Cortical Evoked Potentials and Perception of Paired Flashes

Abstract. *Digital computer techniques have been employed to extract cortical evoked potentials to paired visual stimuli. Changes in the evoked potentials have been related to perceptual phenomena varying as a function of the interval between flashes. Evoked potentials to paired stimuli, which gave rise to perceptual interactions, could be approximated by algebraic summation of the responses to the stimuli when presented separately.*

When a test flash is followed by a brighter, blanking flash, various perceptual changes may be observed, depending upon the stimulus parameters and the interval between flashes. When the interval is very short (0 to 25 msec) the perception of the first flash is interfered with by the second flash (perceptual blanking or masking). If the interval is considerably longer (100 msec or more), two distinct flashes may be seen. In addition, as the interval between flashes is decreased from 100 to 25 msec, there is a gradual increase in apparent brightness (brightness enhancement) of the test flash, which reaches a maximum just before the blanking stage is reached.

The psychophysical aspects of perceptual blanking or masking have been extensively studied in this laboratory (*1*) and elsewhere (*2*). In the work we now report, we studied electrocortical correlates of perceptual blanking and brightness enhancement. Evoked potentials elicited by sensory stimulation and recorded from the scalp of human subjects are minute and are often obscured by other electrical activity. However, since evoked potentials are essentially time-locked to their eliciting stimuli, a time-averaging procedure may be used to estimate their value (*3*).

Electrical potentials were recorded from over the visual area, 1 inch above the inion or occipital protuberance and 1 inch to the right of the midline; the left ear lobe was used as a reference. The potentials were amplified by a Grass model VI electroencephalograph and led to a Sanborn FM tape recorder. Time-averaging was accomplished by a Mnemotron Computer of Average Transients (CAT) with a 1-second epoch and a sampling rate of 400 per second. Each epoch began with presentation of a stimulus, and 100 epochs were used to obtain an average evoked potential. Additional analysis was performed on general-purpose digital computers (*4*).

The light flashes were produced by Sylvania R1131C glow modulator tubes. These light beams were superimposed concentrically and presented in Maxwellian view to the subject's right eye. Luminance was independently controlled by neutral-density filters. The flash duration and delay-time between stimulus onsets was controlled by two Grass S-4 stimulators. Stimulus parameters were monitored with an oscilloscope and an electronic counter.

Both flashes were of 10 msec duration. The test-flash beam was presented through a semicircular limiting stop defining a visual angle of 1°22′ along its diameter, which could be rotated randomly to any of eight different positions. The blanking-flash beam was presented through a circular stop defining a visual angle of 2°6′. The luminance of the test flash was 0.25 mlam, of the blanking flash, 260 mlam.

Subjects fixated four dim red lines converging on the stimulus area and triggered the stimulus combinations arhythmically at a rate of about one each 2 seconds. The perceptual blanking threshold, the point at which the position of the test-flash semicircle was detectable only at a chance level, occurred at delays of approximately 25 msec. Enhancement of test-flash brightness was measured by a direct estimation technique (*5*).

Figure 1 shows for each of four subjects the average evoked potentials generated by 100 test and blanking flashes presented singly. The test flash typically gives a single large negative peak (as well as other earlier and later components) with a latency of about 160 msec, whereas the blanking flash gives two prominent negative peaks with latencies of about 80 and 160 msec. The negative wave of shorter latency is either absent or greatly reduced in the case of the test flash, and preliminary data indicate that this is largely a function of its lower luminance. The pattern and distribution of these responses are similar to those recorded in human subjects by other investigators (*6*) by photic stimulation and averaging methods. The relatively long latency and the absence of a prominent initial surface positive component, as well as the topographic distribution outside the visual area, suggest that we are dealing with "secondary" or "nonspecific" responses rather than primary evoked potentials (*7*). Since the primary visual cortex (area 17) is principally on the mesial surface of the brain, it is probable that any electrode placed on the human scalp over the visual region will be positioned over associative areas 18 or 19 of Brodmann.

The average evoked potentials for subject SY to paired flashes of differing delay intervals are shown in Fig. 2. At delays of 500 or 250 msec between stimulus onsets there is no perceptual interaction and average evoked potentials are differentiated and completely separate. At delays of 100, 60, and 40 msec, the range within which brightness enhancement occurred, the aver-

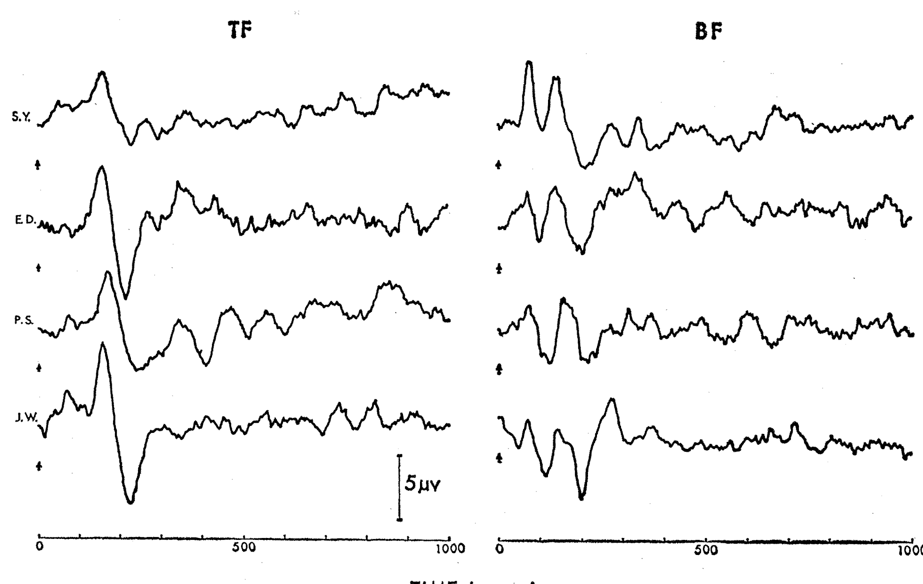

Fig. 1. Average evoked potentials from visual area for each of four subjects. Each average based on 100 stimulations. Test flash (*TF*): semicircle, 0.25 mlam, 10 msec in duration. Blanking flash (*BF*): full-circle, 260 mlam, 10 msec in duration. Arrow indicates onset of flash. Negativity is upward in this and subsequent figures.

