



Faculté de médecine Pierre et Marie Curie
Université Paris VI - Pierre et Marie Curie

Bases neurophysiologiques et expérimentales des Potentiels Evoqués

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Intérêt Clinique des Potentiels Evoqués

- 1 – Ils peuvent **DEMONTRER** l'existence d'anomalies des fonctions sensorielles, lorsque l'histoire clinique ou l'examen neurologique sont douteux;
- 2 – Ils peuvent **REVELER** la présence d'un dysfonctionnement sensoriel non suspecté cliniquement lorsque les symptômes existent dans d'autres territoires;
- 3 – Ils aident à **PRECISER** l'extension anatomique d'un processus pathologique;
- 4 – Ils rendent compte de l'**EVOLUTION** de l'état clinique .

Principes des Potentiels Evoqués



Définition

Les potentiels évoqués sont des différences de potentiel enregistrées (sur le scalp) en réponse à des stimulations sensibles ou sensorielles.

Les réponses se présentent sous forme d'une succession d'oscillations qui comportent des pics positifs et négatifs.

On mesure la latence d'un pic par le temps écoulé depuis le moment d'application du stimulus.

L'amplitude d'un potentiel évoqué n'est pas prise en compte dans l'interprétation des résultats et les conclusions de l'examen (sauf exception).

Matériel et méthode

- Préparation de la peau (impédance)
- Électrodes (cupules, aiguilles...)
- Boîte « têtère », sélection des canaux
- Amplificateurs : gain = 1 / sensibilité
- Filtres : bande passante 1-250 ; 1-3000 Hz
- Moyenneurs : n passages (n = 100 à 2000)
- Fenêtre d'acquisition : 50 ms à 250 ms
- Stimulateur : courant constant, mA
- Logiciels, protocoles

Conventions

- Polarités :

- Onde positive : dirigée vers le bas quand l'électrode active est positive par rapport à l'électrode de référence ;
 - Onde négative vers le haut

- Nomenclature des formes d'ondes :

- N75, P100, N150 ... relative à la latence moyenne observée dans une population de témoins

Mesures - résultats

- L'amplitude des réponses est très faible de l'ordre de quelques μV (pic à pic ou par rapport à la ligne de base)
- D'où la nécessité de répéter les stimulations et d'additionner les réponses (100 à 2000).
- Latences des réponses : ms

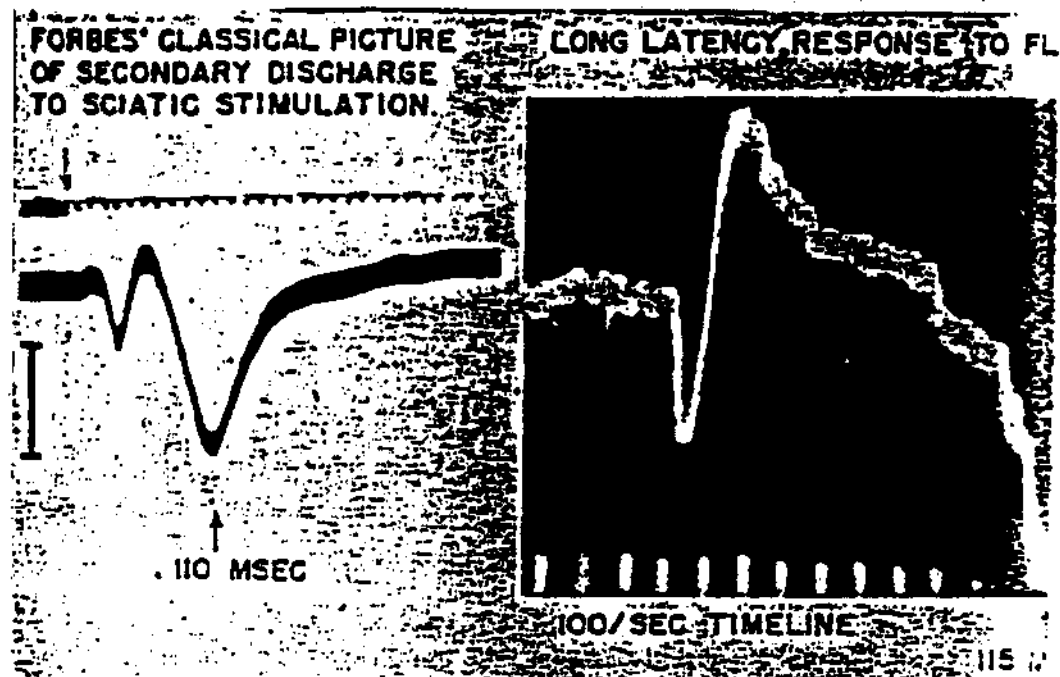
Détermination des valeurs moyennes de latences et des limites normales de l'appareillage sur un groupe de sujets témoins :
moyenne +/- 3 écarts-types (risque alpha 1 %)

FIGURE 4. RÉPONSES DE SURFACE DU POTENTIEL ÉVOQUÉ CORTICAL AU NIVEAU DES AIRES SENSORIELLES PRIMAIRES DU CHAT ANESTHÉSIÉ.

A gauche: réponse de surface dérivée à partir de l'aire somesthésique primaire à la stimulation du nerf sciatique controlatéral au moyen d'un choc électrique unique (de Forbes & Morison, *J. Neurophysiol.* 1939, 2: 117)

A droite: réponse de surface du cortex visuel du chat à un flash; noter la réponse primaire suivie d'une réponse à plus longue latence (de Brazier, *Reticular Formation of the Brain*, Little Brown, Boston, 1958).

(Négativité vers le bas)



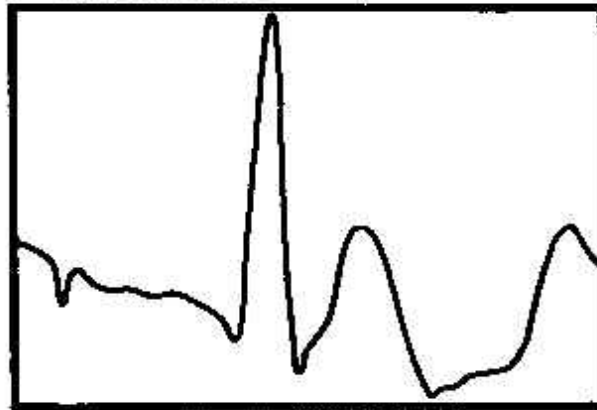
En cas de problème technique :

- Impédances trop élevées d'une ou plusieurs électrodes (vérifier électrode, fils, terre, contact peau)
- Présence d'artéfacts trop nombreux :
Demander au patient de se détendre +++ (EMG)
- Vérifier :
 - stimulus
 - électrodes, connecteurs et câbles
 - réglage des amplificateurs
 - moyennes (niveau rejet artéfact)

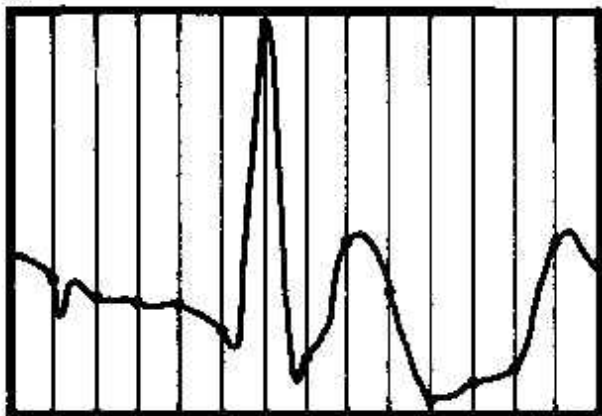
Théorie et pratique de l'échantillonnage - moyennage



BASIC WAVEFORM

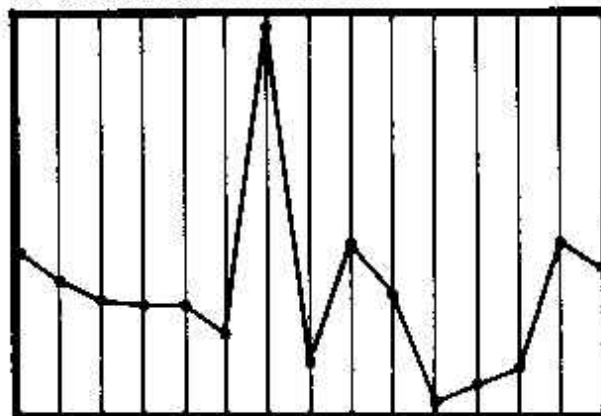


(a) BASIC WAVEFORM



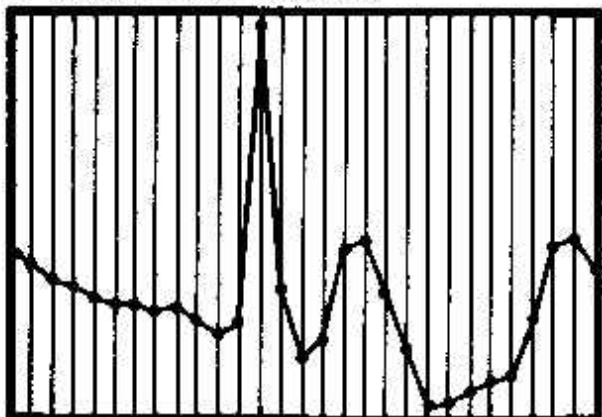
x INTER-SAMPLE INTERVAL (TIME)

(b) RECONSTRUCTED WAVEFORM



x INTER-SAMPLE INTERVAL (TIME)

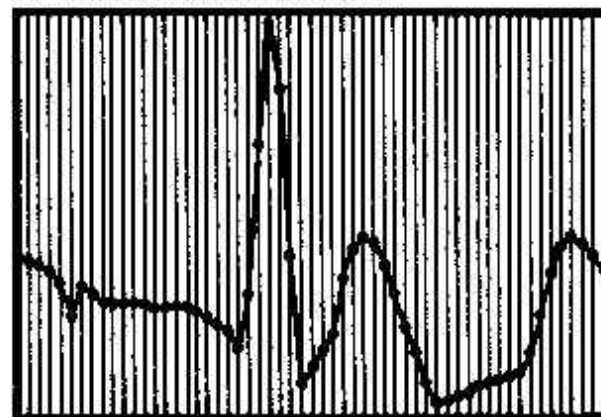
(c) RECONSTRUCTED WAVEFORM



$.5x$ INTER-SAMPLE INTERVAL (TIME)

