Sleep, Memory, and Learning: The Impact of Epilepsy

December 5, 2011

Robert Stickgold, Ph.D.
Beth Israel Deaconess Medical Center & Harvard Medical School
Boston, MA
Disclosure

Actelion Pharmaceuticals    Consultant
Learning Objectives

• Learn the range of sleep-dependent memory processes

• Learn how epilepsy impacts these processes
The Physiology and Chemistry of the Brain Change Across the Night
A Good Night's Sleep

- Sleep onset
- REM sleep
- Stage 2 NREM
- SWS
- Wake
- I/REM
- II
- III
- IV

Time:
- 11 PM
- 1 AM
- 3 AM
- 5 AM
- 7 AM
Sleep Physiology

**EEG**
- Wake
- Stage 2
- Stage 4
- REM

**EOG**
- Stage 1
- Stage 2
- REM

**EMG**
- Wake
- Stage 4
- REM
Neuromodulation Varies Across the Wake-Sleep Cycle

<table>
<thead>
<tr>
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<th>Active Wake</th>
<th>Quiet Wake</th>
<th>SWS</th>
<th>REM</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACh</td>
<td>+++</td>
<td>+</td>
<td>-</td>
<td>++++</td>
</tr>
<tr>
<td>NE 5-HT</td>
<td>+++</td>
<td>+</td>
<td>+</td>
<td>-</td>
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</tbody>
</table>

ACh: Acetylcholine, NE: Norepinephrine, 5-HT: Serotonin
Regional Activation in REM Sleep

- Posterior Cingulate
- Parahippocampal Cortex
- Amygdala
- Dorsolateral Prefrontal Cortex
- Anterior Cingulate

Activated in REM
Deactivated in REM
Sleep, Learning and Memory
Sleep Consolidates Perceptual Learning

• Vipul Patel
• Beth Schirmer
• Dana Whidbee
• LaTanya James
Test interval (h)

Improvement (ms)

Daytime
Overnight

**Time Course of Improvement**

![Graph showing the time course of improvement with data points for sleep deprived first night and normal sleep.](image)

*Stickgold et al., Nat Neurosci 3, 1237-1238 (2000).*
Sleep Enhances Insight

Number Reduction Task

- Ulrich Wagner
- Jan Born

Development of Insight

- **Subjects gaining insight**
  - Wake/Day: 1
  - Wake/Night: 4
  - Sleep/Night: 9

- **Improvement in speed (ms)**
  - Solvers: 4
  - Non-solvers: 9

The graph shows a significant increase in subjects gaining insight and improvement in speed during sleep compared to wake states.
Sleep, Learning and Schizophrenia
(Study funded by Sepracor & Co.)

- Dara Manoach
- Erin Wamsley
- Matt Tucker

Sequence
4-1-3-2-4
Motor Skill Learning in Chronic Schizophrenia

Controls

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<tr>
<th>9</th>
<th>11</th>
<th>13</th>
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Schizophrenia

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<th>12</th>
<th>14</th>
<th>16</th>
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Impact of Eszopiclone Overnight Improvement (%)

5  0  10  15  20  25  30

Baseline  Baseline  Placebo  Eszopiclone

Controls

Schizophrenia patients

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Sleep, Learning and Epilepsy

- Maryann Deak
- Ellen Bubrick
- Aaron Nelson
Motor Skill Learning in Temporal Lobe Epilepsy

Selective Reminding in Temporal Lobe Epilepsy

Word-Pair Recall in Children

Recall (% of words)

Immediate test
Delayed test

$p < .05$

$p < .001$

Word-Pair Recall in Children with Focal Idiopathic Epilepsy

Session 1

Session 2

Recall (% of words)

PM  AM  PM  AM

60  65  70  75  80  85  90

$p < .001$
$n=4$

$p < .001$
$n=2$

Controls
Epilepsy

Impact on Clinical Care and Practice

• The usefulness of memories depends critically on their post-encoding evolution

• This includes a range of sleep-dependent memory processes, from simple stabilization of memories to the discovery of insights

• The post-encoding evolution of both procedural and declarative memory is altered in epilepsy

• But we barely know anything yet about the details of these epilepsy-related memory deficits