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FOR PSYCHOLINGUISTICS

Using rapid invisible frequency tagging to study multimodal language processing in the brain

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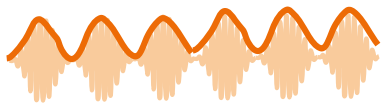
In face-to-face communication, language is multimodal

How do these auditory and visual signals interact in the brain, and how do we distribute our attention to these different signals?

Rapid Invisible Frequency Tagging (RIFT)

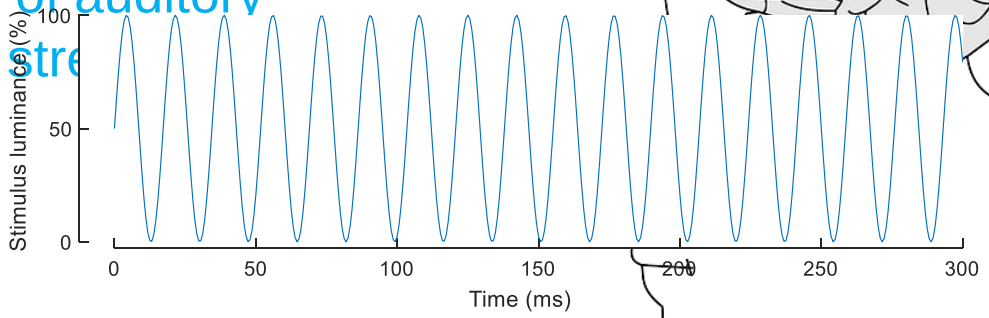


Auditory: amplitude modulation (61 Hz)

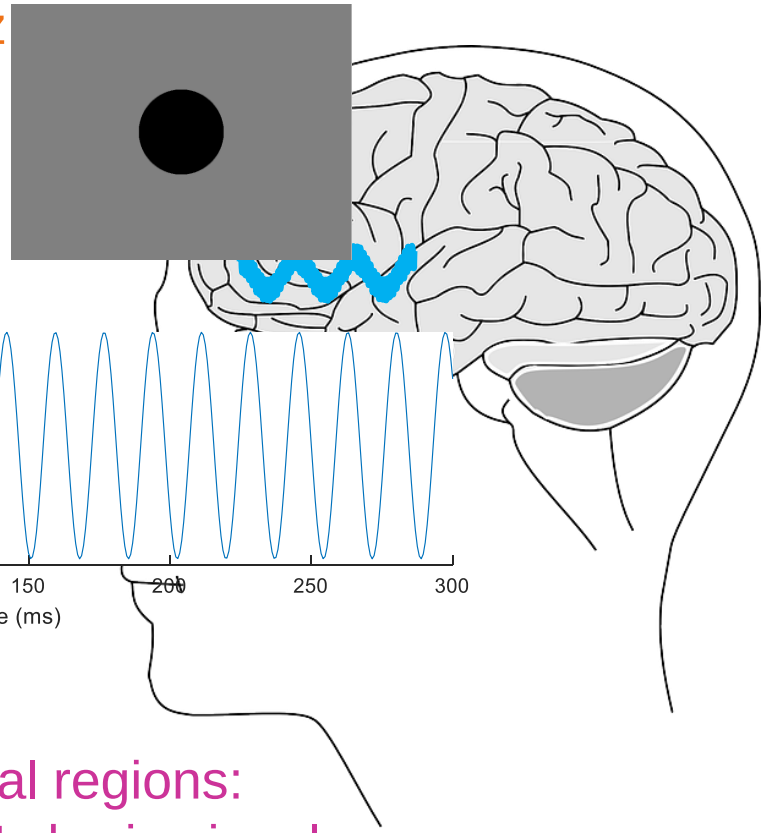
Visual: luminance modulation (68 Hz)

