Neural correlates of encoding in learning of novel names for novel concepts

Maria Korochkina [1,2] Paul F. Sowman [1] Lyndsey Nickels [1] Audrey Bürki [3]

[1]School of Psychological Sciences, Macquarie University
[2]International Doctorate for Experimental Approaches to Language and Brain (IDEALAB): Universities of Potsdam, Newcastle, Groningen, and Macquarie University
[3]Department of Linguistics, University of Potsdam

PREVIOUS RESEARCH

- Cognitive & neural processes that occur during encoding are pivotal to later memorability [1]
- During encoding, items that are later remembered (as opposed to those that are later forgotten) exhibit. . .
  - greater positivity between 400 ms and 800 ms post onset in the centro-parietal region ⟶ *subsequent memory, or Dm, ERP effect* [1, 2, 3]
  - greater synchronisation in theta (4 – 7 Hz) & gamma bands (>30 Hz) [4]
  - greater desynchronisation in alpha (8 – 12 Hz) & beta bands (13 – 29 Hz) [5, 6]
  - greater theta-gamma phase-amplitude coupling [7]
- However, to date, encoding of *novel words* has only been studied once and with ERPs only [8]
  - Dm effect was observed in the translation (trained novel words ⟶ English words) but not in the semantic-relatedness judgement (trained novel primes & English targets) task

RESEARCH QUESTION

- Are there differences between the neural correlates of successful vs. not successful encoding in learning of *novel* names for *novel* concepts?
- 3 measures of neural activity during encoding:
  - ERPs
  - time-frequency representations of power (TFRs) in theta (4 – 7 Hz), alpha (8 – 12 Hz), beta (13 – 29 Hz), low gamma (30 – 60 Hz), & high gamma (61 – 100 Hz) bands
  - theta-low gamma phase-amplitude coupling (PAC; results of this analysis are not reported here, but see https://psyarxiv.com/tfks3/)
- **Pre-registration, data, scripts, pre-print, & supplementary materials are publicly available at** https://osf.io/mg4kr/

