MACQUARIE University SYDNEY·AUSTRALIA

Universität Potsdam

Behavioural and electrophysiological markers of integration in novel word learning

Maria Korochkina[1,2,3], **Lyndsey Nickels**[1], **Audrey Bürki**[2]

[1] School of Psychological Sciences, Macquarie University, Australia

[2] Department of Linguistics, University of Potsdam, Germany

[3] International Doctorate for Experimental Approaches to Language and Brain (IDEALAB): Universities of Groningen (The Netherlands), Newcastle (United Kingdom), Potsdam (Germany) & Macquarie University (Australia)

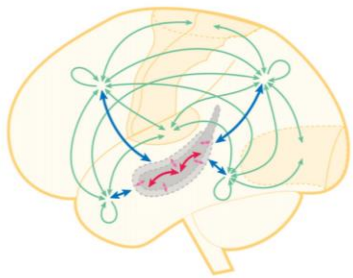
13th Annual Meeting of the Society for the Neurobiology of Language

October 5, 2021

Markers of integration

Complementary Learning Systems [1-4]

- formation of new episodic memory representations
- integration of new information into semantic memory



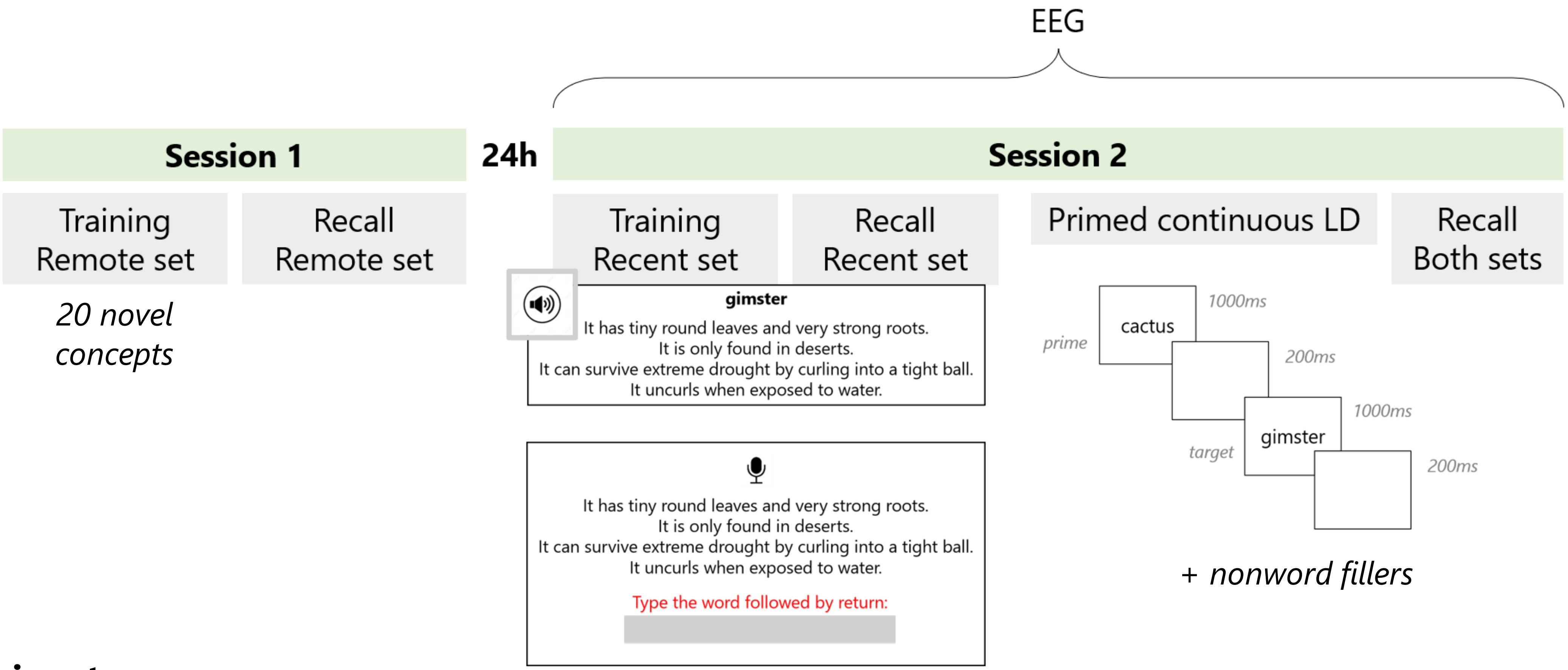
→ Only integrated newly learned words compete with familiar words during lexical selection

