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CLINICAL AND LABORATORY NOTES

DIFFERENTIATION BETWEEN VISUALLY EVOKED F AND V POTENTIALS[1]

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INTRODUCTION

In an earlier analysis of the spatial distributions of individual components of cerebral potentials evoked by light (Kooi and Bagchi 1964), it was recognized that the vertex sharp wave (V wave) — a surface negative event having maximal voltage in posterior frontal and anterior parietal regions — could occasionally be detected as far forward as the pre-frontal region. In subjects with an active blink reflex, it was seen to arise from the base of the positively-going phase of the corneoretinal potential field artifact. Further examination of these, and other normative and clinical data, has convinced us of the presence of another wave which follows closely upon the vertex wave but is distinct from it by virtue of spatial and temporal characteristics. The purposes of this paper are to point up the existence of the evoked frontal dominant wave (F wave), to differentiate it from the V wave, and to provide normative data that may be utilized in the evaluation of evoked responses in various patient groups.

SUBJECTS AND PROCEDURE

The 243 normal subjects were all healthy non-hospitalized adults. Age ranged from 19 to 72 years. Average age was 44.2 years. One hundred ninety-one of the subjects were male; 52 were female.

The photic stimulus was provided by a Grass PS2 Photostimulator. The subjects' eyes were open. Stimulation was binocular in all subjects. In seven, monocular stimulation was also employed, one eye being completely shielded from the light.

Summation was accomplished by the Mnemotron Computer of Average Transients. Reference is made to technical data previously published (Kooi and Bagchi 1964).

Sums of 50 responses recorded between joined ear reference and electrodes placed (1) 3 cm above the left eye and 4 cm from the midline, (2) 4 cm to the left of the midline on the interaural plane, and (3) on the inferior margin of the left orbit, were examined and latencies of major deflections plotted. Relative amplitudes and phase relationships were noted. Studies with added electrodes for more exact estimation of spatial voltage distributions were carried out in some subjects.

The blink artifact was judged to be marked if its V shaped deflection, which generally culminated between 100 and 150 msec, was greater than 80 μV in frontal recordings.

RESULTS

The frontal wave under study was readily identified in 90 of the 243 subjects. In 37 subjects, marked blink artifact made its detection impossible. Thus, its incidence, in those subjects in whom reliable judgments could be made, was 43.7%. All subjects with frontal waves also had vertex waves. Illustrations of these waves will be found in Fig. 1. The F wave was present in the infraorbital recording in 37 instances (Fig. 1, *A* and *D*). Additional data in regard to the areal distributions of F and V waves are presented in Fig. 2. Fig. 3 shows that the F wave may be evoked bilaterally with monocular stimulation.

Fig. 4 reveals that the latency to peak of the F wave generally falls between 150 and 200 (mean 176) msec whereas that of the V wave lies between 110 and 160 (mean 137) msec. In any given subject, the difference between latencies was likely to be in the order of 30–40 msec. Wave duration could be reliably measured in 63 of the 90 subjects and its range was from 17.5 to 112.5 (mean 52) msec; in 58 of the 63 subjects it fell between 25 and 75 msec.

Reasonably reliable estimates of amplitude could be obtained in 81 subjects. Measurements derived from the left pre-frontal tracing are tabulated in Fig. 5. Mean amplitude was 8.9 μV.

Simultaneous left and right frontal recordings were carried out in 37 subjects (Fig. 6). In 20 subjects, amplitudes of the F waves were larger on the right and in 10 they were larger on the left. Mean amplitudes for the left and right sides were 8.4 and 9.4 μV respectively. The significance of the difference between the means fell between 0.10 and 0.20 ($t = 1.55$). The mean difference, neglecting direction, was 2.7 μV. The left–right difference

