REPORT PARAMETERS FOR POLYSOMNOGRAPHY

PARAMETERS TO BE REPORTED FOR PSG

- There are parameters recommended by the AASM that must be reported for each sleep study run.
- There are also optional parameters that can be monitored and documented at the discretion of the sleep clinician/sleep center.
- AASM Scoring Manual guidelines do change over the years, so it is important that you keep up-to-date with the current scoring manual.

GENERAL PARAMETERS

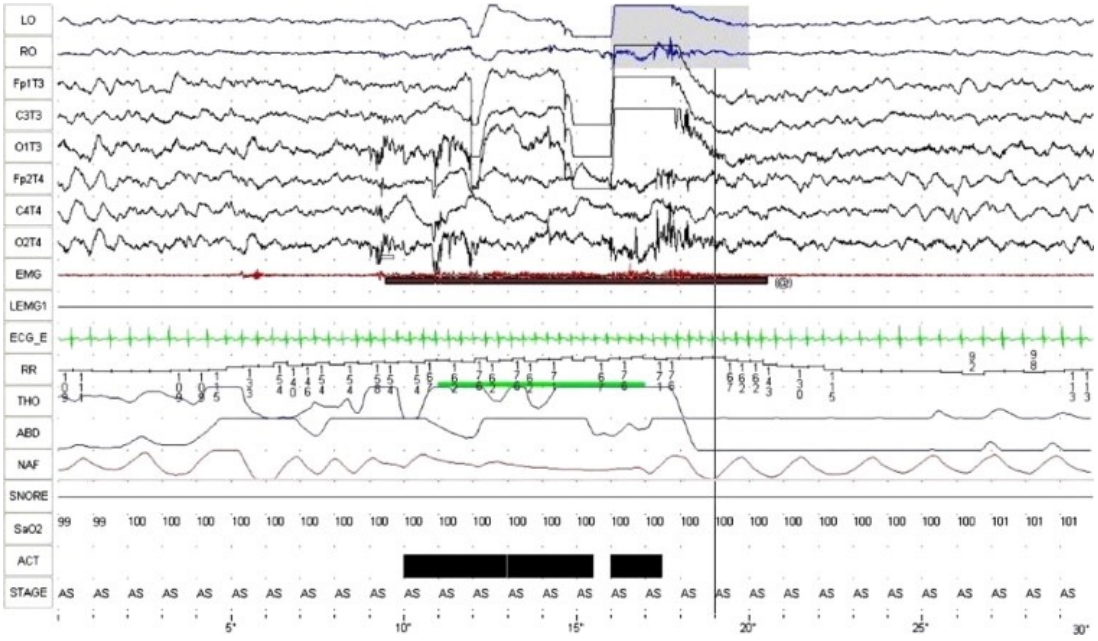
- The following general parameters are recommended by the AASM to be reported:
  - EEG derivations
  - EOG derivations
  - Chin EMG
  - Leg EMG
  - Airflow signals
  - Respiratory Effort Signals
  - O2 saturation
  - Body position
  - ECG
  - Synchronized PSG video

SLEEP SCORING DATA

- The AASM recommends the following sleep scoring data be reported:
  - Lights out = Start of recording (clock time)
  - Lights on = End of recording (clock time)
  - TST = Time spent in N1 + N2 + N3 + REM
  - TRT = “Lights out” to “Lights on”
  - Sleep latency (SL) = Time it takes to reach the first epoch of sleep
    - “Lights out” to first epoch of any sleep
  - REM latency = Sleep onset to the first epoch of REM
  - WASO = Wake after sleep onset
    - TRT-SL-TST
  - Sleep efficiency = % of TRT spent asleep
    - TST/TRT x 100
  - Time in each sleep stage
  - % of TST in each sleep stage

AROUSAL EVENTS

- Arousal events that the AASM recommends to be reported are:
  - # of arousals
  - Arousal index
    - # of arousals x 60/TST



CARDIAC EVENTS

- Cardiac events that the AASM recommends to be reported are:
  - Average heart rate (HR) during sleep
  - Occurrence of bradycardia
    - Lowest HR observed
  - Occurrence of asystole
    - Longest pause observed
  - Occurrence of sinus tachycardia during sleep
    - Report highest HR
  - Occurrence of narrow complex tachycardia
    - Report highest HR
  - Occurrence of wide complex tachycardia
    - Report highest HR

CARDIAC EVENTS

- Occurrence of atrial fibrillation
  - Report average HR
- Occurrence of other arrhythmias
  - List the arrhythmia

- Optional cardiac events to report:
  - Highest and lowest HR during sleep
  - Highest and lowest HR during recording

MOVEMENT EVENTS

- Movement events that the AASM recommends to be reported are:
  - Number of PLMS
  - Number of PLMS with arousals
  - PLMS index
    - # of PLMS x 60/TST
  - PLMS arousal index
    - PLMS with arousals x 60/TST
- An optional movement event that can be reported is REM without atonia (RWA), but you must list in the report which EMG leads were used to determine the atonia.

RECOMMENDED RESPIRATORY EVENTS

- Respiratory events that the AASM recommends to be reported are:
  - # of obstructive apneas
  - # of mixed apneas
  - # of central apneas
  - # of hypopneas
  - # of apneas + hypopneas
  - Apnea index
    - (# OA + # CA + # MA) x 60 / TST
  - Hypopnea index
    - # hypopneas x 60 / TST
  - AHI
    - (# apneas + # hypopneas) x 60 / TST

RECOMMENDED RESPIRATORY EVENTS

- Arterial O2 saturation, mean value
- Time below specified oxygen saturation threshold
- Minimum O2 saturation during sleep
- Occurrence of hypoventilation in children during diagnostic study
- Occurrence of Cheyne-Stokes breathing in adults
- Occurrence of periodic breathing in children
- Occurrence of snoring in children

OPTIONAL RESPIRATORY EVENTS

- Respiratory events that AASM deems as optional to report are:
  - # of obstructive hypopneas
  - # of central hypopneas
  - Obstructive AHI (OAHI)
    - (# OA + # MA + # OH) x 60 / TST
  - Central Apnea Index (CAI)
    - # CA x 60/TST
  - Central AHI (CAHI)
    - (# CA + # CH) x 60 / TST
  - # of RERAs
  - RERA index
    - # RERAs x 60 / TST
  - RDI
    - (# apneas + # hypopneas + # RERAs) x 60 / TST

OPTIONAL RESPIRATORY EVENTS

- # of O2 desaturations ≥ 3% or ≥ 4%
- O2 desaturation index ≥ 3% or ≥ 4%
  - # oxygen desats ≥ 3% or ≥ 4% x 60 / TST
- Occurrence of hypoventilation in adults during diagnostic study
- Occurrence of hypoventilation during PAP titration for both adults and children
- Duration of Cheyne-Stokes breathing or # of Cheyne-Stokes breathing events
- Occurrence of snoring in adults

SUMMARY STATEMENTS

- Summary statements that the AASM recommends to be included in the sleep study report are:
  - Findings related to sleep diagnoses
  - EEG abnormalities
  - ECG abnormalities
  - Behavioral observations
- The AASM considers sleep hypnograms as an optional parameter that can be reported.