SWEEP TIME

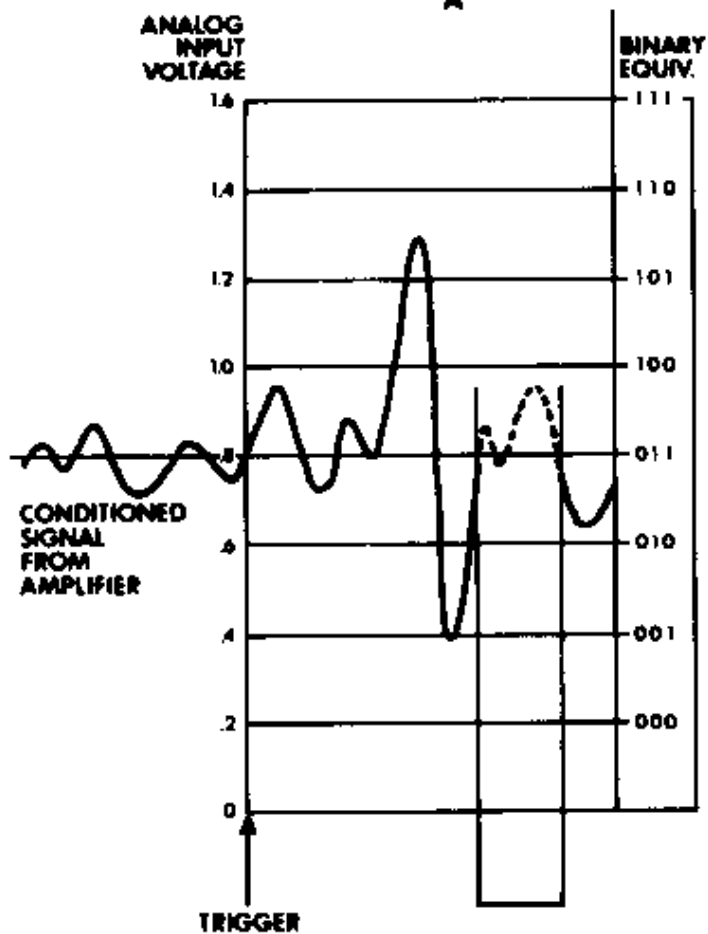
(d) RECONSTRUCTED WAVEFORM



$.25x$ INTER-SAMPLE INTERVAL (TIME)