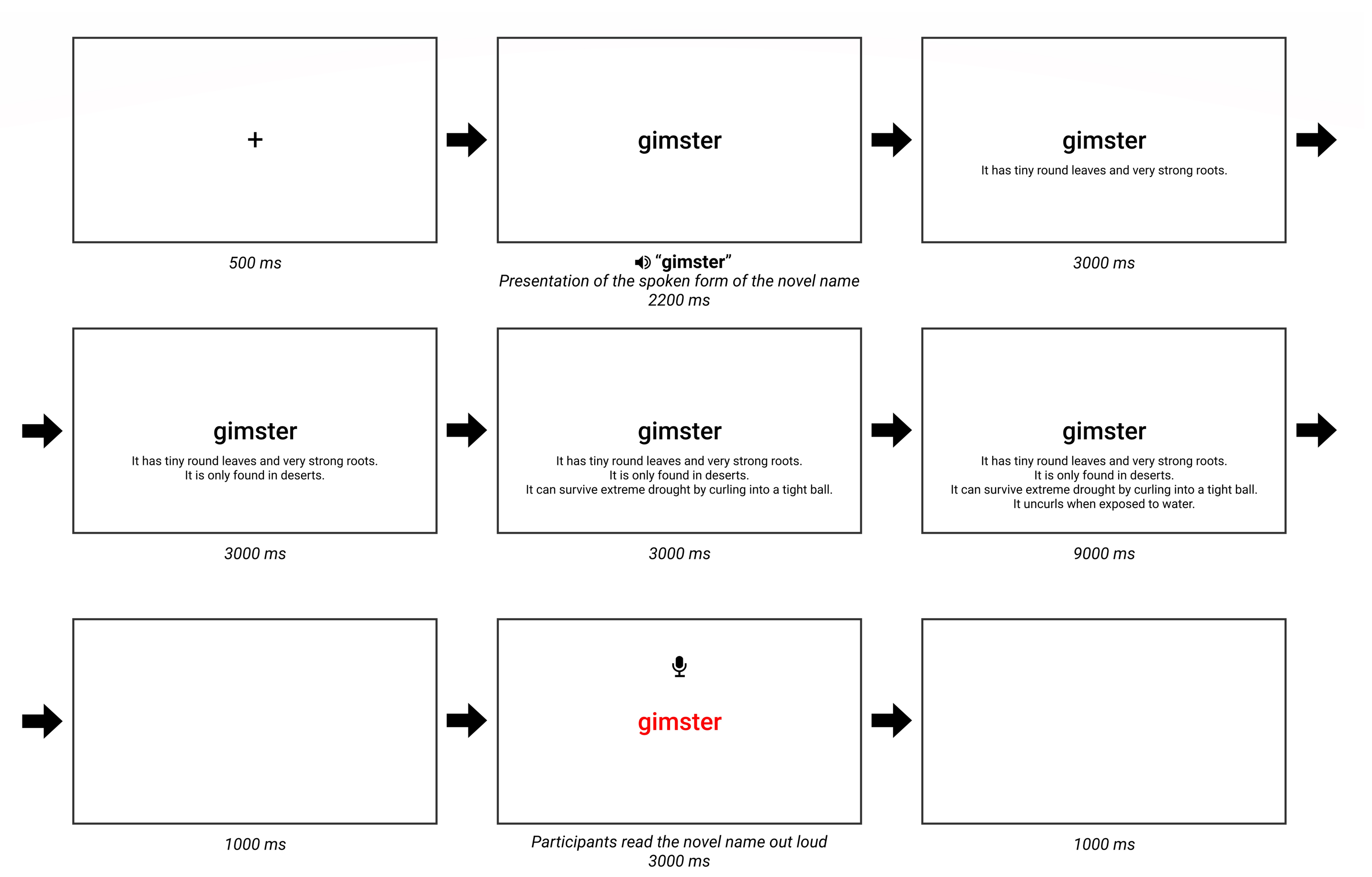
DESIGN & PROCEDURE

Participants

- 72 neurotypical & monolingual speakers of Aus English (28 male, age: $M = 20.94$, $SD = 3.86$)

Learning phase

- novel names for a set of 20 novel concepts presented with their definitions
- 4 EEG recordings per word, recordings 2–4 used for the analysis



Example of one trial in the learning phase.

Cued recall

- type the names of the trained novel concepts given their definitions

Pre-processing of EEG data

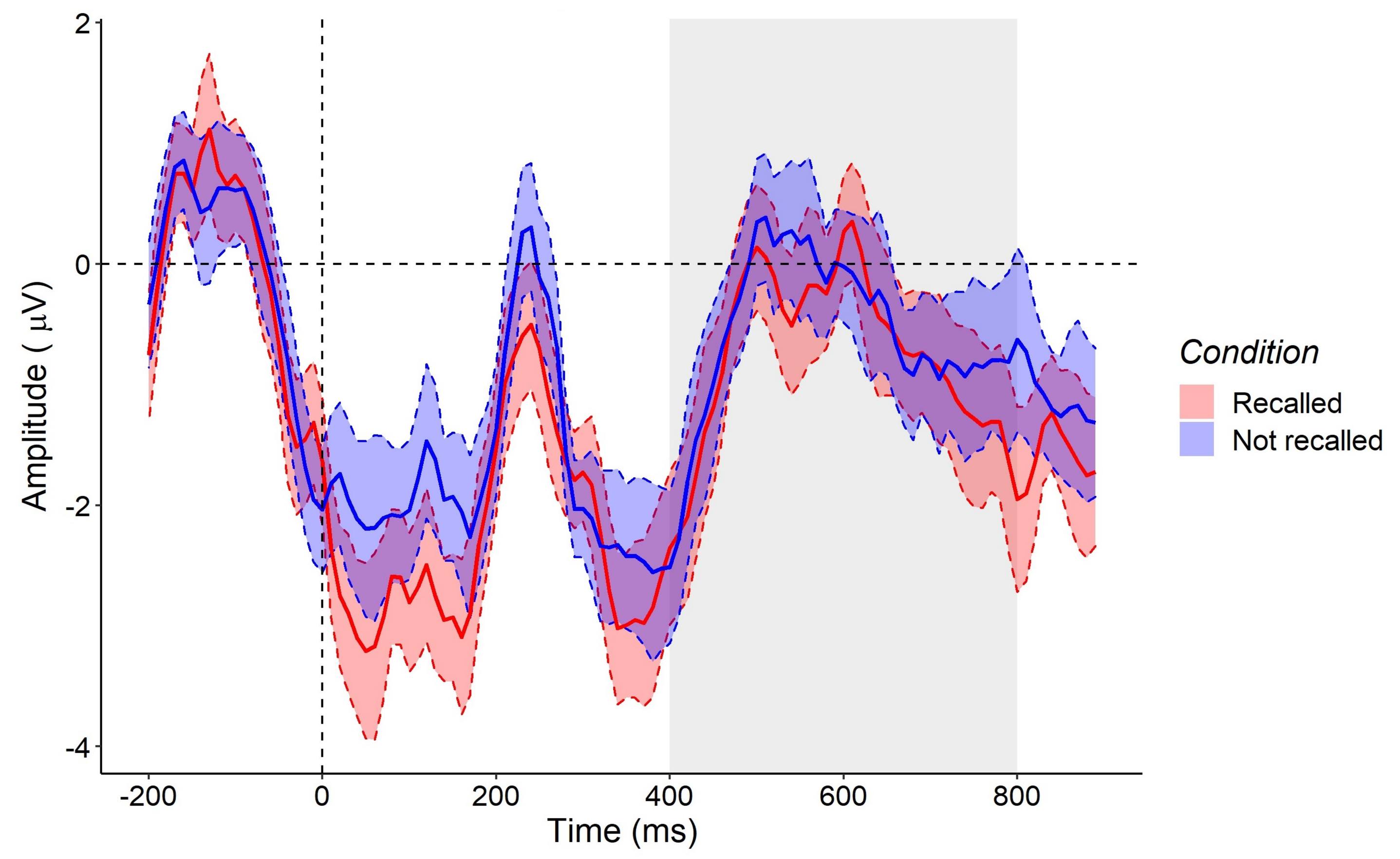
- at least 20 trials per participant per condition (correct vs. incorrect)
  - *ERP dataset*
    - Epochs: −200 ms to 1000 ms relative to stimulus onset
    - 31 participants (12 male, age: $M = 21.77$, $SD = 3.93$)
  - *TFR dataset*
    - Epochs: −200 ms to 1500 ms relative to stimulus onset
    - 25 participants (9 male, age: $M = 22.32$, $SD = 4.10$)