- **Semantic priming effect** as a marker of integration [e.g., 5-7]
  - longer RTs to (familiar) targets preceded by (trained novel) unrelated vs related primes

But… **how does the behavioural priming effect map onto electrophysiology?**

- Automatic or controlled lexical-semantic retrieval? [e.g., 8-9]
- Two spatiotemporal windows, the N400 and the LPC [e.g., 10-11]

Methods



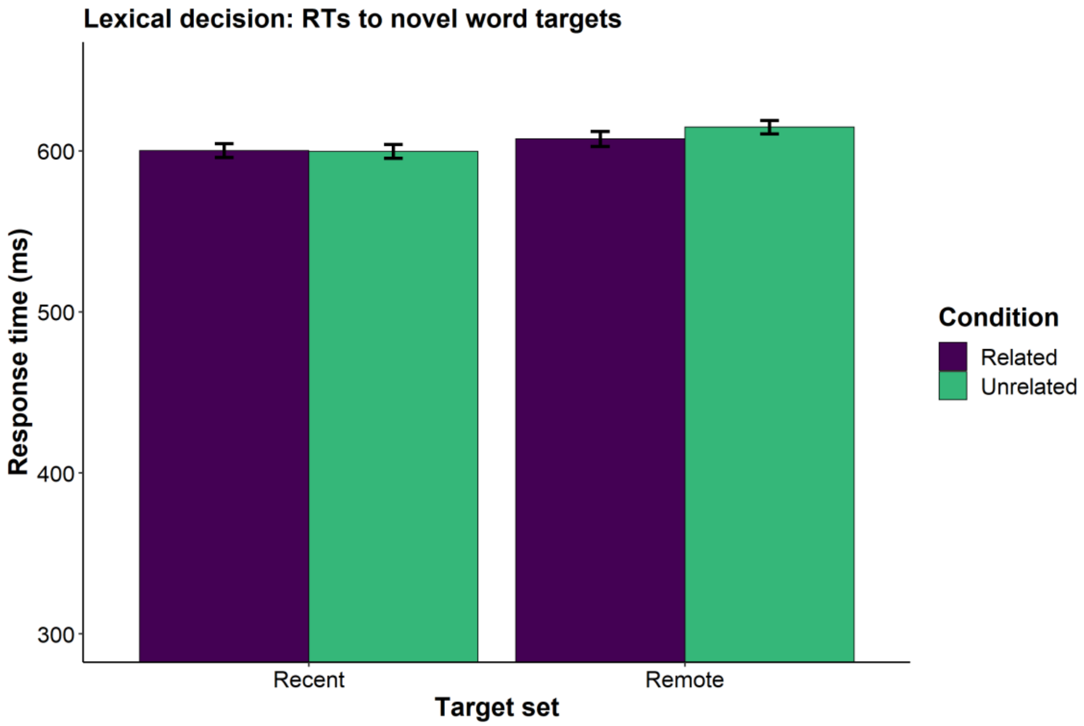
Participants

- 72 monolingual speakers of Aus English
- 28 males, *mean* age 20.94, *SD* 3.86
- Analysed: N = 71, 27 males, *mean* age 20.94, *SD* 3.87

