Scoring of Sleep and Associated Events
Rules, Terminology and Technical Specifications

Sleep Stage Scoring – Maximizing your expertise
Pamela Minkley RRT, RPSGT, CPFT
Objectives

- Define scoring criteria for sleep stages N1, N2, N3, REM and Wake
- Identify and score wake and sleep stage epochs in a sample
The AASM Manual for the SCORING of SLEEP & Associated EVENTS

- TERMINOLOGY
- TECHNICAL SPECIFICATIONS
- RULES
The New Rules

Technologist’s Handbook for understanding and Implementing AASM Manual for the Scoring of Sleep
www.aasmnet.org

Read FAQs & submit questions
VISUAL RULES
Visual Rules (adult & children)

F4-M1
C4-M1
O2-M1
A minimum of three (3) EEG derivations is required
Back-up electrodes: F3, C3, O1, M2

F = Frontal   C = Central   O = Occipital   M = Mastoid
Visual Rules (adult & children)

- Recommended EEG derivations (referential)
  - F4/M1  C4/M1  O2/M1
  - Backup electrodes @ F3, C3, O1, M2
  - Back up derivations F3/M2  C3/M2  O1/M2

- Back up derivations should only be used if recommended placement(s) fails or scalp anomaly precludes preferred placement(s)*

*AASM Scoring Manual FAQ*
Visual Rules (adult & children)

• Alternative EEG Derivations
  – Fz/Cz (bipolar)  Cz/Oz (bipolar)  C4/M1
  – Back up electrodes @ Fpz, C3, O1, M1
  – Substitute Fpz for Fz, C3 for Cz or C4, O1 for O2, M2 for M1
• Back up derivations should only be used if recommended placement(s) fails or scalp anomaly precludes preferred placement(s)*
• Note: Bipolar Fz/Cz may be inappropriate for scoring N3 since amplitude is greatly diminished from standard F4/M1

*AASM Scoring Manual FAQ
Visual Rules (adult & children)

EOG Electrode Placement

Recommended

E2 – 1 cm above the right outer canthus

Reference to M2

Alternative

E1 – 1 cm below the left outer canthus

Reference to M2

Chin EMG - Midline, 1 cm above inferior edge of mandible (referred to R or L EMG below)

2 cm below inferior edge of mandible and 2 cm right/left of midline
Thank you
Dan Herold & Mayo Technologists
For
Polysomnographic Recordings
With
Recommended and Alternative Derivations
Used in this presentation!!!!
E1 – Fpz

E2 – Fpz

E1 – M2

E2 – M2

Slow Rolling Eye Movements

Slide courtesy of Dan Herold
Visual Rules (adult & children)

• Rationale for new EEG Derivations
  – Alpha rhythm is maximal over occipital regions
  – K-complexes are maximal over frontal regions
  – Spindles are maximal over central regions
  – Slow waves are maximal over frontal regions
Visual Rules (adult & children)

New Sleep Stage Terminology

W (Wake)
N1 (NREM stage 1 sleep)
N2 (NREM stage 2 sleep)
N3 (NREM stage 3 sleep)
R (REM sleep)

R & K Terminology

W (Wake)
1
2
3/4
R
### Visual Rules (adult & children)

<table>
<thead>
<tr>
<th>Visual Waveform</th>
<th>Stage</th>
<th>Brain Region</th>
<th>Comment</th>
</tr>
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<tbody>
<tr>
<td>Alpha Rhythm</td>
<td>W</td>
<td>Occipital</td>
<td>8-13hz, &gt;0.5 sec, &lt;50µv Attenuates with EO</td>
</tr>
<tr>
<td>Vertex Sharp</td>
<td>N1</td>
<td>Central</td>
<td>&lt; 0.5 sec, stands out</td>
</tr>
<tr>
<td>K Complex</td>
<td>N2</td>
<td>Frontal</td>
<td>Total duration &gt; 0.5 sec</td>
</tr>
<tr>
<td>Sleep Spindle</td>
<td>N2</td>
<td>Central</td>
<td>11 – 16 Hz</td>
</tr>
<tr>
<td>Slow Waves</td>
<td>N3</td>
<td>Frontal</td>
<td>0.5 – 2 Hz</td>
</tr>
<tr>
<td>Sawtooth waves</td>
<td>REM</td>
<td>Central</td>
<td>2 – 6 Hz</td>
</tr>
<tr>
<td>Dominant Posterior rhythm (DPR)</td>
<td>Peds W</td>
<td>Occipital</td>
<td>Preferred term for alpha in children. Frequency is age dependent. &gt; 50µv</td>
</tr>
</tbody>
</table>
Visual Rules (adult & children)