RESULTS

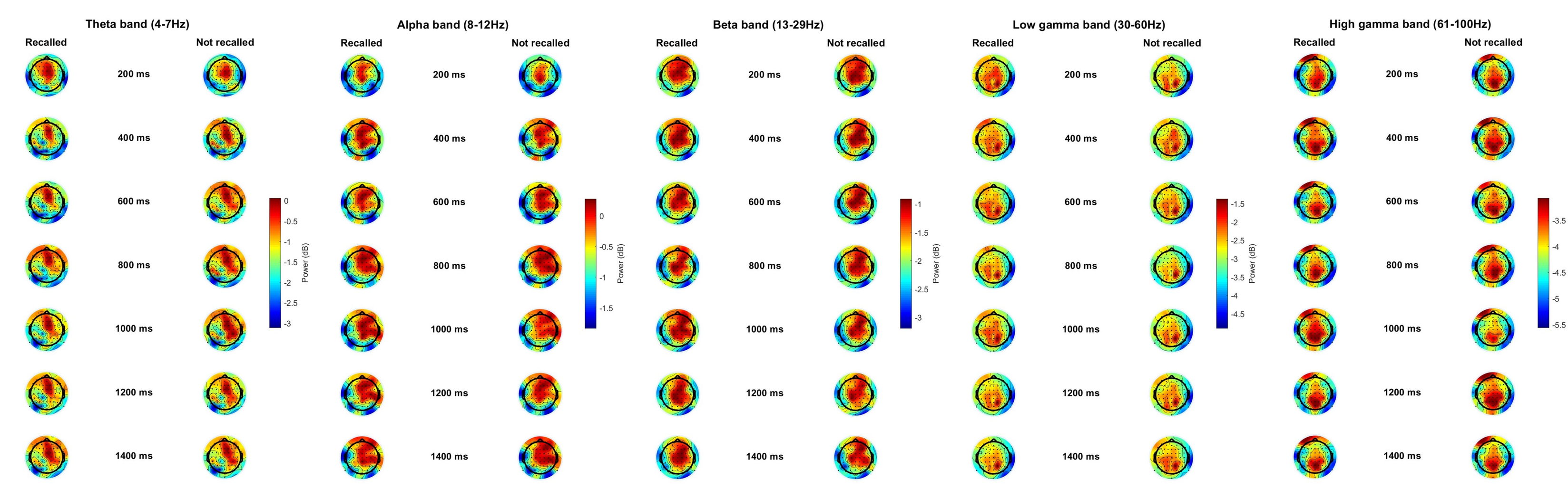
Note that below we only report results of two of the pre-registered analyses; for outcomes of the pre-registered PAC analysis as well as those of exploratory analyses see https://psyarxiv.com/tfks3/.

- Mass univariate analyses using LIMO [9]
- Correction for multiple comparisons via Threshold Free Cluster Enhancement technique with bootstrapping [10, 11]
- No t-values remained significant after correction in either analysis!