Pre-registered at https://osf.io/su7d3 on March 17, 2021

Behavioural results

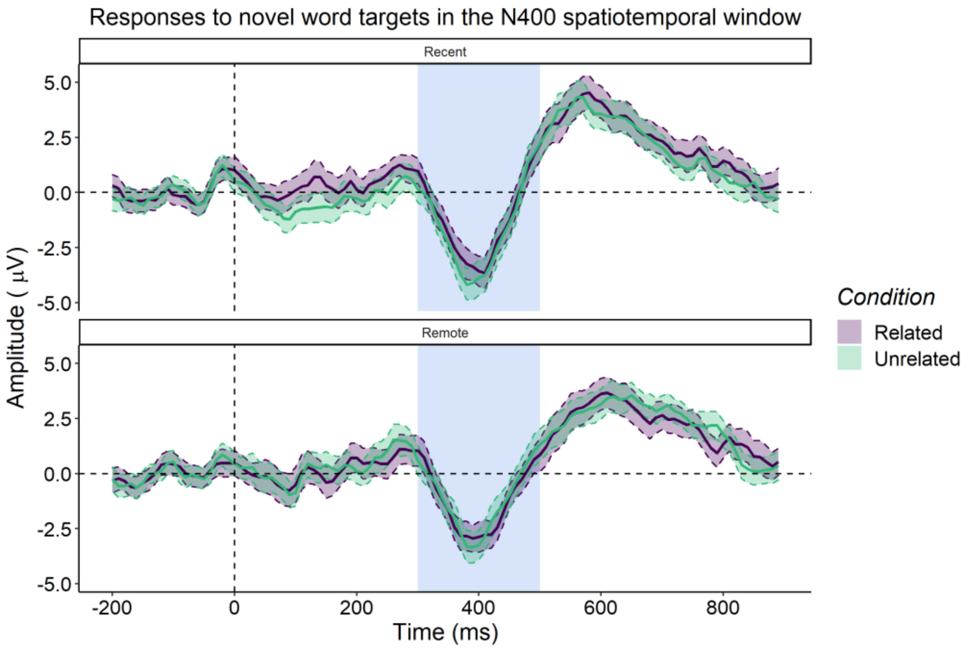
Bayesian LMMs with correlated varying intercepts and slopes

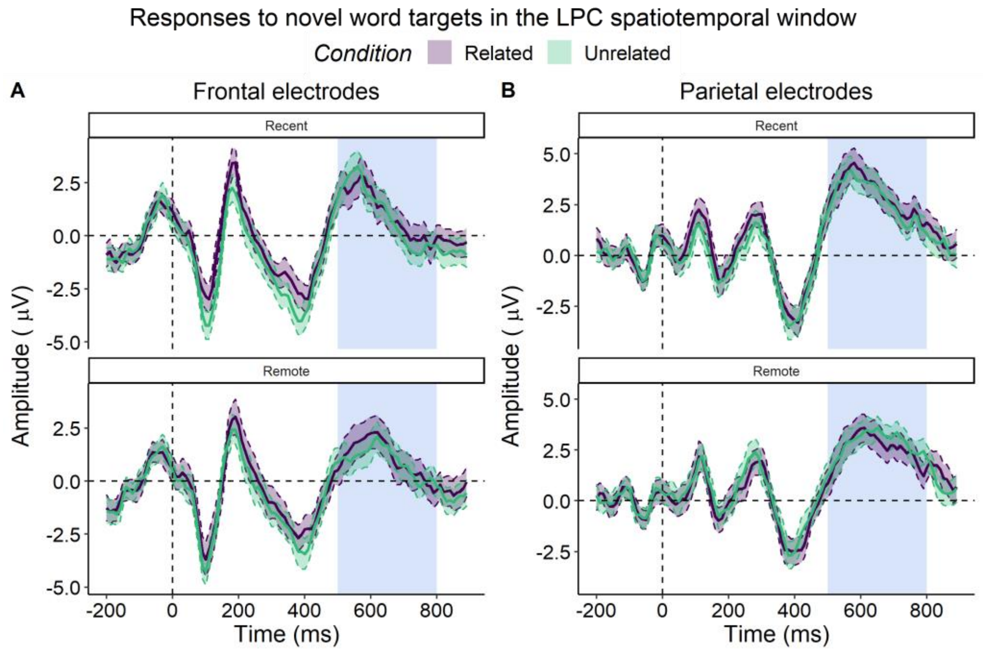


- Anecdotal evidence **for** ME set, diff = 11ms, β = -0.01, *95%CrI* = [-0.018, 0.002], BF_{10} = 3.95
- Moderate evidence **against** ME condition, β = 0.003, *95%CrI* = [-0.005, 0.012], BF_{10} = 0.12
- Moderate evidence **against** the interaction, β = -0.004, *95%CrI* = [-0.011, 0.004], BF_{10} = 0.13

Semantic priming: EEG analysis 1

Bayesian distributional regression models with correlated varying intercepts and slopes for μ and varying intercepts for δ [12]



