

# Computer mouse tracking shows evidence of immediate lexical engagement effects in adults

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## Introduction

- Leach and Samuel (2007) described two properties of lexical knowledge/representations:
  - **Lexical configuration**: static, 'factual' knowledge (e.g., of a word form or referent);
  - **Lexical engagement**: a dynamic, interactive property occurring between lexical and sub-lexical representations (e.g., 'nurse' priming 'doctor').
- Complementary learning systems (CLS)** accounts (e.g., Davis & Gaskell, 2009; Lindsay & Gaskell, 2010): the **lexical configuration** of a representation is available **quickly**, but the **lexical engagement** property emerges **slowly and possibly only with sleep** (e.g., Dumay & Gaskell, 2007).
  - This draws on the CLS model of memory by Jay McClelland and colleagues (1995, 2013, 2020). Representations are **firstly episodic** in nature and then are **consolidated slowly** to become **abstracted and generalised** representations.
- But *when* are newly learnt words capable of lexical engagement, and thus truly 'word-like' (i.e., **lexicalised**), in accordance with predictions of speech perception models (e.g., Gaskell & Marslen-Wilson, 1997)?
- Lexical competition** is one way of measuring lexical engagement.
  - How is processing of a known word disrupted by the processing of a similar-sounding new word?;
  - Typical finding: **responses to 'alien' are only slowed** (e.g., on a lexical decision task) **after sleep**: explained theoretically by the **sleep-based consolidation of 'aliet'** into the lexicon, resulting in it **acting as a competitor** to 'alien' during word recognition.
- Newer data** suggests that time and sleep are **neither necessary nor sufficient conditions of lexicalisation** (e.g., see McMurray et al., 2017).
- There is the suggestion in these papers that **experimental methodology may be a reason** for such findings not being reported earlier.
- Mouse tracking** is a **novel and under-used methodology** with particular advantages for psycholinguistics (e.g., Bartolotti & Marian, 2012; Spivey et al., 2005).
- The present study**: **conceptually replicates an eye tracking paper (Weighall et al., 2017) reporting pre-sleep lexical engagement effects, and extends it to mouse tracking.**

## Methods

- Study design**: within-subjects; over two days; using Weighall et al. (2017) stimuli and design;  $N = 59$ ; 24 words (forms and referents) learnt per day; 12 exposures per word.
- Two day design to study **pre- and post-sleep novel word representations**. Study had **three phases**:

### 1. Training:

- repetition** of a heard novel label; novel referent held on-screen for 2s;
- phoneme segmentation** of a heard novel label; novel referent held on-screen for 2s;
- 2-AFC task, with feedback**. Participants saw two referents they had learnt (target & foil), and heard the word for the target referent, which they had to select. Regardless of response accuracy, participants would after 2s see only the target referent centred on-screen and hear its label.

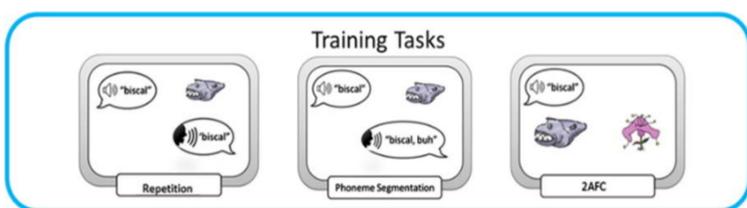


Fig. 1: Training procedure. Figure adapted from Weighall et al. (2017)

- Lexical engagement task** (mouse tracking). Participants had to click on a referent for which they heard a label. All word types (familiar, post-sleep, pre-sleep) appeared, with trials interleaved. There were three main trial types:

- Competing trials** (designed to evoke lexical competition). Novel and familiar referents with overlapping labels appeared (e.g., BAKER-BACON; BISCAL-BISCUIT).
- Non-competing trials** (designed to act as control trials). Novel and familiar objects with labels different from the first phoneme appeared (e.g., KITTEN-LOLLY; BALCONY-ALIET).
- Super-novel target trials**. Included as participants otherwise did not click on novel objects. These objects were **untrained**.

- Lexical configuration tasks** (cued recall). Participants had to say aloud the novel word when cued either with its **stem**, or its **referent**.

