EEG Course

A Systematic Approach to the Electroencephalogram & Activation Methods

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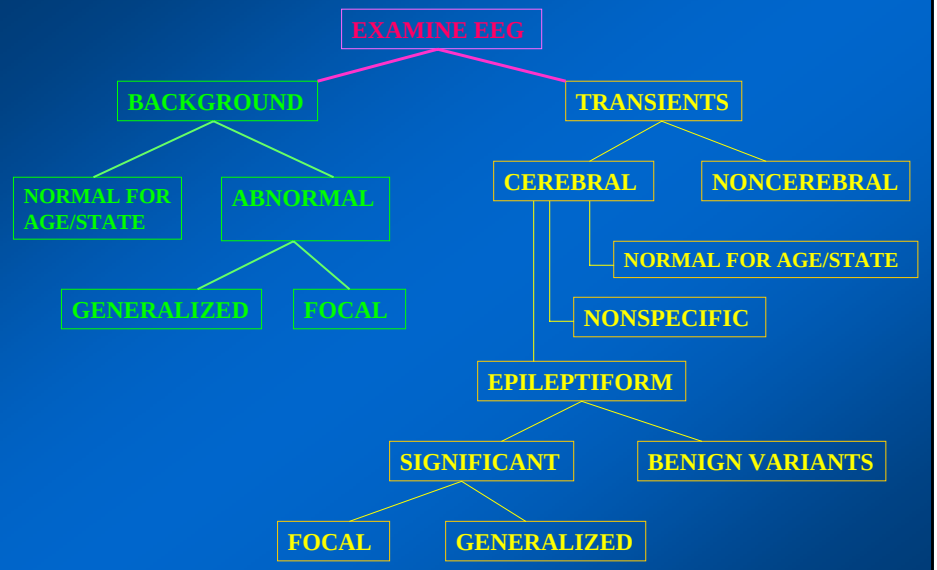
June 21st – 22nd, 2010

OUTLINE

1. **Step of EEG approach**
2. **Activation Methods**
   - 2.1 Reactivity
   - 2.2 Hyperventilation
   - 2.3 Photic stimulation
   - 2.4 Pattern stimulation
   - 2.5 Other stimuli
   - 2.6 Sleep & sleep deprivation
   - 2.7 Pharmacologic stimuation

Algorithm displaying an approach to the orderly visual analysis of EEG activity



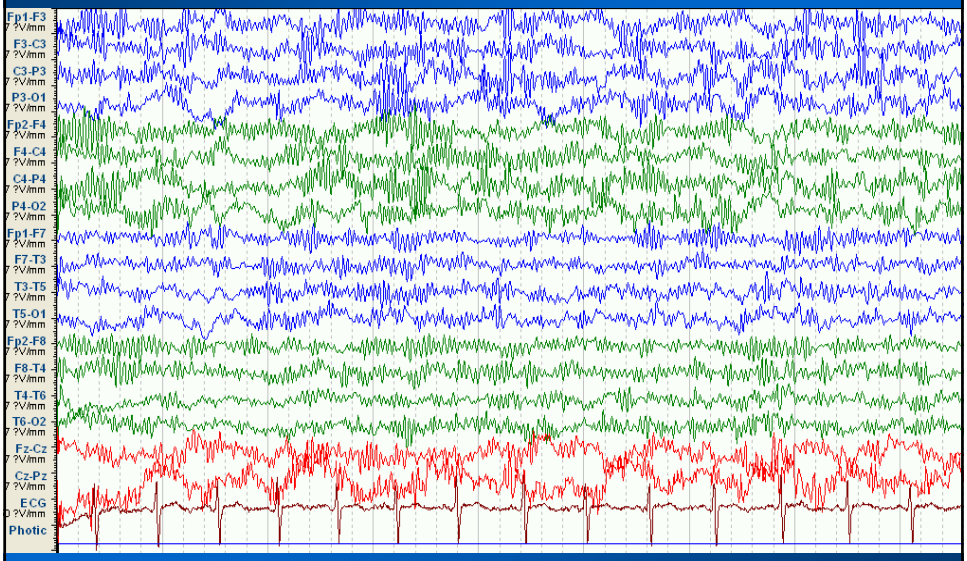
Epilepsia 2002;43 (suppl 3): 17-26

Activation Methods

EEG study in children:

Sedation is not routine !

Excessive beta activity due to chloral hydrate



2. Activation Methods

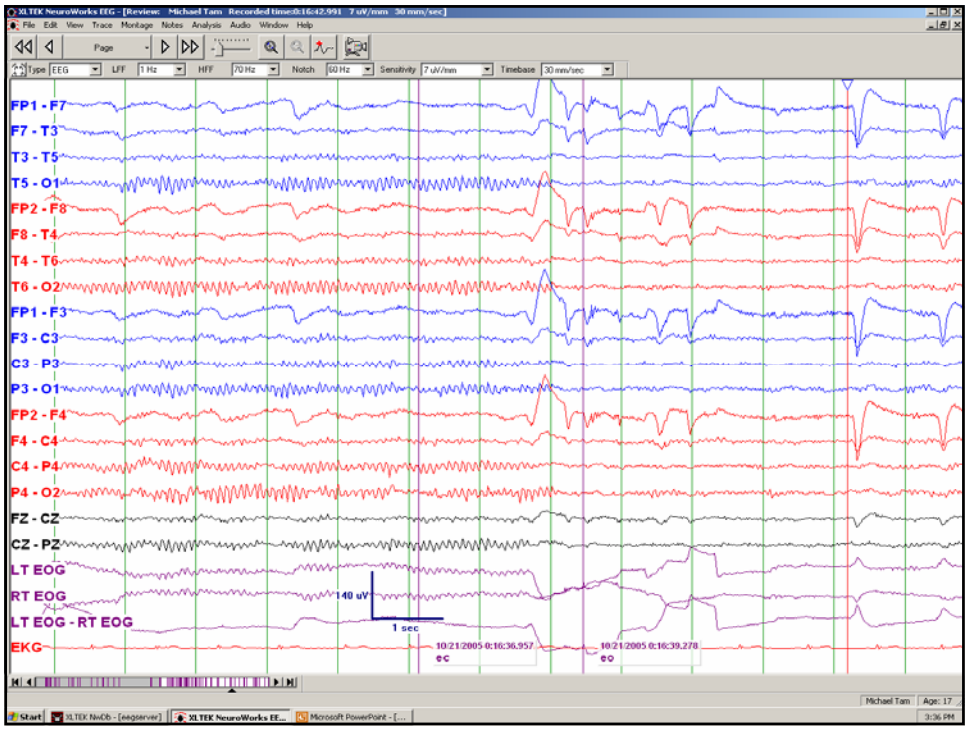
2.1 Reactivity (eye opening & closing)
2.2 Hyperventilation
2.3 Photic stimulation
2.4 Pattern stimulation
2.5 Other stimuli
2.6 Sleep & sleep deprivation
2.7 Pharmacological activation

2.1 Reactivity

- Children : the occipital alpha rhythm may totally block with the eye open.
- Adults : 24%, no alpha blocking

Bancaud's phenomenon

– unilateral failure to attenuate with eye opening
– indicates abnormality of the same hemisphere that fails to attenuate


FP1 - F7
F7 - T3
T3 - T5
T5 - O1
FP2 - F8
F8 - T4
T4 - T6
T6 - O2
FP1 - F3
F3 - C3
C3 - P3
P3 - O1
FP2 - F4
F4 - C4
C4 - P4
P4 - O2
FZ - CZ
CZ - PZ
LT EOG
RT EOG
LT EOG - RT EOG
EKG
140 uV
1 sec
10/21/2005 0:16:36.957
ec
10/21/2005 0:16:39.278
eo

Note

2.2 Hyperventilation (HV)

2.2 Hyperventilation (HV)

- Alternation of PCO_2 is the most important factor in producing the EEG response to HV.
- **Procedure**: over-breathe for at least 3 min.
  (children: cry or sob during the recording)
- The magnitude of HV response depends on
  - Effort -Age - Posture - Blood sugar (< 80 mg/100mL)
- The generation of epileptiform discharges during HV:
  80% for idiopathic generalized epilepsies
  50% for symptomatic generalized epilepsies
  <10% for localization-related epilepsy