1440 Hz

Interaction of auditory and visual stre



Auditory regions:
61 Hz



Visual regions:
68 Hz brain signal

Seijdel, Marshall, Drijvers, 2022
Drijvers, Jensen & Spaak, 2021

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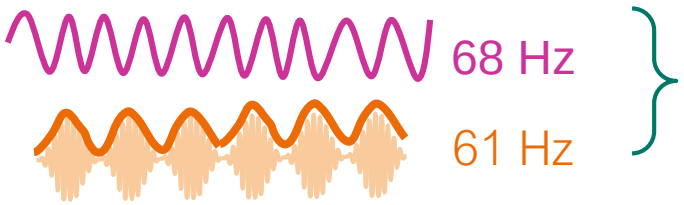
Rapid Invisible Frequency Tagging (RIFT)



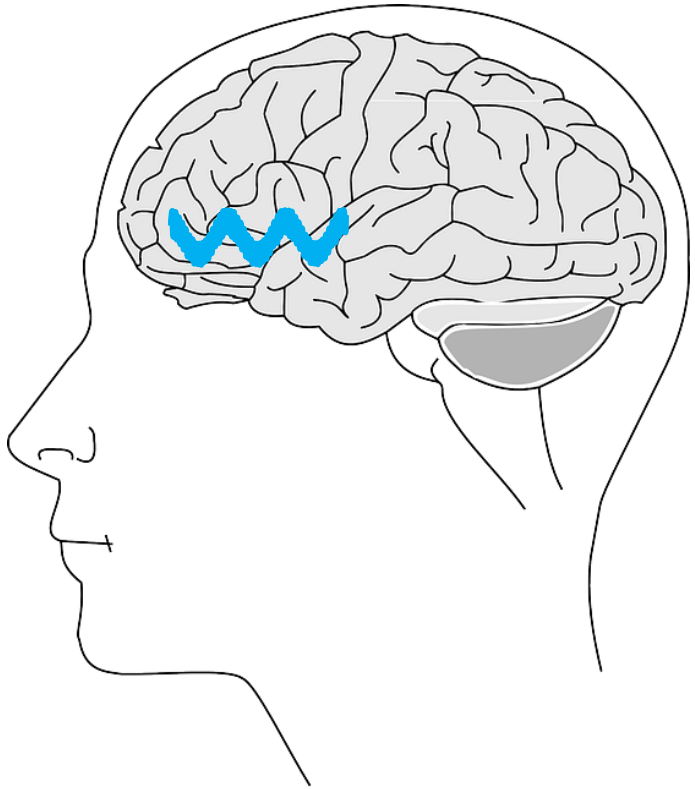
68 Hz

61 Hz

Intermodulation frequency

7 Hz

129 Hz



Seijdel, Marshall, Drijvers, 2022

Drijvers, Jensen & Spaak, 2021

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RIFT: advantages

1. RIFT leaves low-frequency oscillations unperturbed, and thus open for investigation.

2. The tagging is invisible (>60 Hz), resulting in more naturalistic paradigms, and a lack of participant awareness.

   → RIFT could be used as a means to investigate sensory processing without interfering with it, i.e., to “wiretap” perceptual processing.