TECHNICAL AND DIGITAL SPECIFICATIONS

DIGITAL SPECIFICATIONS FOR ROUTINE PSG

- Maximum Electrode Impedances = 5000 Ohms
- Minimum Digital Resolution = 12 bits per sample
- Sampling Rates as recommended by AASM:

	Desirable	Minimal
EEG, EOG, EMG, ECG, Snoring Sounds	≥500 Hz	200 Hz
Airflow, Nasal Pressure, End-Tidal PCO2, PAP Device Flow, Esophageal Pressure, Rib Cage and Abdominal Movements	≥100 Hz	25 Hz
Oximetry, Transcutaneous PCO2	25 Hz	10 Hz
Body Position	≥1 Hz	≥1 Hz

ROUTINELY RECORDED FILTER SETTINGS

	LFF	HFF
EEG, EOG	0.3 Hz	35 Hz
EMG, Snoring	10 Hz	100 Hz
ECG	0.3 Hz	100 Hz
Oronasal Thermal Flow, Thoracoabdominal Belt Signals	0.1 Hz	15 Hz
Nasal Pressure	DC or ≤0.03 Hz	100 Hz
PAP Device Flow	DC	DC

ADDITIONAL AASM SPECIFICATIONS

- The ability to display raw data for review, manual scoring, or editing of automated scoring is Recommended.

PSG RECORDING FEATURES

- The AASM recommends the following PSG recording features:
  - Method for permitting visual (on-screen), standard, negative 50 uV DC calibration signal for all channels to demonstrate polarity, amplitude, and time constant settings for each recorded parameter
  - Separate 50/60 Hz notch filter control for each channel
  - Capability of providing the minimal recommended sampling rate (or higher) and minimal registry length (digital amplitude) or higher for all signals as specified

PSG RECORDING FEATURES

- The AASM recommends the following PSG recording features:
  - Method of measuring actual individual electrode impedance against a reference
  - Capability of retaining and viewing the data in the exact manner in which it was recorded by the attending technologist
  - Capability of retaining and viewing the data in the exact manner it appeared when it was scored by the scoring tech
  - Filter design for data collection which functionally simulates/replicates conventional (analog-style) frequency response curves rather than removing all activity and harmonics within the specified bandwidth

PSG DISPLAY FEATURES

- The AASM recommends the following PSG display features:
  - Display for scoring and review of sleep study data must meet/exceed the following criteria: 15” screen size, 1600 pixels horizontal and 1050 pixels vertical
  - Histogram with stage, respiratory events, leg movement events, O2 saturation, body position, and arousals, with cursor positioning on histogram and ability to jump to the page
  - Ability to view a screen on a time scale ranging from the entire night to windows as small as 5 seconds

PSG DISPLAY FEATURES

- The AASM recommends the following PSG display features:
  - Recorded video data must be synchronized with PSG data within one second and have an accuracy of at least one video frame per second
- The following are optional PSG display features:
  - Page automatic turning and scrolling
  - Channel-off control key/toggle
  - Channel-invert control key/toggle
  - Change order of channel by click and drag
  - Multiple display setup profiles that may be activated at any time
  - Fast Fourier transformation or spectral analysis on specifiable interval

DIGITAL ANALYSES OF PSG

- The AASM recommends the following guidelines for digital analyses of PSG:
  - Ability to display whether sleep stage scoring was performed visually or computed by the system
- The following are optional guidelines for digital analyses of PSG:
  - Ability to turn off and on, as demanded, highlighting of EEG patterns used to make sleep stage decisions
  - Ability to turn off and on, as demanded, highlighting of patterns identifying respiratory events
  - Ability to turn off and on, as demanded, highlighting of patterns identifying the movement analysis

AASM RECOMMENDED CALIBRATIONS

- Perform and document an impedance check of the EEG, EOG and EMG electrodes
- Record a minimum of 30 seconds of EEG with patient awake lying quietly with eyes open
- Record a minimum of 30 seconds of EEG with patient awake lying quietly with eyes closed
- Ask the patient to look up and down without moving head (x5)
- Ask the patient to look left and right without moving head (x5)
- Ask the patient to blink (x5)

AASM RECOMMENDED CALIBRATIONS

- Ask the patient to grit teeth and/or chew (5 seconds)
- Ask the patient to simulate a snore or hum (5 seconds)
- Ask the patient to breathe normally and assure that airflow and effort channel signals are synched
- Ask the patient to perform a breath hold (10 seconds)
- Ask the patient to breathe through the nose only (10 seconds)

AASM RECOMMENDED CALIBRATIONS

- Ask the patient to breathe through the mouth only (10 seconds)
- Ask the patient to flex the left foot (x5)
- Ask the patient to flex the right foot (x5)
- If upper extremity EMG is recorded, ask the patient to flex/extend the fingers on the left hand, as appropriate
- If upper extremity EMG is recorded, ask the patient to flex/extend the fingers on the right hand, as appropriate

AASM RECOMMENDED CALIBRATIONS

- Adjust ECG signal to provide a clear waveform—the R wave should deflect upward
- Perform and document a repeat impedance check of the EEG, EOG, and EMG electrodes at the end of the PSG recording
- Repeat impedance measures and physiological calibrations at the end of the PSG recording
- Optional calibrations:
  - Ask the patient to breathe normally – check polarity and mark the record IN and OUT accordingly
  - Ask the patient to take a deep breath and exhale slowly (prolonged expiration—10 seconds)

APPROACH TO THE PSG RECORDING

HISTORY OF SLEEP SCORING

- Sleep scoring has been around over 50 years since the landmark "Manual of Standardized Terminology, Techniques and Scoring System for Sleep Stages of Human Subjects," edited by Allan Rechtschaffen and Anthony Kales came it out. It was used until 2007 as the standard method for evaluating sleep and was developed to cope with the huge volume of data generated by pen and ink polysomnographs, which could be up to 1,000 pages in a single night. Each page of the paper recording was 20 or 30 seconds long. The system is based on recognition of key waveforms and the application of rules of context (what happens when a certain stage follows another, or when key waveforms are not present). This methodology, with some revisions, forms the basis for the current *AASM Manual for the Scoring of Sleep and Associated Events* (abbreviated as the "AASM Manual").