2.2 Hyperventilation (HV)

Contraindications

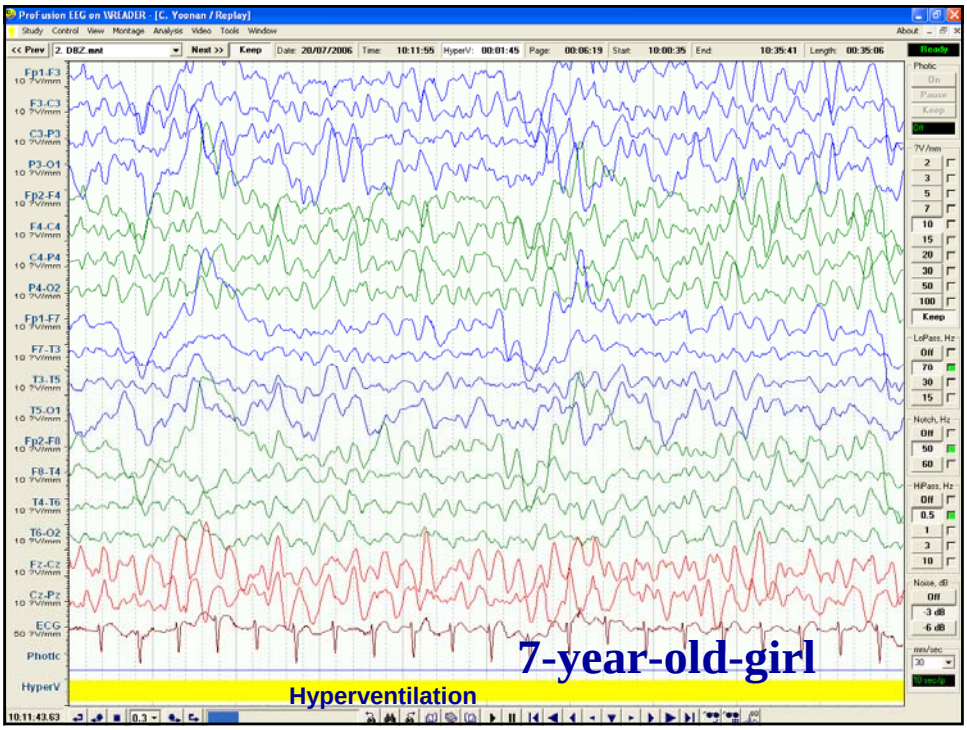
- Severe cardiac disease
- Recent myocardial infarction
- Active or recent asthma
- Recent stroke or TIA
- Intracerebral hemorrhage
- Severe carotid stenosis
- Moya-moya disease
- Hyperviscosity state
- Sickle cell anemia
- Uncontrolled hypertension

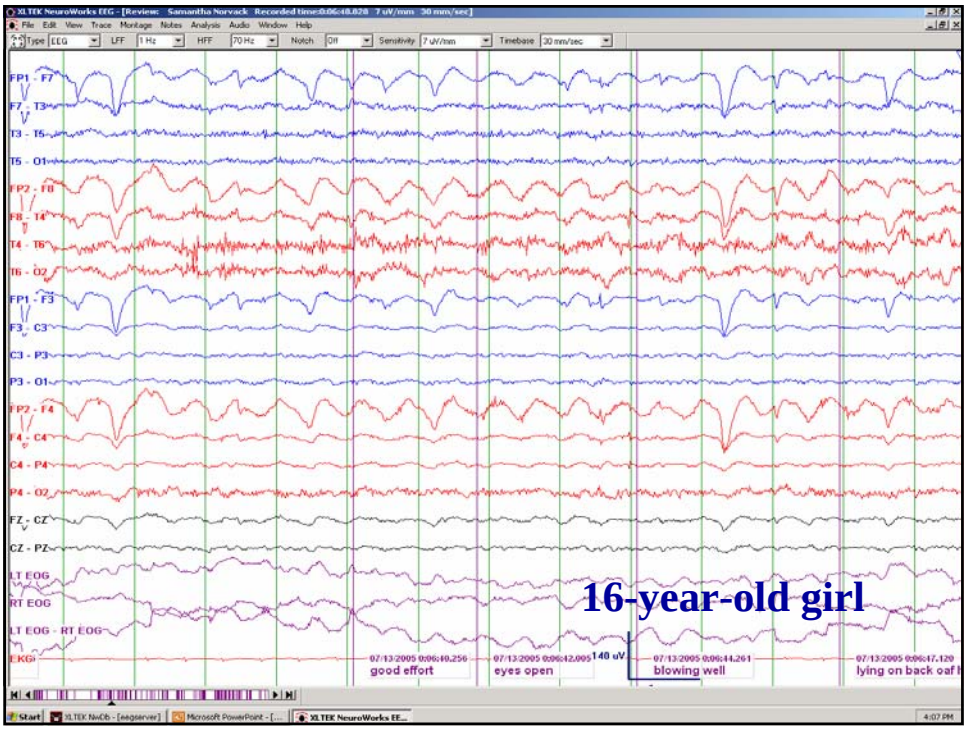
Relative contraindications

- Not cooperate patient
- A child whose EEG has already contained frequent generalized spike and wave

2.1 Hyperventilation (HV)

- **Normal response:**
  - buildup of medium to high amplitude, bisynchronous delta and theta waves.
  - Adults: 10% response; anterior dominant
  - Children: 70% response; ant^{r}/post^{r} dominant
    (85% occurred between 8 and 12 years of age)
  - return to baseline within 60 seconds after stop HV
  - often includes FIRDA, or OIRDA in children