Seijdel, Marshall, Drijvers, 2022

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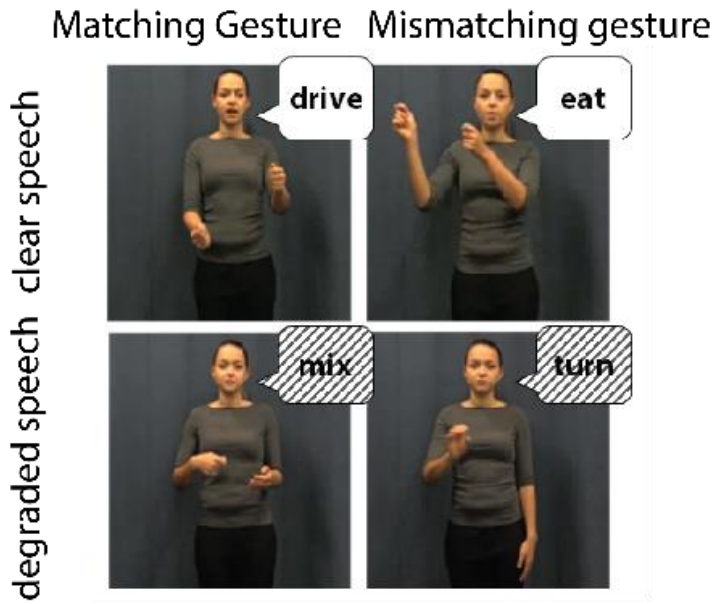
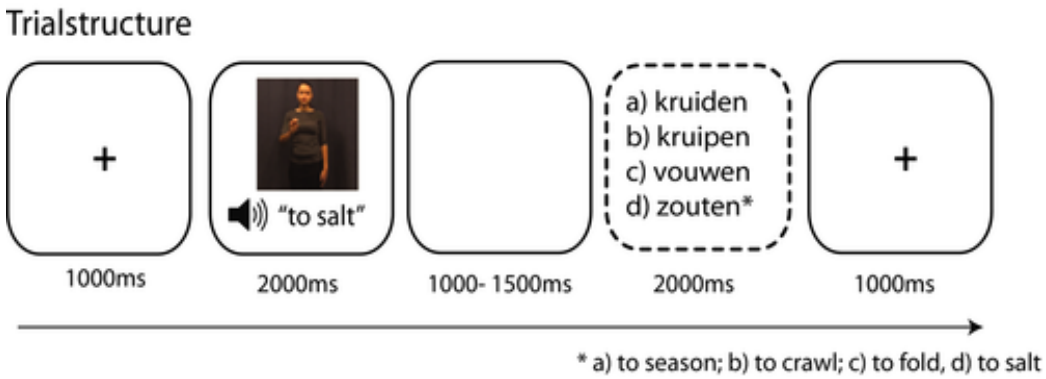
RIFT: a proof of principle

speech - 61 Hz (amplitude modulation)
gesture - 68 Hz (luminance)

MEG - 26 participants
Cued-recall task





Drijvers, Jensen & Spaak, 2021

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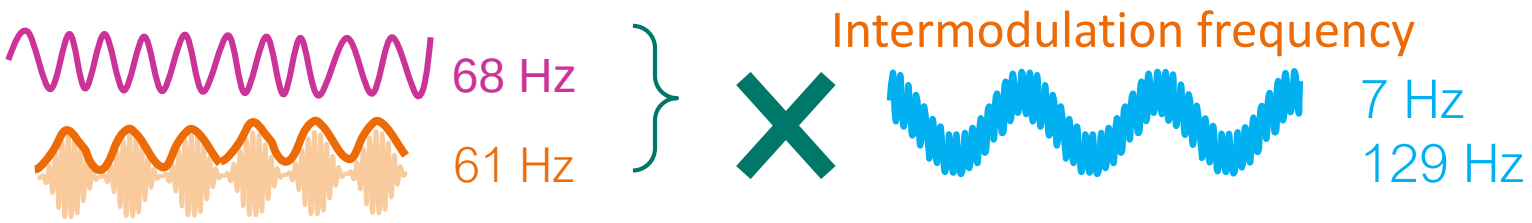
RIFT: a proof of principle

- Visual tagging of gesture (68 Hz) → coherence strongest at 68 Hz in occipital regions
- Auditory tagging of speech (61 Hz) → coherence strongest at 61 Hz in auditory regions

- Interactions between visually tagged and auditory stimuli → at 7 Hz/129 Hz, LIFG and pSTS/MTG (known to be involved in speech-gesture integration)