SCORING POLYSOMNOGRAMS

- Review patient history and clinical information
  - Medications may affect the PSG
  - Patients may have known abnormalities (EEG, EKG)
- Review the order for the study
- Review technologist notes from the night of the study
  - Sensor displacements, bathroom trips, etc.
- Use a two-pass scoring technique
  - Score sleep stages, EEG abnormalities, cardiac events, and arousals on the first pass (30 sec screen). This is Pass 1.
  - Score breathing events and limb movements on Pass 2 (2 min screen).

TWO-PASS METHOD: PASS 1

- The 30-second window allows for the recognition of key waveforms (such as sleep spindles) used in the definition of sleep stages. A sleep stage is assigned to the epoch based on what constitutes most of the epoch. This means if there is 16 seconds scored as wake and 14 seconds of N1 sleep, the epoch is an epoch of Wake. Compression of the window (to 60 seconds or more) is considered inadequate for stage scoring.

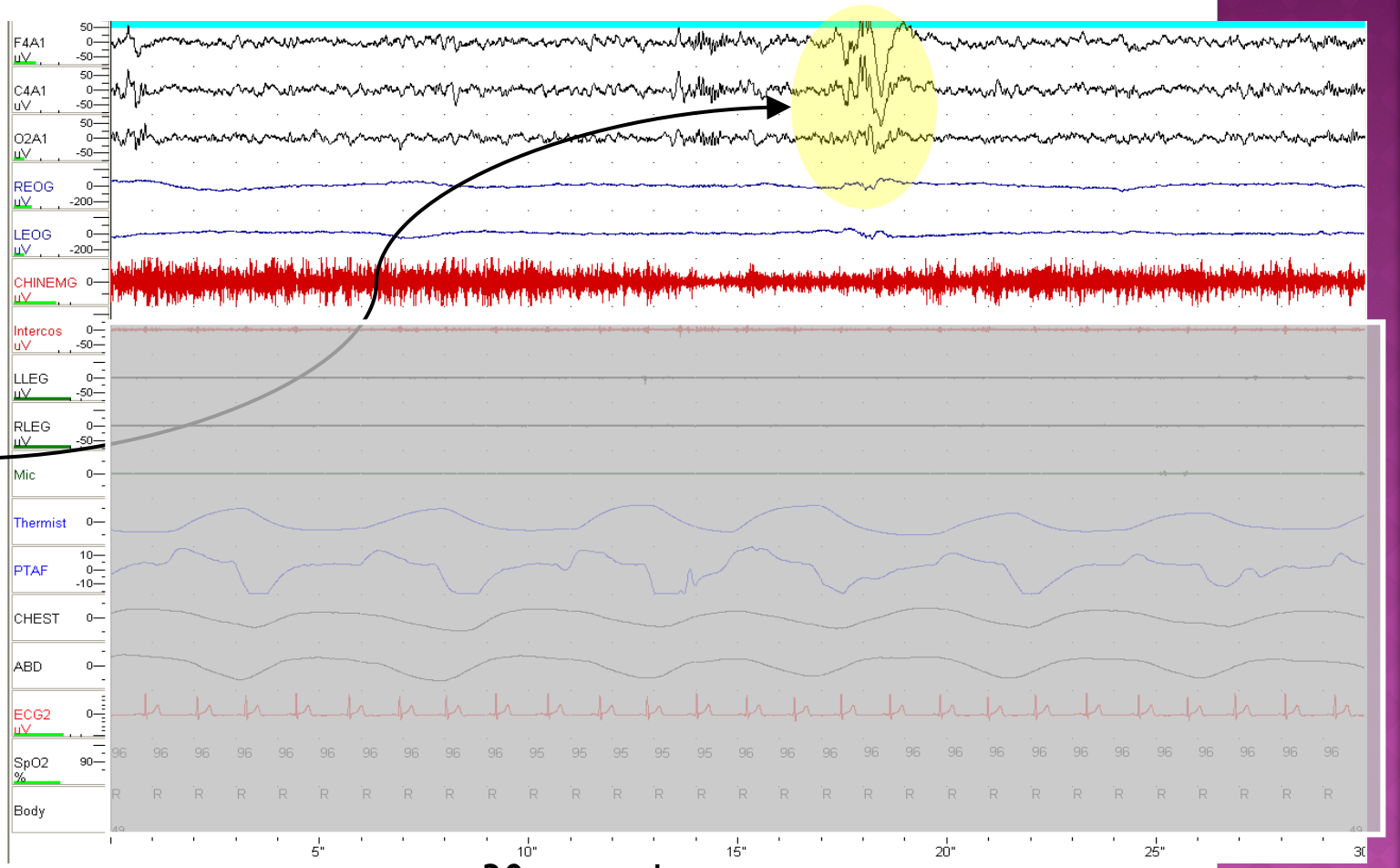
- The 30-second window is considered sufficient for the recognition of arousals (defined by an increase in EEG frequency) and abnormal EEG waveforms. Abnormal EEG waveforms may require further expansion of the window (10 seconds is standard for seizure interpretation) in order to measure waveform duration. Respiratory event and leg movement signals are generally not reviewed or scored at a 30-second window.

TWO-PASS METHOD: PASS 1

Focus on top half of this montage for Pass 1

Detect arousals, normal and abnormal EEG waveforms

Assign sleep stage to each epoch



30 seconds per screen

TWO-PASS METHOD: PASS 2

- A 120-second window is used for evaluation of breathing and limb movements during sleep. This is generally done on Pass 2 after sleep stages have been identified in Pass 1. Waking limb movements and apneas are not included in the polysomnogram summary, so if the stage scoring is complete, the technologist can ignore waking epochs on Pass 2. However, there are events that can occur while awake (i.e., periodic limb movements while awake) that could be suggestive of RLS. Central apneas can occur while awake, and obstructive apneas can occur in the transition to sleep. These cannot be included in the scoring summary but should be noted in the technologist notes.

