Sleep Deprivation Does Not Prevent Learning and Generalisation of a New Artificial Script
Active Consolidation Theory

- Sleep *after* learning strengthens memories (Diekelmann & Born, 2010).

- Sleep *before* learning benefits encoding capacity (Saletin & Walker, 2012).
Effects of Sleep Deprivation

- Sleep deprivation disrupts item-specific memory for word pairs and images (Yoo et al., 2007; Gais et al., 2007).

- Little is known about effects of sleep or sleep deprivation on learning a new language or acquiring general linguistic knowledge.

- Research suggests learning individual exemplars occurs quickly, but generalisation requires time (Tamminen et al., 2012).

Research Question:
Does sleep deprivation before or after learning impair acquisition of item-specific or general linguistic knowledge?
Methods

Participants: Native, monolingual English speakers, aged 19-35.
• Deprivation after learning: 23 SD, 24 controls
• Deprivation before learning: 24 SD, 22 controls

Stimuli: 36 monosyllabic consonant-vowel-consonant pseudowords.
### Methods – Deprivation After Learning

<table>
<thead>
<tr>
<th></th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Monday</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 1</td>
<td>Day 2</td>
<td>Day 3</td>
<td>Day 4</td>
<td>Day 5</td>
<td>Day 15</td>
</tr>
<tr>
<td>SLEEP DEPRIVATION</td>
<td>WAKE</td>
<td>WAKE</td>
<td>WAKE</td>
<td>WAKE</td>
<td>WAKE</td>
<td></td>
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<tr>
<td>SLEEP CONTROL</td>
<td>SLEEP</td>
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<td>SLEEP</td>
<td>SLEEP</td>
<td>SLEEP</td>
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</tr>
</tbody>
</table>

**TRAINING**

- Deprivation after learning (8-10pm)

**Collect actigraph & sleep diary**

**TEST 1** — **TEST 2**
Methods – Deprivation Before Learning

**SLEEP DEPRIVATION**
- Monday: Day 1 (Wake), Night 1 (Sleep)
- Tuesday: Day 2 (Wake), Night 2 (Wake)
- Wednesday: Day 3 (Wake), Night 3 (Sleep)
- Thursday: Day 4 (Wake), Night 4 (Sleep)
- Friday: Day 5 (Wake)
- Monday: Day 15 (Calendar Icon)

**SLEEP CONTROL**
- Monday: Day 1 (Wake), Night 1 (Sleep)
- Tuesday: Day 2 (Wake), Night 2 (Sleep)
- Wednesday: Day 3 (Wake), Night 3 (Sleep)
- Thursday: Day 4 (Wake), Night 4 (Sleep)
- Friday: Day 5 (Calendar Icon)
- Monday: Day 15 (Calendar Icon)

**Collect actigraph & sleep diary**

**TRAINING**
- Deprivation before learning (8-10am)

**TEST 1** → **TEST 2**
Methods – Training Task

Pre-Exposure Phase

Training Blocks

Reading Aloud Task

Spelling Task

Max. 8 blocks

Min. 4 blocks

/baɪɡ/

/baɪɡ/

Well done!
Methods – Test Tasks

Old-New Decision Task

Reading Aloud Task

Spelling Task

Phoneme Task
### Results – Training

#### Deprivation After Learning

<table>
<thead>
<tr>
<th></th>
<th>Deprivation</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max blocks to criterion*</td>
<td>4.04</td>
<td>4.58</td>
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<tr>
<td>Reading Aloud</td>
<td>79%</td>
<td>77%</td>
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<tr>
<td>Spelling</td>
<td>93%</td>
<td>92%</td>
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</table>

#### Deprivation Before Learning

<table>
<thead>
<tr>
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<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max blocks to criterion*</td>
<td>4.62</td>
<td>4</td>
</tr>
<tr>
<td>Reading Aloud*</td>
<td>75%</td>
<td>85%</td>
</tr>
<tr>
<td>Spelling*</td>
<td>89%</td>
<td>95%</td>
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</tbody>
</table>

*Significant difference between groups*
Old-New Decision Task Accuracy

Deprivation After Learning

Deprivation Before Learning

No effect of sleep deprivation
Old-New Decision Task RT - Test 1

No effect of sleep deprivation
Old-New Decision Task RT – Test 2

No effect of sleep deprivation
Reading Aloud Accuracy – Test 1

Deprivation After Learning

Deprivation Before Learning

No effect of sleep deprivation
No effect of sleep deprivation
No effect of sleep deprivation
Reading Aloud RT – Test 2

No effect of sleep deprivation
Spelling Accuracy – Test 1

Deprivation After Learning

Deprivation Before Learning

No effect of sleep deprivation
No effect of sleep deprivation
Spelling Accuracy - Combined

Deprivation Before Learning

Main effect of sleep deprivation
Spelling RT – Test 1

Deprivation After Learning

Deprivation Before Learning

No effect of sleep deprivation
Spelling RT – Test 2

Deprivation After Learning

Deprivation Before Learning

No effect of sleep deprivation
Phoneme Task Accuracy

Deprivation After Learning

Deprivation Before Learning

No effect of sleep deprivation

Main effect of sleep deprivation
Phoneme Task RT

Deprivation After Learning

Deprivation Before Learning

Main effect of sleep deprivation

No effect of sleep deprivation
## Conclusions

<table>
<thead>
<tr>
<th>Task</th>
<th>Deprivation After Learning</th>
<th>Deprivation Before Learning</th>
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</thead>
<tbody>
<tr>
<td>Old-New Decision</td>
<td>✘</td>
<td>✘</td>
</tr>
<tr>
<td>Reading Aloud</td>
<td>✘</td>
<td>✘</td>
</tr>
<tr>
<td>Spelling</td>
<td>✘ (accuracy)</td>
<td></td>
</tr>
<tr>
<td>Phoneme</td>
<td>✓ (RT)</td>
<td>✓ (accuracy)</td>
</tr>
</tbody>
</table>
Results are inconsistent with the current theory of active consolidation:

- Deprivation after learning – first night of sleep is not critical for learning.
- Deprivation before learning – slows learning but does not prevent learning.
- Individual differences – what are the implications for active consolidation theory?
Thank you! Any questions?

Jakke Tamminen, **Chloe Newbury**, Lydia Vinals, Rebecca Crowley, Benedetta Cevoli, & Kathleen Rastle.
Attention Tasks - PVT

Deprivation After Learning
Attention Tasks - PVT

Deprivation Before Learning
Attention Tasks – Digit Span

Deprivation After Learning
Attention Tasks – Digit Span

Deprivation Before Learning