Drijvers, Ozyurek, Jensen, 2018

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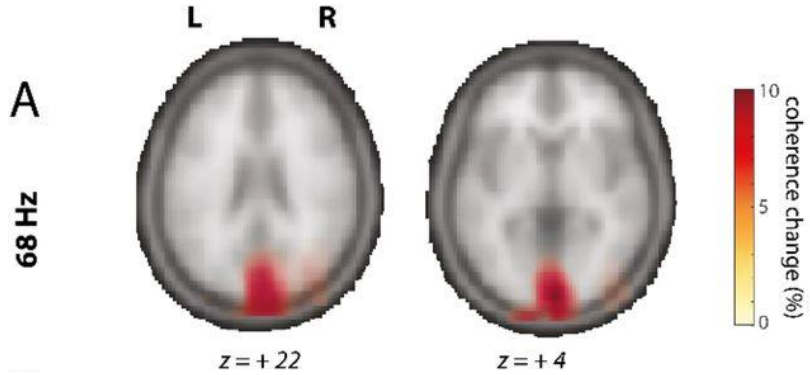
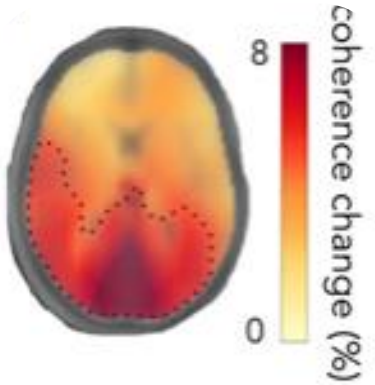
Coherence strongest at occipital regions for the visually tagged signal (68 Hz)





Drijvers, Jensen & Spaak, 2021

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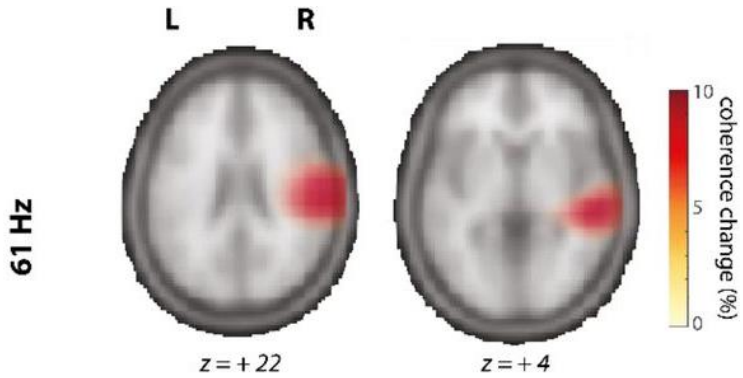
Coherence strongest at right-temporal regions for auditory tagged signal (61 Hz)



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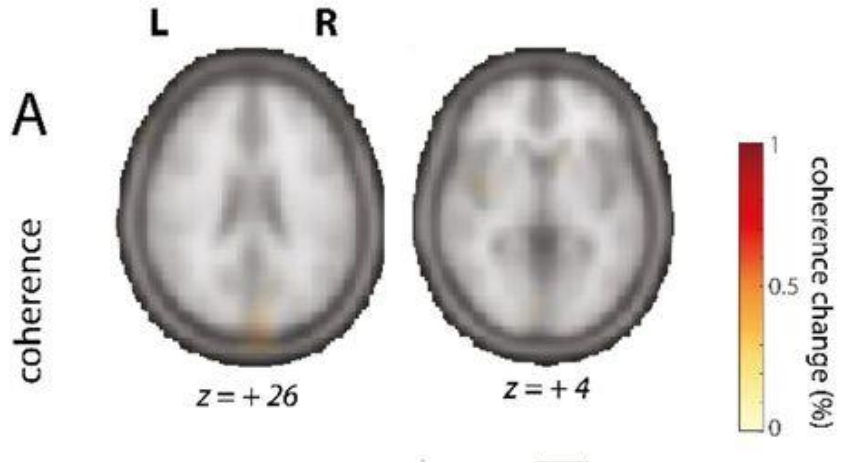
Sources of intermodulation frequency at 7 Hz (LIFG / pSTS/MTG)