- The recording should be reviewed for cardiac arrhythmias. The *AASM Manual* provides guidelines for identifying and reporting significant arrhythmias.

TWO-PASS METHOD: PASS 2

- All limb movements during sleep should be identified and scored. Limb movements associated with arousals are differentiated from limb movements not associated with arousals. Some of the limb movements may be part of a train; if they meet criteria they may be scored as a "PLM series." Limb movements are used to calculate indices based on the number of events per hour of sleep.

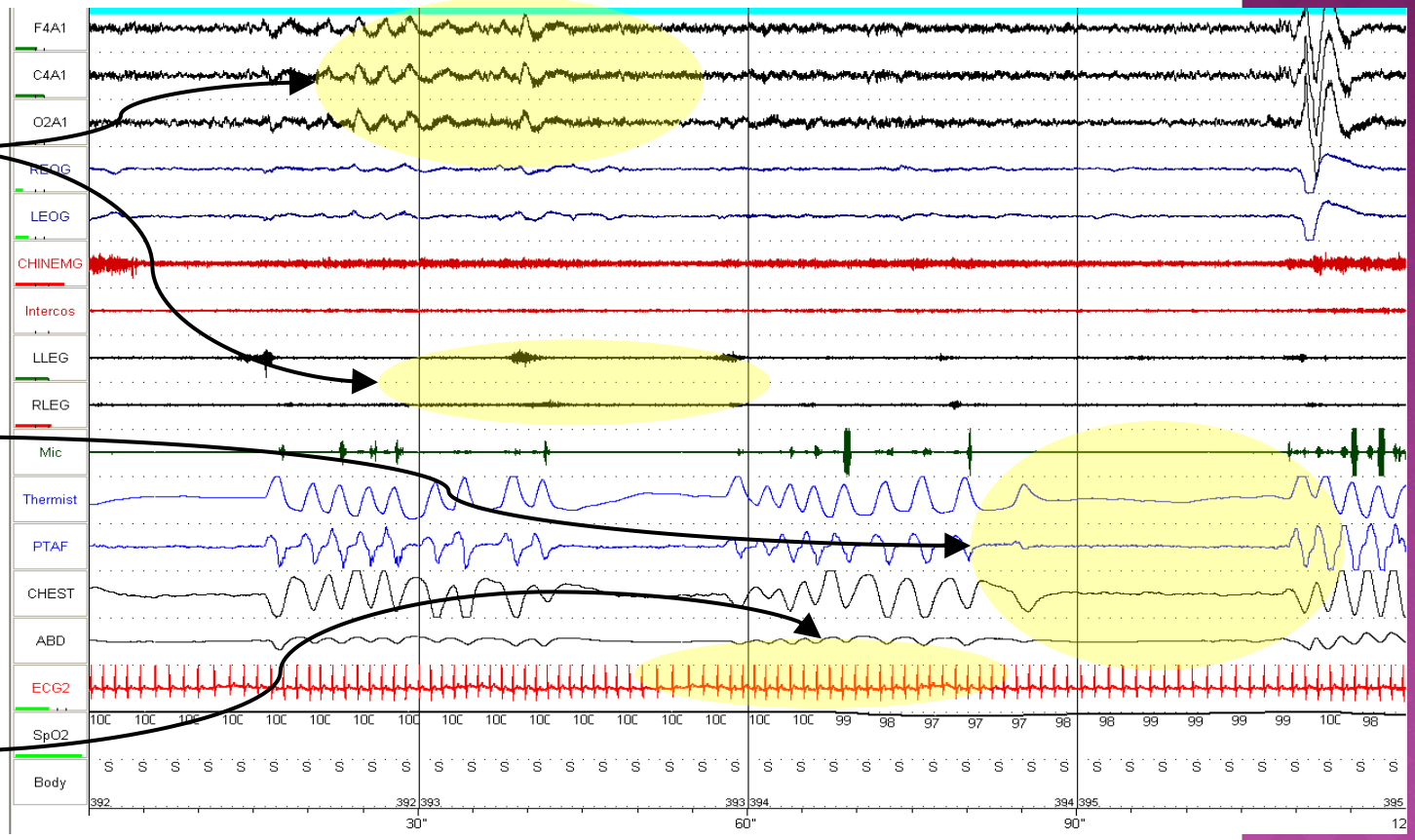
- The *AASM Manual* provides criteria for scoring sleep-related breathing events. These are based on changes in airflow and effort signals, as well as oxyhemoglobin desaturations. The 120-second window facilitates recognition of these events. Like limb movements, respiratory events are summarized as the number of events per hour of sleep.

TWO-PASS METHOD: PASS 2

Detect limb movements (check for arousals in EEG)

Detect apneas, hypopneas and RERAs (check for desaturations)

Check for ECG abnormalities



120 seconds per screen
(Revert to 30 second screen as needed.)

A BRIEF DIGRESSION INTO LEARNING THEORY

- Two common ways to categorize stimuli are rule-based learning and exemplar- (or prototype-) based learning.
- Objects that one encounters in the world can be quickly placed into categories.
- An epoch from a sleep recording can be seen as an object that must quickly be put in a category (i.e., one of the sleep stages).

Reference: "Rules and Exemplars in Categorization, Identification, and Recognition" by Nosofsky, Clerk and Shin, 1989

APPLYING LEARNING THEORY TO SLEEP STAGE SCORING

- The **rules** in our system are provided by the *AASM Manual for the Scoring of Sleep and Associated Events*.
- The **exemplars** in our system are developed by looking at multiple epochs and getting feedback on whether your categorization is the same as a "gold standard."
- Both systems are valid and additive. Therefore, for maximum accuracy, memorize the rules *and* look at lots of epochs of recording.