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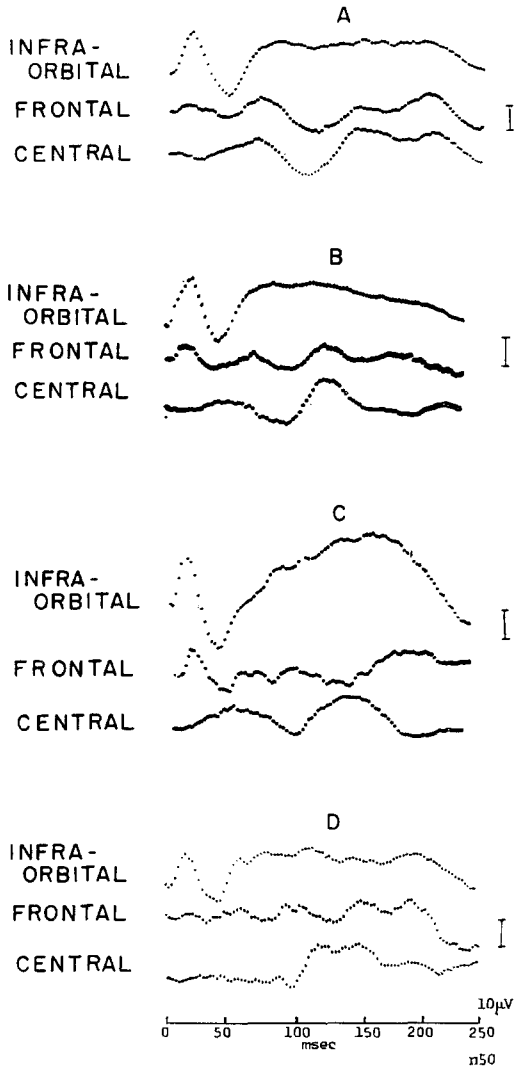

Fig. 1

Varieties of F and V potentials. *A*: F wave with peak latency of 195 msec dominant in frontal region; V wave with peak latency of 140 msec dominant in central region. Each spreads to other's area of dominance. The a and b waves of the ERG are recorded by the infraorbital and frontal electrodes. *B*: V wave dominant in frontal region followed by smaller amplitude F wave. *C*: F and V wave dominant in their respective area without reflection in other's zone. The long duration, surface negative wave following the initial components of the ERG in the infraorbital region is largely blink artifact due to upward rotation of the eyeball. Late retinal activity may also contribute to this wave. *D*: Unusual F wave variant showing two waves in early and late portions of normal latency range. Note late wave in simultaneous infraorbital recording synchronous with second wave. Recordings from areas designated to joined-ear reference. n50 = sum of 50 responses.

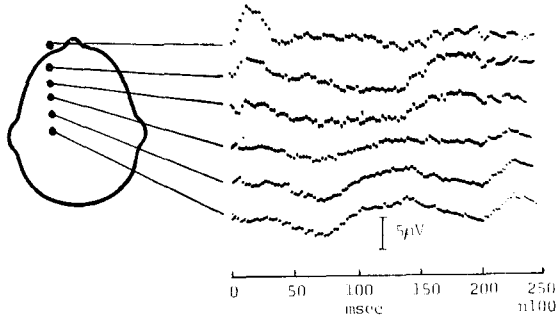

Fig. 2

Binocular stimulation. Subject's eyes open. No appreciable eye blink. Illustrates typical spatial distribution of F wave. F wave latency, 175 msec; V wave latency, 145 msec. The most anterior electrode is immediately below the eye. The second electrode is 3 cm above the eye, the others being each 3.5 cm apart.

