Waves of Binding: EEG oscillations during integration of visual, auditory, and lexical stimuli

Poster D85

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BACKGROUND

- **In current views of semantic memory, conceptual knowledge about objects is represented across brain regions that are active when those objects are perceived** (Allport, 1985).
  - E.g., the shape and roar of a lion is represented in visual and auditory areas, respectively.

How are different types of information (e.g., visual and auditory) integrated into a coherent whole?

- **Synchronized firing of neurons may support binding features of concepts into a coherent whole** (Singer & Gray, 1995).
  - More early gamma activity for congruent vs. incongruent stimuli (e.g., a lion roaring vs. a lion mooing; Schneider et al., 2008; Yuval-Greenberg & Deouell, 2007)
  - More late theta activity for crossmodal compared to unimodal integration (e.g., *silver* + *loud,* for *whistle* vs. *silver* + *shiny,* for *whistle)* with lexical stimuli (van Ackeren & Rueschemeyer, 2014; van Ackeren et al., 2014).
- **Different frequency bands may have different roles in binding:**
  - Gamma for interactions between local cell assemblies
  - Lower frequencies for long-distance interactions (von Stein & Sarnthein, 2000; Donner & Siegel, 2011).

PREDICTIONS

If gamma plays a role in local interactions between cell assemblies in multimodal integration:

- Congruent visual and auditory information should produce more gamma (relative to incongruent).

If theta plays a role in long-distance interactions between cell assemblies in multimodal integration:

- Congruent visual and auditory information should produce more theta (relative to incongruent), and this increase should be greater/more sustained when the auditory stimulus includes lexical information.

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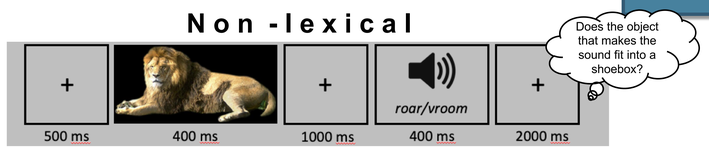
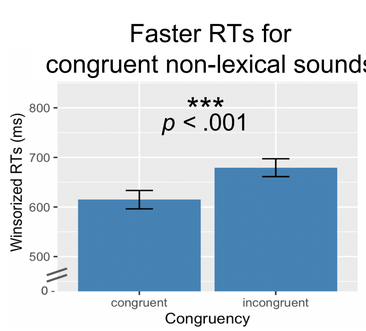
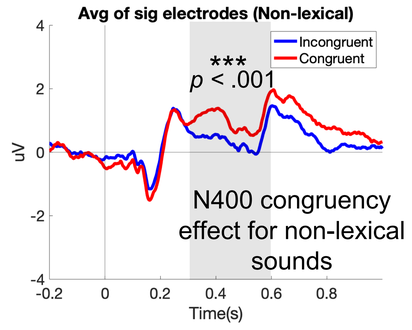
RESULTS

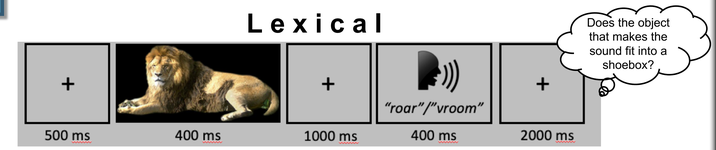


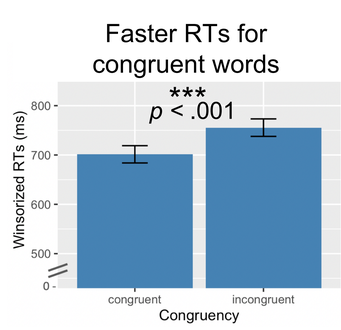


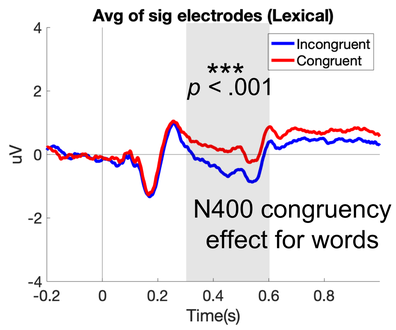


Sanity check:

Non-lexical and lexical conditions DO show congruency effects in RTs and N400s



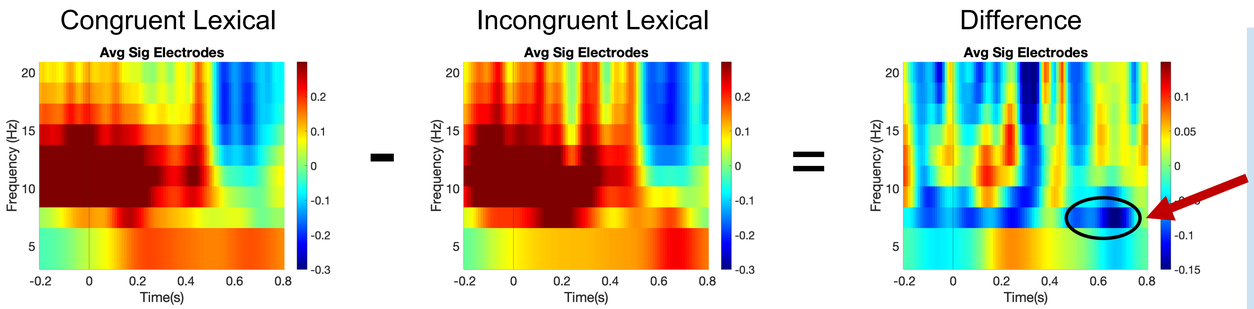




Time-frequency analyses:

When all item pairs analyzed, no effects of congruency in gamma or theta (results not shown)

BUT…

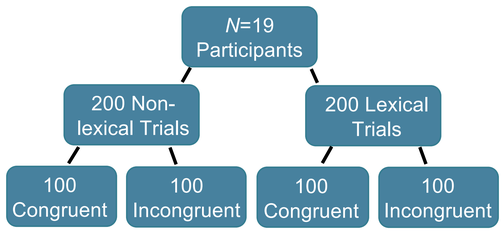


… in pairs that showed *behavioral* priming, there is a significant increase in theta for incongruent lexical trials. (Same pattern appears for non-lexical trials)

Plots show total oscillatory activity as %change relative to baseline (-750 to -250ms)

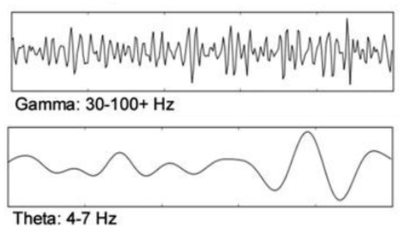
METHODS

Within-subjects design



- Stimuli = 100 images, matched with 100 non-lexical and 100 lexical sounds.
- Each stimulus appeared in a congruent and incongruent trial, but never in the same block (4 blocks of 100 trials, order counterbalanced across subjects).
- 17% of stimuli referred to animals, 83% referred to objects.

- Data collected with 256-channel EEG (EGI) cap at 500 Hz
- Preprocessing and analysis in Fieldtrip
- Average reference and FASTER channel repair and ICA functions (Nolan et al., 2010)
- Gamma analyzed with multitapers with windows of 200ms
- Theta analyzed with Morlet wavelets with a fixed width of 3 cycles



DISCUSSION & CONCLUSIONS

Does gamma have a role in multimodal integration?

- Although prior literature links gamma to integration (e.g., Schneider et al., 2008; Yuval-Greenberg & Deouell, 2007), our study differed by controlling for things like response congruency between stimuli in incongruent conditions, which may contribute to our failure to observe increased gamma for congruent conditions.

Does theta have a role in multimodal integration?

- We found no evidence that increased theta supports integration. However, when restricting analysis to only pairs which showed a behavioral priming effect, we found an increase in theta power for *incongruent* lexical trials compared to congruent.
- Theta increases have been suggested to contribute to the negative deflection in the N400 effect (Hald et al., 2006), so our findings could be due to theta power related to the N400 in the incongruent condition.

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