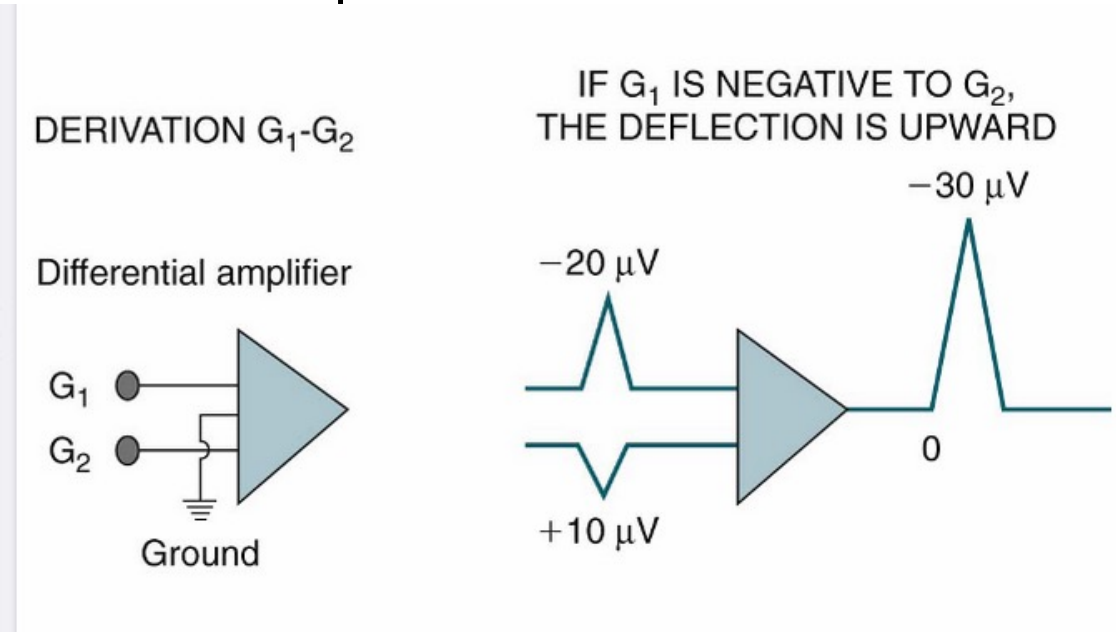
EEG

TECHNICAL SPECIFICATIONS FOR EEG

- The recommended EEG derivations are:
  - Three EEG channels (F4 – M1, C4 – M1, O2 – M1)
    - Six EEG channels are preferred (F3-M2, F4-M1, C3-M2, C4-M1, O1-M2, O2-M1)
      - EEG channels on left side of head used as backup
    - Alternative acceptable derivations can be used, and backup electrodes are recommended
  - Acceptable EEG derivations are:
    - Fz-Cz
    - Cz-Oz
    - C4-M1
      - Backup electrodes should be placed at Fpz, C3, O1, and M2 to allow substitution of Fpz for Fz, C3 for Cz or C4, O1 for Oz and M2 for M1 if electrodes malfunction during the study.

EEG PATTERNS

- EEG is recorded through the AC amplifier.
  - It looks at the difference in voltage between 2 inputs, G1 and G2.
    - If input G1 is negative with respect to G2, this will cause an upward deflection.

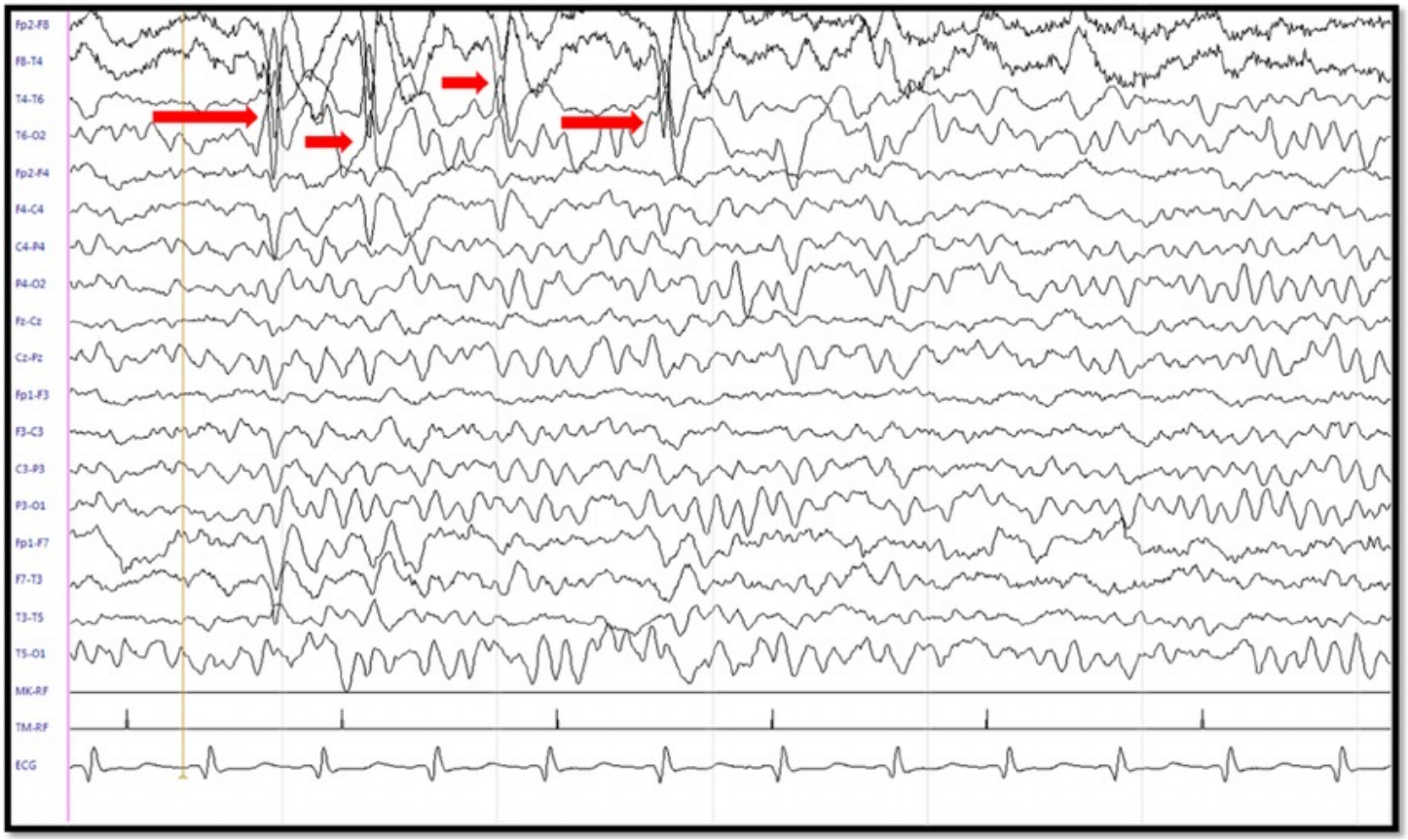


EEG PATTERNS

- Standard waveforms seen in sleep studies are:
  - Slow wave activity (SWA/SWS)
    - Frequency = 0.5-2 Hz
    - Amplitude = > 75 uV
  - Delta = 0-3.99 Hz
  - Theta = 4-7.99 Hz
  - Alpha = 8-13 Hz
  - Beta = > 13 Hz