7-year-old-girl
Hyperventilation

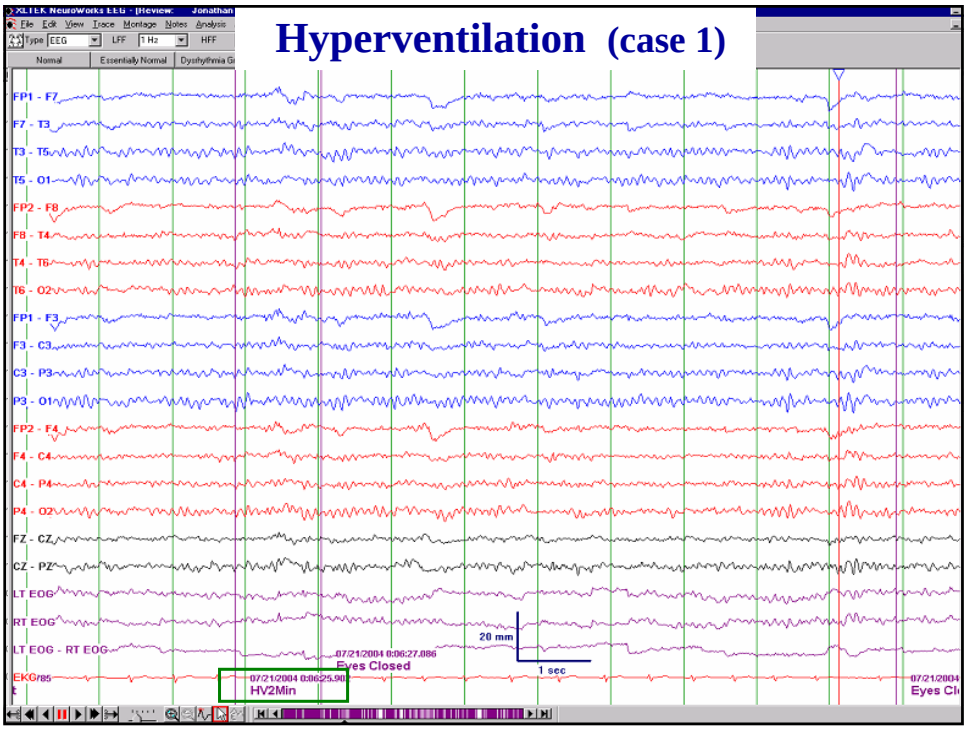

16-year-old girl
good effort
eyes open
blowing well

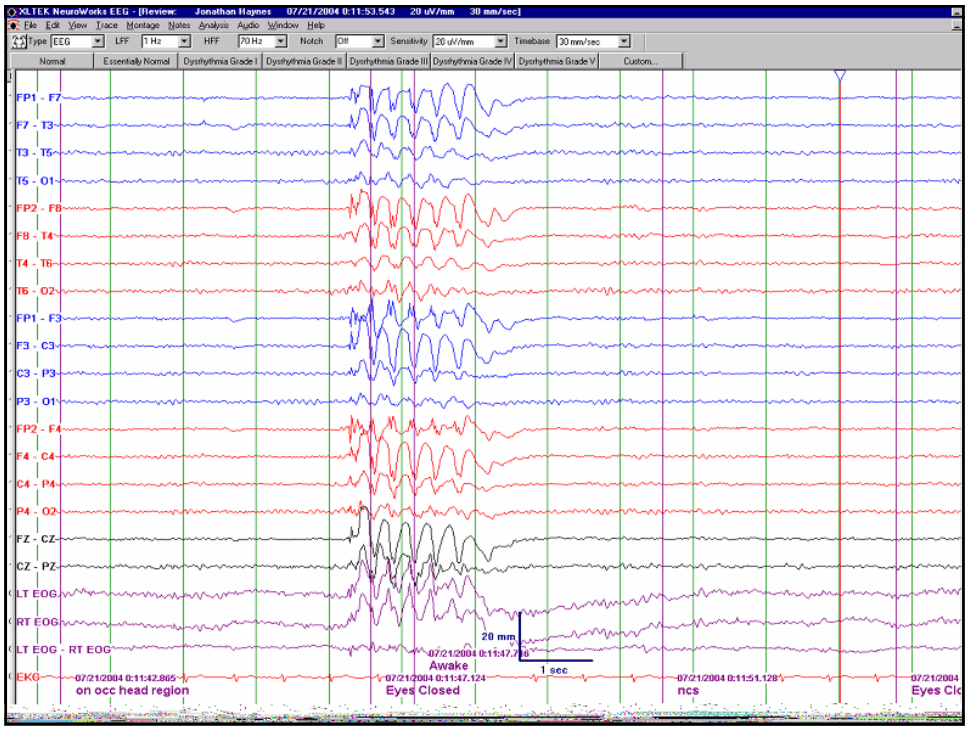
2.1 Hyperventilation (HV)

Abnormal response:

1. **Lateralized or localized slowing**
2. **Delayed symmetrical or lateralized slowing**
   - Moyamoya disease: a buildup of slowing several minutes after HV ends (~ 5 min. after HV ends)
3. **Asymmetry of background activity**
   - Usually the abnormality is on the side of higher amplitude response
4. **Epileptiform patterns**
   - >80% of untreated children with absence seizures
   - typical anterior-dominant 3-Hz spike-and-wave

Pseudo-absence seizures : impaired responsiveness during HV + generalized high amplitude 2-to 3- Hz activity




XLTEK NeuroWorks EEG - [Review: Jonathan Haynes 07/21/2004 0:11:53.543 20 uV/mm 30 mm/sec]
File Edit View Trace Montage Notes Analysis Audio Window Help
Type EEG LFF 1 Hz HFF 70 Hz Notch Off Sensitivity 20 uV/mm Timebase 30 mm/sec
Normal Essentially Normal Dysrhythmia Grade I Dysrhythmia Grade II Dysrhythmia Grade III Dysrhythmia Grade IV Dysrhythmia Grade V Custom...
FP1 - F7
F7 - T3
T3 - T5
T5 - O1
FP2 - F8
F8 - T4
T4 - T6
T6 - O2
FP1 - F3
F3 - C3
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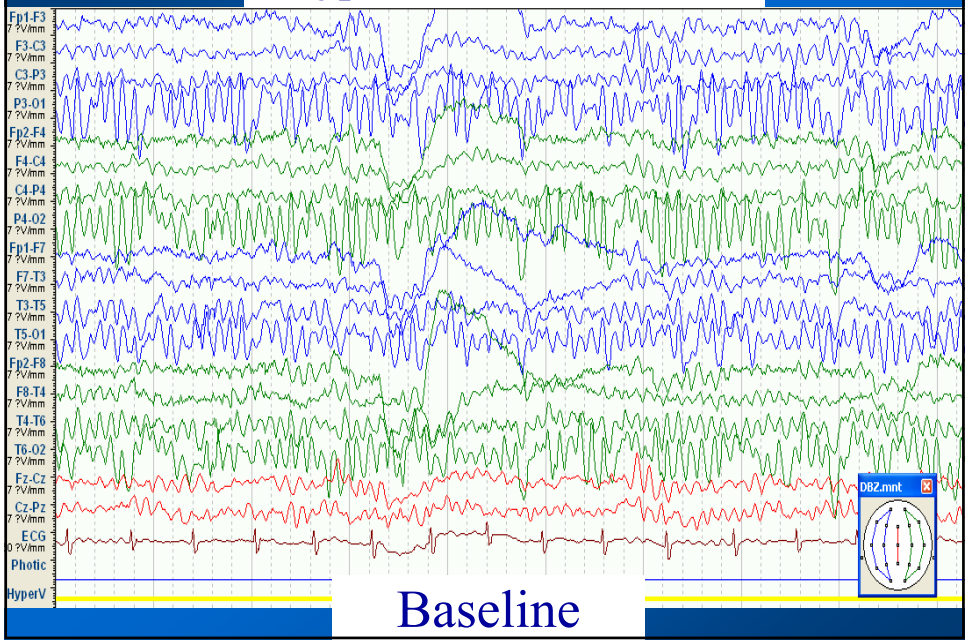
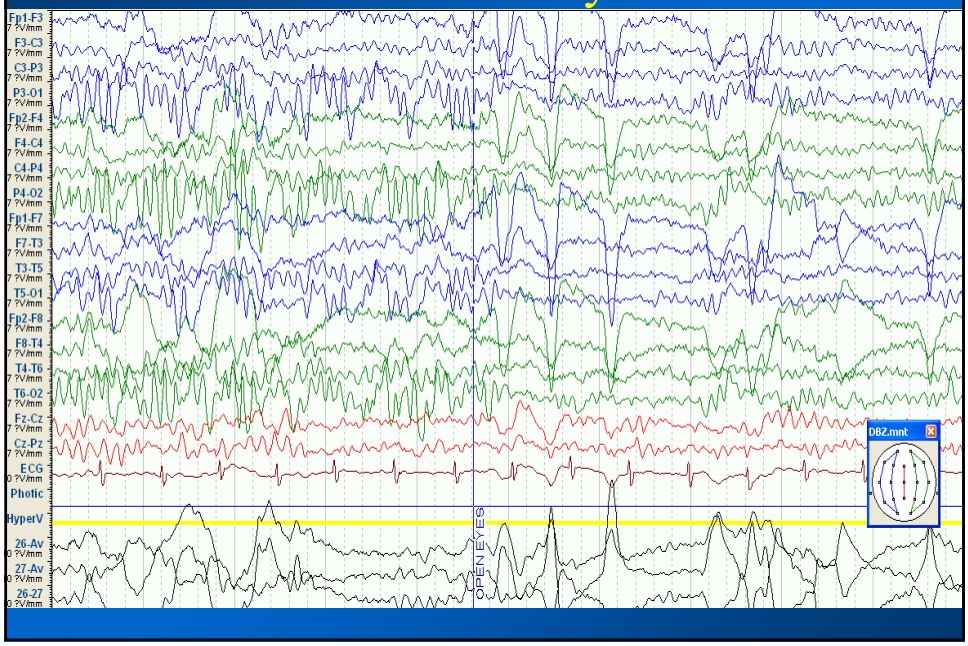
P4 - O2
FZ - CZ
CZ - PZ
LT EOG
RT EOG
LT EOG - RT EOG
EKG
20 mm
1 sec
07/21/2004 0:11:42.865
on occ head region
Awake
07/21/2004 0:11:47.124
Eyes Closed
07/21/2004 0:11:51.128
ncs
07/21/2004
Eyes Clo

Hyperventilation (case 2)

