### Grammar Learning in Adults: A Role for Offline Memory

**Consolidation and Prior Knowledge**

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#### Background

The Complementary Learning Systems model (CLS; McClelland, 2013) posits that the reactivation of newly learned hippocampal representations during offline periods (e.g., post-learning sleep) enables their long-term consolidation (i.e., integration with the long-term neocortical knowledge). However, when new knowledge is consistent with existing knowledge, there may be less need for integration to occur offline. Instead, the availability of existing knowledge supports new learning and in doing so advances neocortical integration (James et al., 2019). In line with this hypothesis, immediately after training, newly learned words that are related to existing knowledge phonologically or semantically are recalled better than words that are unrelated to it. This is unlike new words that are unrelated to existing knowledge, which are recalled better after offline consolidation (James et al., 2019). The aim of the present study was to test this hypothesis in grammar learning. Moreover, there is mixed evidence for a role of sleep-related offline consolidation in grammar learning with some research reporting improvements in learning following a period of sleep (e.g., Batterink et al., 2014) where others have found no influence (Mirković & Gaskell, 2016). Therefore, by focusing on the role of prior knowledge, this study set out to further explore the extent to which CLS applies to grammar learning.

Here we use an artificial language paradigm to investigate: the contributions of offline processes (in sleep and in wake) to the learning of different types of grammatical mappings: those that are dependent on prior knowledge versus those that are less dependent on prior knowledge.

#### Design

**Prior knowledge dependent mappings**

- **Character:** female
- **Semantic-category:** mermaid, e.g., mermaid

**Prior knowledge independent mappings**

- **Character:** male
- **Semantic-category:** insects, e.g., fisherman

#### Participants

60 participants (sleep group n = 30; wake group n = 30)

#### Procedure

- **Session 1:** training + immediate test
- **Session 2:** 12 hr delay test
- **Session 3:** 1 week delay test

#### Tasks

- **Training**
  - Repetition Task: 8 repetitions per word
- **Test tasks**
  - **Grammar learning:** Determiners (tib/zed) + Suffixes (eem/ool)
    - Picture Naming
    - Speeded-Shadowing (training + generalisation)
    - Explicit Knowledge Questionnaire – “Did you notice any patterns in the items?”
- **Word learning:** Stems (e.g., zeap in tib zeapern)
  - Picture Naming + 2AFC

#### Conclusions

Consistent with CLS, a prior knowledge benefit for the new grammatical mappings is present immediately after learning. This benefit remains after 12 hours and 1 week, and there is no influence of offline consolidation for the prior knowledge independent mappings. This suggests that the hippocampus might be less involved in grammar learning and therefore less influenced by sleep-related consolidation. By contrast, for word learning, there is evidence of sleep-related offline consolidation as there is maintenance in recall accuracy of the stems after a 12-hour sleep interval and forgetting after a 12-hour wake interval. This is consistent with previous findings (e.g., Duman & Gaskell, 2007; Schreiner & Rasch, 2015) and provides further evidence, that unlike grammar, the hippocampus is involved in the learning and consolidation of new meaning—sound mappings in lexical learning.