Nap-Related Consolidation in Learning the Grammar and Vocabulary of a Novel Language

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Background

Sleep-related consolidation processes play an important role in language learning (e.g. Dumay & Gaskell, 2007; Gomez et al., 2006; Tamminen et al., 2010, 2012). For example, in infants a short post-learning nap benefits the abstraction of newly learned grammatical regularities (Gomez et al., 2006). The transfer of information from the hippocampus to the neocortex occurring during sleep is assumed the underlie these effects (e.g. Tamminen et al., 2010).

The role of the hippocampus in the initial encoding of information in declarative memory has been particularly emphasized for arbitrary mappings (e.g. Eichenbaum et al. 1999; McClelland et al. 1995). Given that in human languages there are mappings with different degrees of arbitrariness, the role of sleep-related consolidation may depend on the specific dimension of language learning being investigated. For example, individual words for things are highly arbitrary (i.e. there is no reason that an apple is called an apple, or a lemon a lemon, and moreover even though both words refer to similar things (fruit), they are not similar in how they sound). However, grammatical aspects of words are often systematically related to their sound – e.g. most plurals in English are marked with '*s*', and many past tenses with '*ed*'.

Hypotheses

Aim: To investigate the role of sleep related consolidation in adult language learning using the nap paradigm.

Hypothesis: Sleep-related consolidation will depend on the level of arbitrariness in the material to be learned, with greater levels of arbitrariness associated with an increased role of sleep. Specifically, we hypothesized that learning a new vocabulary (new labels for existing concepts) will be influenced relatively more by sleep related consolidation than learning new, highly systematic, aspects of grammar.

Design

The Language


tib bisesh


tib scoiffesh


tib mofeem

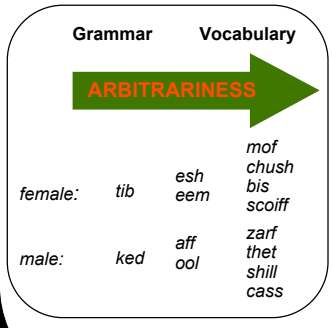

tib chusheem


ked zarfaff


ked thetaff


ked shillool


ked cassool



Language Training

- word repetition (3 x item)
- word-picture matching (stochastic: 8 x correct match, 4 x incorrect, Breitenstein et al. 2007)

Language Testing

Grammar: Determiners

- old items: determiner selection
- new items: word-picture matching

consistent with training: tib zimbesh

inconsistent with training: ked felchool

Grammar: Endings

- old items: picture naming (recall)
- new items: word-picture matching

consistent with training: tib jurbesh

inconsistent with training: tib shegool

Vocabulary: Words

- auditory translation recognition
- picture naming (recall)

Procedural Memory

Finger-tapping (Walker et al. 2002, 2003)

Declarative Memory

2D object location task (Rasch et al. 2007)

Participants

32 (16 Nap, 16 Wake)

Schedule

Nap: training – 90min nap – testing
Wake: training – DVD – testing

Results

Language Training

No significant differences between the groups – in the final block of training the average accuracy was 77% (M_{nap} = 78.6%, M_{wake} = 74.9%).

Language Testing

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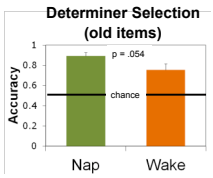
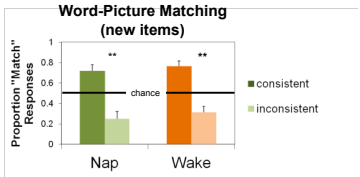
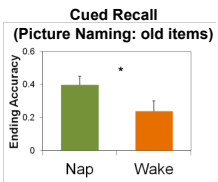
Grammar: Determiners

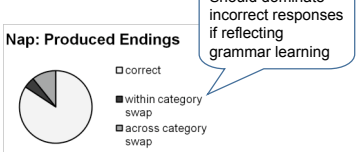


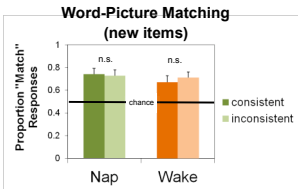


Both groups learned the most systematic mapping, and generalized the acquired knowledge to new untrained items.

Grammar: Endings

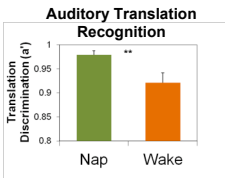


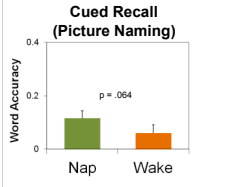




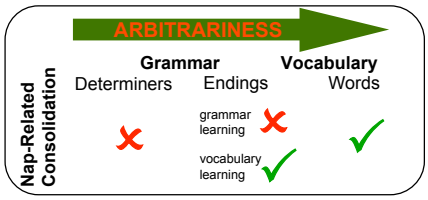
Nap group recalled more correct endings than the wake, but this reflects item/label learning rather than grammar.
Neither group learned, nor generalized to the new untrained items, the mapping with the intermediate level of arbitrariness.

Vocabulary: Words





The nap group was significantly better than the wake group in matching English translations to the new words, and recalled more words than the wake group.



Standard Procedural and Declarative Memory Tasks

No significant differences between the groups in procedural memory consolidation, and no training-test or group differences on the standard declarative memory task.

Conclusions

We have shown that the benefits of a 90 min nap in adult language learning depend on the arbitrariness of the newly learned mappings within the declarative memory system: consistent with models of hippocampal encoding, sleep was selectively beneficial to the most arbitrary mappings (new vocabulary).

Napping did not seem to benefit the mappings at the intermediate level of arbitrariness. Future research will address whether the number of sleep cycles (Conte & Ficca, 2012) may be a contributing factor.

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