- First day**: training of novel words only. Note: new words were learnt each day.
- Second day**: further training, interleaved lexical engagement task, interleaved lexical configuration tasks.

## Results

- Response accuracy in the **2-AFC training task** was high ( $M = 95.7\%$ ,  $SD = 4.56\%$ ).
- Lexical engagement** analysed with two repeated-measures ANOVAs:
  - The **first ANOVA** compared **pre- and post-sleep novel words** by competition, and found a **main effect of Competition** ( $p < 0.001$ ), but **no consolidation effect, or an interaction** (all  $ps > 0.229$ ). **Pre- and post-sleep representations were thus collapsed for subsequent analyses** against familiar words;
  - The **second ANOVA** compared **familiar and novel words** by competition. **Competition and word type effects, and an interaction, were observed** (all  $ps < 0.001$ ); see Fig. 2.

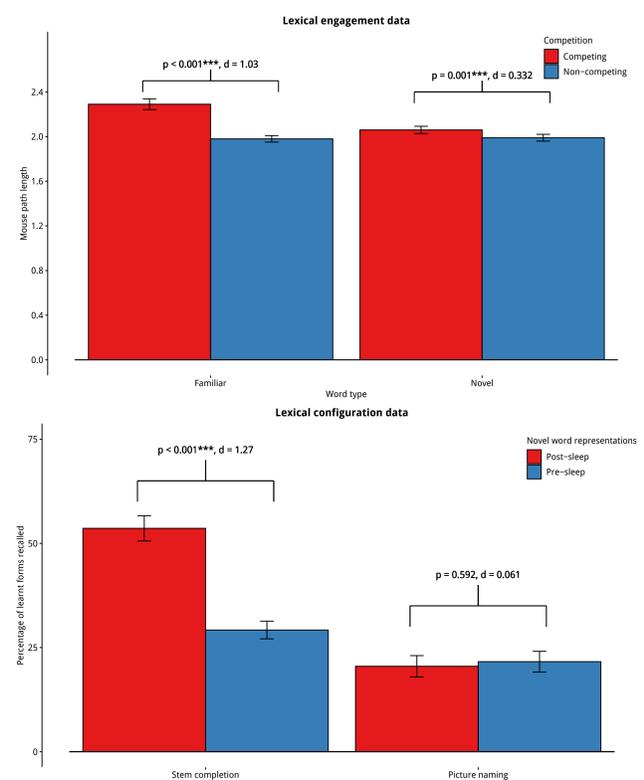


Fig. 2: Summary of lexical engagement (top) and lexical configuration (bottom) data. Error bars indicate  $\pm 1SE$

- Lexical configuration** compared pre- and post-sleep novel word representations.
  - **Stem completion**: strong evidence of consolidation (overnight boost in recall accuracy).
  - **Picture naming**: no evidence of consolidation. Poor recall accuracy ( $\sim 20\%$  on both days).

## Discussion and summary

- In contrary to previous theoretical accounts (Davis & Gaskell, 2009; Lindsay & Gaskell, 2010), **novel words are capable of immediate lexical engagement** (see McMurray et al., 2017);
- Mouse tracking** is **well suited** to word learning research;
- There is **limited evidence for consolidation** (present in some of the LC, but not LE, data), **consistent with other findings** (e.g., Kapnoula & Samuel, 2019; Weighall et al., 2017);
- Taken at face value, the data would suggest support for episodic accounts of the lexicon** (e.g., Goldinger, 1998; Kapnoula & Samuel, 2019).

## Future work

- What role does semantics play in these competing novel word representations?
  - Is the competition effect driven purely by 'alien' evoking its similar-sounding lexical competitor 'aliet', or is competition mediated by the on-screen referent?
    - \* Our lab currently have an experiment underway to address this (delayed by CoViD-19).
- Tension exists between abstractionist and episodic accounts of the lexicon – especially in the light of the present research and other recent papers (e.g., Kapnoula & Samuel, 2019). This should be addressed.
- Further specification of the conditions under which consolidation does and does not occur is required.
  - Why is there no consolidation evident in the cued-recall picture naming data, or the engagement data – despite its presence in the cued-recall stem completion data? Also, cf., Kapnoula & Samuel, 2019; Dumay & Gaskell, 2007.