metabolic derangements induced by convulsant drugs might be expressed as a depletion of cerebral ATP. Any agent that markedly interferes with the substrate supply, major enzyme systems, cofactors, and the electron transport chain (the major source of ATP production under aerobic conditions), or that grossly stimulates hydrolysis of ATP by way of increased adenosine triphosphatase activity, could lead to decreased ATP concentrations in the brain. Various convulsive agents decrease nicotinamide-adenine dinucleotide (*10*) (essential for 9/11 of ATP production in aerobic metabolism); inhibit glutamic decarboxylase (*11*) and γ-aminobutyric acid transaminase (*12*), both of which have been implicated as critical enzyme systems in providing essential substrate for ATP production under conditions of stress (*9*); and stimulate membrane adenosine triphosphatase activated by sodium and potassium ions (*13*). These observations support the hypothesis that decreased ATP concentration precedes and perhaps contributes to the onset of convulsions.

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Electrophysiological Evidence for Binocular Disparity Detectors in Human Visual System

Abstract. *Evoked potentials have been recorded from humans in response to two moving gratings presented stereoscopically to both eyes. The amplitude of the evoked potential is greater when the two gratings have slightly different spatial frequencies, which produces an apparent inclination of the binocularly fused image. The amplitude of the response is correlated with the degree of the perceived inclination.*

Binocular vision is a mechanism for depth perception. The stimulus for the stereoscopic experience of depth is the geometrical disparity between the images, in the two eyes, of objects located at different distances from the observer. Neurons have recently been found in the cat visual cortex which are mostly activated when the two eyes are stimulated by equal stimuli in two noncorresponding areas of their retinas (*1*). These neurons have been interpreted to be responsible for binocular depth perception. We have attempted to correlate the psychophysical findings on binocular depth perception in man with the electrical activity of the brain by recording the visual evoked potentials.

Recently, evoked potentials have been recorded from the human scalp when a moving grating is used as a stimulus (*2*). The response obtained was a rather simple waveform and it originates mainly in the central nervous system. This stimulus is particularly suitable for our purposes, because the parameters of the response can be readily evaluated and because gratings of different spatial frequencies presented stereoscopically to the two eyes supply a convenient pattern to generate binocular depth perception.

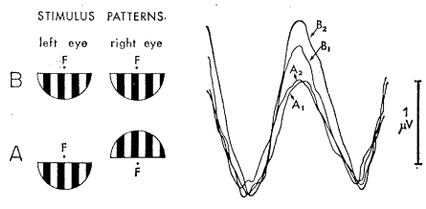


Fig. 1. Average evoked responses from the occipital area of scalp. One electrode was positioned just above the inion; the other was displaced 6 cm to the left. The responses A_1 and A_2 were recorded with two square-wave gratings that were not binocularly superimposed (A). For A_1 the two gratings had the same spatial frequency (1.33 cycle/deg); for A_2 the two spatial frequencies were 1.33 (right eye) and 1.60 cycle/deg (left eye). The responses B_1 and B_2 were recorded with two gratings that appeared binocularly superimposed (B) and had spatial frequencies as for A_1 and A_2, respectively. The gratings were semicircular with a diameter of 5.5 deg. In the schemes *F* indicates the fixation point. The contrast of the gratings was about 1.5 log units above threshold.

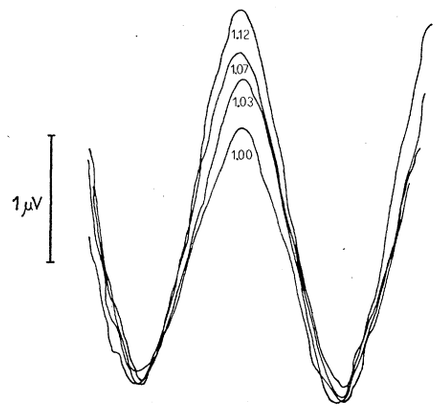
Fig. 2. Average evoked responses recorded as for Fig. 1. The stimulus patterns were two circular square-wave gratings 5.5 deg in diameter, which were binocularly superimposed. The spatial frequency of the right-eye grating was 1.33 cycle/deg. The spatial frequency of the left-eye grating had four different values. The ratios of the two frequencies are indicated in the figure. The contrast of the gratings was about 1.5 log units above threshold.

