The Neural Basis of the Negativity Bias

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INTRODUCTION

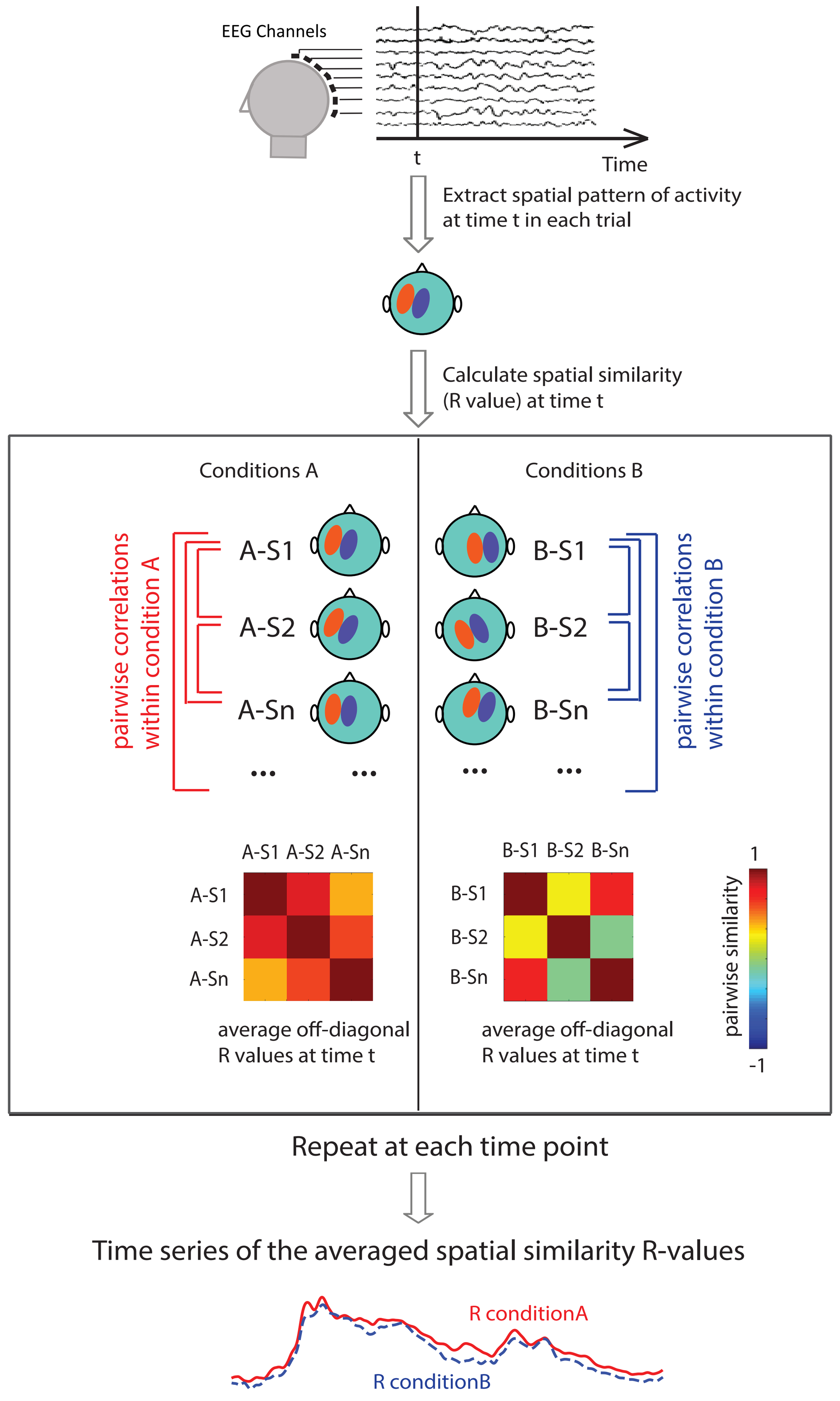
- Negativity bias: When attending to emotional valence, we devote more attentional resources to evaluating negatively-valenced stimuli than positive or neutral stimuli (Baumeister et al., 2001; Ito et al., 1998).
- ERPs: Negativity bias manifests as a larger late positivity evoked by negative stimuli, from 500ms after stimulus onset (Citron, 2012; Delaney-Busch et al., 2016).
- Question: does the neural negativity bias reflect deeper (re)-analysis of semantic representations during this late of evaluative processing?
- A large body of work suggests that the semantic representation of a word can be inferred "by the company it keeps" (Firth, 1957).
- Therefore, we used computational models, which build semantic representations (high-dimensional vector spaces) through a statistical analysis of the contexts in which words occur, in combination with EEG and Representational Similarity Analysis (RSA) to probe the nature of the neural negativity bias.