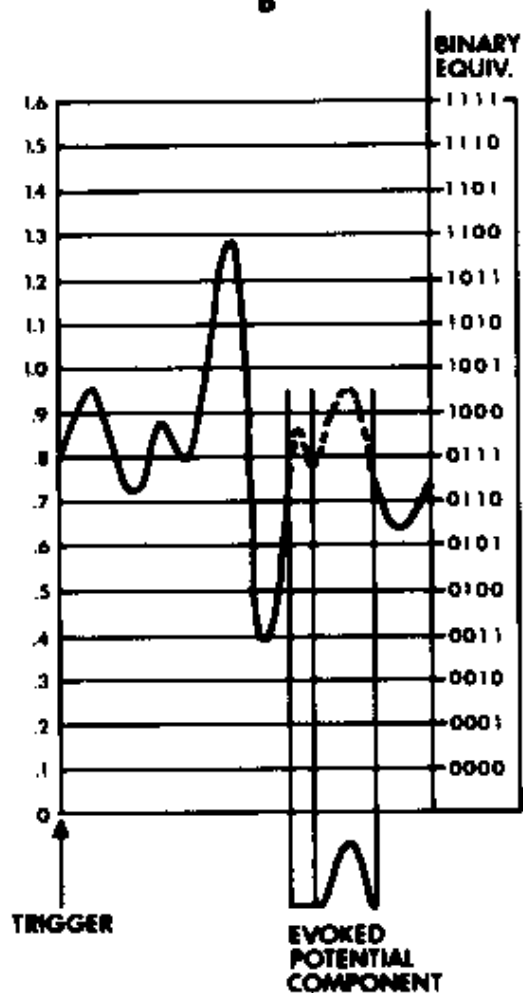
A/D CONVERTER

A



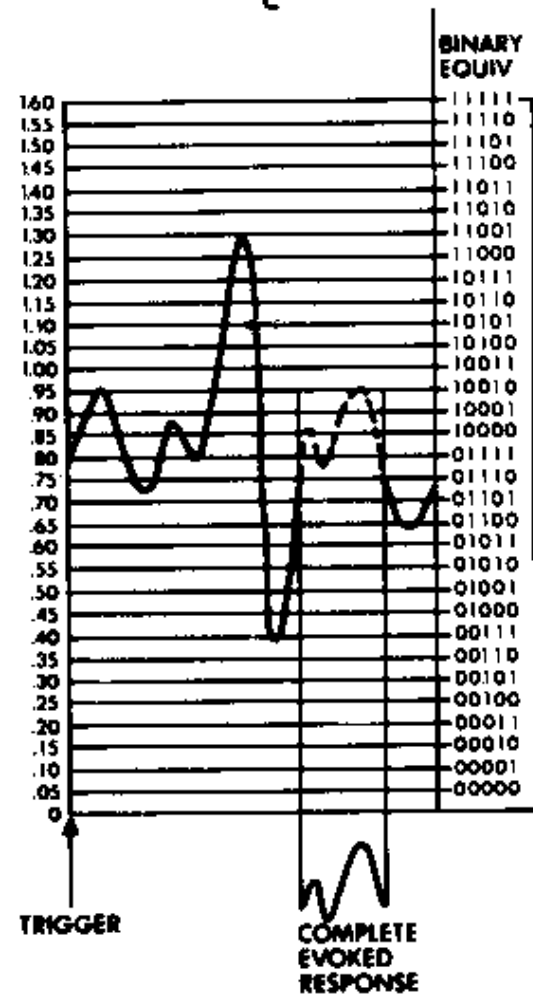
A/D CONVERTER

B



A/D CONVERTER

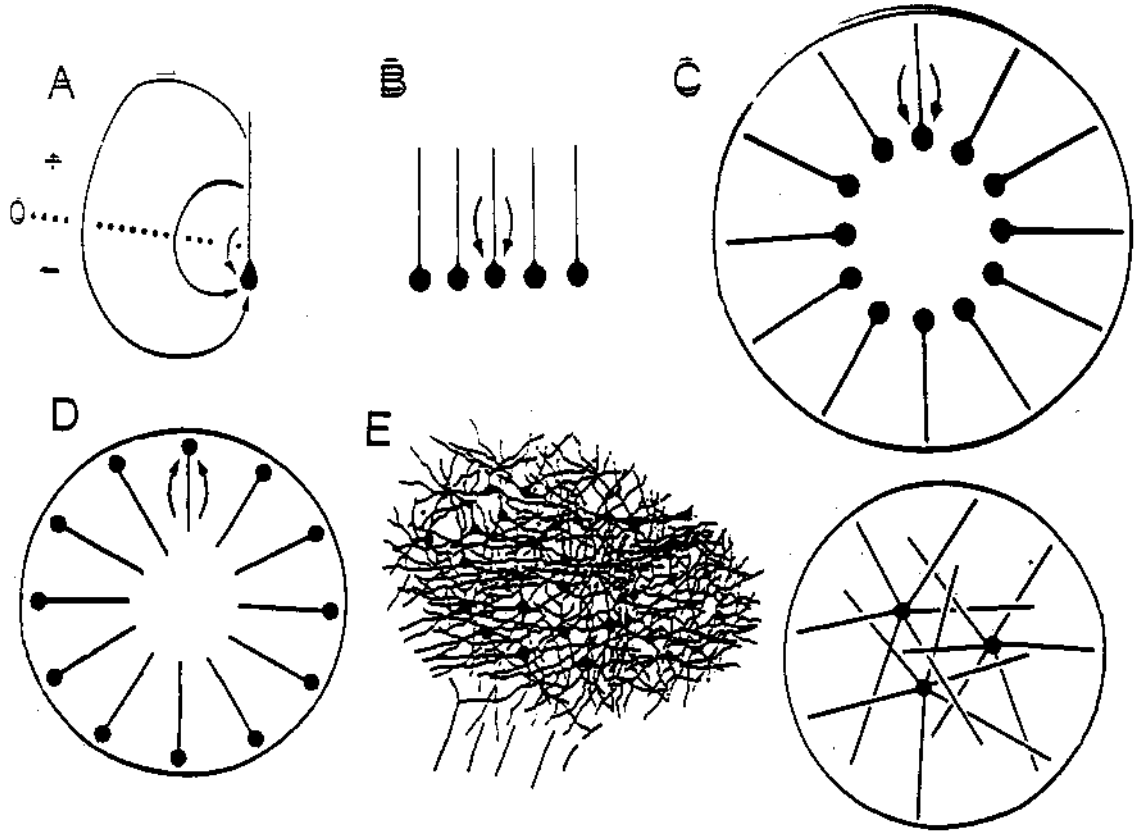
C

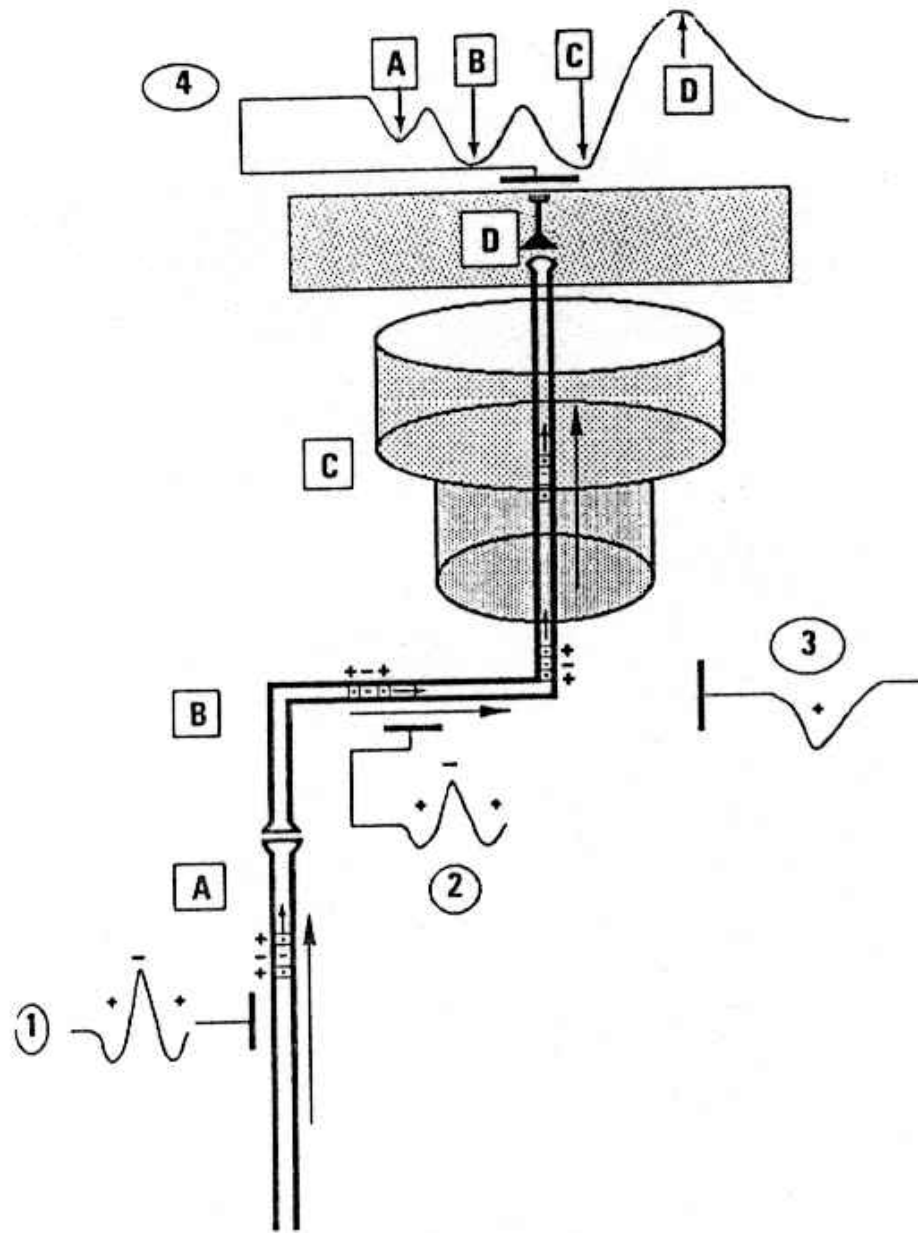


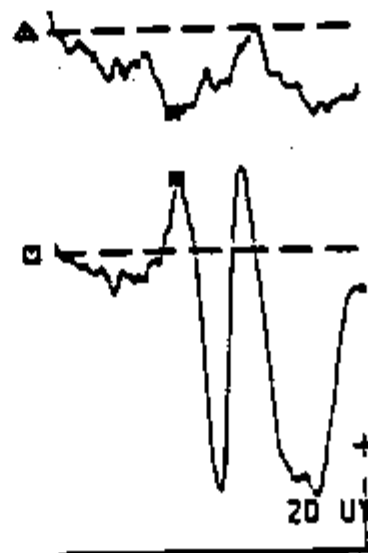
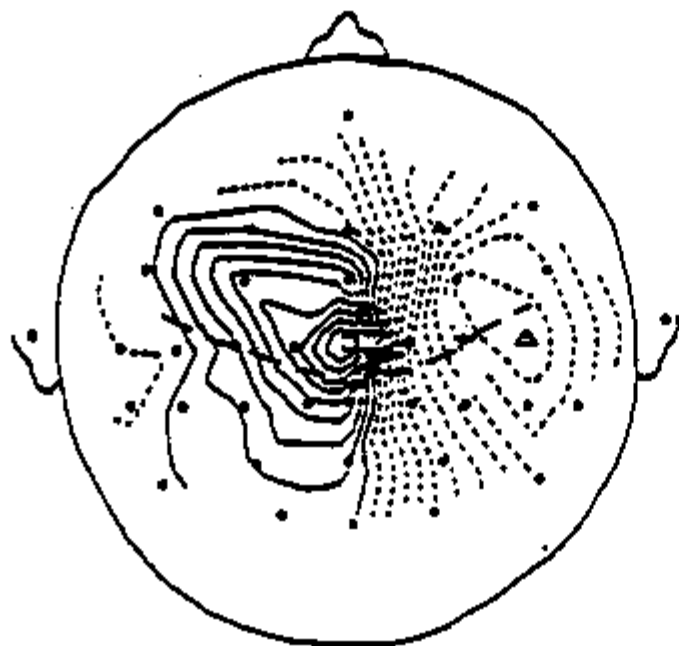
Champs Electriques à l'origine des différences de potentiel enregistrées:

- Champs électriques proches
- Champs électriques lointains



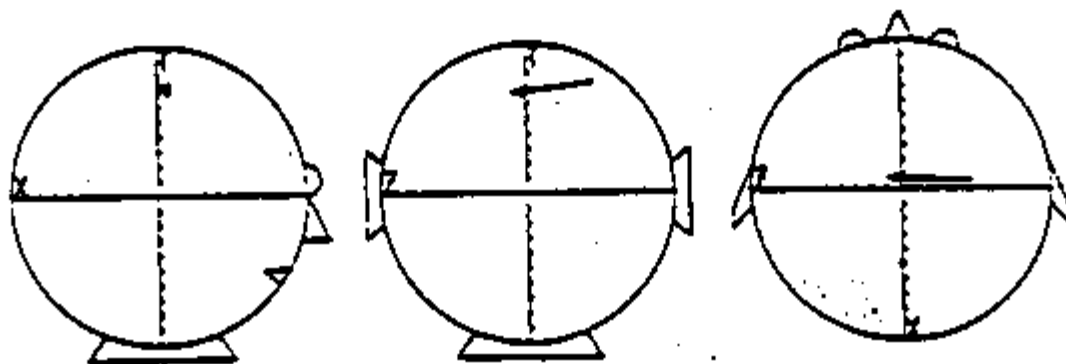






5-100 MSEC

LEFT TIBIAL NERVE



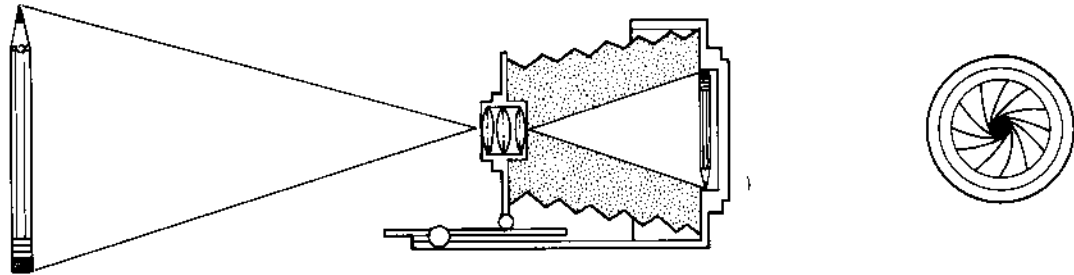
Anatomie fonctionnelle des voies visuelles