Gratings, consisting of vertical bars, were electronically generated on two equal oscilloscopes viewed stereoscopically by the subject, from a distance of 75 cm. The luminance varied along the horizontal direction either sinusoidally or as a square wave. This pattern was then shifted in phase through 180 deg at a temporal frequency of 8 cycle/sec. In this way the light flux entering the eye remained constant. Such a moving pattern evoked potentials that may be recorded from the occipital area of the scalp (Figs. 1 and 2).

When the spatial frequencies of the two gratings were equal, a single grating was perceived stereoscopically which appeared to lie in a frontal plane. If the spatial frequency of one grating was slightly different from the other, the fused binocular image appeared to be inclined, with the left side closer to the subject and the right side farther, or conversely, according to whether the grating seen by the left eye had the higher or the lower spatial frequency (*3*). The apparent inclination of the grating increases with the difference in frequency up to a maximum that for the conditions of our experiment occurred when one frequency was about 12 percent greater than the other.

The records presented in Figs. 1 and 2 are each the average of 1000 responses. The first set of evoked potentials (Fig. 1A) was obtained with two gratings, which were not superimposed, with equal (Fig. 1, A_1) or different (Fig. 1, A_2) spatial frequencies. The second set was obtained with two gratings which appeared binocularly superimposed, again with either equal (Fig. 1, B_1) or different (Fig. 1, B_2) spatial frequencies. The difference in spatial frequency was such that the grating perceived under the latter condition appeared with the greatest inclination.

The first set of responses (Fig. 1, A_1 and A_2) have approximately the same amplitude but are both considerably smaller than the responses of the



second set (Fig. 1, B_1 and B_2). Furthermore, the response B_1, obtained with gratings of equal spatial frequency, is appreciably smaller than the response B_2 obtained with gratings of different spatial frequencies. The difference in amplitude between B_1 and B_2 has been repeatedly verified at different average spatial frequencies in 21 experiments. The average amplitude of B_2 is 1.3 times greater than that of B_1, with a standard deviation of 0.2.

The responses presented in Fig. 2 have been obtained with two binocularly superimposed gratings for a constant spatial frequency in one eye (1.33 cycle/deg) and various spatial frequencies in the other eye. The amplitude of the responses increases as the difference in frequency increases from 0 to 12 percent; this corresponds to the increasing apparent inclination of the binocular pattern. For differences in frequency above 25 percent, at which no tilt of the pattern is any longer perceived, the amplitude of the evoked potential seems to remain constant or to decrease.

Clearly, it is only when the visual neurons are stimulated binocularly that a difference in the spatial frequency of the two monocular patterns, such as to produce depth perception, brings about a consistent increase in the amplitude of the response. This fact is in agreement with the electrophysiological findings in the cat visual cortex, where most of the neurons that are binocularly driven present the highest firing frequency when the two monocular stimuli are disparate (*4*).

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Cognitive Model of Problem-Solving in Chess

Abstract. *By performing a series of five experiments with two subjects, several aspects of one of the subject's behavior in solving chess problems were found to be predictable, and a model was developed to explain this predictability. The heuristics used in this model may be applicable in developing future computer programs for chess play.*

Newell and Simon (*1*) have developed a methodology for analyzing the cognitive processes of a human chess player. By inducing a subject to "think out loud" while he is deciding on a chess move, a protocol of the subject's thinking, as he explores alternative moves, can be obtained. This protocol can then be analyzed into a number of episodes or sequences of moves and possible countermoves generated from an initial or base move postulated by the player. It is then possible to draw out from these episode sequences a decision tree or trees—such as are discussed in descriptions of Bayesian statistics—stemming from an initial base move (or moves) and comprising all the possible moves by the player and countermoves by the opponent considered by the player. The aim of this enterprise is to understand an individual's cognitive processes when he is playing chess and to make accurate predictions based on that understanding.

With this methodology, the protocols obtained when a subject analyzed the