METHOD

- Semantic similarity measures of pairs of words: word2vec (Mikolov, 2013) and Latent Semantic Analysis (LSA; Landauer et al., 2007).
  - Random sample of 4637 words from the Warriner, Kuperman, & Brysbaert (2013) corpus: varied in emotional valence (negative, neutral, positive).
  - 468 words that were used in an EEG study: varied in emotional valence (negative, neutral, positive) and were matched on arousal and lexical properties (word length, word frequency, and concreteness).
- EEG recorded as 22 healthy adults read and judged the valence of the matched set of 467 words .
  - Analysis of ERPs: late positivity (500-800 ms; previously reported by Delaney-Busch et al., 2016).
  - Spatial similarity analysis
    - Cluster-based permutation ANOVA to test similarity of patterns of neural activity elicited by emotionally valenced words.

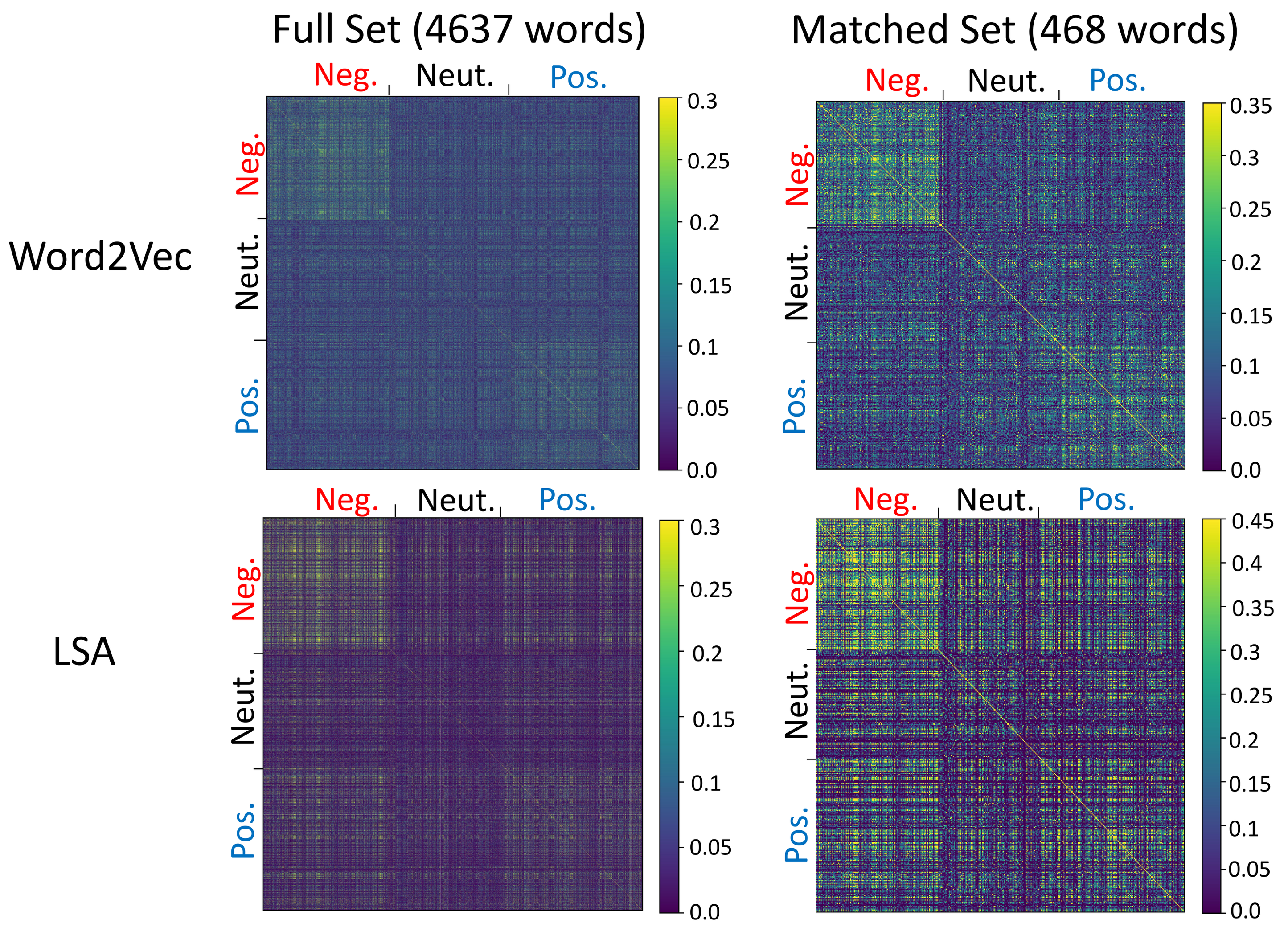
Spatial Similarity Analysis Pipeline

(see also Wang et al., 2020)