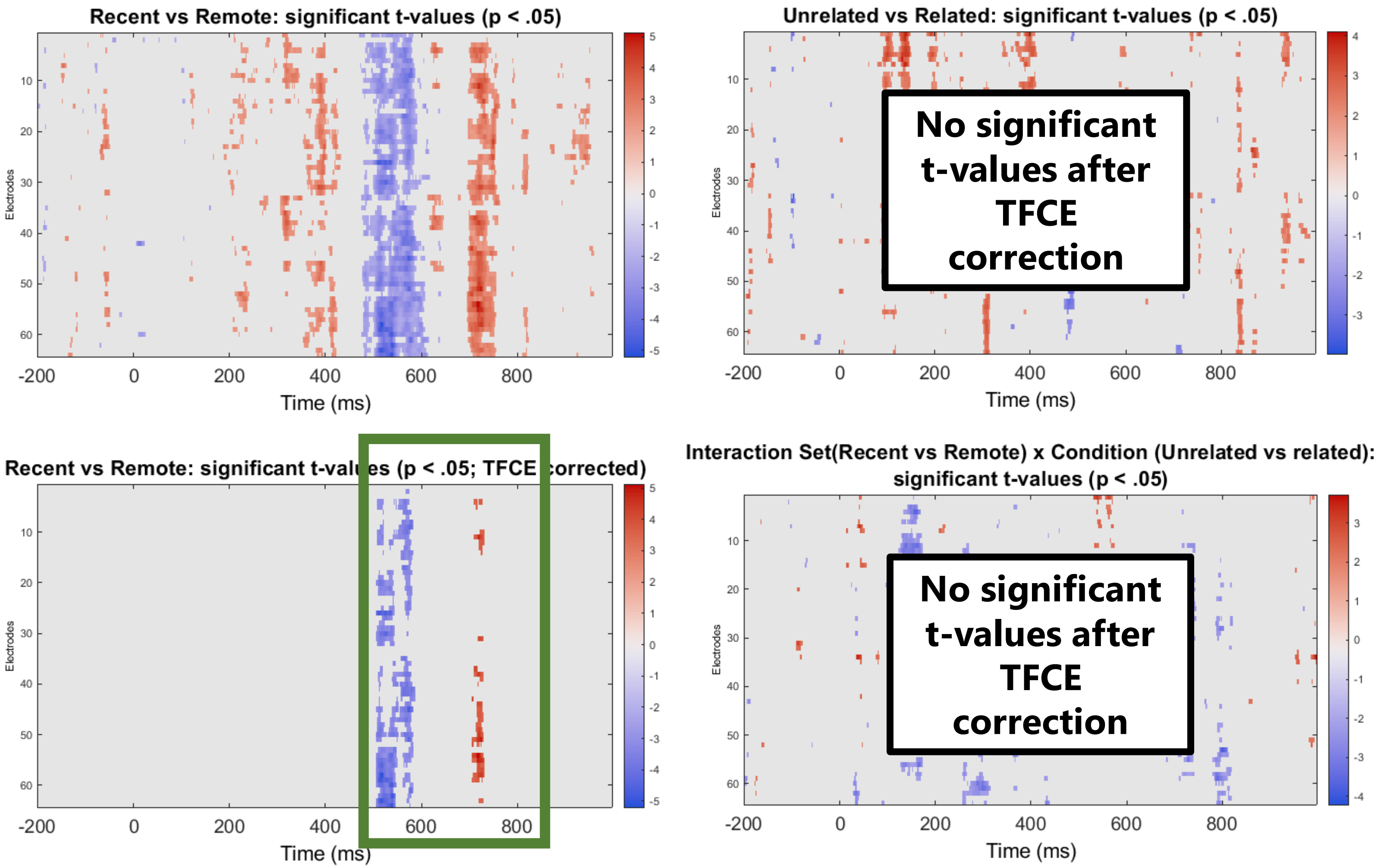


Strong evidence **against** ME condition (β = -0.06, *95%CrI* = [-0.26, 0.14], BF_{10} = 0.017), ME set (β = -0.14, *95%CrI* = [-0.33, 0.06], BF_{10} = 0.04) & interaction (β = -0.08, *95%CrI* = [-0.03, 0.11], BF_{10} = 0.03)

Strong evidence **against** all MEs and interactions both at frontal and parietal electrodes