ERP responses for recalled vs. not recalled novel names at centro-parietal electrodes



Topographic maps of time-frequency power during encoding of novel names



DISCUSSION

Most likely reasons for these outcomes:

- Low signal-to-noise ratio
  - But note that effects of interest were also found in studies with N of participants and trials similar to ours [12, 13]
- Genuine differences in encoding of familiar (i.e., well-established in semantic memory) vs. novel words (both name & concept are novel)
- Neural correlates of successful encoding are domain-general but experimental effects (on ERPs, TFRs, or PAC) manifest only under certain conditions
  - Are existing theories [4, 5, 6] underspecified and/or based only on a subset of available findings?

⟶ See pre-print for a detailed discussion of these & other possible accounts

https://psyarxiv.com/tfks3/

REFERENCES

[1] K. A. Paller and A. D. Wagner. "Observing the transformation of experience into memory". In: *Trends in Cognitive Sciences* 6.2 (2002), pp. 93–102. DOI: https://doi.org/10.1016/s1364-6613(00)01845-3.

[2] D. Friedman and R. Johnson. "Event-related potential (ERP) studies of memory encoding and retrieval: A selective review". In: *Microscopy Research and Technique* 51.1 (2000), pp. 6–28.

[3] A. D. Wagner, W. Koutstaal, and D. L. Schacter. "When encoding yields remembering: Insights from event-related neuroimaging". In: *Philosophical Transactions of the Royal Society B: Biological Sciences* 354.1387 (1999), pp. 1307–1324. DOI: https://doi.org/10.1098/rstb.1999.0481.

[4] E. Nyhus and T. Curran. "Functional role of gamma and theta oscillations in episodic memory". In: *Neuroscience & Biobehavioral Reviews* 34.7 (2010), pp. 1023–1035. DOI: https://doi.org/10.1016/j.neubiorev.2009.12.014.

[5] S. Hanslmayr, T. Staudigl, and M.-C. Fellner. "Oscillatory power decreases and long-term memory: The information via desynchronization hypothesis". In: *Frontiers in Human Neuroscience* 6 (2012), p. 74. DOI: https://doi.org/10.3389/fnhum.2012.00074.

[6] S. Hanslmayr, B. P. Staresina, and H. Bowman. "Oscillations and episodic memory: Addressing the synchronization/desynchronization conundrum". In: *Trends in Neurosciences* 39.1 (2016), pp. 16–25. DOI: https://doi.org/10.1016/j.tins.2015.11.004.

[7] B. Lega et al. "Slow-theta-to-gamma phase-amplitude coupling in human hippocampus supports the formation of new episodic memories". In: *Cerebral Cortex* 26.1 (2016), pp. 268–278. DOI: https://doi.org/10.1093/cercor/bhu232.

[8] L. Batterink and H. Neville. "Implicit and explicit mechanisms of word learning in a narrative context: An event-related potential study". In: *Journal of Cognitive Neuroscience* 23 (2011), pp. 3181–3196. DOI: https://doi.org/10.1162/jocn_a_00013.

[9] C. R. Pernet et al. "LIMO EEG: A toolbox for hierarchical LInear MOdeling of ElectroEncephaloGraphic data". In: *Computational Intelligence and Neuroscience* 11 (2011), e831409. DOI: https://doi.org/10.1155/2011/831409.

[10] S. Smith and T. Nichols. "Threshold-free cluster enhancement: Addressing problems of smoothing, threshold dependence and localisation in cluster inference". In: *NeuroImage* 44.1 (2009), pp. 83–98. DOI: https://doi.org/10.1016/j.neuroimage.2008.03.061.

[11] C. R. Pernet et al. "Cluster-based computational methods for mass univariate analyses of event-related brain potentials/fields: A simulation study". In: *Journal of Neuroscience Methods* 250.Supplement C (2015), pp. 85–93. DOI: https://doi.org/10.1016/j.jneumeth.2014.08.003.

[12] U. Friese et al. "Successful memory encoding is associated with increased cross-frequency coupling between frontal theta and posterior gamma oscillations in human scalp-recorded EEG". In: *NeuroImage* 66 (2013), pp. 642–647. DOI: https://doi.org/10.1016/j.neuroimage.2012.11.002.

[13] M. Köster et al. "Theta-gamma coupling during episodic retrieval in the human EEG". In: *Brain Research* 1577 (2014), pp. 57–68. DOI: https://doi.org/10.1016/j.brainres.2014.06.028.

maria.korochkina@rhul.ac.uk / mariakna.github.io

AMLaP / 7 September 2022 / York, UK