Potentiels Evoqués Visuels

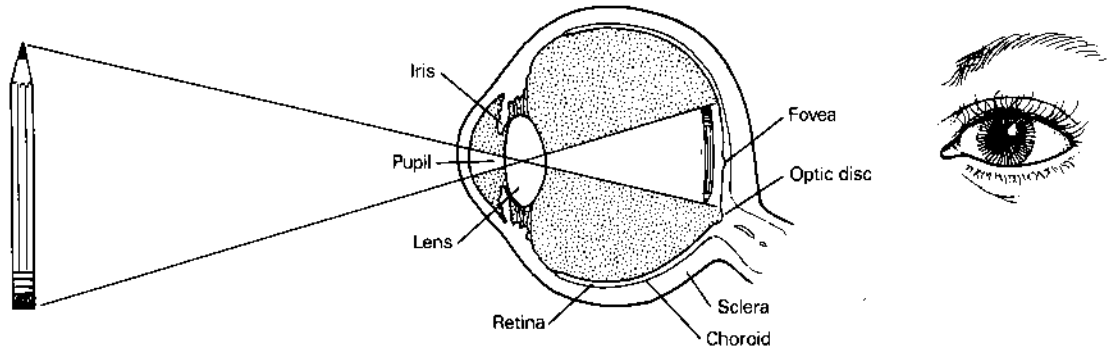
PEV

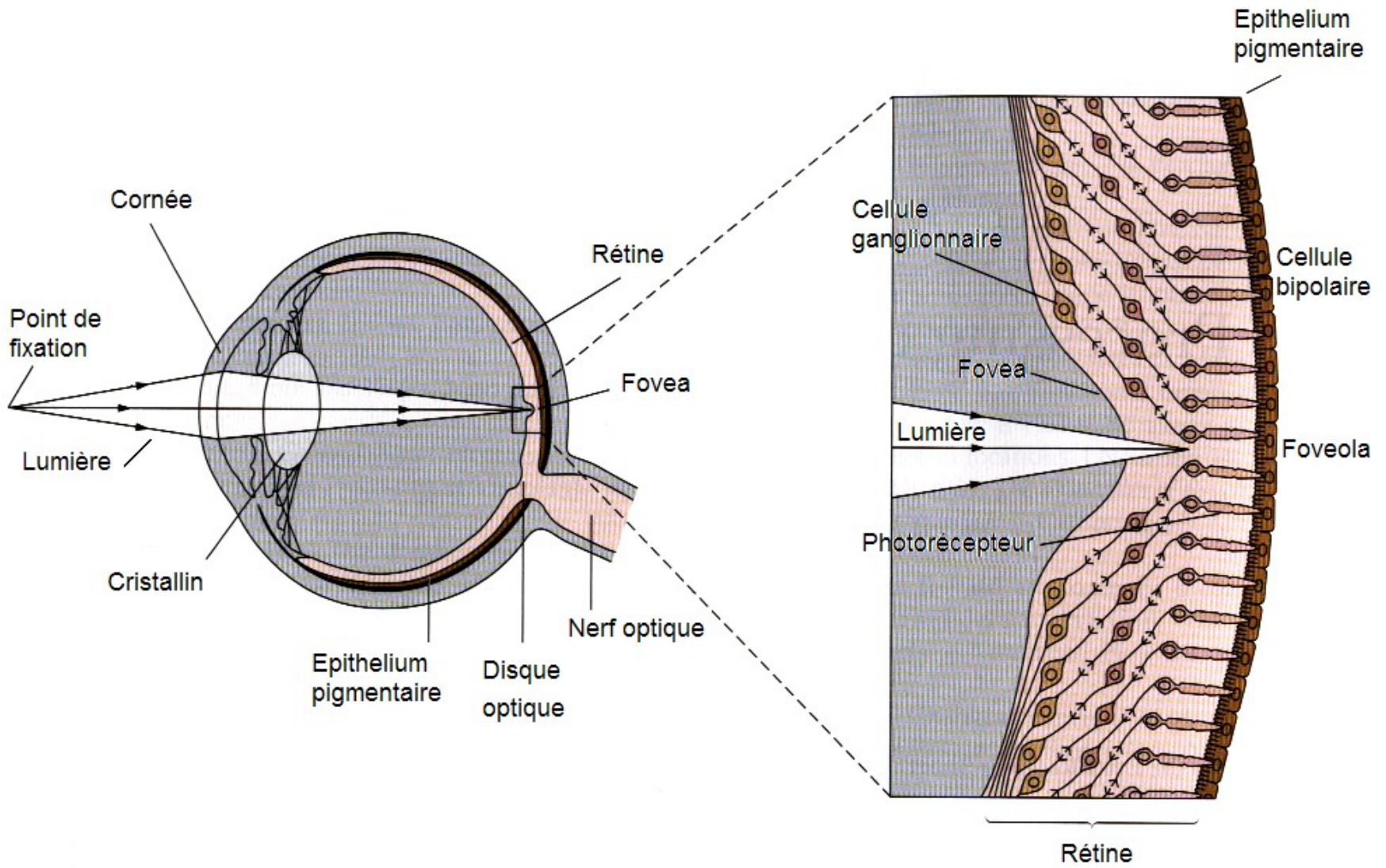


1

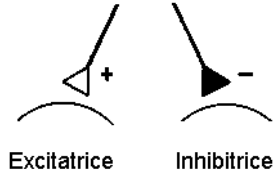


3

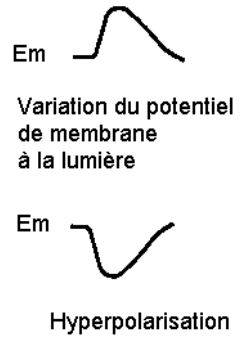




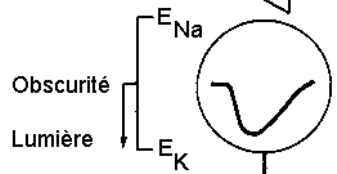
Synapses



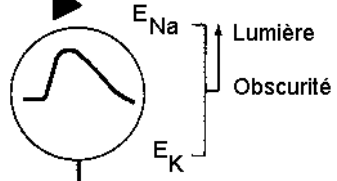
Dépolarisation



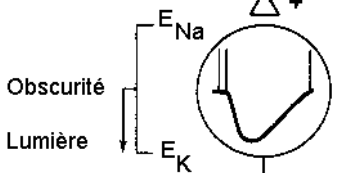
Cellule bipolaire centre-Off



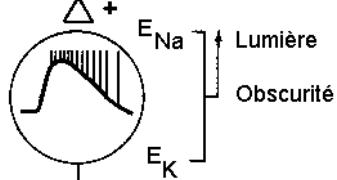
Cellule bipolaire centre-On



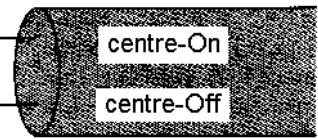
Cellule ganglionnaire centre-Off

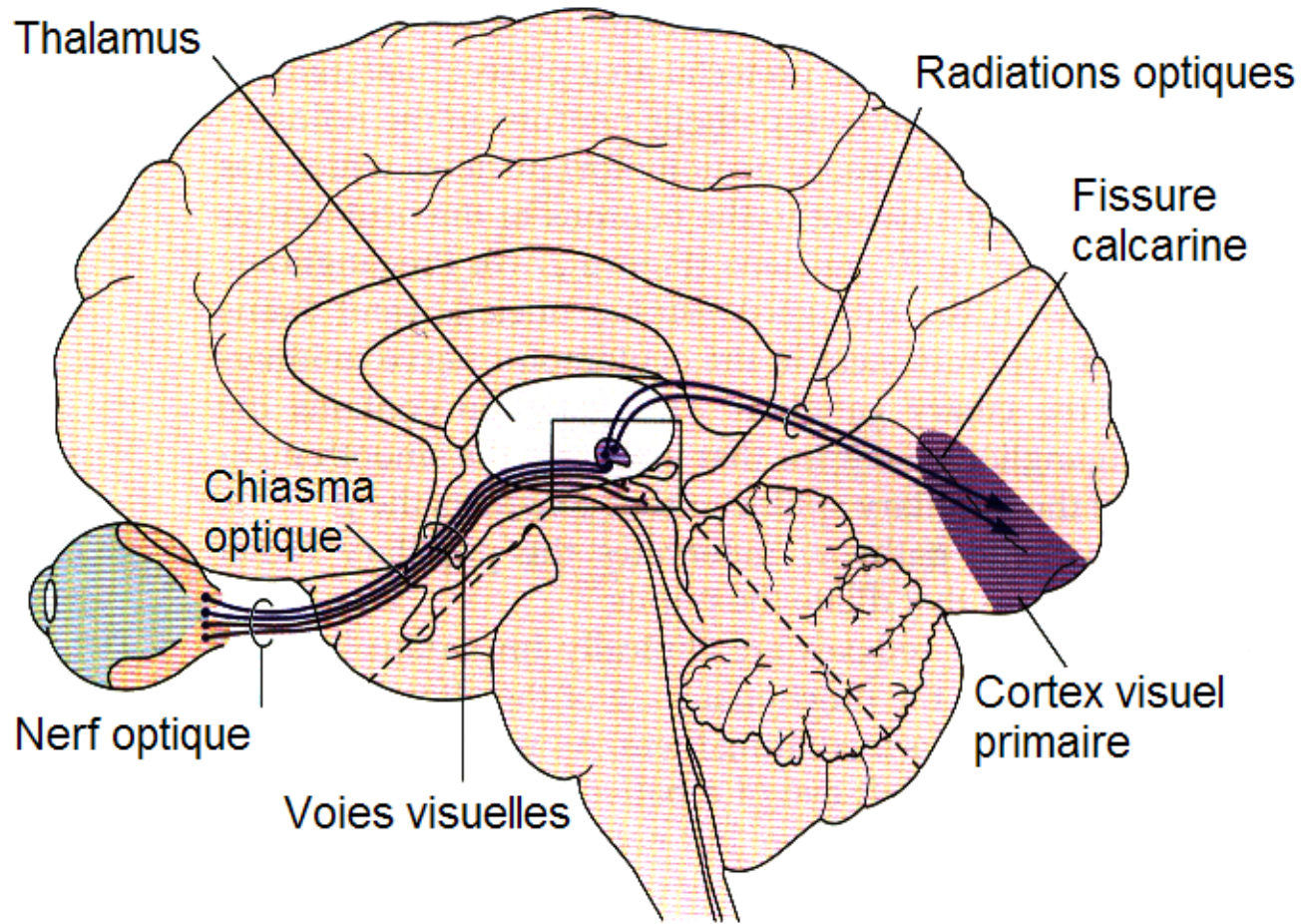