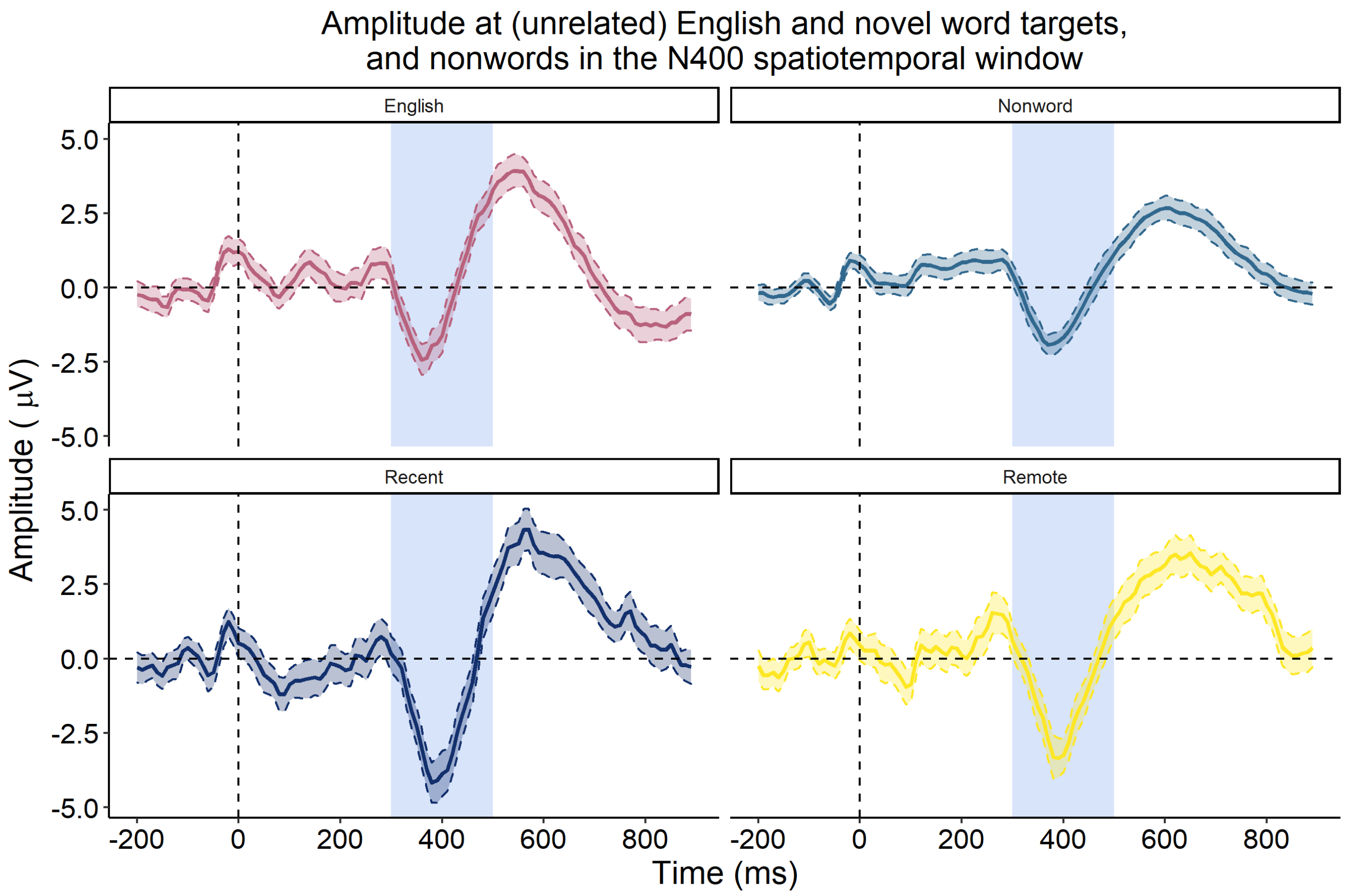
Semantic priming: EEG analysis 2

- Mass univariate analysis [e.g., 13-14]
- Correction for multiple comparisons with Threshold Free Cluster Enhancement (TFCE) [15-16]