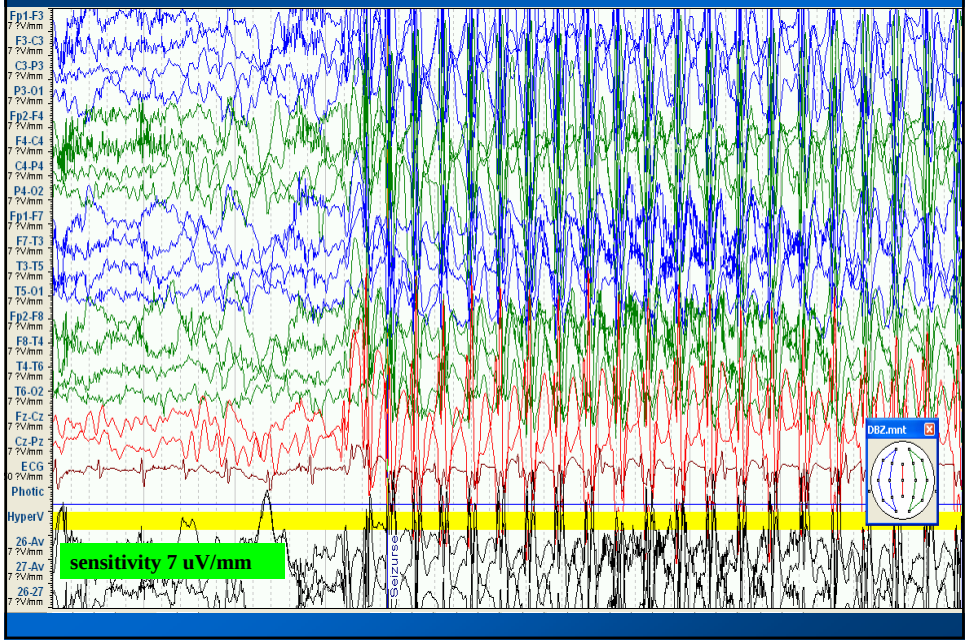


Baseline

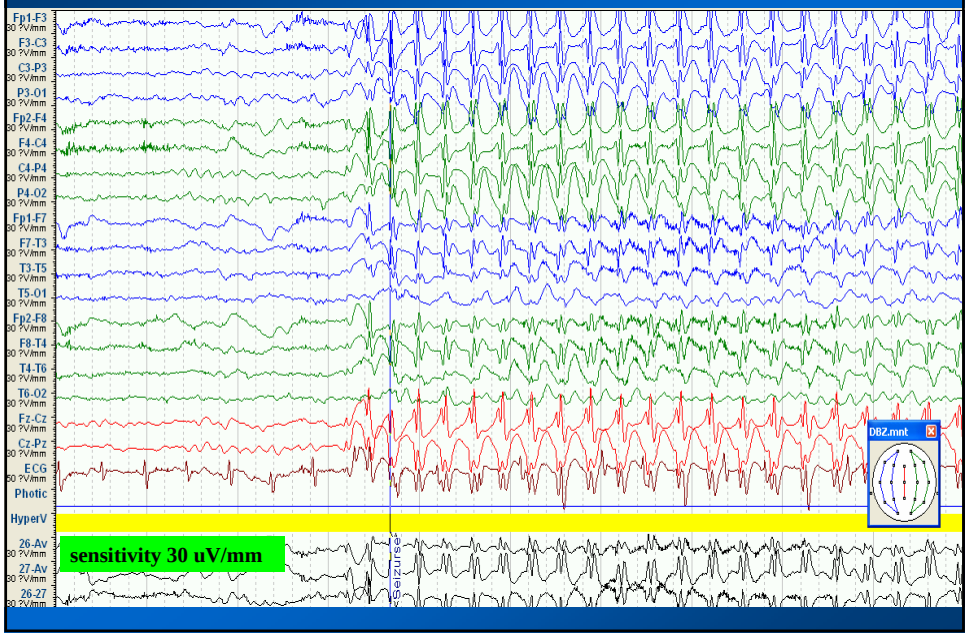
Reactivity



Start HV for 20 seconds

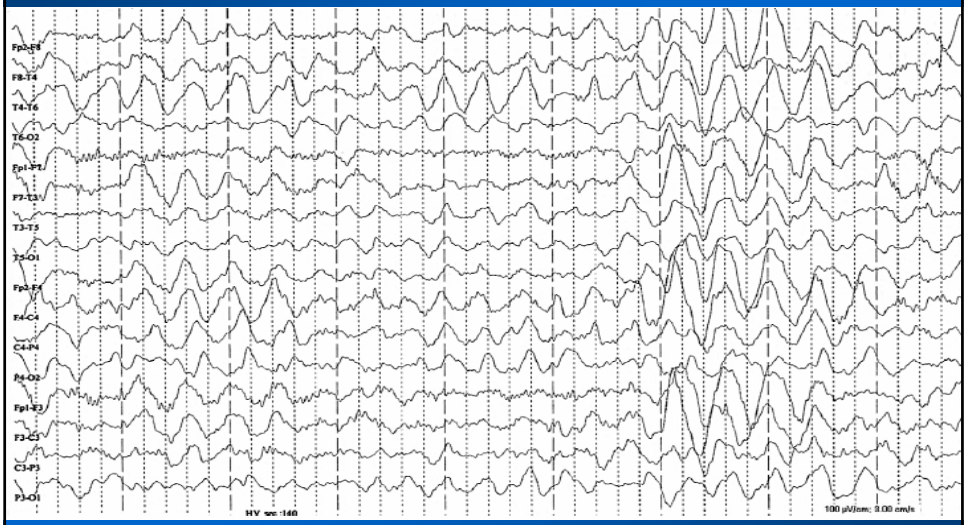


Start HV for 20 seconds



Hyperventilation (case 3)

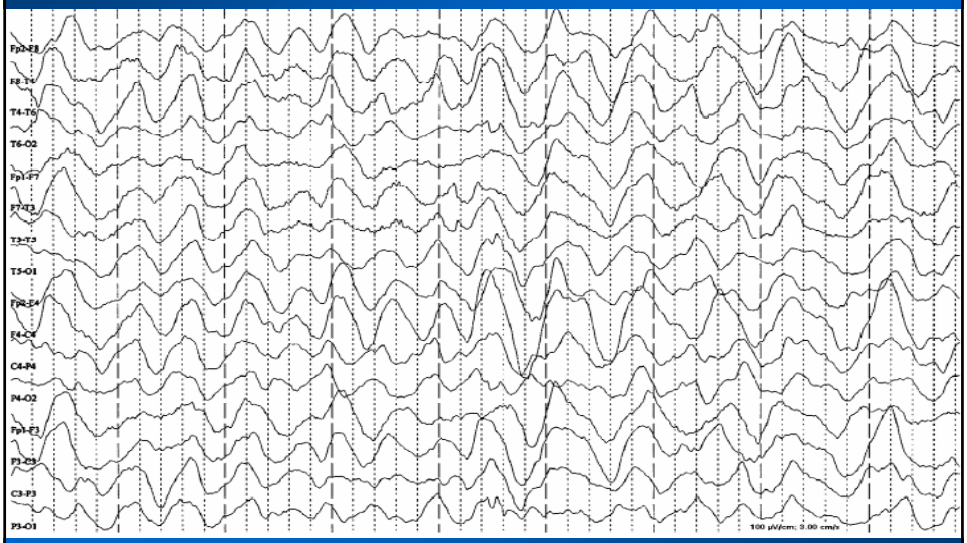
Brain Dev. 2007 Oct;29(9):603-6



140th second of HV

Hyperventilation (case 3)

Brain Dev. 2007 Oct;29(9):603-6



Re-build up phenomenon @ 60th second after stop HV

case 3: Moyamoya

Note

2.3 Photic Stimulation (PS)

Photic stimulator

2.3 Photic Stimulation (PS)

- **Photic stimulator characteristics**
  - Max. intensity > 100 Nit-s per flash
  - Circular field diameter of 13 cm
  - Granular diffuser producing light diffusion similar to that of the Grass stimulator
  - Central fixation point on diffuser
  - Attachment of patterns available
  - Single flashes or trains that can be delivered with constant intensity from 1 to 60 Hz