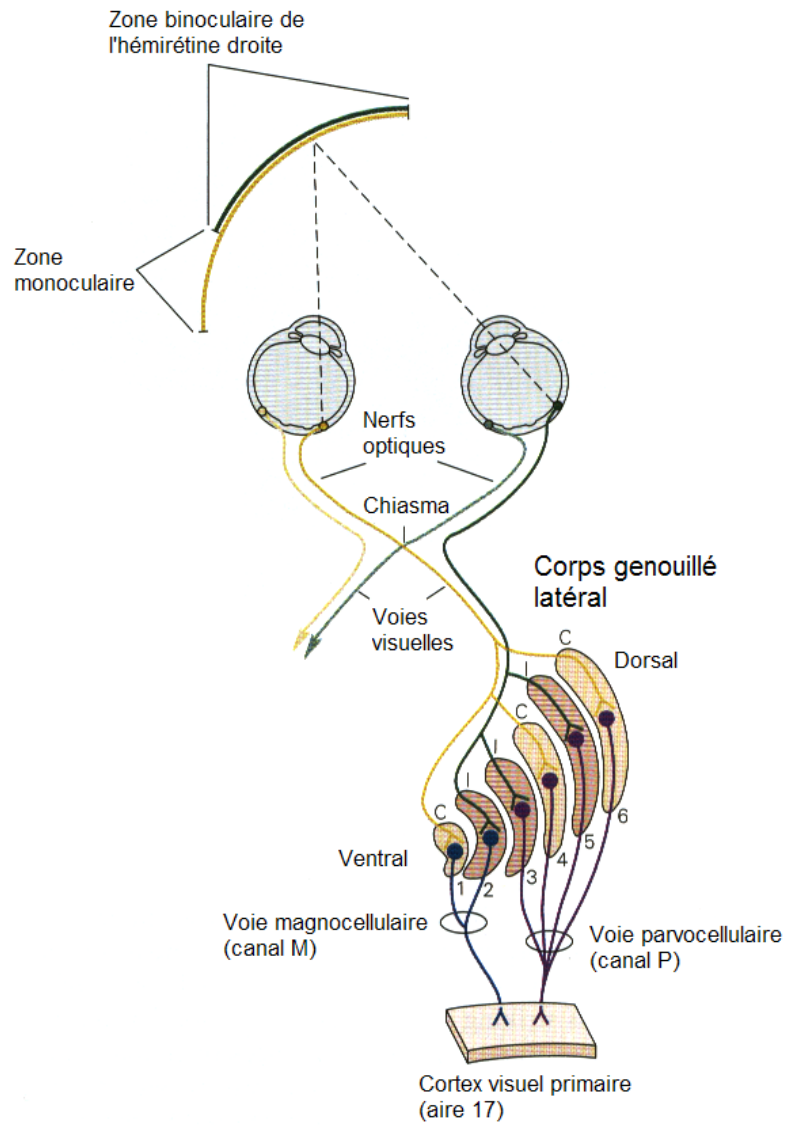
Cellule ganglionnaire centre-On

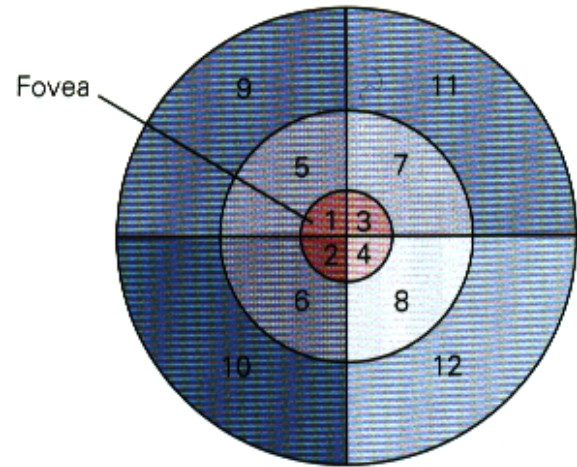


Lumière

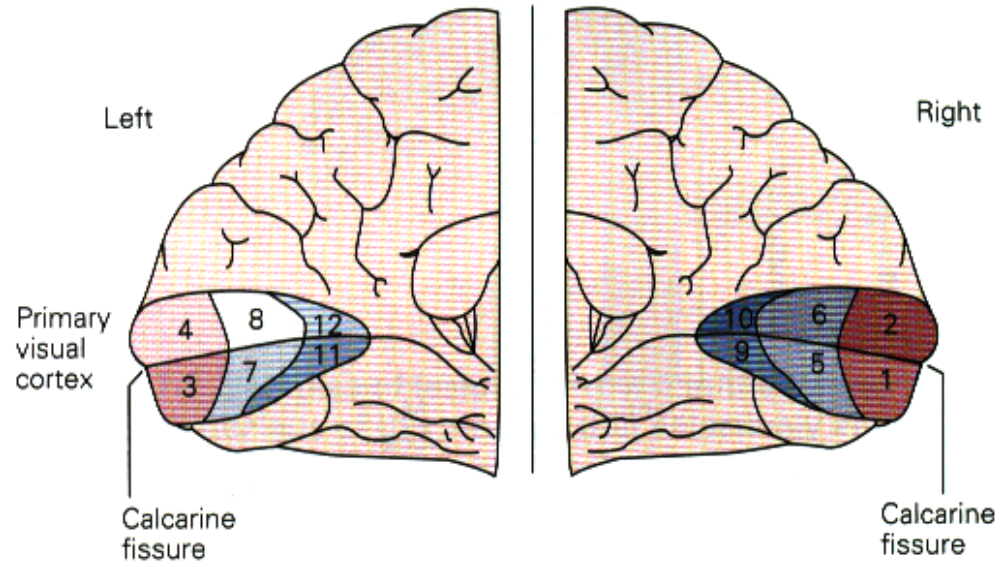


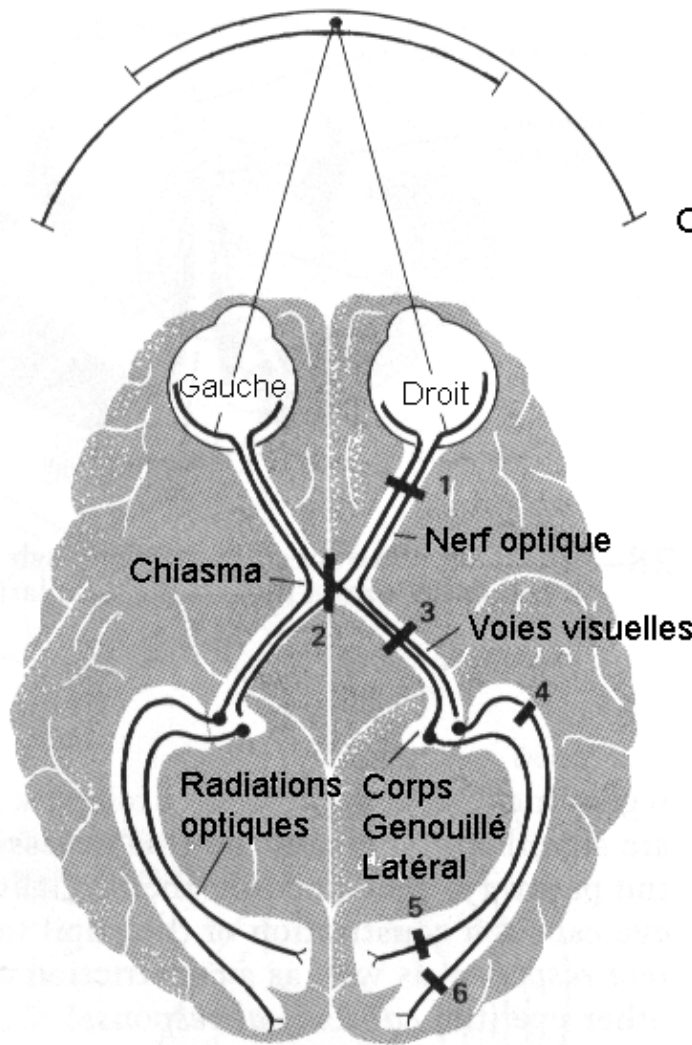






Visual field



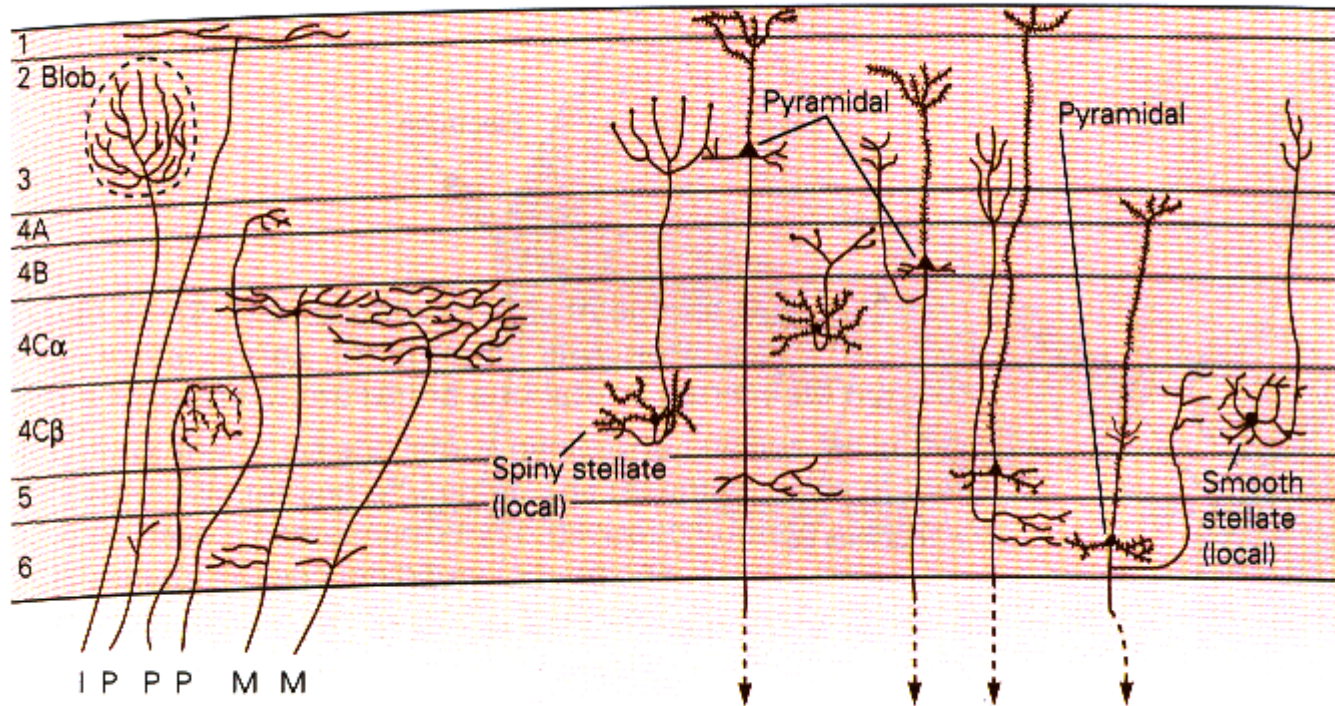


Amputation du champ visuel

	Oeil gauche	Oeil droit
1		
2		
3		
4		
5		
6		

A Inputs from lateral geniculate nucleus

B Resident cells



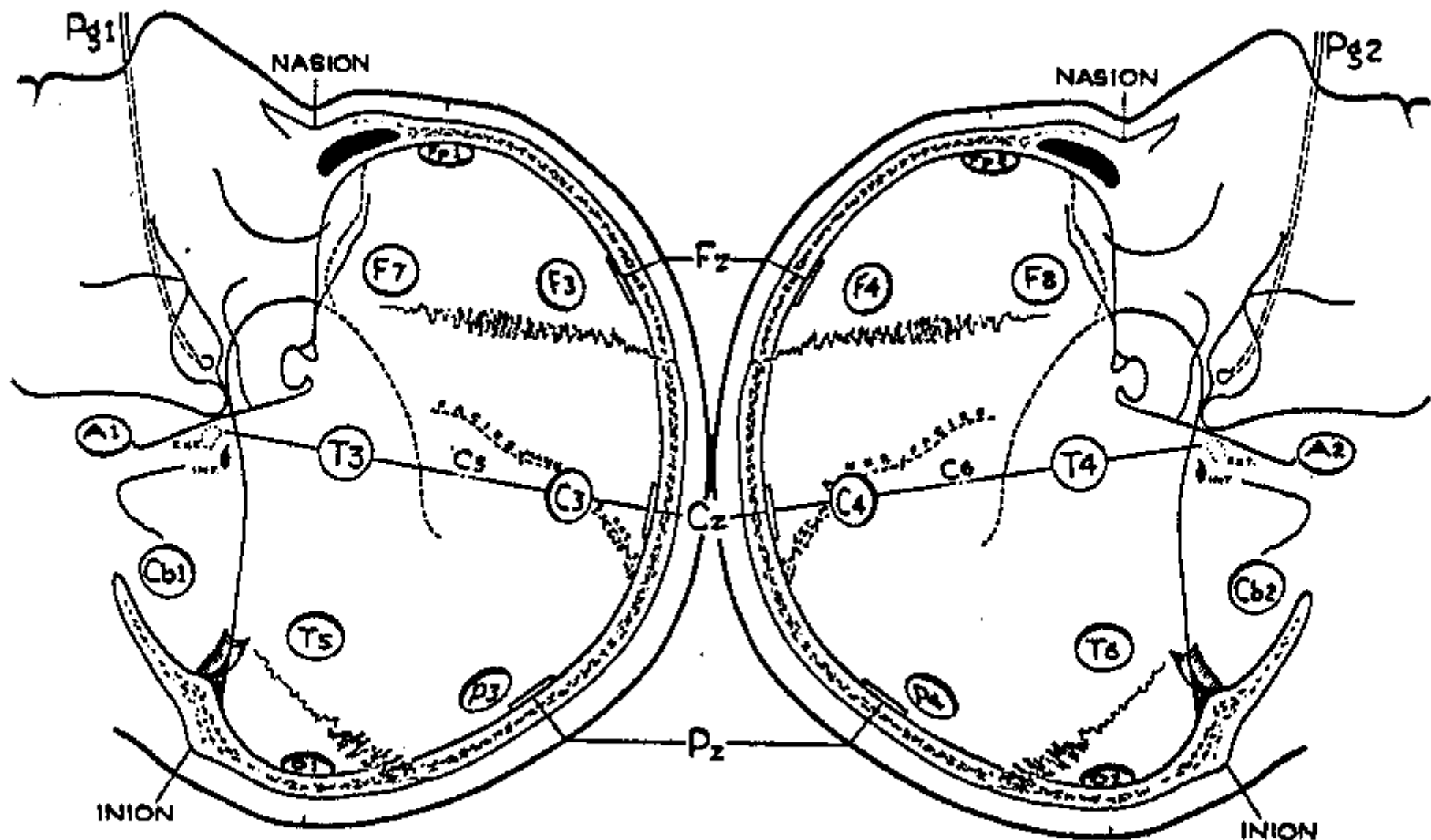


FIG. 4

The lateral view of left and right hemispheres showing all standard electrode positions, omitting intermediate