Drijvers, Jensen & Spaak, 2021

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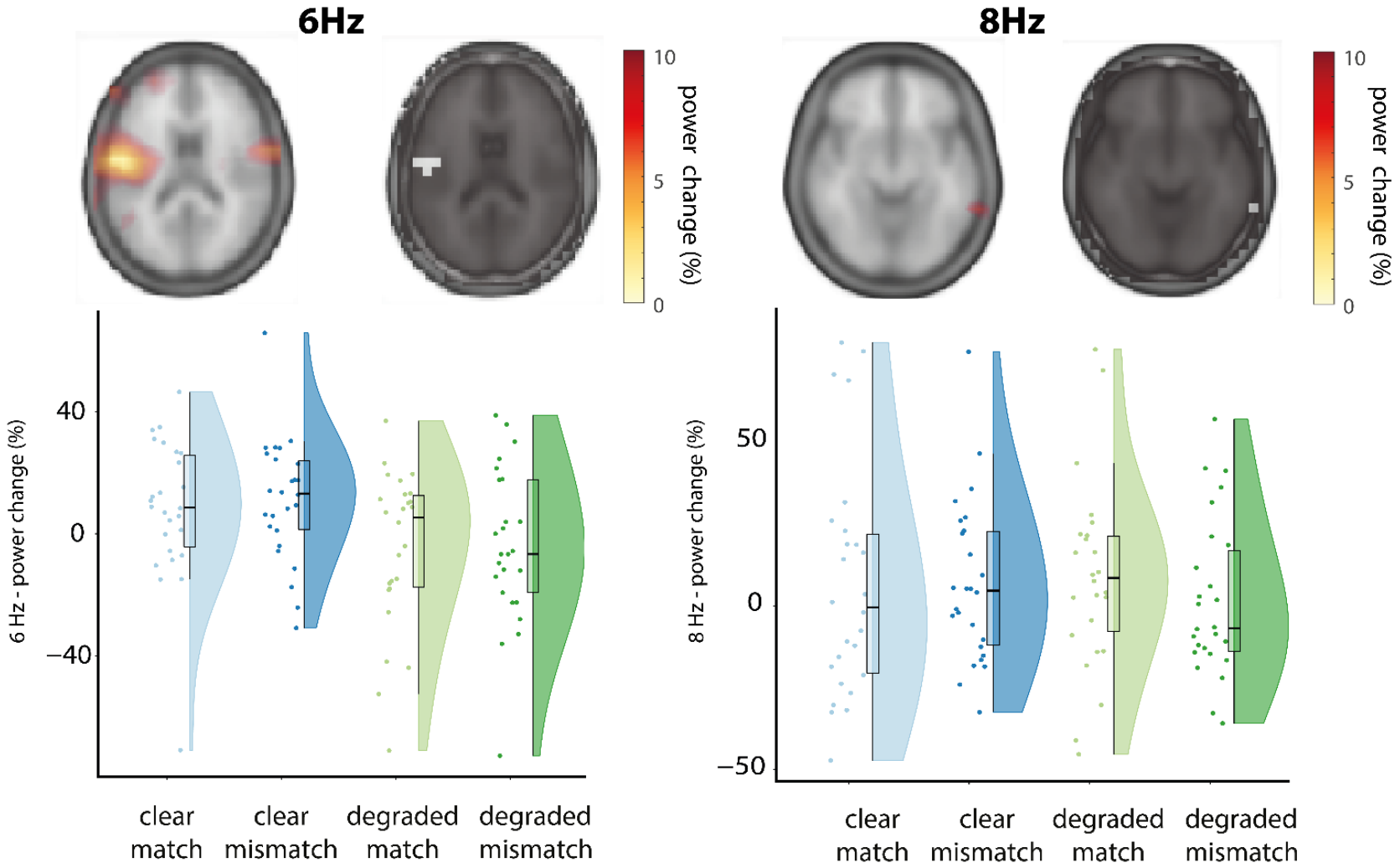
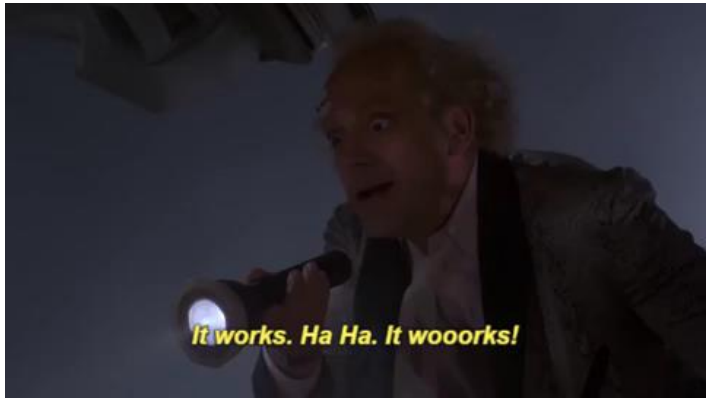
Intermodulation frequency cannot be observed at 6/8 Hz



