Representational Similarity Analysis reveals unique patterns associated with the fulfillment and violation of lexico-semantic prediction within the N400 time window: An MEG study

Lin Wang[1,2], Ole Jensen[3], Gina Kuperberg[1,2]

[1] Department of Psychiatry and the Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Harvard Medical School;
[2] Department of Psychology, Tufts University; [3] Centre for Human Brain Health, University of Birmingham, Birmingham, UK

Introduction

• In EEG/MEG, facilitated lexico-semantic processing is classically indexed by a reduced N400 to expected versus unexpected words between 300 – 500 ms [1].

• Sources of the N400 effect:
- Left superior, middle and inferior temporal cortices, left inferior frontal cortex (EEG/MEG source localization + fMRI studies) [2].
- Medial temporal region: hippocampus, parahippocampus, fusiform (Intracranial recordings) [3].

• Multivariate Pattern Analysis (MVPA), such as Representational Similarity Analysis (RSA), has been used to identity brain activity associated with representationally similar items [4].

• We used RSA in conjunction with MEG to identify brain regions associated with lexico-semantic processing within the N400 time window.

Methods

• Participants: 26 native Chinese speakers (13 males).

• Experimental stimuli: 120 pairs of high-constraining sentence contexts, which ended with either expected or unexpected but plausible words.

P1-A: In the crib, there is a sleeping baby.
P1-A': In the hospital, there is a newborn child.

P2-B: In order to keep the food fresh, the family bought a new fridge.
P2-B': In order to prevent the milk from going bad, mum put it in the freezer.

• Task: sentence comprehension.

• Procedure: word-by-word visual presentation.

Fig 1. Sentence presentation procedure.

• MEG signal time-locked to the onset of sentence-final words (SFWs).

RSA: Spatial Similarity Analysis

Fig 2. Illustration of spatial RSA.

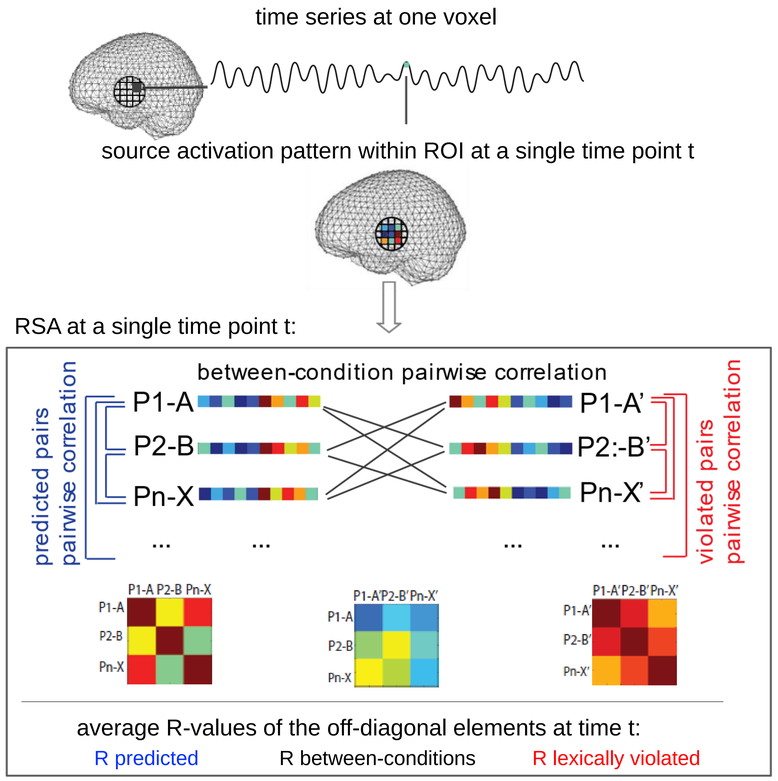
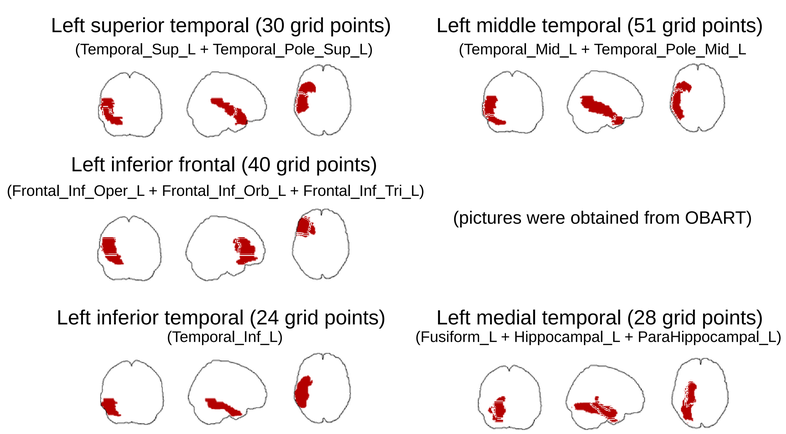
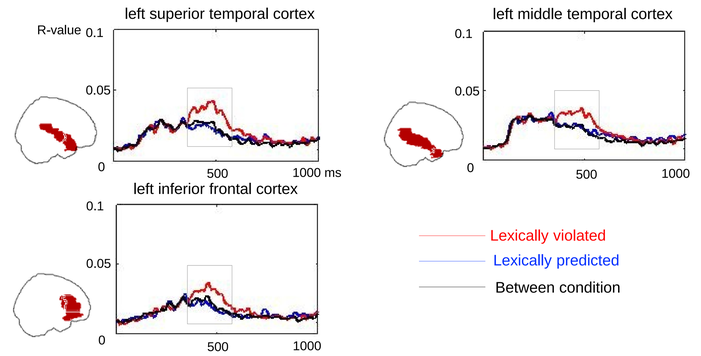