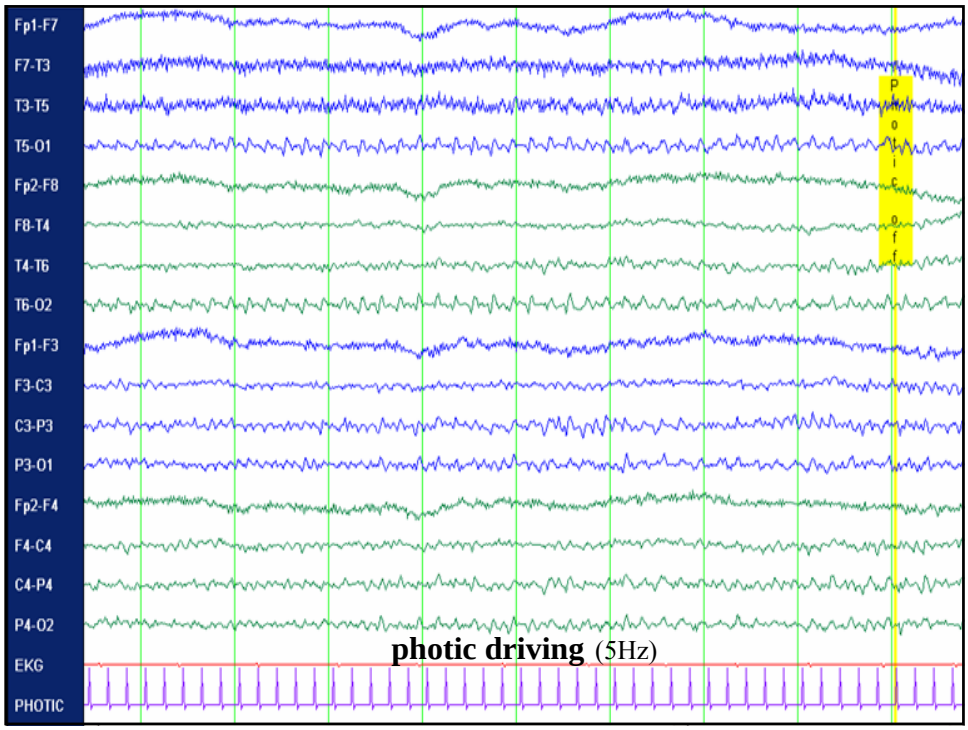
2.3 Photic Stimulation (PS)

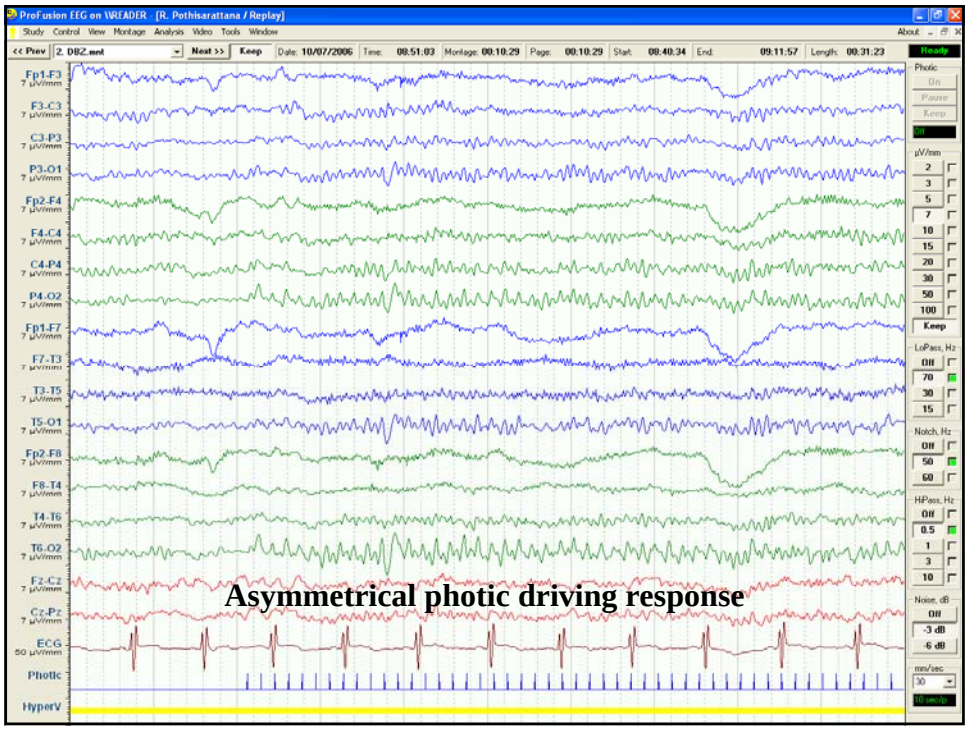
- **Procedure**
  - IPS should not be performed during or within 3 min of HV
  - Nasion-to-lamp distance of 30 cm
  - Longitudinal bipolar or common reference montage
  - Flash trains of 10s with at least 7-s intervals
  - Eyes open for first 5s of IPS and then closed
  - Eyes fixated on center of stimulator
  - IPS frequencies: 1,2,3,4,6,8,10,12,14,16,18,20,60,50,40,30,25
  - IPS is stopped abruptly if a PPR appears

*IPS = intermittent PS
*PPR = photoparoxysmal response

2.3 Photic Stimulation (PS)

- **Normal response:**
  - Rhythmic, occipital-dominant waveforms
  - Harmonic (an integer multiple) or subharmonic (an integer dividend) of flash frequency
  - Onset: 70- to 150-millisecond delay
  - At slower flash rates (<5Hz), the photic response consists of a diffuse light evoked potential
  - Photomyogenic responses
  - Unilateral driving may be seen. Interpretation as abnormal usually requires other abnormal features.

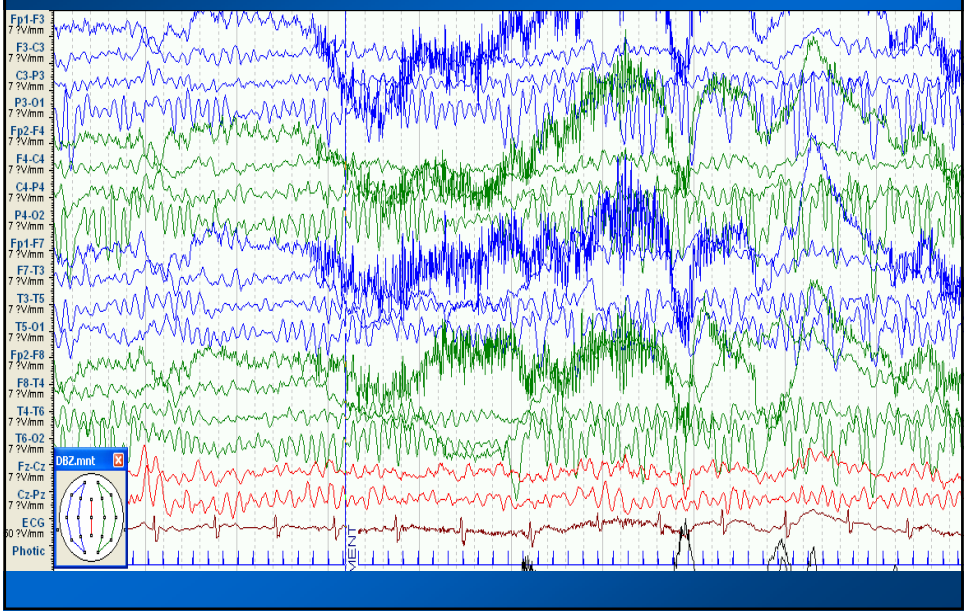

Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
EKG
PHOTIC
Photic
on
photic driving (5Hz)


ProFusion EEG on \\READER - [R. Pothisarattana / Replay]
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fz-Cz
Cz-Pz
ECG
Photic
HyperV
Asymmetrical photic driving response

Photomyogenic (photomyoclonic) response

- First described by Gastuat and Remond
- Prominent in 1% of individuals
- Brief, repetitive muscle spikes in the anterior head region
- Electromyographic potentials time locked to the flash frequency, anterior-dominant.
- Prominent with emotional tension or metabolic/toxic states
- Distinguish from PPR by immediate cessation of the response at the end of stimulation and prominent EMG activity
- Unknown clinical significance