Interim results

- ✓ Clear speech enhances visual attention to gestural information
- ✓ Degraded speech enhances auditory attention to speech information
- ✓ The auditory tagged speech signal and visually tagged gesture signal interact in left-frontotemporal regions
- ✓ Enhanced power at the intermodulation frequency reflects the ease of lower-order audiovisual interaction



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And now what?

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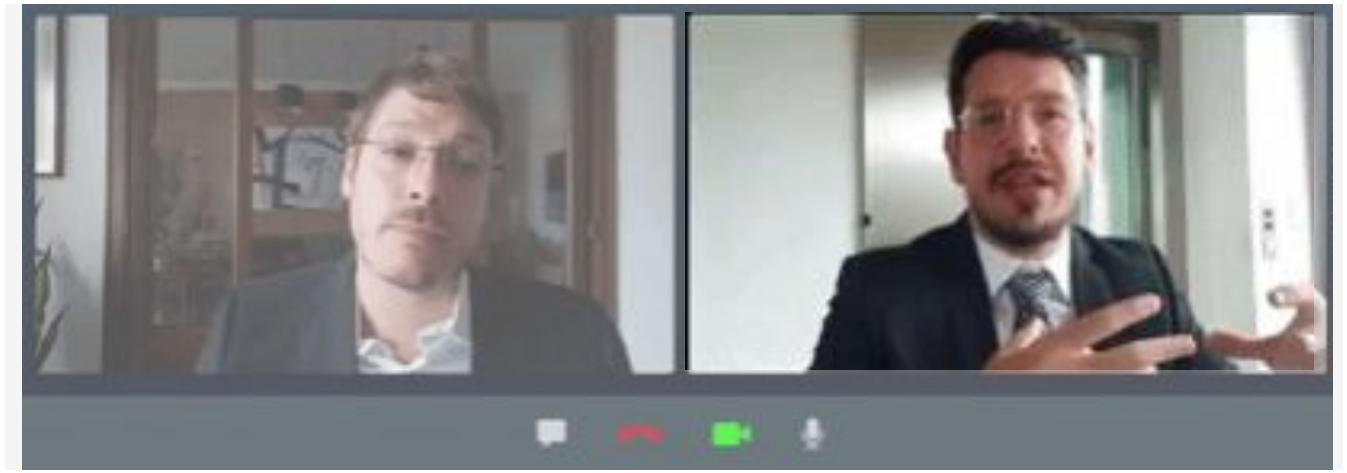
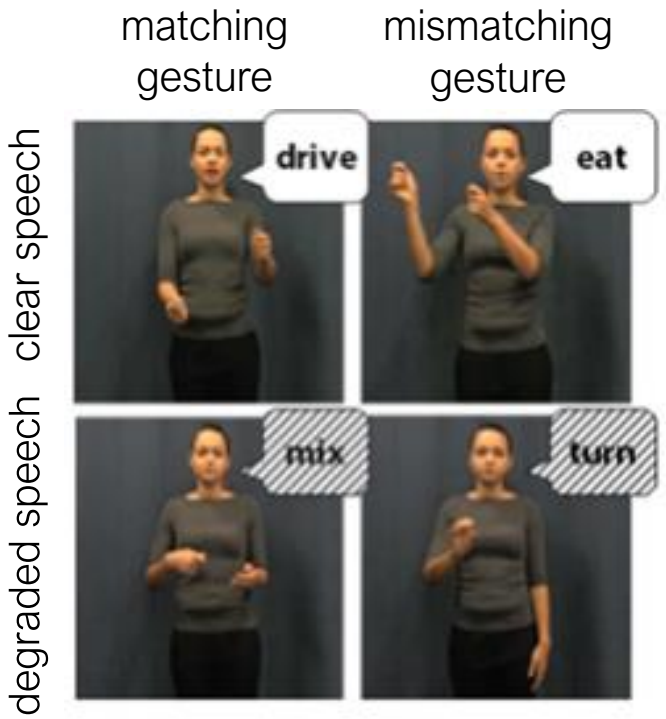
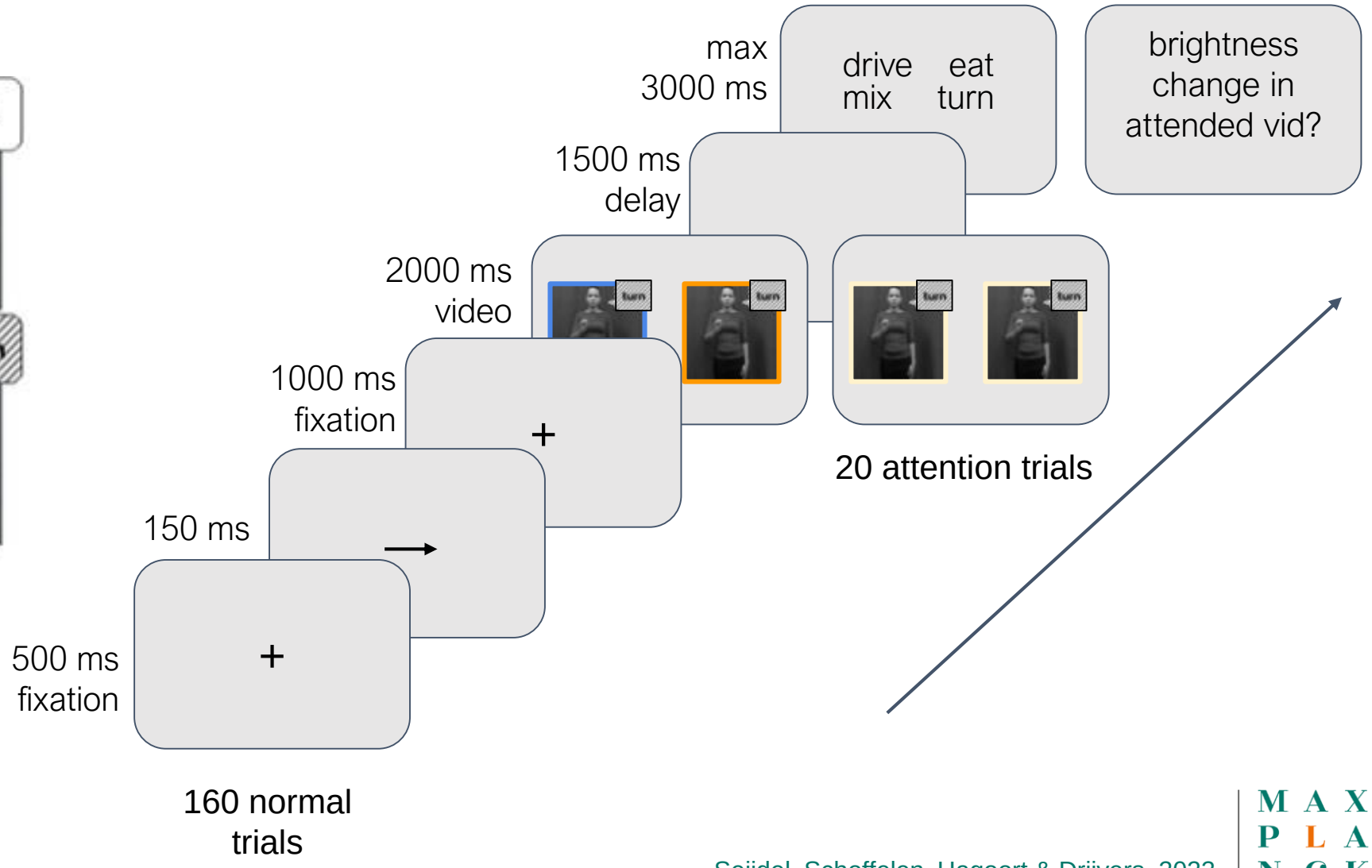
Attention and audiovisual integration during communication