positions (such as C5 and C6) which are used only for special studies with more closely spaced electrodes. These drawings were made from a series of X-ray projections with true lateral views. The location of principal fissures was determined by silver clips placed at operation and by other anatomical studies described in the text. The location of pharyngeal electrodes (Pg1 and Pg2) was also obtained from X-ray studies with these electrodes in place.

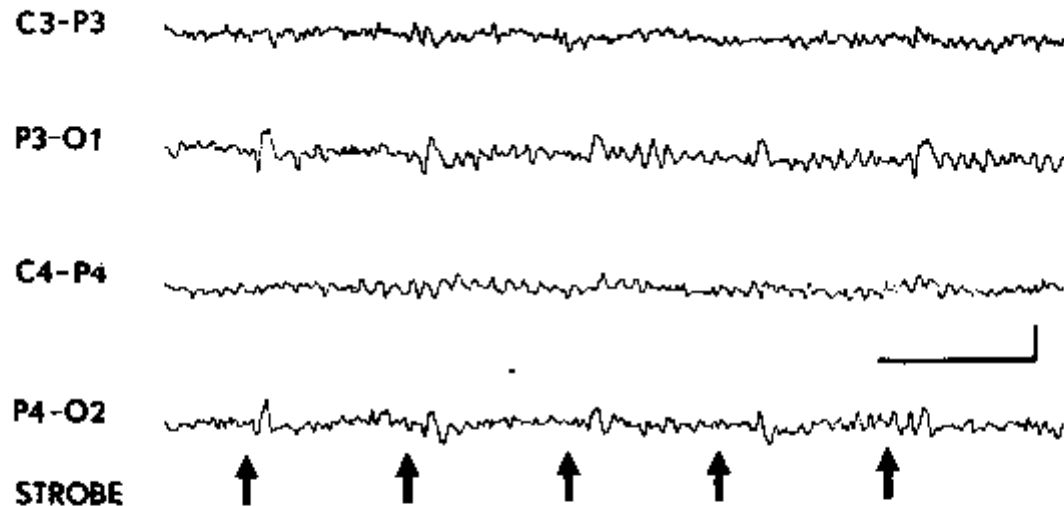
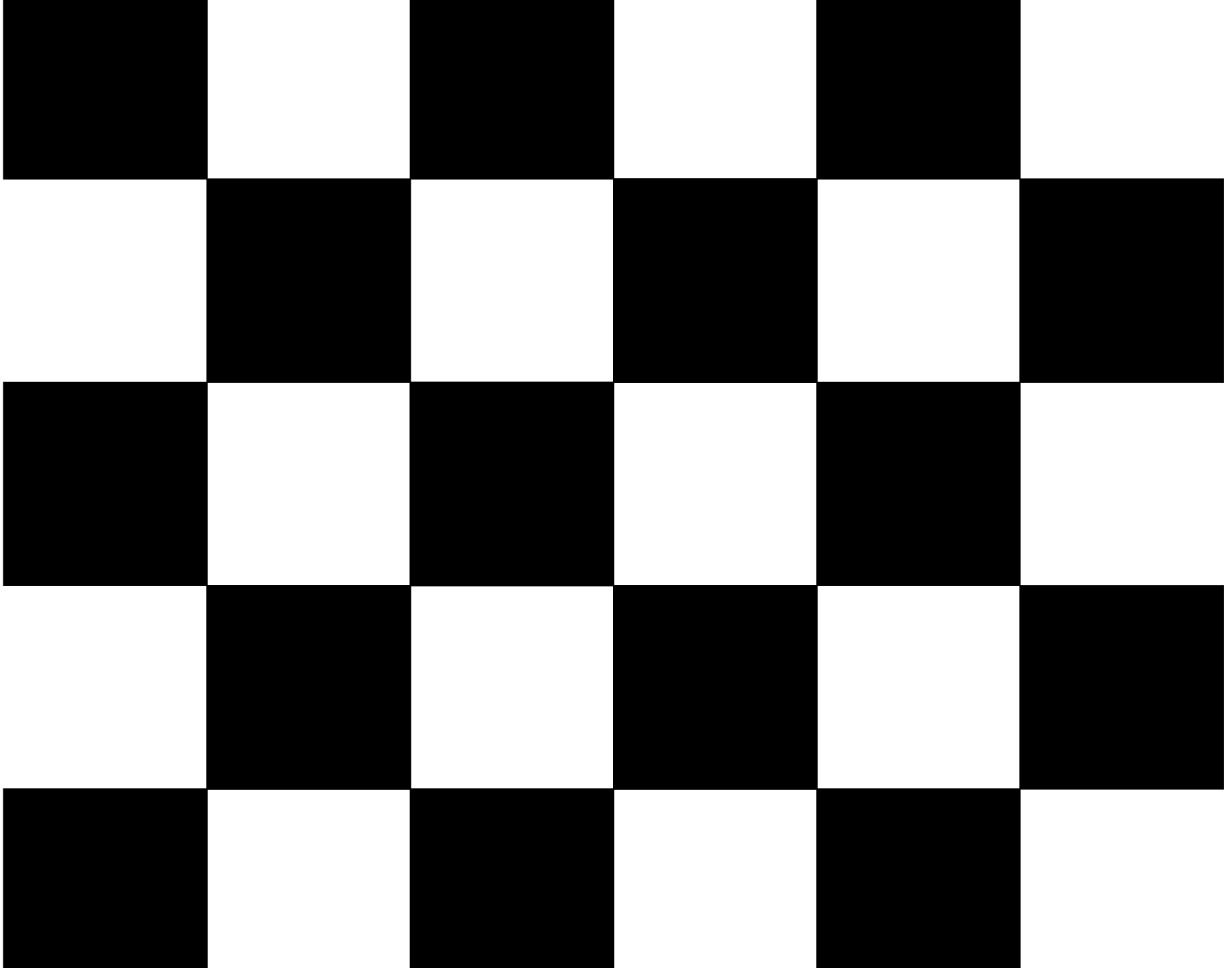
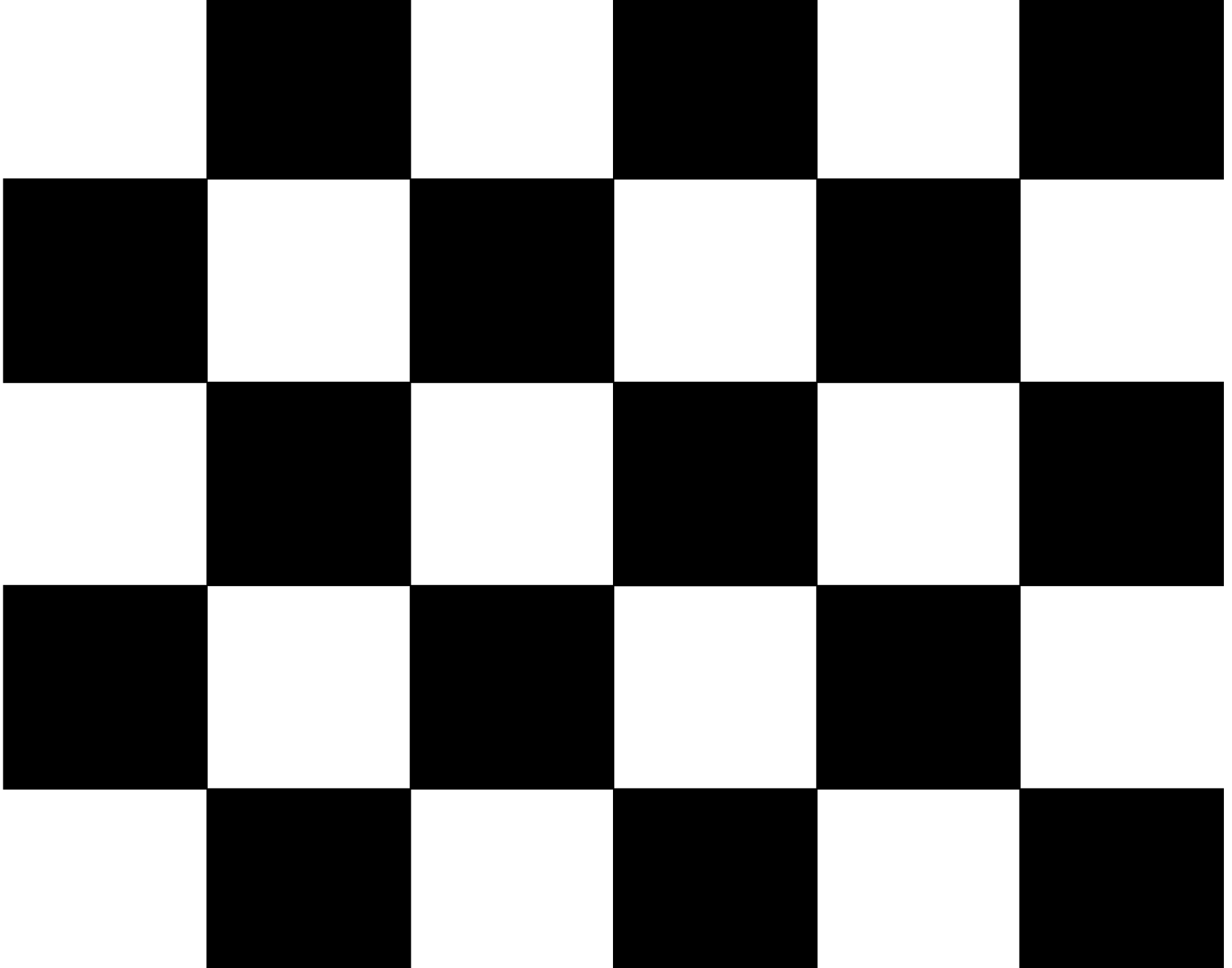