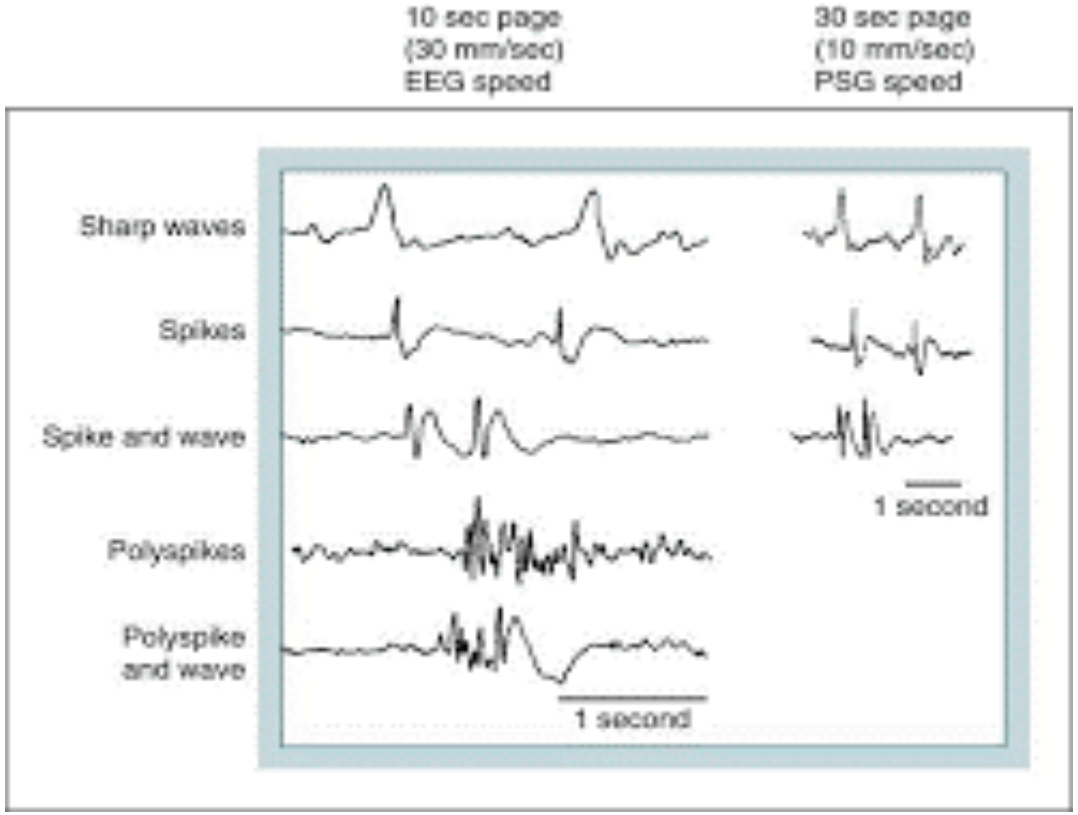
EEG PATTERNS

- Sharp waves are narrow waves of 70-200 msec duration.



EEG PATTERNS

- Spikes are a shorter duration of 20-70 msec in comparison to sharp waves.



SUMMARY OF IMPORTANT WAVE CHARACTERISTICS

	Alpha	Spindle	K Complex	Vertex	Delta	Sawtooth
Frequency (Hz)	8-13	11-16	N/A	N/A	0.5-2	2-6
Amplitude / shape	Oscillation	Spindle-shaped oscillation	High amplitude. Stands out against EEG background. Biphasic-negative sharp wave followed by positive component.	Sharp wave	High-amplitude broad wave. >75 uV peak to peak.	Triangular, serrated
Duration	Variable	≥ 0.5 sec	> 0.5 sec	< 500 msec	0.5-2 sec	Variable
Location of highest amplitude	Occipital	Central	Frontal	Central	Frontal	Central
Associated sleep stages / events	Any stage Arousals	N2	N2	N1	N3	REM

SCORING EPOCHS

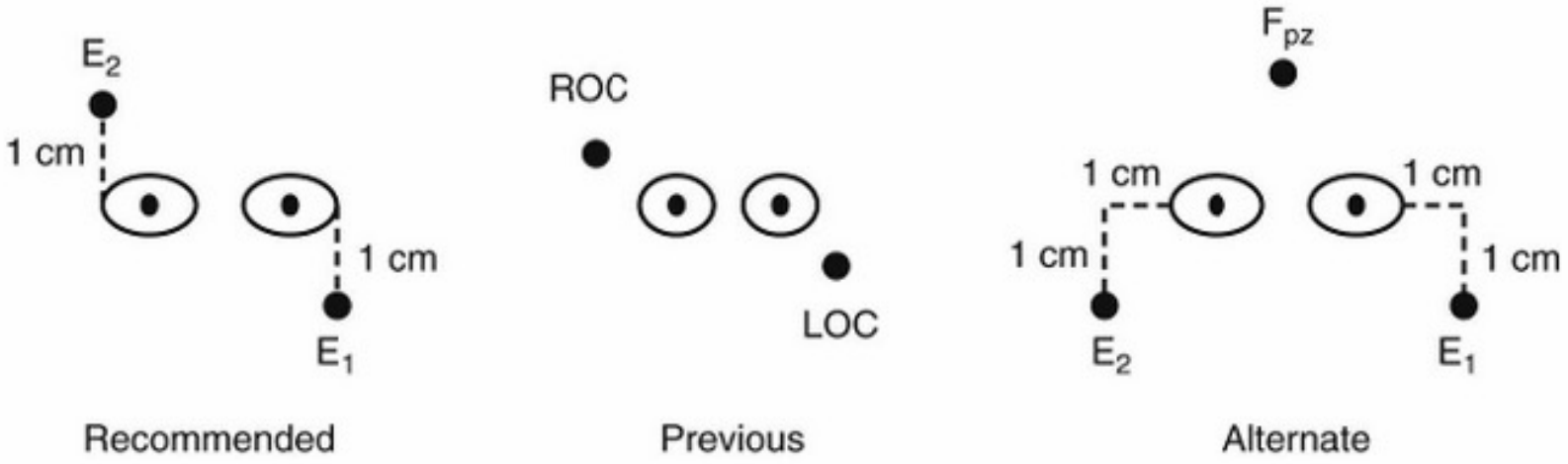
- Sleep stages are scored in 30-second epochs.
- Each epoch is assigned a sleep stage.
- If 2 or more stages coexist in a single epoch, you will assign the stage that constitutes the greatest portion of the epoch.
- When 3 or more segments of an epoch meet criteria for different sleep stages:
  - Score the epoch as sleep if most of the epoch is sleep criteria.
  - Assign the sleep stage that occurs for most of the sleep within the epoch.