Photomyogenic response



2.3 Photic Stimulation (PS)

- **Abnormal responses:**
  1. Photoparoxysmal response (photoepileptiform, photoconvulsive)
  2. Abnormal response in specific cerebral disorders

1. Photoparoxysmal response (PPR)

(Photoepileptiform response, PER)

- Generalized spike-and-slow wave and polyspike-and-slow wave complexes
- ~ 4% of patient with epilepsy have a PPR
- 70% - 77% of patient with PPR have epilepsy
- Maximal incidence : 6-15 years of age
- Clinical correlation:
  1. GTC
  2. Myoclonic (JME ~38%)
  3. Absence (~24%)

PPR

- Two types of PPRs:

1. Prolonged or self sustaining
   : outlasts at least 100 ms, suggests probable epilepsy (93%)
   : generalized spike-and-wave response shows a strong association with epilepsy

2. Self-limited
   : ceases before or when the flash stops
   : not diagnostic for epilepsy

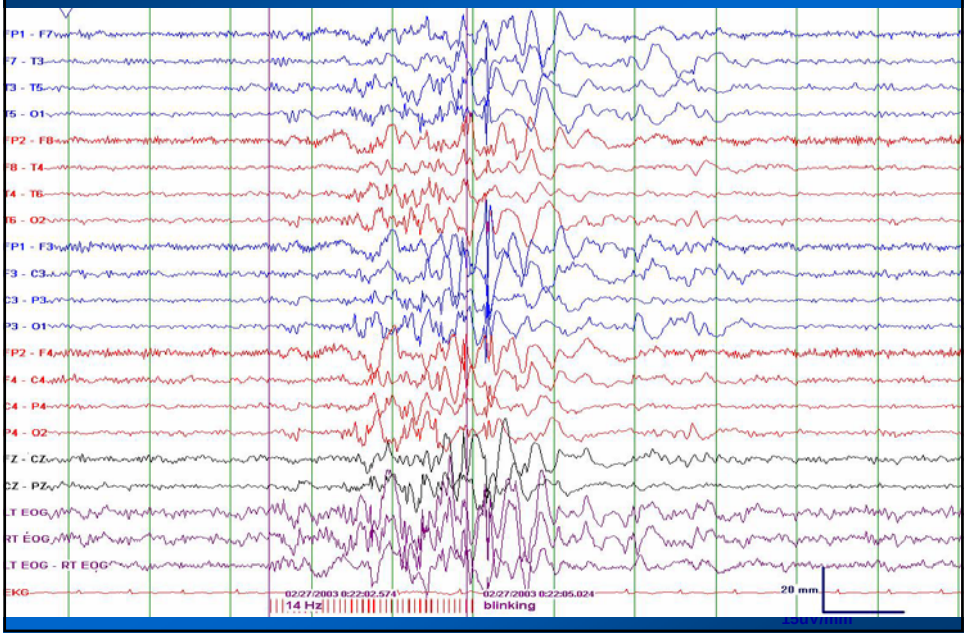
PER

- The most suggestive features of posterior-dominant PER are:

1. Medium- to high-amplitude spikes or sharp waves persists well beyond (>200 msec.) the termination of the flash stimulus.

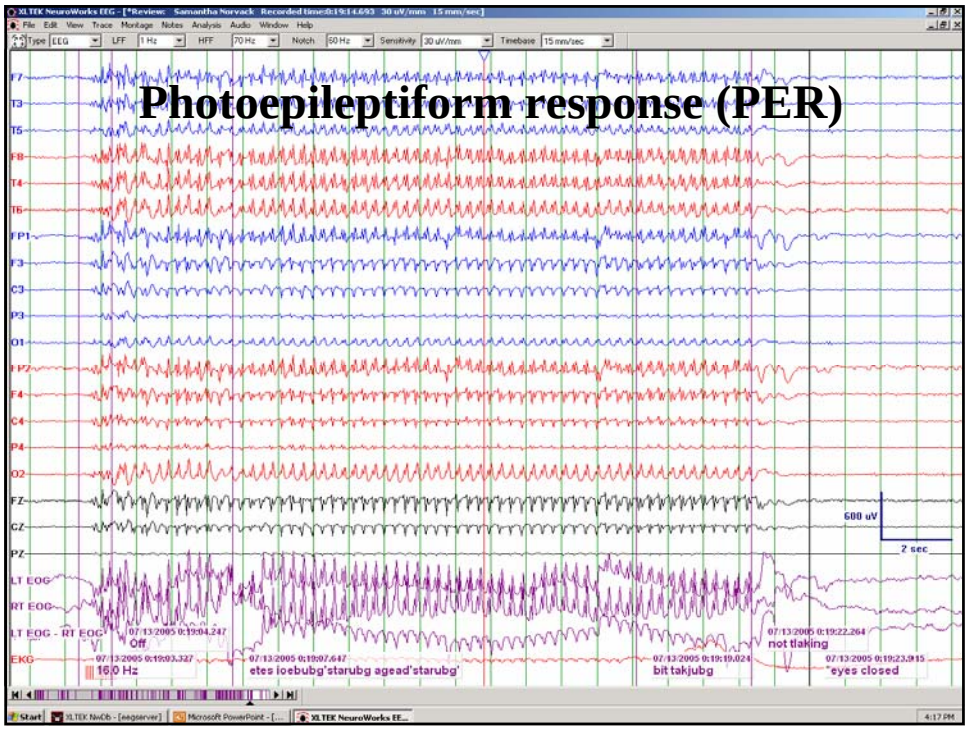
2. Association with clinical convulsive or nonconvulsive seizure activity.

Photoparoxysmal response (PPR)



2.3 Photic Stimulation (PS)

- **Pitfalls:**
  - PS is less effective when performed during sleep
  - Unilateral monocular stimulation or stimulation during conjugate ocular deviation away from the stimulus is less effective than binocular gaze-directed stimulation
  - Repeat the same stimulus train to verify that PPR is related to the flash stimulus
    - Don't repeat immediately (habituation with blocking of the response will occur)
    - Repeat same stimulus train after > 30 seconds later



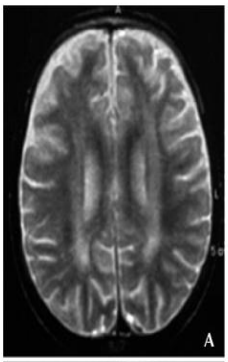
2. Abnormal responses in specific cerebral disorders

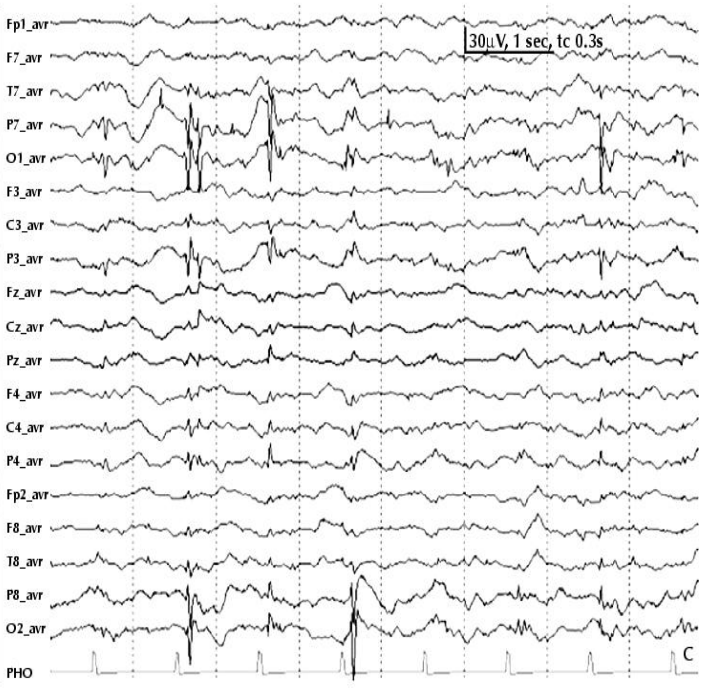
- ↑ amplitude of photic driving found in
  - cortical epileptogenic lesions
  - skull defects
- ↓ amplitude of photic driving found in
  - destructive brain lesion
- Photosensitivity
  - partial epilepsy ~ 2.8%
  - generalized epilepsy (idiopathic) ~21%

2. Abnormal responses in specific cerebral disorders

Q: What is the pathognomonic EEG findings in patient with late infantile NCL

(Bielschowsky-Jansky form of Batten's disease)





2.4 Pattern-activated PPR

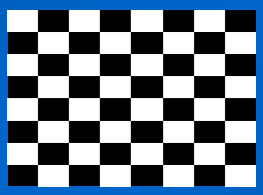
- The first report of a patient with pattern sensitivity appeared in 1953 by Bickford et al.
- Virtually all patients with pattern sensitivity also show sensitivity to PS
- However, very few patients with sensitivity to PS also have pattern sensitivity
- Distribution of elicited epileptiform discharges
  : generalized in two thirds of patients,
  : restricted to the posterior head region in one-third.