Fig 3. Anatomically defined spatial ROIs (AAL)



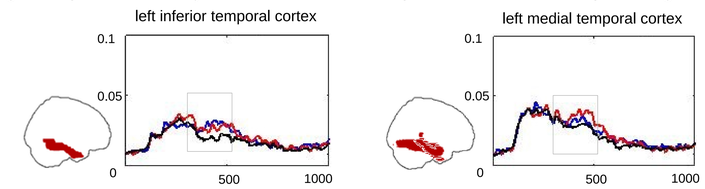
Results

Fig 4a. Spatial similarity within left superior and middle temporal, left inferior frontal regions



lexically violated > predicted = between-condition

Fig 4b. Spatial similarity within left inferior temporal and medial temporal regions



lexically violated = predicted > between-conditions

Conclusions

• We were able to identify brain regions associated with the violation and fulfillment of lexico-semantic prediction within the N400 time window using a multivariate approach.

• As expected, the spatial pattern of activity produced by predicted and lexically violated words was dissimilar in all regions tested (low between-condition R values). This serves as a baseline for subsequent comparisons.

• Within all regions tested, the spatial pattern of activity produced by lexically violated words was more similar than that between lexically violated and predicted words (baseline), perhaps reflecting the engagement of these regions in retrieving unpredicted semantic information.

• Within just the *left inferior and medial temporal regions,* the spatial pattern of activity produced by lexically predicted words was also more similar than that between lexically violated and predicted words (baseline). These regions are known to play a role in generating lexico-semantic prediction [5], and so this increased spatial similarity may reflect their role in recognizing fulfilled lexico-semantic predictions.

References

[1] Kutas & Federmeier (2011). Annual Review of Psychology, 62, 621-647.
[2] Lau, Phillips & Poeppel (2008). Nature Review Neuroscience, 9(12), 920-933.
[3] Nobre, & McCarthy. (1995). Journal of Neuroscience, 15(12), 1090-1098.
[4] Kriegeskorte, Mur, & Bandettini. (2008). Frontiers in Systems Neuroscience, 2, 4.
[5] Wang, Kuperberg, & Jensen (2018). BioRxiv.