EOG

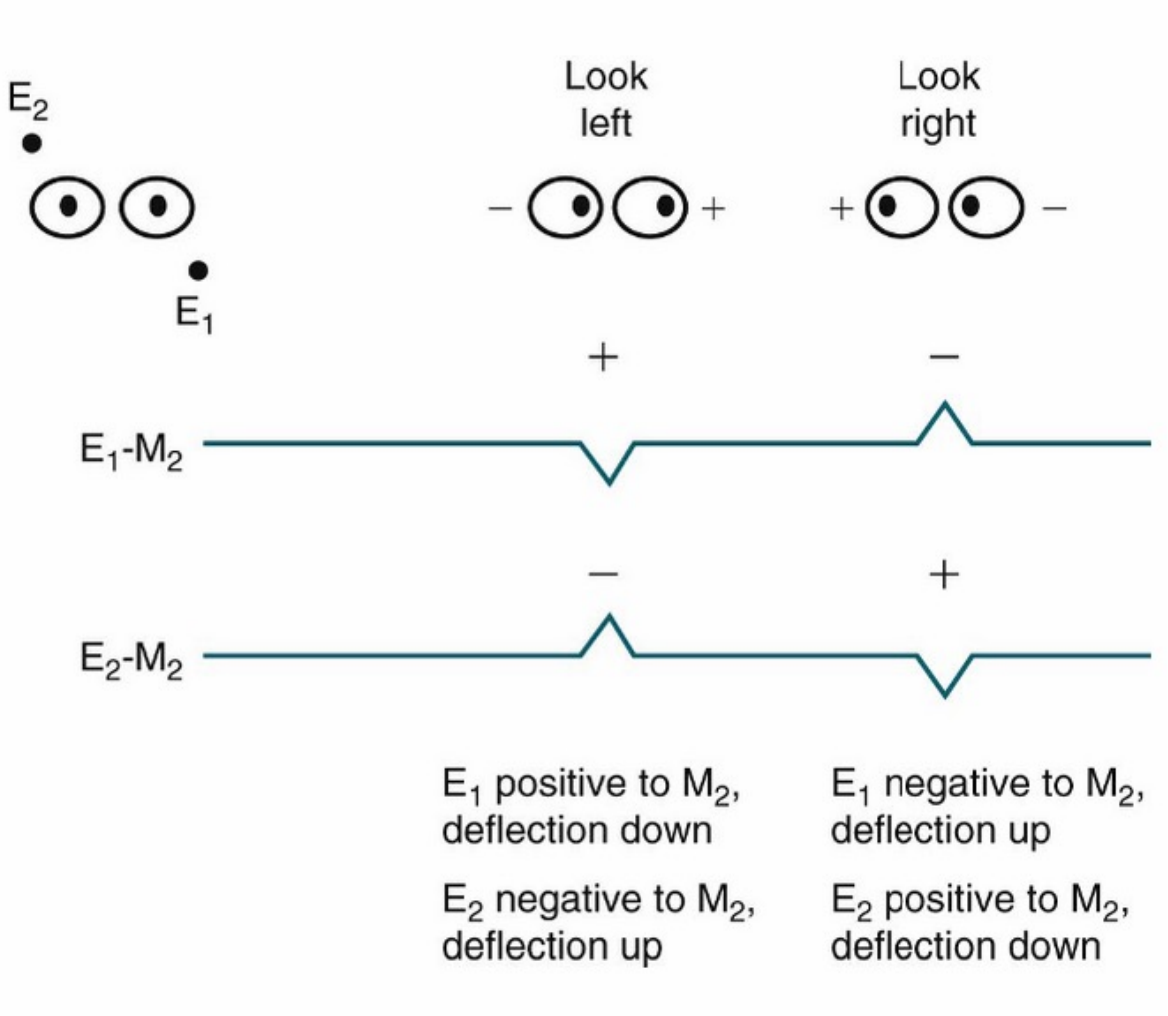
TECHNICAL SPECIFICATIONS FOR EOG

- AASM recommended EOG derivations and electrode positions are:
  - Derivations: E1-M2, and E2-M2
  - Electrode positions: E1 is placed 1 cm below and 1 cm lateral to the left outer canthus and E2 is placed 1 cm above and 1 cm lateral to the right outer canthus
- Acceptable EOG derivations and electrode positions are:
  - Derivations: E1-Fpz, and E2-Fpz
  - Electrode positions: E1 is placed 1 cm below and 1 cm lateral to the left outer canthus and E2 is placed 1 cm below and 1 cm lateral to the right outer canthus