2.4 Pattern-activated PPR

What is the most effective activating pattern ?

A

B



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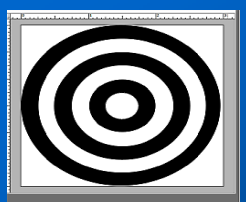

D

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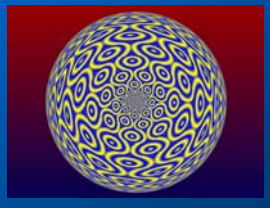


2.5 Other stimuli activation

- may be used in cases where episodic symptoms or signs suggest a convulsive disorder triggered by known stimuli and where a diagnosis is wanting.
- These procedures should be used with caution and with the intention of inducing EEG abnormalities while avoiding precipitation of seizure.
- The benefits of the diagnostic information obtainable by activation of EEG discharges must be weighed against the minor risk of inducing a seizure.

2.5 Other stimuli activation

1. **Pattern sensitivity**
   - Virtually all patients with pattern sensitivity also show sensitivity to PS
   - However, very few patients with sensitivity to PS also have pattern sensitivity
2. **Video game**
   - Hormes et al., 1995: 40 patients with PPR to stroboscopic PS, 30% of these patients also had sensitivity to video games.
3. **Auditory stimuli**
   - Sudden loud noise (reflex epilepsy)
   - Specific musical piece (musicogenic epilepsy)

2.5 Other stimuli activation

4. Reading

Primary reading epilepsy (intrinsic or perceptive):

- epileptiform bursts occur after a period of reading
- max. in the parieto-occipital regions
- assoc. with clinical jaw jerking or 'clicking' while reading

Secondary reading epilepsy (extrinsic or sensorial):

- epileptiform discharges appear not only with reading but also under other conditions
- assoc. with pattern sensitivity

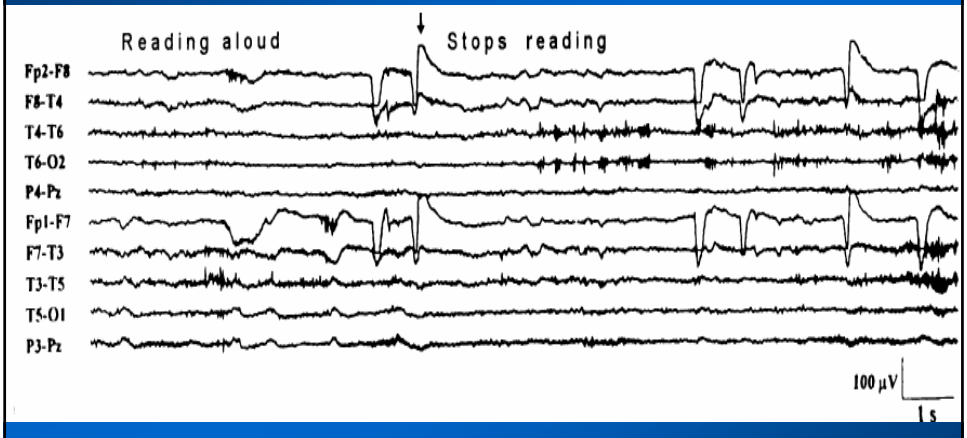
Reading Stimuli

Reading Stimuli

Brain 1998;121:1409-1427

Reading Stimuli

Brain 1998;121:1409-1427



Bursts of low voltage monomorphic slow activity during reading aloud

2.5 Other stimuli Activation

5. Mental concentration

- mental calculation with eye closure
- rarely, mental calculation will precipitate a seizure

6. Tactile stimulation

- touching certain parts of body may induce of abolish epileptiform activity and seizures in some patients
- Somatosensory epilepsy
  - interictal medium to high amplitude spikes over the perisylvian or central parasagittal head regions
  - evoked by tapping on the distal contralateral limbs

Note

2.6 Sleep & Sleep Deprivation

2.6 Sleep Activation

During sleep

- increase of epileptic discharges rates from 77 to 98% in absences and GTC combined with absences.

