

# LEARNING ABOUT THE NULE IN SLEEPNULE: ACQUISITION AND ABSTRACTION OF NEWLY LEARNED MORPHEMES

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## DEVELOPMENT OF CONTEXT-INDEPENDENT KNOWLEDGE

Morphological systems are highly productive. We combine a limited set of stem morphemes with prefixes and suffixes to form the majority of our words:

un + kind + ness

We can even create completely novel combinations to form new words which are nonetheless instantly comprehensible:

re + tweet + able

This highlights that affixes like -able are context-independent and can be generalised to new contexts.

Complementary learning systems (CLS) accounts of memory (see box) postulate that affix knowledge is context-dependent immediately after learning, and becomes context-independent only after consolidation.

### EXPERIMENT 1

Does generalisation of new affixes require memory consolidation?

70 participants learned 64 words, formed by a stem and a novel affix (e.g. "sleepnule is someone who participates in sleep research", "chopnule is the cook who chops all the vegetables"). There were 8 affixes, each had a consistent meaning (person, tool, cost, or place), and occurred with 8

different stems. Half of the participants were tested immediately after training, half one week later.

The main test task was shadowing (speeded repetition). We expected to see a learning effect in RTs, i.e. faster RTs to words with a trained affix vs. untrained affix:

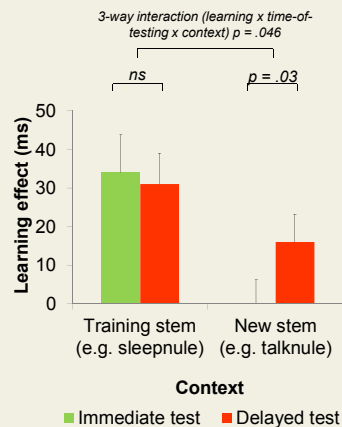
$sleepnule < sleeptege = learning\ effect\ in\ trained\ context?$

But does this training effect extend to cases where the stem is untrained?

$talknule < talktege = learning\ effect\ in\ untrained\ context?$

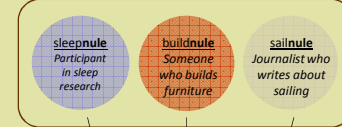
In shadowing a learning effect was found in the trained context at both times. When the context (stem) was new, the effect only emerged after consolidation suggesting that generalisation requires consolidation.

In a definition selection task we asked participants to choose a definition for untrained words (talknule) from two options. Accuracy was 87% (immediate) and 81% (delayed), showing that generalisation can occur immediately in an offline, non-speeded task when explicitly required.



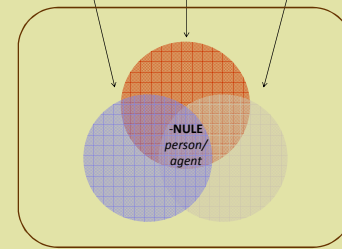
## COMPLEMENTARY LEARNING SYSTEMS (CLS)

Hippocampal, immediate representation



CLS models postulate that new memories are initially stored in discrete, context-dependent (episodic) representations, separate from existing stores of knowledge.

Over the course of offline memory consolidation (sleep in particular) the new memories are reactivated and gradually form permanent, overlapping neocortical representations, allowing abstraction of generalities and integration with existing knowledge.

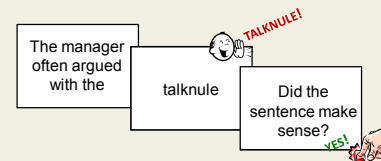


Neocortical, slowly-emerging representation

### EXPERIMENT 2

Does generalisation of new semantic affix representations require memory consolidation?

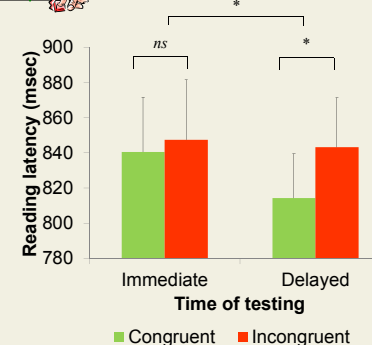
24 participants learned 32 novel words that carried 4 new affixes. Half were tested immediately, half after one week. Main test was sentence priming, participants read aloud a novel word that formed a congruent or incongruent ending to a sentence presented on screen. We measured reading latency.



The novel word was always presented as an untrained stem + trained affix combination. Therefore we were testing generalised affix knowledge.

Priming was found only in the delayed group, not immediately, suggesting that consolidation is needed for these generalised semantic effects to emerge.

Explicit congruency decision accuracy was however identical in both groups (86%), suggesting that both groups had equal explicit knowledge of the affixes.



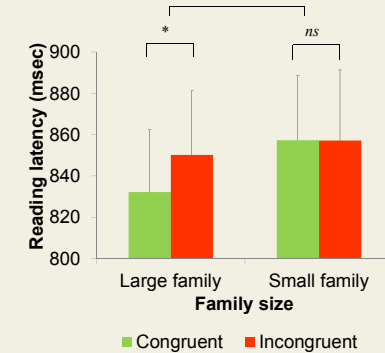
### EXPERIMENT 3

Are multiple exemplars required to create a generalised affix representation?

24 participants learned 40 novel words that carried 8 new affixes, 4 occurred with just two different stems (small family size) and 4 with eight different stems (large family size). Test session took place one week after training.

Priming was found only with large-family affixes, not small-family, suggesting that context-independent affix representation emerge only when enough exemplars are provided in training.

Explicit congruency decision accuracy was again high in both large-family (70%) and small-family (67%) words, suggesting that meanings of both family size affixes had been learned well.



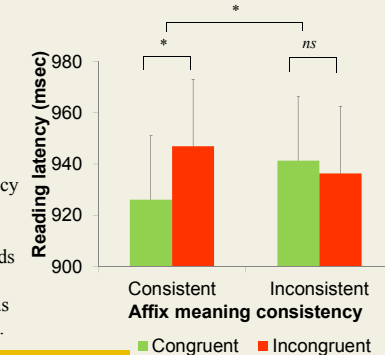
### EXPERIMENT 4

Are consistent affix meanings needed to create a generalised representation?

24 participants learned 64 novel words that carried 8 new affixes, 4 occurred with two different meanings (inconsistent) and 4 with one meaning (consistent). Test session took place one week after training

Priming was found only with semantically consistent affixes, not inconsistent, suggesting that context-independent affix representations emerge only when the affix has a consistent meaning.

Explicit congruency decision accuracy was higher in consistent (75%) than inconsistent (60%) affixes. Training data showed that meanings of all words had been learned equally well, so consistency affected explicit as well as implicit knowledge of affix meanings.



## CONCLUSIONS

- 4 factors are critical for generalisation of context-independent affix representations:
- Memory consolidation when measuring online language processing (E1 & E2).
- Immediate generalisation can be achieved based on hippocampal context-dependent representations if the task allows time to retrieve and combine these (E1). Ask for a copy of our paper, now in press in Cognition.
- A sufficient number of exemplars (hippocampal episodic traces; E3). Affixes that were trained with only 2 exemplars failed to show priming.
- A consistent link between form and meaning (E4). Affixes which have two different meanings failed to show priming.