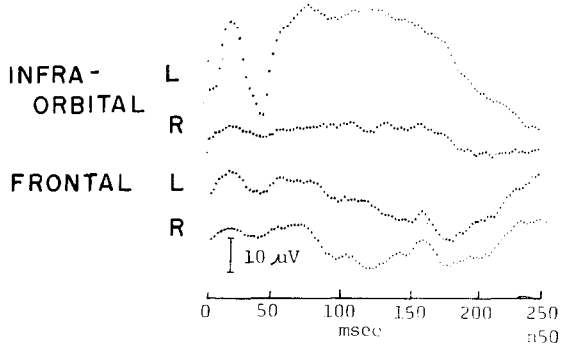

Fig. 3

Monocular stimulation, left eye only. Bilateral F wave with surface negative peak at 160 msec. The difference between the curves presumably reflects dissimilar retinal contributions from the two eyes.

was greater than 50% in 5 of the 37 (13.5%). Latencies to peak on the two sides generally fell within 10 msec of each other except in two instances. Mean latencies for the left (173 msec) and right (172 msec) sides were not significantly different. Wave form was highly similar in all subjects.

Amplitudes of the F waves were assessed relative to the presence or absence of a blink artifact. There was no evidence of blinking in 54 subjects. In the remainder, the amplitude of the blink artifact was below 20 μV in 20, between 20 and 40 μV in 12 and between 40 and 80 μV in 4. The mean amplitudes of the F waves in the two groups of subjects with and without a blink artifact did not differ significantly ($t = 0.60$).

In order to determine the extent to which either the F or V wave might be mistakenly confused with the other, a tabulation was made of the number of instances in which either wave appeared as a significant deflection in

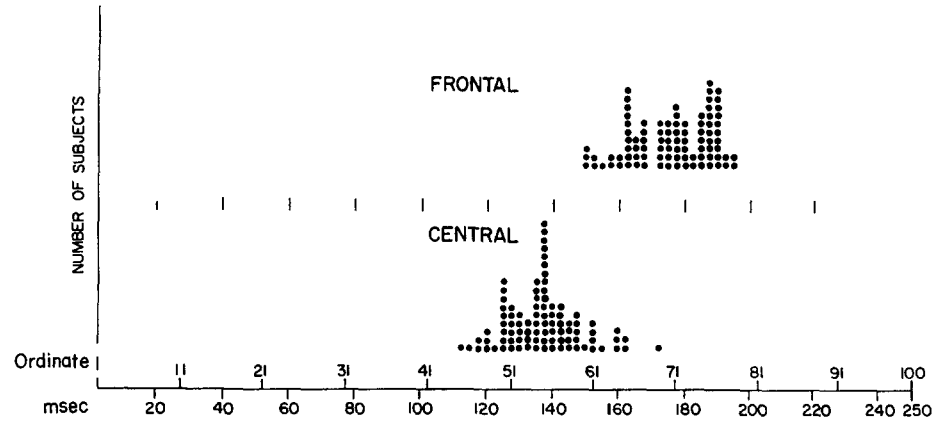

Fig. 4

Latencies of F and V waves for 90 subjects. Ordinate refers to number of sequential address of average response computer. Address dwell time: 2.5 msec.

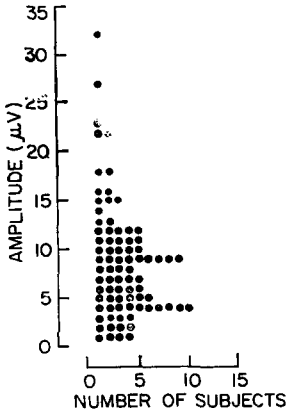

Fig. 5

Amplitudes of F waves for 81 subjects.

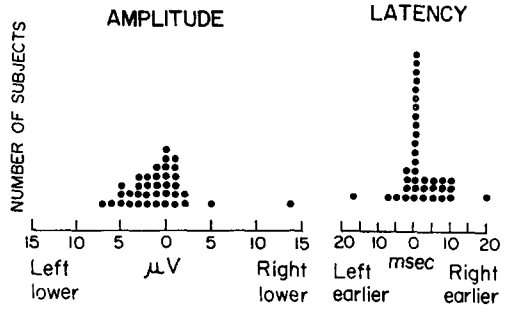

Fig. 6

Left–right amplitude and latency differences of F waves in 37 subjects.

