Contextual information modulates speech-aligned neural tracking

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Background

Predictive processing implies the balanced interaction between two sources of information:
internal expectations and external evidence.

Contextual information driving internal expectations is continuously contrasted with external sensory evidence.

How are these two sources of information integrated?

H1: if predictive processing enhances perception, we expect that most predictive stimuli are represented with more perceptual detail.

H2: if predictive processing weights more the information provided by internal expectations, we expect that more predicted stimuli are analysed in less detail.

The present study

Here we investigated how semantic expectations affect auditory perception during speech listening.

We evaluated the “neural investment” on perceptual processing by analysing the synchronization between electrophysiological neural activity and the temporal amplitude modulations (i.e., the envelope) of speech time locked to a target word, that was semantically highly or minimally constrained.

Participants and Materials

27 Spanish native (14 females; age range 29-51) speakers took part in an EEG session.

They listened to 14 minutes speech and had to answer some comprehension questions at the end of the session.

We constructed the text so that the same target word (45 high-frequency Spanish words served as target) could be contextually highly (cloze-probability>0.5) or minimally predictable (c.p.<0.5).

The target word was always sentence final and the number of words preceding it was controlled across conditions.

EEG details

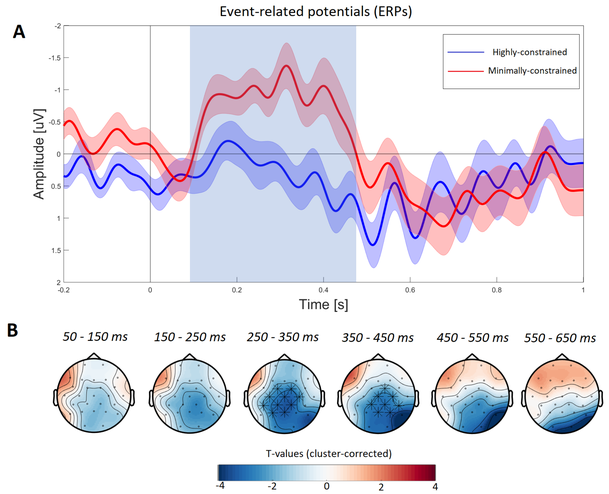
EEG data recorded from 32 electrodes arranged according to the 10-20 system at a sampling rate of 1 kHz.

Data re-referenced to the average activity of the mastoid electrodes and segmented into epochs of 5 seconds centred to the onset of the target word.

Segments were low-pass filtered at 35 Hz, ICA corrected and visually inspected for rejection (8.49 % average rejection).

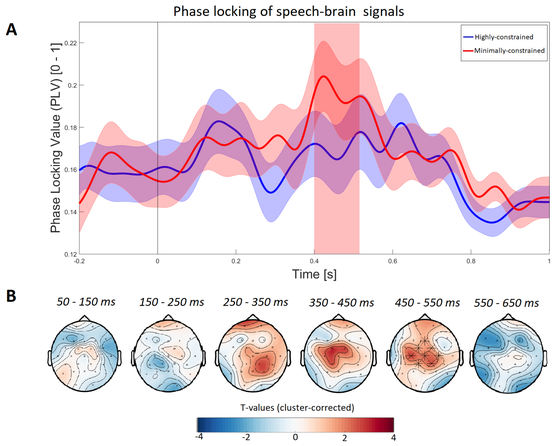
Event-related activity

We first validated our semantic contextual manipulation by verifying the presence of a N400 effect time-locked to our target words (stats based on cluster-based permutations).

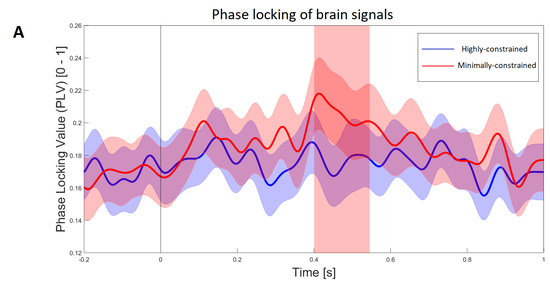


Speech-Brain Phase-Locking Value

We then analysed the phase-coupling between the envelope of the target word and the EEG signal



We also analysed the inter-trial phase alignment to the onset of the target words to evaluate the presence of a phase reset of the on-going EEG during the N400 time interval.



Summary of results and conclusions

- During the N400 time interval (250-450 ms) we observed higher speech-brain coupling for the minimally predictable compared to the highly predictable condition (after ~400 ms).
- This increased phase alignment after ~400 ms is associated with an EEG phase reset across trials that constantly emerges in the same time-interval, probably reflecting a mechanism that is recruited at each word proportional to contextual predictability

Results indicate that increased contextual predictability of a word reduces the focus on the temporal structure of the auditory input. In other words, predicted words are perceptually represented with less detail.