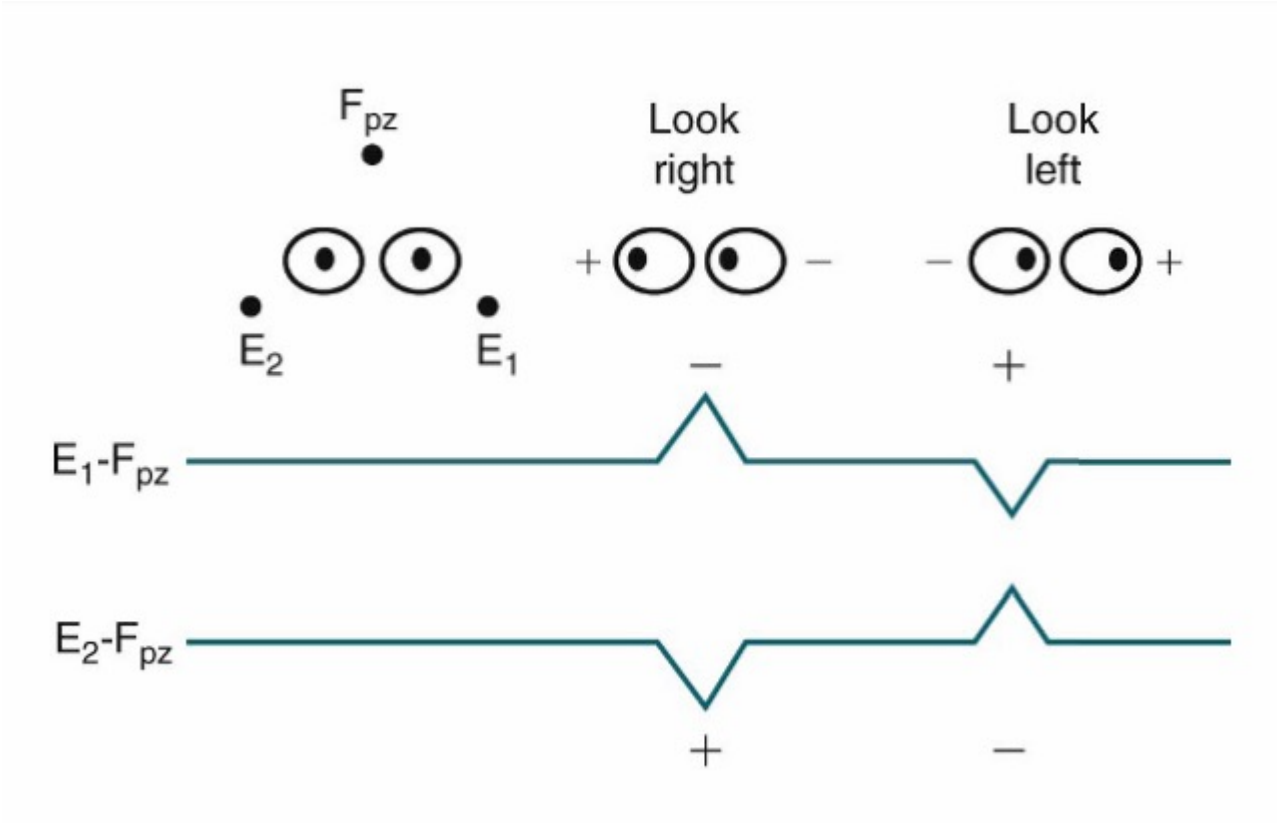
ELECTRODE PLACEMENT



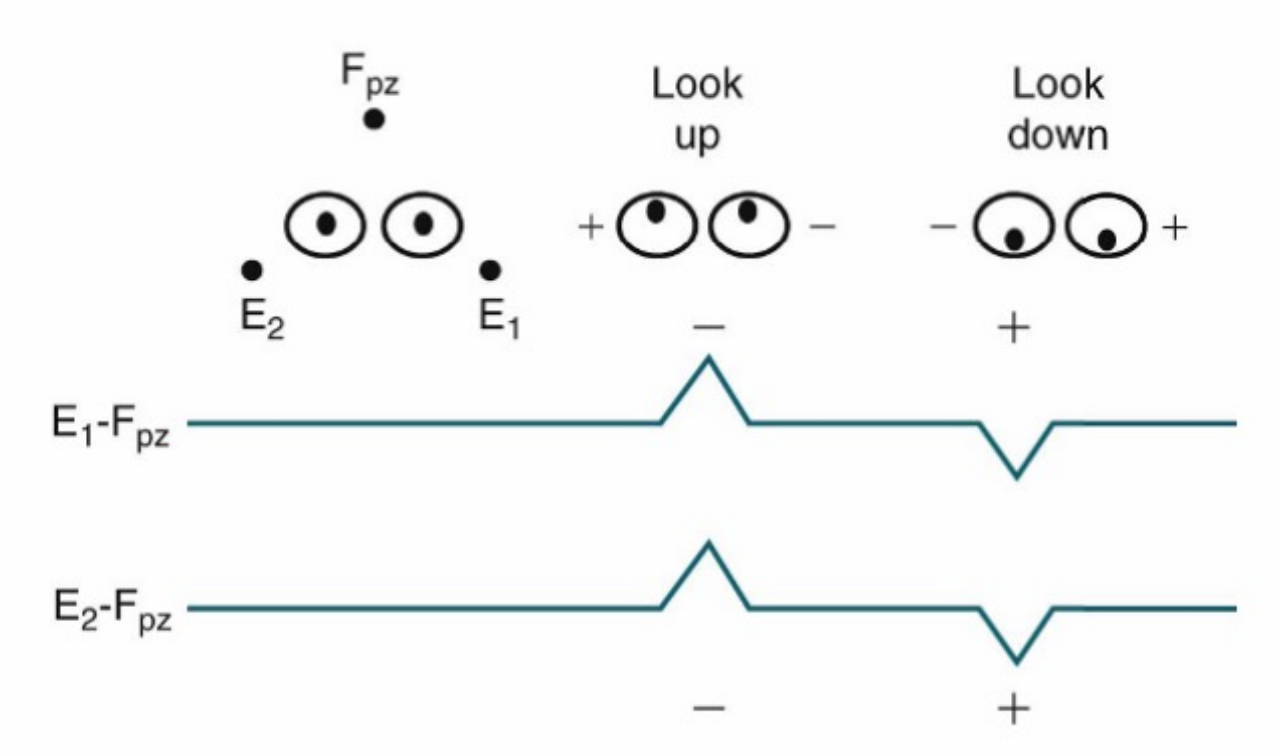
EYE DEFLECTIONS - RECOMMENDED PLACEMENT



EYE DEFLECTIONS - ALTERNATE DERIVATIONS



EYE DEFLECTIONS - ALTERNATE DERIVATIONS



EYE MOVEMENT PATTERN DEFINITIONS

Eye blinks	Conjugate vertical eye movements at a frequency of 0.5-2 Hz present in wake with the eyes open or closed
Reading eye movements	Trains of conjugate eye movements consisting of a slow phase followed by a rapid phase in the opposite direction as the subject reads
Slow eye movements	Conjugate, fairly regular, sinusoidal eye movements with an initial deflection lasting > 500 msec
Rapid eye movements	Conjugate, irregular, sharply peaked eye movements with an initial deflection usually lasting < 500 msec. Seen in REM and in wakefulness with the eyes open.

EMG

TECHNICAL SPECIFICATIONS FOR EMG

- Chin EMG should have 3 electrodes
  - 1 in midline 1 cm above inferior edge of mandible
  - 1 that is 2 cm below inferior edge of mandible and 2 cm to right of midline
  - 1 that is 2 cm below inferior edge of mandible and 2 cm to left of midline
- The standard chin EMG derivation consists of either of the electrodes below the mandible referred to the electrode above the mandible. The other inferior electrode is a backup electrode to allow for continued display of EMG activity if one of the primary electrodes malfunctions.