the other's zone of dominance. The waves were identified on the basis of their spatial distributions and the latency ranges previously plotted. Corresponding waves were in most instances identical in form and latency to peak (within ± 5 msec) in the two regions, differing only in amplitude. This tabulation revealed that the F wave extended to the central region in 26 subjects (28.9%) and that the V wave was reflected in the frontal region in 34 (37.8%). In these cases, double peaks existed in one or the other or both regions, the frontal and vertex waves often coalescing to variable degrees. In only 3 instances did the F wave appear as the higher of the two peaks in the central region, whereas the central dominant wave gave rise to the major peak in the frontal region in 6 instances (Fig. 1, *B*).

DISCUSSION

There are a number of lines of evidence suggesting that the F wave, like the V wave, arises from the brain rather than ocular or other structures of the head: (1) a bilaterally symmetrical F wave may be evoked by monocular photic stimulation; (2) this wave is not related to either presence or amplitude of the blink artifact; (3) polarities of the wave are in-phase both above and below the eye (Fig. 1, *A* and *D*) rather than out-of-phase as would be expected if the wave were reflecting vertical movement of the eyeball; (4) its amplitude, duration and form resemble rather closely those of the V wave, a cerebral event; (5) its latency, longer than the V wave and its average duration make it less probable that it is of myogenic origin, as also do the left–right amplitude asymmetries encountered in some subjects; (6) left–right voltage or latency asymmetries of the F wave occur along with asymmetries of other cerebral evoked responses in lesions of the brain differentially affecting the two hemispheres (unpublished data).

The F wave, even discounting possible masking by the blink artifact, is not frequently detected. This fact,

coupled with the observation that its maximum amplitude is comparable to that of waves more consistently present, such as the vertex wave and the occipito-parietal wave (OIII), suggests that it reflects activity in a relatively labile system. The left–right amplitude variability also contributes to this impression.

Although cerebral mechanisms involved in the genesis of the evoked F wave are not known, it is of interest that it has a spatial distribution similar to that of the spontaneous F wave of sleep (Liberson 1944, 1949; Brazier 1949). Both have maximal amplitudes over the rostral portion of the frontal lobes in the region of areas 9 and 10 of Brodmann. This suggests that we have demonstrated electrophysiologically a cohesive functional system, also active in sleep, that may be identified with the pre-frontal association cortex.

SUMMARY

A frontal dominant wave (F wave), evoked by single photic stimuli presented at intervals of several seconds, and made evident by computer averaging technique, has been described in man and differentiated from the evoked vertex dominant wave (V wave) on the basis of its distribution and latency. The F wave typically culminated between 150 and 200 msec as compared with 110 to 160 msec for the V wave. Amplitude was ordinarily below 20 μV. Normative data have been presented for a group of ninety subjects, in which the wave could be positively identified, in regard to range of latencies, mean latency, range of amplitudes, mean amplitude, range of wave duration, mean duration, frequency of spread to central regions and left–right wave symmetry.

RÉSUMÉ

DIFFÉRENTIATION DES POTENTIELS ÉVOQUÉS VISUELS F ET V

Une onde dominante en frontal (onde F) évoquée par des stimuli visuels isolés, répétés à des intervalles de plusieurs secondes et rendue visible par une technique de calcul de moyenne, est décrite chez l'homme et différentiée de la réponse prédominante au vertex (onde V) sur la base de sa distribution et sa latence. L'onde F culmine typiquement entre 150 et 200 msec, alors que l'onde V culmine entre 110 et 160 msec. L'amplitude est ordinairement sous 20 μV. Des données normatives sont présentées à partir d'un groupe de 90 sujets, chez lesquels l'onde peut être positivement identifiée; ces données concernent l'écart des latences et la latence moyenne, écart d'amplitude et amplitude moyenne, écart des durées et durée moyenne, fréquence de l'extension aux régions centrales et symétrie des ondes droites et gauches.

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