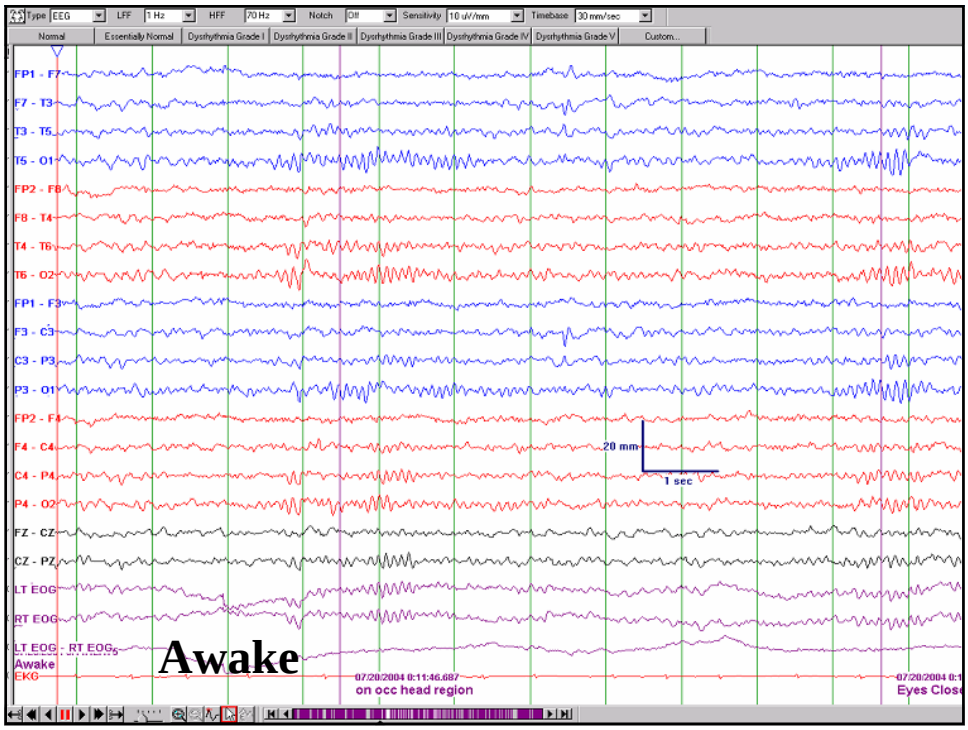
During sleep deprivation

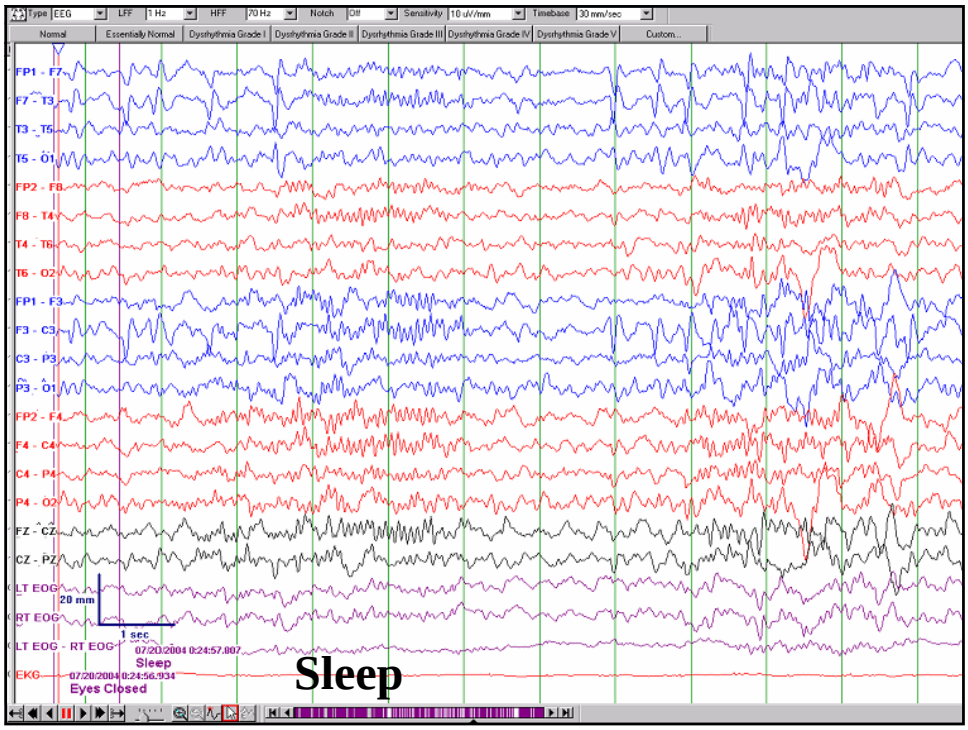
- permit only about 4 hours of sleep
- increase of epileptiform discharges rates from 50 to 80%.

2.6 Sleep Activation

Epileptic syndromes activated by sleep:

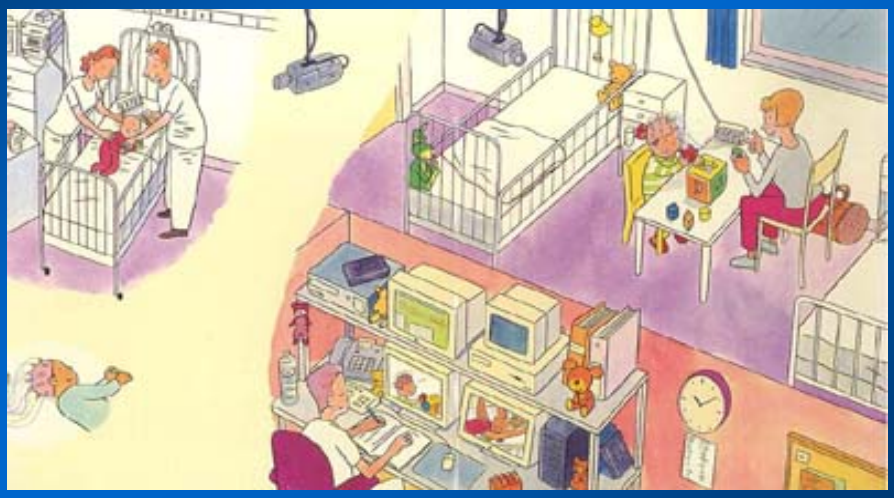
- CSWS
- LGS
- Benign JME
- Benign Rolandic epilepsy (BECTS)
- Frontal lobe epilepsy
- ADNFLE
- Benign occipital epilepsy in infancy
- Nocturnal epileptic myoclonus
- Epilepsy with generalized tonic-clonic seizures on awakening





2.7 Pharmacological activation

- Discontinuing AEDs for video-EEG recording



Drug Effects on EEG

J Clin Neurophysiol 2006;23:306-311

Background slower (theta and delta)

- "Older" AEDs e.g. PB, PHT, CBZ, VPA
- Neuropsychiatric drugs e.g. clozapine, TCA, lithium

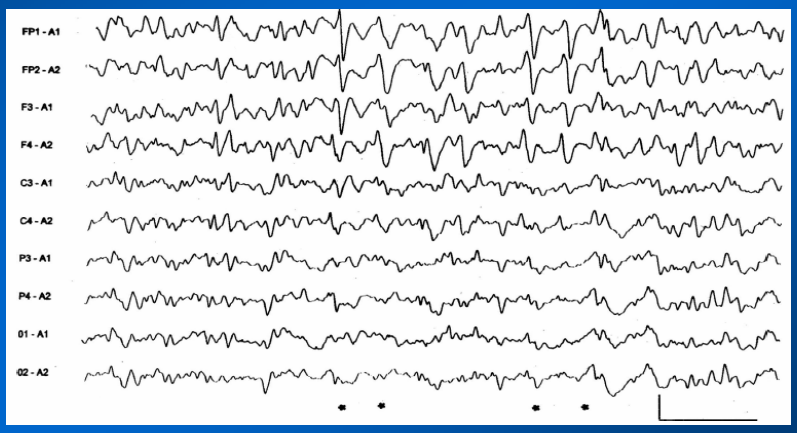
Excess beta

- Barbiturates
- Benzodiazepines
- Cocaine
- Amphetamine
- Methylphenidate
- Tricyclic antidepressants
- Withdrawal from alcohol and barbiturates

Drug Effects on EEG

Triphasic waves

- Drug intoxication e.g. VPA-associated hyperammonemic encep.
- Other drugs e.g. baclofen, lithium, L-dopa, pentobarbital, SSRI



Drug Effects on EEG

Epileptiform activity

a) Bursts of bisynchronous spikes or polyspikes

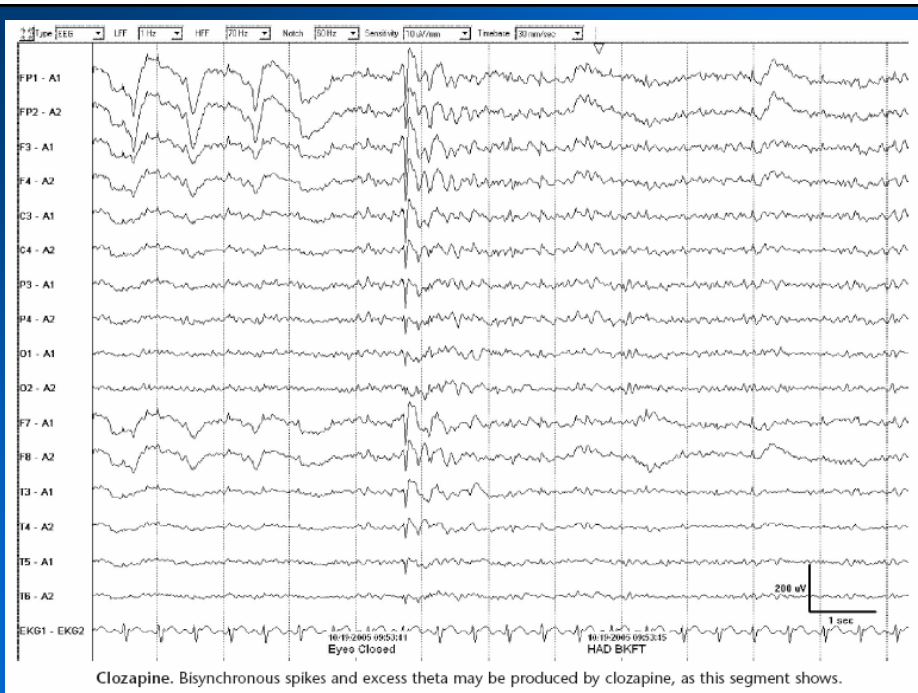
- high doses of clozapine, lithium, phenothiazines, SSRI, TCA
- acute withdrawal of alcohol or barbiturates

b) Augmentation of epileptiform discharges

- reduction of AEDs
- morphine in neonates

Coma pattern

- Drug intoxication e.g. pentobarbital, BZD



Clozapine. Bisynchronous spikes and excess theta may be produced by clozapine, as this segment shows.

Take home messages

- Step of EEG approach should be always kept in mind before start to interpret EEG recording.
- Good understanding of EEG waveforms, and specific pattern recognition will increase accuracy of EEG interpretation.
- Skill of EEG interpretation is crucial and need to be increased by regular practice.