FIG. 1-1. Conventional bipolar EEG recording from a normal subject, eyes open, with some alpha activity still visible. Strobe flashes occur at *arrows*—note the visible but poorly defined EPs in the occipital areas with peaks at about 150 msec after each stimulus. Electrode locations: C, central; P, parietal; O, occipital; odd numbers, left; even, right. Calibration marks are 1 sec and 50 μ V. Relative negativity of the first electrode produces an upward trace deflection. (Reprinted, with the publisher's permission, from Chiappa, 1979.)





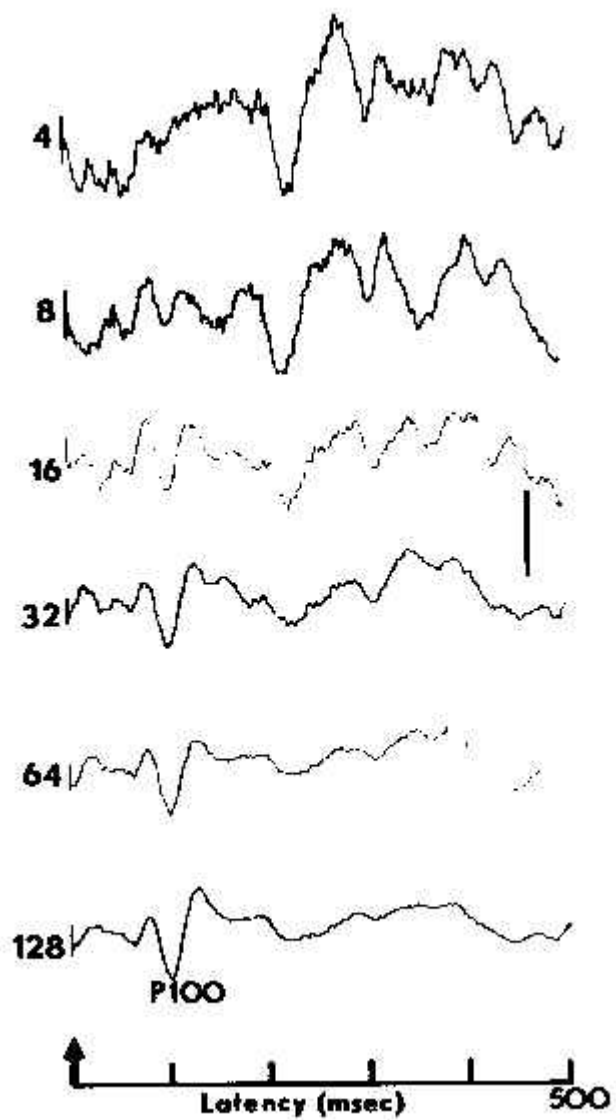


TABLE 2-1. *Full-field PSVEP normal values*

	<i>N</i>	Mean	Range	SD	Mean + 3 SD
Latency of P100	86 Eyes	102.3 msec	89–114 msec	± 5.1	117.6 msec
Latency difference between two eyes	43 Subjects	1.3 msec	0–6 msec	± 2.0	7.3 msec
Amplitude of P100	86 Eyes	10.1 μV	3–21 μV	± 4.2	—
Absolute amplitude difference between two eyes	43 Subjects	1.6 μV	0–5.5 μV	± 1.4	5.8 μV
Proportional amplitude difference between two eyes:					
$\frac{\text{smallest amplitude}}{\text{largest amplitude}} \times 100$	21 Subjects	85.5%	—	± 10.5%	53.9%
Duration of P100	86 Eyes	63 msec	47–86 msec	± 8.7	89.1 msec
Duration difference between two eyes	43 Subjects	2.8 msec	0–6 msec	± 2.9	11.5 msec

Normal values for full-field PSVEP testing using a fixed-luminance device (slide projector/rotating mirror), screen size 8.7°, check size 25.8'. Data from 21 normal volunteers and 22 patient controls. (From Shahrokhi et al, 1978, with permission.)

Corrélations Cliniques



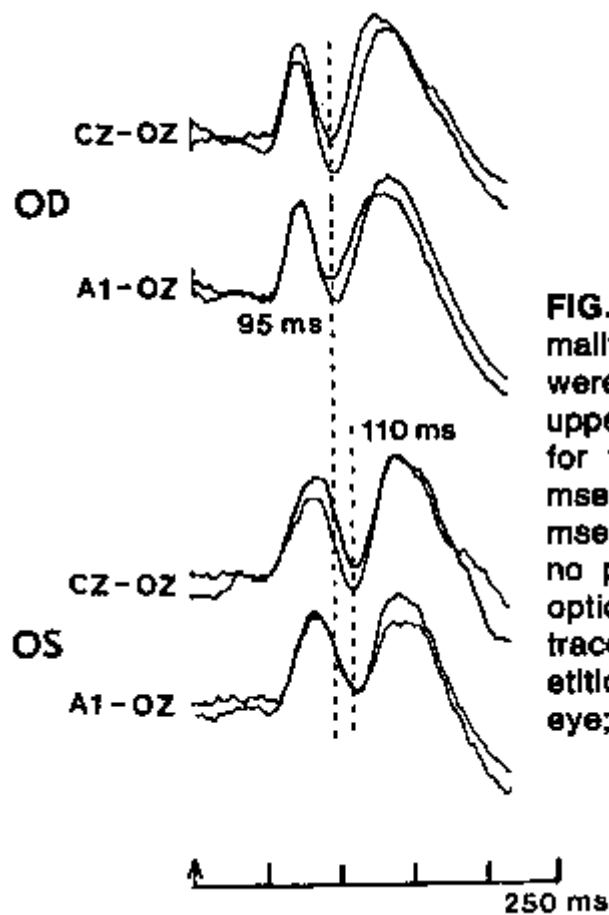


FIG. 3-3. Interocular latency difference abnormality in patient with MS. Absolute latencies were within normal limits in both eyes. The upper limit of normal (normal mean + 3 SD) for the interocular latency difference was 8 msec; the difference in this patient was 15 msec. The patient had no visual symptoms and no previous history of visual difficulties. The optic discs were "probably slightly pale." Each trace is the average of 128 stimuli, with a repetition superimposed. A1 is left ear. OS, left eye; OD, right eye. Calibration mark is 10 μ V.

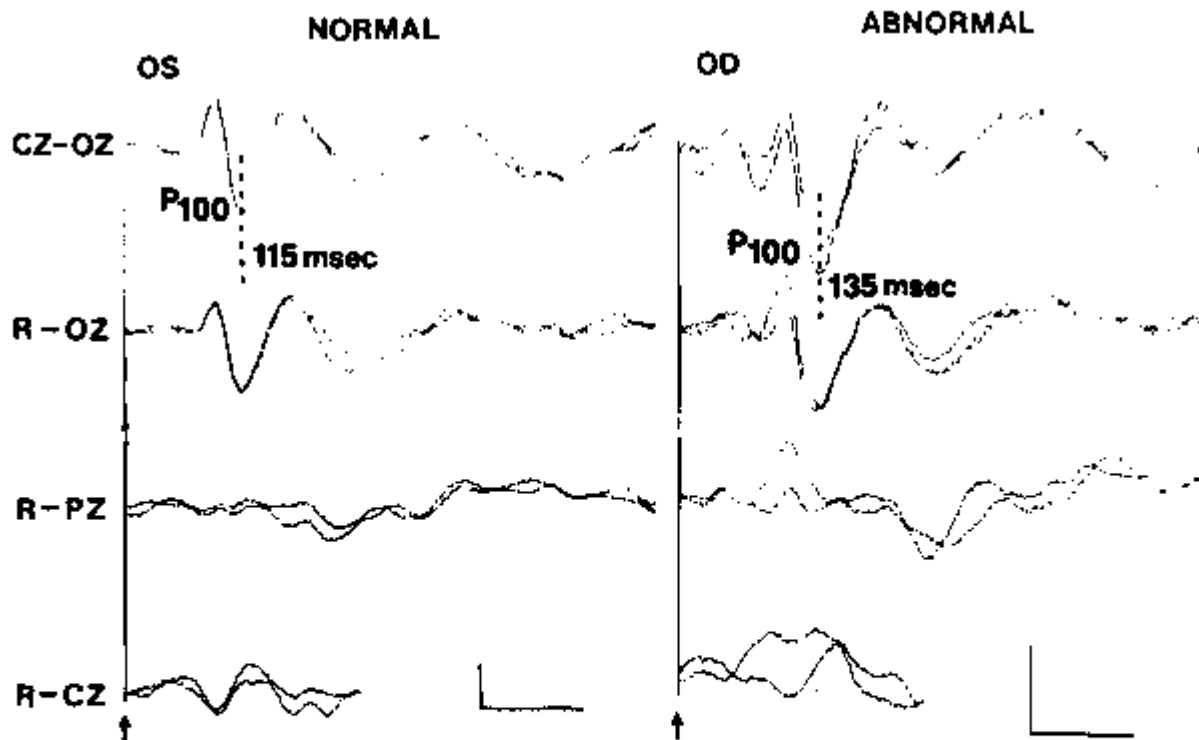


FIG. 3-1. PSVEPs recorded from a patient with MS showing a monocular latency abnormality. Left-eye (OS) response was normal at 115 msec, right eye (OD) response was abnormal with P100 peak delayed in latency at 135 msec (normal mean + 3 SD with this pattern-shift stimulator was 117 msec). Each trace is the average of 128 stimuli with a repetition superimposed. Reference was linked ears, relative positivity at G2 causes a downward trace deflection. Calibration marks are 100 msec and 5 μ V. (Reprinted, with permission, from Brooks and Chiappa, 1982.)