Lexicality: EEG analysis 1

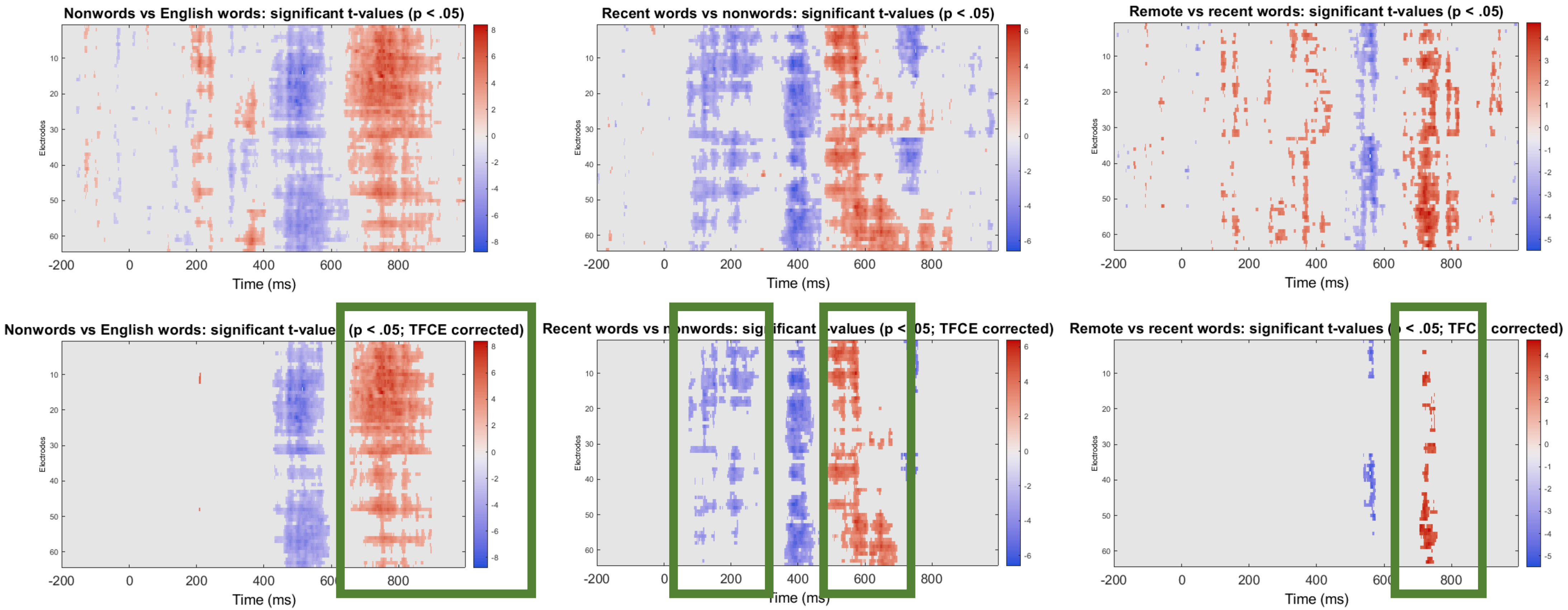
Bayesian distributional regression models with correlated varying intercepts and slopes for μ and varying intercepts for δ



- Moderate evidence **for** the difference between nonwords and English words (β = -0.4, *95%CrI* = [-0.84, 0.03], BF_{10} = 6.87)
- Extreme evidence **for** the difference between recent words and nonwords (β = -0.93, *95%CrI* = [-1.42, -0.45], BF_{10} = 846.21)
- Strong evidence **against** the difference between remote and recent words (β = 0.39, *95%CrI* = [-0.12, 0.9], BF_{10} = 0.09)

Lexicality: EEG analysis 2

- Mass univariate analysis
- Correction for multiple comparisons with Threshold Free Cluster Enhancement (TFCE)



Conclusions

- Compared to *nonwords*, *(unrelated) recent words* elicited
  - greater negativity 100-200ms post onset
  - greater negativity in the N400 spatiotemporal window
  - greater positivity 500-700ms post onset
- No difference between (*unrelated) recent and remote words* in the N400 spatiotemporal window, but *remote words* elicited greater positivity 700-750ms post onset
- Evidence *against semantic priming* effects in both sets
- Greater positivity to *(related & unrelated) recent vs remote words* 500-600ms post onset

→ Immediately after exposure, novel words are processed differently compared to previously unseen nonwords in **both episodic and semantic memory**

→ 24h after exposure to novel words (remote), the system still **relies on episodic memory** to distinguish between those words and the words acquired on the following day (recent)

References

[1] Davis, M., & Gaskell, M. (2009). A Complementary Systems Account of word learning: neural and behavioural evidence. *Philos. Trans. R. Soc. B*, 364, 3773–3800. https://doi.org/10.1098/rstb.2009.0111.