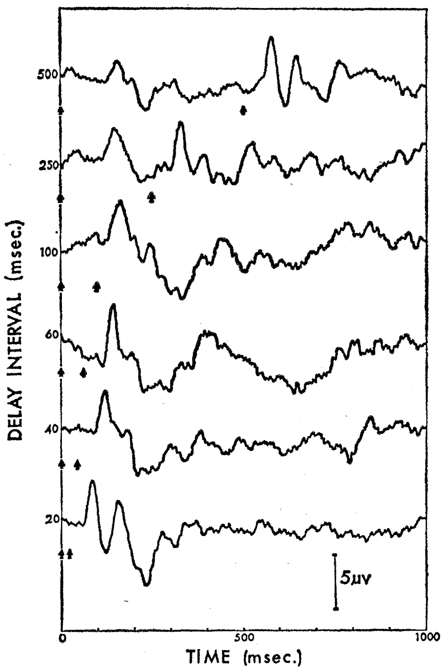

Fig. 2. Average evoked potentials from visual area of subject SY to paired flashes separated by different delay intervals. Onset of first flash indicated by arrow on ordinate, second flash by second arrow; interval of delay between flashes shown on ordinate. Both flashes the same as in Fig. 1.

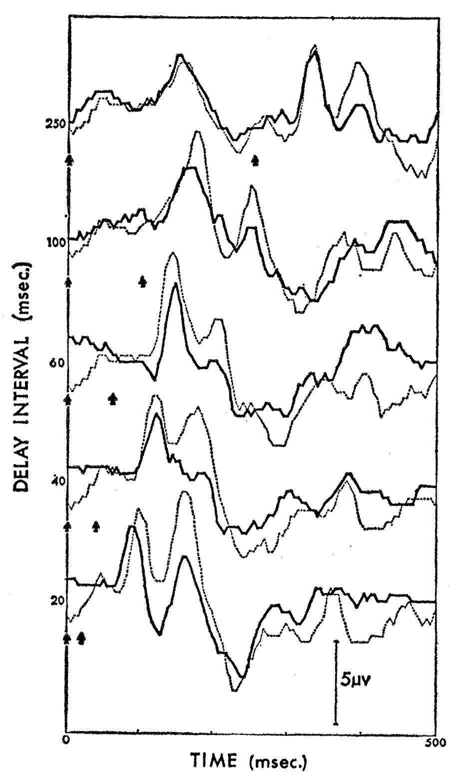

Fig. 3. Comparison of average evoked potentials to paired test and blanking flashes (solid line) and synthesized average evoked potentials for test and blanking flashes recorded separately (dotted line). For both records arrows indicate, respectively, the onset of the test and blanking flashes.

age evoked potentials for the blanking flash appear to merge with those of the test flash. By contrast, at 20-msec delay, where the first stimulus is perceptually blanked by the second, the potentials appear to be like those of the blanking flash either at 500-msec or when presented alone (see Fig. 1). This suggests that in the blanking stage the evoked potentials for the second stimulus displace those of the first stimulus.

The foregoing results seem to show that the average evoked responses obtained with paired stimuli can be classified into three general groups as a function of the interval between flashes: (i) *no perceptual interaction*—two stimuli are perceived separately, accompanied by average evoked potentials which do not overlap; (ii) *perceptual interaction*—the apparent brightness of the first flash is enhanced by the second, accompanied by potentials which overlap; (iii) *perceptual blanking*—the first flash is obliterated by the second, accompanied by potentials which suggest displacement of responses to the first flash by those of the second.

In an attempt to evaluate the specific contributions of each of the flashes to the average evoked potentials obtained for paired stimulations, hypothetical potentials were constructed by algebraic summation of the separate average evoked potentials for the two flashes. In performing this synthesis on the I.B.M. 7094 computer, the average evoked potentials for the blanking flash were shifted temporally to correspond to the delay interval between the paired stimuli. Figure 3 illustrates the remarkable similarity of the potentials obtained (solid line) to the hypothetical potentials (dotted line). The temporal and amplitude correspondences for the major wave components appear to be quite close, except for the second negative and positive components of the blanking flash, which consistently have a higher amplitude in the curve for the hypothetical potentials than they do in the curve for the potentials obtained. Within limits, therefore, the data suggest that the electrocortical activity associated with perceptual interactions to paired flash stimulations may result from additive brain processes. This tends to support the assumptions of other workers (*8*) who have used paired somesthetic stimuli. Further investigations of the deviations between the potentials actually obtained and the hypothetical potentials are now being made, and by a process of successive approximations we may be able to approach a definition of the operations performed by the brain in the generation of the average evoked potentials to the paired visual stimuli (*9*).

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References and Notes

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Fear and Pain: Their Effect on Self-Injection of Amobarbital Sodium by Rats

Abstract. *Rats receiving occasional brief electric shocks pressed a bar, which caused them to be injected with amobarbital sodium, more frequently than the control rats to which they were yoked and which were injected when their partners pressed but whose own bar activated only a recorder. This differential effect was not shown by pairs run without shocks.*

A variety of experimental studies summarized by Miller (*1*) support the hypothesis that one of the effects of amobarbital sodium is to reduce fear.