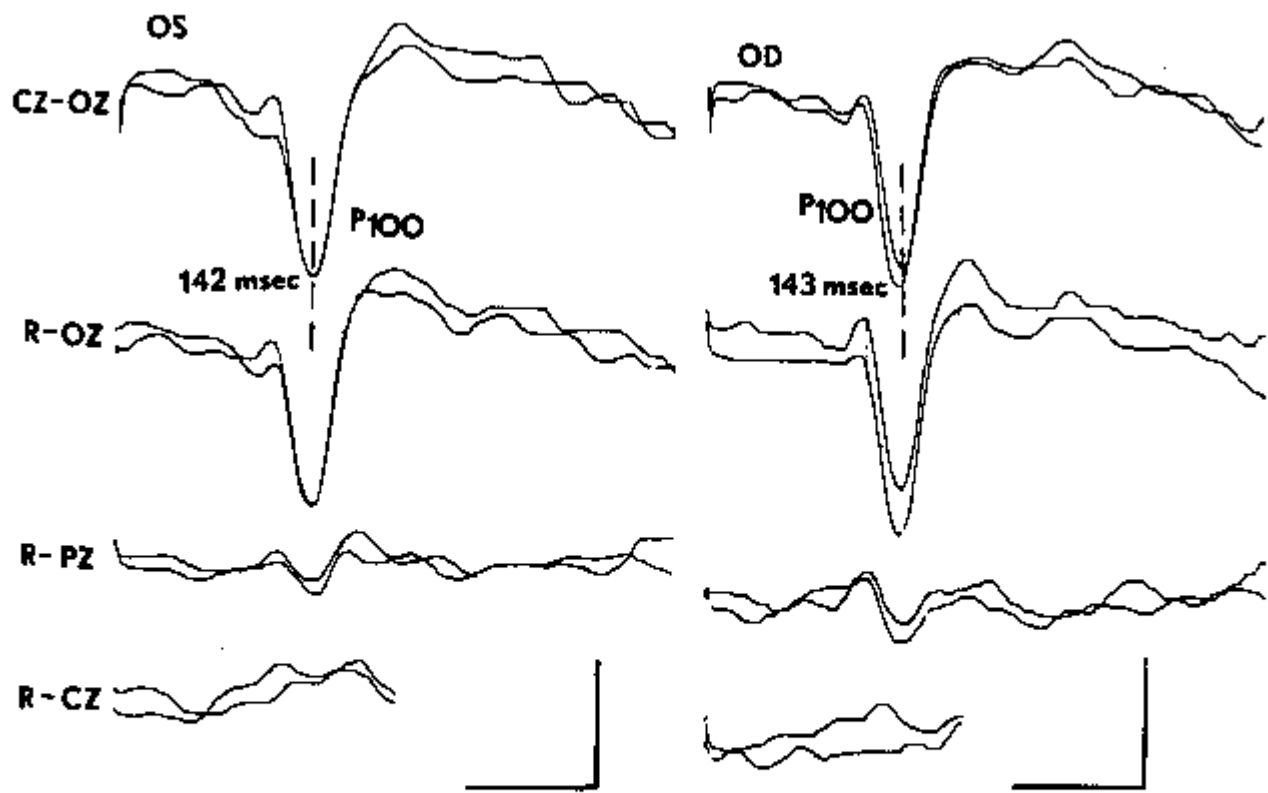


FIG. 3-2. PSVEPs recorded from a patient with MS showing binocular latency abnormalities (see Fig. 3-1 legend for normal limits). Each trace is the average of 128 stimuli, with a repetition superimposed. Reference was linked ears. Calibration marks are 100 msec and 10 μ V. OS, left eye; OD, right eye. (Reprinted, with the publisher's permission, from Chiappa, 1983.)

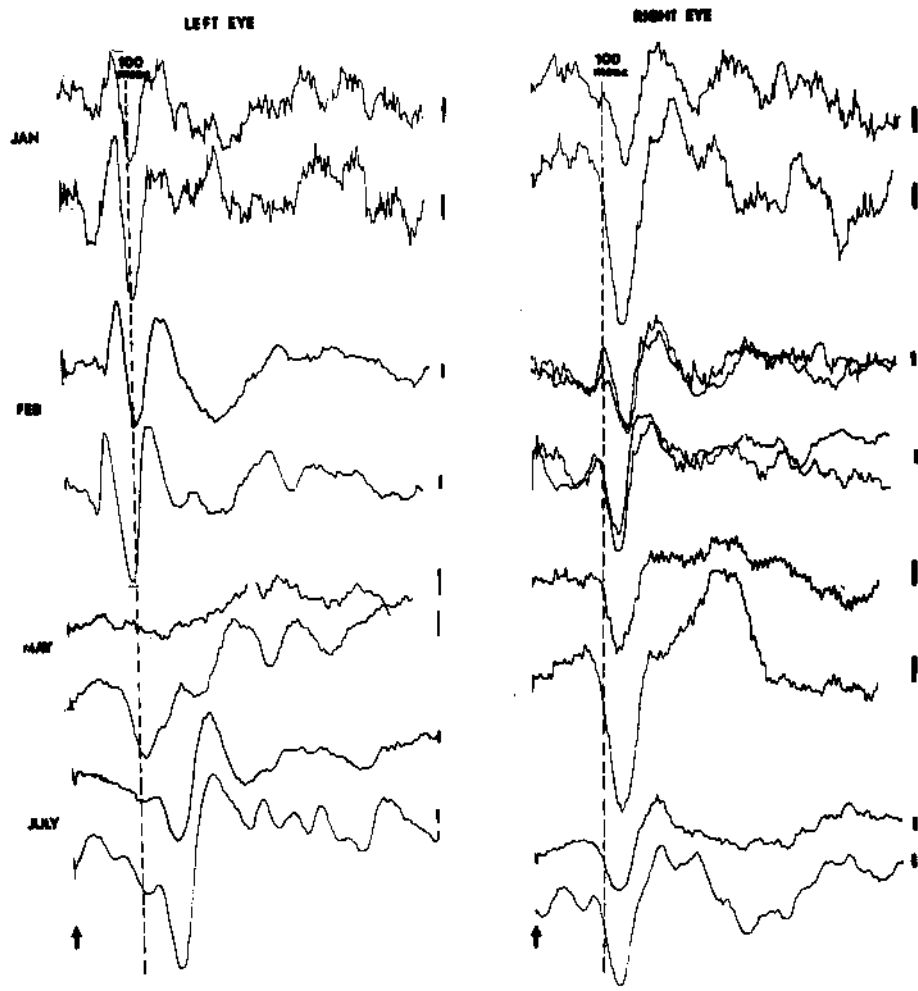


FIG. 3-6. PSVEPs from a patient with an attack of optic neuritis in the right eye initially (Jan).

TABLE 3-2. *The incidence of abnormal PSVEP in MS and optic neuritis*

	Definite	Probable	Possible	Total
MS patients with a history of optic neuritis	75/83	21/28	9/17	105/128 (82%)
MS patients without a history of optic neuritis	38/56	38/85	16/80	92/221 (42%)
All patients with MS	113/139 (81%)	59/113 (52%)	25/97 (26%)	197/349 (56%)
Pure optic neuritis group	—	—	—	79/82 (96%)
All patients with a history of optic neuritis				184/210 (88%)

Normal values and stimulus parameters for testing as in Table 2-1.

TABLE 3-3. Evidence of clinically unsuspected lesions revealed by BAEP, PSVEP, and SEP tests

	Definite	Probable	Possible	Total
BAEP alone	4/81(5%)	6/67(9%)	5/54(9%)	15/202(7%)
PSVEP alone	28/79(33%)	24/67(36%)	11/54(20%)	61/200(31%)
SEP alone	4/16(25%)	6/21(29%)	2/14(14%)	12/51 (24%)
BAEP and PSVEP	0/79	0/67	4/54(7%)	4/200(2%)
BAEP and SEP	0/16	0/21	0/14	0/51
PSVEP and SEP	0/16	2/20(10%)	0/14	2/50 (4%)
All three	0/16	1/20(5%)	1/14(7%)	2/50 (4%)

Note that PSVEPs and SEPs are approximately equally useful in revealing "silent" lesions whereas BAEPs are about one-third less sensitive in this regard. "Clinically unsuspected" indicates that there was no history or physical sign suggesting abnormal function in that sensory system, either present or past. For BAEP some nonspecific data (e.g., nystagmus) were taken as indications of "clinically suspected" brainstem lesions (see Chapter 5, Section 3.4 for further explanation). All patients did not have all three tests (see Table 3-4). SEP testing was upper limb only.

TABLE 3-4. Evidence of clinically unsuspected lesions revealed by PSVEP, BAEP, and SEP in patients who had all three tests

	Definite	Probable	Possible	Total
PSVEP overall	13(57%)	11(41%)	2(10%)	26(37%)
BAEP overall	4(17%)	11(41%)	2(10%)	17(24%)
SEP overall	11(48%)	12(44%)	6(30%)	29(41%)
PSVEP alone	8(3%)	6(22%)	1(5%)	15(21%)
BAEP alone	3(13%)	6(22%)	1(5%)	10(14%)
SEP alone	7(30%)	8(30%)	4(20%)	19(27%)
PSVEP and BAEP only	1(4%)	3(11%)	0	4(6%)
PSVEP and SEP only	4(17%)	2(7%)	1(5%)	7(10%)
BAEP and SEP only	0	2(7%)	1(5%)	3(4%)
PSVEP, BAEP and SEP	0	0	0	0
No. patients	23	27	20	70

"Overall" refers to abnormality rate irrespective of clinical suspicion of a lesion. Other data refer to "clinically unsuspected" lesions (see Table 3-3). The number of patients with two and three tests indicating such lesions is much smaller since it is less likely that a patient with MS will not have symptoms or signs in two or three systems.



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