- Epoch based
- 30 second epoch
- Majority of the epoch rules
  - If 2 or more stages co-exist on a single epoch, it is staged as the sleep stage comprising the majority of the epoch
- Sleep onset is the start of the first epoch scored as any stage of sleep
- New stage 1 (N1) definition for non-alpha generators is included
Visual Rules (adult & children)
Summary of Changes

• Stages 3 & 4 are combined
• Movement time (MT) has been eliminated
• 3-minute rule for stage 2 is eliminated
• Frontal leads recommended for scoring slow wave (N3) sleep
• Alternative EEG and EOG derivations are proposed
Visual Rules (adult & children)
Summary of Changes

• Reference sites (ear lobe) A1 & A2 are renamed (mastoid) M1 & M2, consistent with the actual placement
• LOC & ROC sites are named E1 & E2
• Stages 1, 2 and 3 are renamed N1, N2 and N3
  – N is for NON-REM
  – R & K stages 3 & 4 are combined for N3
• REM is renamed stage R
Visual Rules (adult & children)

• Each stage includes definitions for:
  – EEG waveforms
    • Alpha rhythm: trains of sinusoidal 8-13 Hz activity recorded over the occipital region with eye closure, attenuating with eye opening
  – EOG activity
    • Eye blinks: conjugate vertical eye movements at a frequency of 0.5 – 2 Hz present in wakefulness with eyes open or closed
  – Other stage dependent EEG, EOG or EMG activity
Visual Rules (adult) – Stage W

• More then 50% of the epoch has alpha rhythm
• Without visually discernable alpha rhythm if any of the following are present. (20% of population)
  – Eye blinks at a frequency of 0.5 – 2 Hz
  – Reading eye movements
  – Irregular conjugate rapid eye movements associated with normal or high chin muscle tone
Visual Rules (adult) – Stage N1

• Sleep onset = first epoch of any stage of sleep
• Less than 50% of the epoch is alpha
• For Non-alpha generators score N1 if any of the following are present
  – EEG activity 4-7 Hz with slowing background frequencies by ≥ 1 Hz from those of stage W
  – Vertex sharp waves
  – Slow eye movements
• Consider every epoch N1 unless there is a marker for another stage
  – Alpha, K, Spindle, Slow waves
  – Eyes and chin tell you it’s R
• When an arousal or body movement occurs, the following epochs always revert to N1 until there is a marker for another stage
• Majority of the epoch always determines the scoring.
Recommended

E1 – M2

E2 – M2

F4 – M1

C4 – M1

O2 – M1

Chin EMG
Visual Rules (adult) – Stage N2

• K-complex
  – Maximal amplitude from frontal derivation
  – Same description as R & K
  – Defines “arousal K”
    • Arousal commences no more than 1 second after termination of K-complex
    • Not an indicator of stage N2 sleep

• Sleep Spindle
  – Train of 11-16 Hz waves (most commonly 12-14 Hz)
  – Central derivation

Helpful Hint
K-complexes and sleep spindles must STAND OUT FROM THE BACKGROUND
Visual Rules (adult) – Stage N2

• Start of N2
  – Absence of criteria for N3
  – One or both of the following occur in the first half of the current epoch or last half of the previous epoch
    • One or more K complexes NOT associated with an arousal
    • One or more trains of sleep spindles

Quick question: Why do we need a rule for when to start N2? We didn’t have one for N1.
Visual Rules (adult) – Stage N2

- Continuation of Stage N2
  - “Continue to score epochs with low amplitude, mixed frequency EEG activity without K complexes or sleep spindles as stage N2 if they are preceded by
    a) K complexes unassociated with arousals OR
    b) sleep spindles”
- No 3 minute rule
Visual Rules (adult) – Stage N2

• End of stage N2
  – Transition to another stage of sleep
  – An arousal occurs
    • Change to stage 1
  – A major body movement

No 3 minute rule

See rule illustrations in manual
Recommended

E1 – M2

E2 – M2

F4 – M1

C4 – M1

O2 – M1

Chin EMG

Slide courtesy of Dan Herold
Visual Rules (adult) – Stage N3

• Slow wave activity = waves 0.5 – 2 Hz and a peak-to-peak amplitude > 75µv measured over the frontal regions
  – Frontal derivation yields greater amplitude than central used in R & K
• Score stage N3 if 20% or more of the epoch consists of SW activity regardless of age
Fz – Cz
Cz – Oz
C4 – M1
F4 – M1
O2 – M1

Alternative
Recommended

Slide courtesy of Dan Herold
\[ \mu \text{v peak to peak} \]