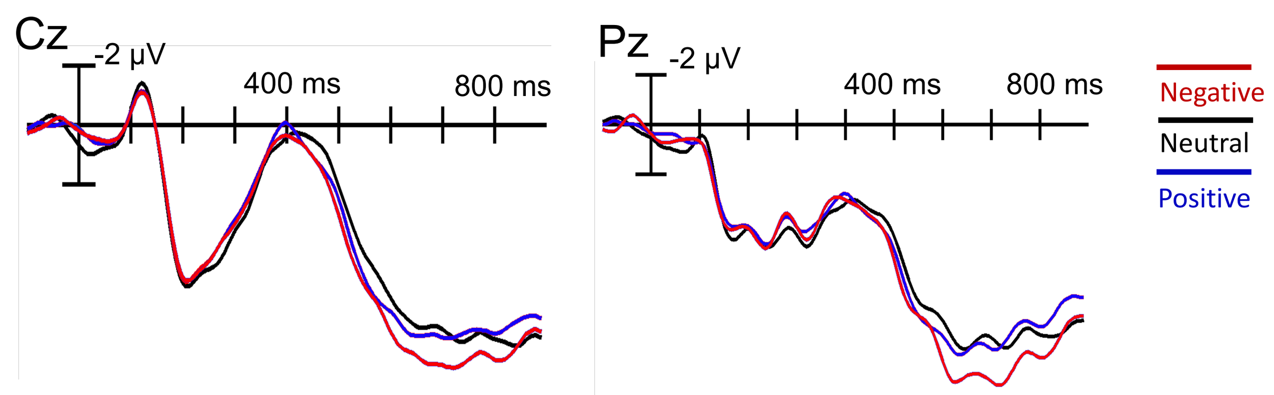


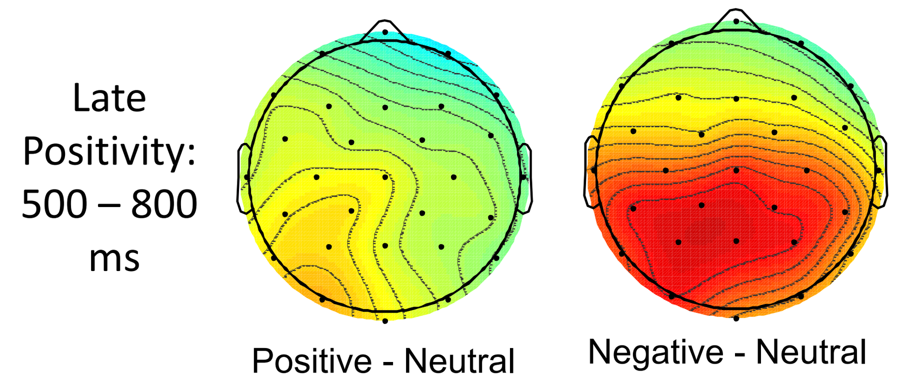
RESULTS

Pairwise Semantic Similarity



ERP Analysis

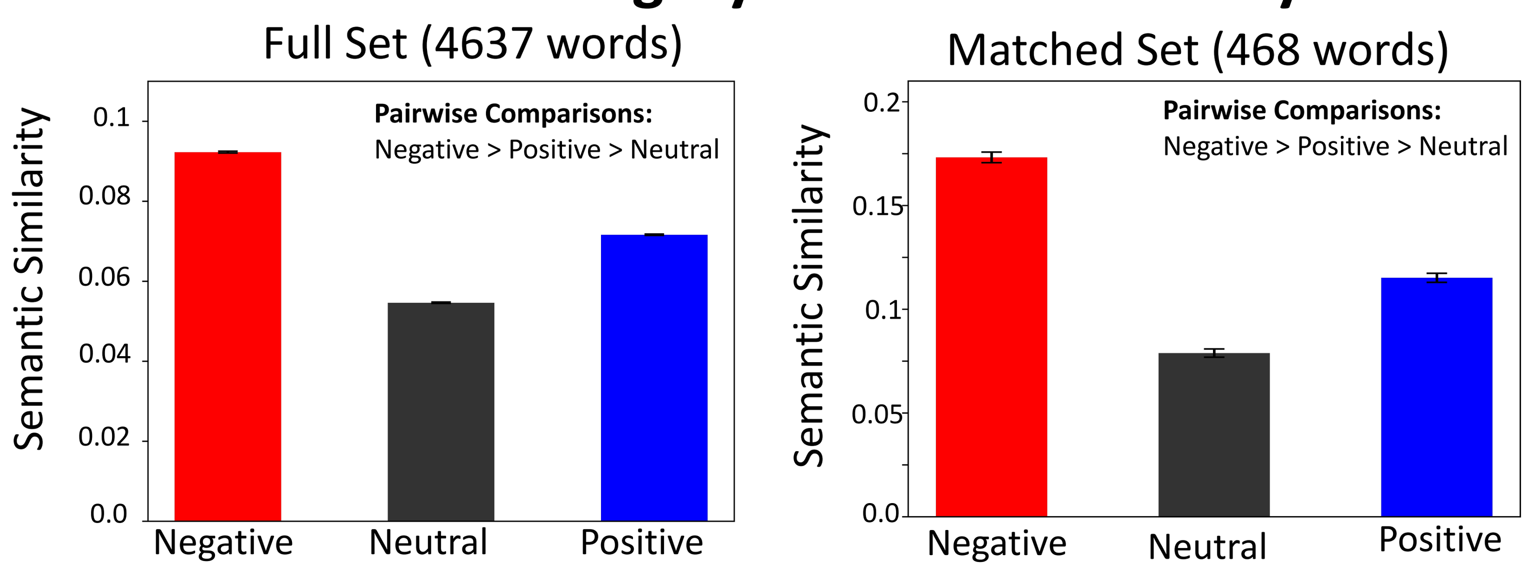




ANOVA: main effect of valence on late positivity

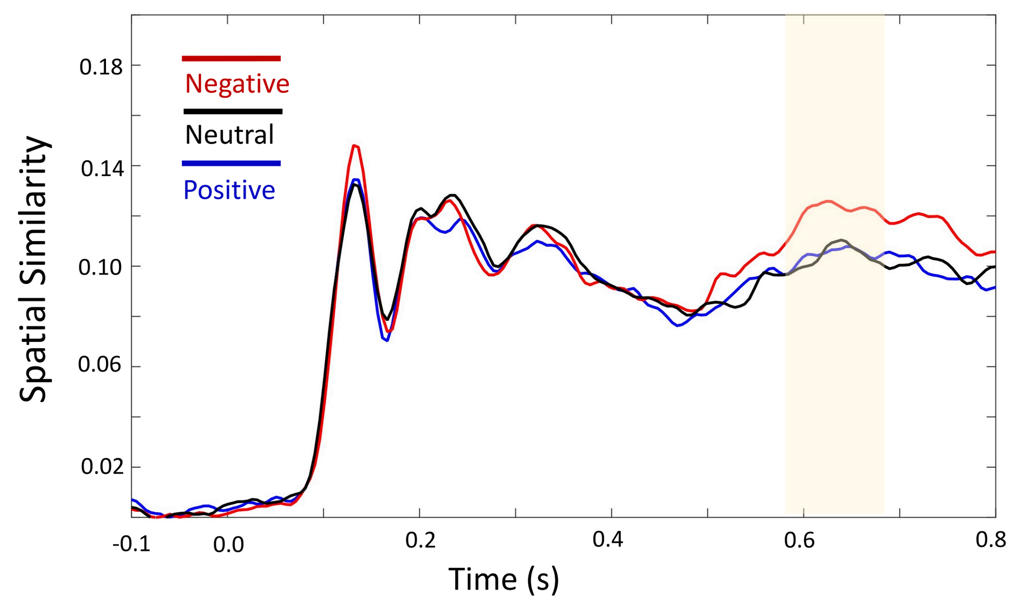
Pairwise Comparisons:
- Negative > Positive, Neutral

Within-Category Semantic Similarity



(LSA, Word2Vec combined)

EEG Spatial Similarity Analysis



Cluster Permutation ANOVA revealed one significant cluster, from 595-695 ms
- Cluster mass = 109.398, p = .014

Pairwise Comparisons: Negative > Positive, Neutral

CONCLUSIONS

- Computational model-based similarity measures showed greater semantic similarity amongst negative words than amongst positive words, and greater similarity among positive words than neutral words.