[2] Kumaran, D., Hassabis, D., & McClelland, J. L. (2016). What learning systems do intelligent agents need? Complementary Learning Systems Theory updated. *Trends Cogn. Sci.*, 20(7), 512–534. https://doi.org/10.1016/j.tics.2016.05.004.

[3] McClelland, J. L., McNaughton, B. L., & O'Reilly, R. C. (1995). Why there are complementary learning systems in the hippocampus and neocortex: Insights from the successes and failures of connectionist models of learning and memory. *Psychol. Rev.*, 102(3), 419–457. https://doi.org/10.1037/0033-295X.102.3.419.

[4] McClelland, J.L., McNaughton, B. L., & Lampinen, A.K. (2020). Integration of new information in memory: new insights from a complementary learning systems perspective. *Philos. Trans. R. Soc. B,* 375: 20190637. http://dx.doi.org/10.1098/rstb.2019.0637.

[5] Dumay, N., Gaskell, M. G., & Feng, X. (2004). A day in the life of a spoken word. In K. Forbus, D. Gentner, & T. Regier (Eds.), *Proceedings of the twenty-sixth annual conference of the Cognitive Science Society* (pp. 339 – 344). Erlbaum.

[6] Tamminen, J., & Gaskell, M.G. (2013). Novel word integration in the mental lexicon: Evidence from unmasked and masked semantic priming. *Q. J. Exp. Psychol.*, 66 (5), 1001-1025. https://doi.org/10.1080/17470218.2012.724694.

[7] van der Ven, F., Takashima, A., Segers, E., & Verhoeven, L. (2015). Learning word meanings: Overnight integration and study modality effects. *PLoS ONE*, 10, e0124926. https://doi.org/10.1371/journal.pone.0124926.

[8] Bakker, I., Takashima, A., van Hell, J., Janzen, G., & McQueen, J. (2015). Tracking lexical consolidation with ERPs: Lexical and semantic-priming effects on N400 and LPC responses to newly-learned words. *Neuropsychologia*, 79, 33-41. https://doi.org/10.1016/j.neuropsychologia.2015.10.020.

[9] Liu, Y., & van Hell, J. (2020). Learning novel word meanings: An ERP study on lexical consolidation in monolingual, inexperienced foreign language learners. *Language Learning*, 70(S2), 45-74. https://doi.org/10.1111/lang.12403.

[10] Kutas, M., & Federmeier, K.D. (2011). Thirty years and counting: finding meaning in the N400 component of the event-related brain potential (ERP). *Annu. Rev. Psychol.*, 62, 621-647. https://doi.org/10.1146/annurev.psych.093008.131123.

[11] Rugg, M.D., & Curran, T. (2007). Event-related potentials and recognition memory. *Trends Cogn. Sci.*, 11(6), 251-257. https://doi.org/10.1016/j.tics.2007.04.004.

[12] Bürkner, P.C. (2017). Bayesian Distributional Non-Linear Multilevel Modelling with the R package *brms*. https://mran.microsoft.com/snapshot/2017-04-05/web/packages/brms/vignettes/brms_multilevel.pdf

[13] Groppe, D. M., Urbach, T. P., & Kutas, M. (2011a). Mass univariate analysis of event-related brain potentials/fields I: A critical tutorial review. *Psychophysiology*, 48(12), 1711–1725. doi: https://doi.org/10.1111/j.1469-8986.2011.01273.x.

[14] Groppe, D. M., Urbach, T. P., & Kutas, M. (2011b). Mass univariate analysis of event-related brain potentials/fields II: Simulation studies. *Psychophysiology*, 48(12), 1726–1737. doi: https://doi.org/10.1111/j.1469-8986.2011.01272.x.

[15] Smith, S.M., & Nichols, T.E. (2009). Threshold-free cluster enhancement: addressing problems of smoothing, threshold dependence and localisation in cluster inference. *Neuroimage*, 1, 44(1): 83-98. https://doi.org/10.1016/j.neuroimage.2008.03.061.

[16] Pernet, C.R., Latinus, M., Nichols, T.E., & Rousselet, G.A. (2015). Cluster-based computational methods for mass univariate analyses of event-related brain potentials/fields: A simulation study. *J Neurosci Methods*, 30 (250): 85-93. https://doi.org/10.1016/j.jneumeth.2014.08.003.