1 sec

50 \text{mV}

1 sec
Visual Rules (adult) – Stage R

- Definitions provided for Rapid Eye Movements, Low chin EMG tone, Sawtooth waves, Transient muscle activity
- Score stage R in epochs with ALL of the following
  - Low amplitude, mixed frequency EEG
  - Low chin EMG tone
  - Rapid eye movements
Visual Rules (adult) – Stage R

• Transition between stage N2 & R
  – In between epochs of definite stage N2 and definite stage R, score an epoch with EEG & EMG consistent with stage R as stage R even in the absence of rapid eye movements.
  – Epochs should be scored as stage R even in the presence of K complexes and sleep spindles when the chin tone remains low AND rapid eye movements are evident IN THAT EPOCH. (page 31, notes)
    • The following epoch is N2 unless REMs occur and other markers of REM are present.

Quick Question;
Why do we need this rule?
Visual Rules (adult) – Stage R

• End of stage R
  – Transition to another stage
  – Increase in chin EMG
  – Arousal AND slow eye movements (score N1)
  – Major body movements followed by slow eye movements
  – One or more K complexes or sleep spindles occur in the first half of an epoch WITHOUT rapid eye movements.

See rule illustrations in manual
E1 – M2
E2 – M2
F4 – M1
C4 – M1
O2-M1
Chin EMG

Recommended

Slide courtesy of Dan Herold
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<th>2</th>
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<th>4</th>
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R 1 R R R R R R
### Stage 2
Three minute rule

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### Recommended Filter Settings in Hertz

<table>
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<tr>
<th>Channel</th>
<th>LFF</th>
<th>HFF</th>
<th>Comment</th>
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<tbody>
<tr>
<td>EEG</td>
<td>0.3</td>
<td>35</td>
<td>Increase HFF &amp; sample rate for spike identification</td>
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<tr>
<td>EOG</td>
<td>0.3</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>EMG</td>
<td>10</td>
<td>100</td>
<td>up HFF aids amplitude retention</td>
</tr>
<tr>
<td>ECG</td>
<td>0.3</td>
<td>70</td>
<td>Use standard ECG patches</td>
</tr>
<tr>
<td>Respiration</td>
<td>0.1</td>
<td>15</td>
<td></td>
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<tr>
<td>Snoring</td>
<td>10</td>
<td>100</td>
<td>Vibratory recording vs dB</td>
</tr>
</tbody>
</table>
Visual Rules (adult) – Major Body Movements

In an epoch with a major body movement (*movement artifact obscures more than ½ the epoch, stage score cannot be determined*)

- If alpha rhythm is present for part of the epoch (even < 15 sec) score as stage W
- If no alpha rhythm is discernable, but an epoch scorable as stage W either precedes or follows the epoch with the major body movement, score as stage W
- Otherwise, score same as the epoch that follows the epoch with the major body movement.
Slide courtesy of Dan Herold
VISUAL RULES
for
CHIDREN
Visual Rules (children)

- Dominant posterior rhythm (DPR) replaces the term alpha rhythm*.
  - Relaxed wakefulness
  - Occipital region
  - Usually >50µv
  - Frequency is age dependent

<table>
<thead>
<tr>
<th>Age</th>
<th>Frequency</th>
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<tbody>
<tr>
<td>3-4 months*</td>
<td>3.5 - 4.5 Hz</td>
</tr>
<tr>
<td>5-6 months</td>
<td>5 – 6 Hz</td>
</tr>
<tr>
<td>3 years</td>
<td>7.5 – 9.5 Hz</td>
</tr>
</tbody>
</table>

*Not seen before 3 months

See manual for more information
Dr. Stephen Sheldon

“Score it when you can, Don’t when you can’t!”

“I mourn the loss of indeterminate sleep in infants”
Visual Rules (children) – Stage W

• More than 50% of epoch has reactive alpha or age appropriate DPR
• If no alpha or DPR score W with any of the following
  – Eye blink at a 0.5 – 2 Hz frequency
  – Reading eye movements
  – Irregular conjugate REMS associated with normal or high chin muscle tone

Observational comments are critical
Visual Rules (children)

• Score N1 if age appropriate DPR or alpha attenuates and >50% of the epoch is low amplitude mixed frequency EEG activity
• If non-alpha generator score N1 with any of the following
  – Activity @ 4-7 Hz with slowing EEG background by 1-2 Hz < stage W
  – Slow eye movements
  – Vertex sharp waves
  – Rhythmic anterior theta activity
  – Hypnagogic hypersynchrony
  – Diffuse or occipital predominant high amplitude rhythmic 3-5 Hz activity