- ERPs confirmed the negativity bias: Negative words evoked a larger late positivity between 500-800ms than neutral or positive words (see also Delaney-Busch et al., 2016).
- Spatial similarity analysis: within the late positivity time window, there was greater similarity between patterns of neural activity produced by negative words than patterns of activity produced by positive or neutral words.
- Together, these data suggest that the prolonged neural processing associated with negatively-valenced stimuli may reflect a re-evaluation of their underlying semantic representations.
- Future: Trial-by-trial spatial similarity analysis to confirm that greater neural similarity in the late positivity time window is linked to greater semantic similarity on a trial-by-trial basis.

REFERENCES

- Baumeister, R. F., Bratslavsky, E., Finkenauer, C., & Vohs, K. D. (2001). Review of General Psychology, 5, 323–370.
- Citron, F. M. (2012). *Brain and Language*, 122, 211–226.
- Delaney-Busch, N., Wilkie, G. & Kuperberg, G. *Cogn Affect Behav Neurosci* 16**,** 415–432 (2016).
- Firth, J. R. (1957). A synopsis of linguistic theory, 1930-1955. Studies in linguistic analysis.
- Ito, T. A., LLandauer, T. K., McNamara, D. S., Dennis, S., & Kintsch, W. (2007). Lawrence Erlbaum Associates.
- Landauer, T. K., McNamara, D. S., Dennis, S., & Kintsch, W. (2007). Lawrence Erlbaum Associates.
- Mikolov, T., Chen, K., Corrado, G., Dean, J., Sutskever, L., & Zweig, G. (2013).
- Wang, L., Wlotko, E., Alexander, E., Schoot, L., Kim, M., Warnke, L., & Kuperberg, G. (2020). *J. Neuroscience* , 40 (16), 3278-3291.

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