Attention and audiovisual integration during communication



MEG - 40 participants
Cued-recall task



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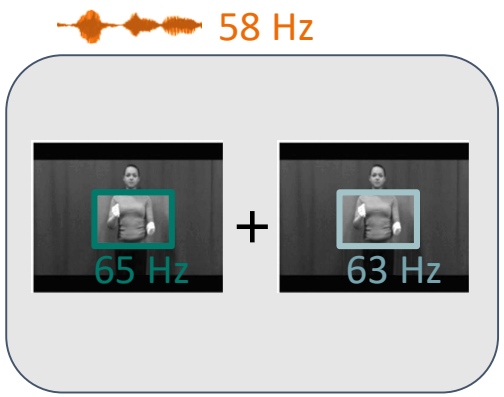
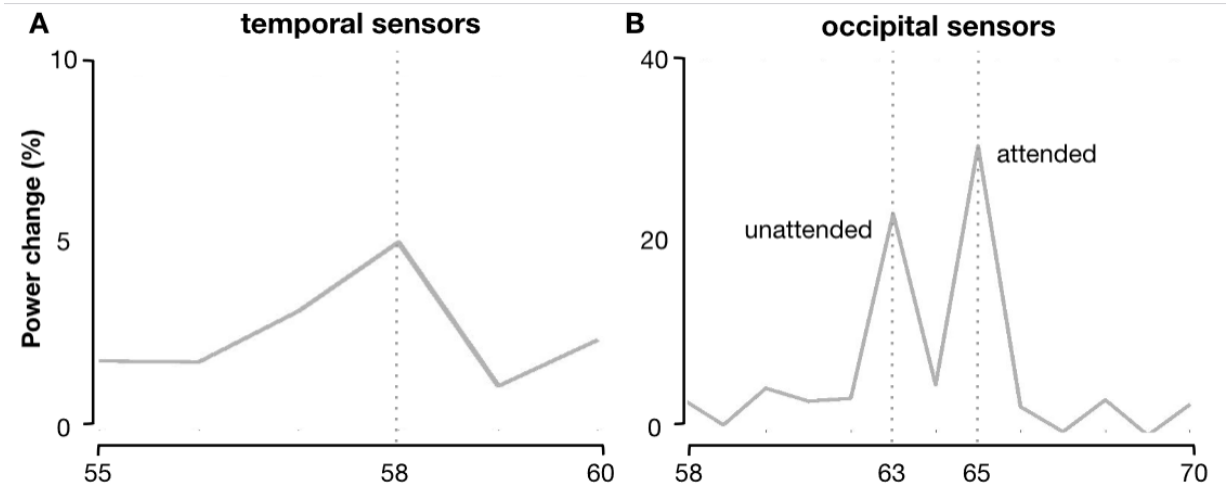

58 Hz
65 Hz
+
63 Hz

Modulated by attention



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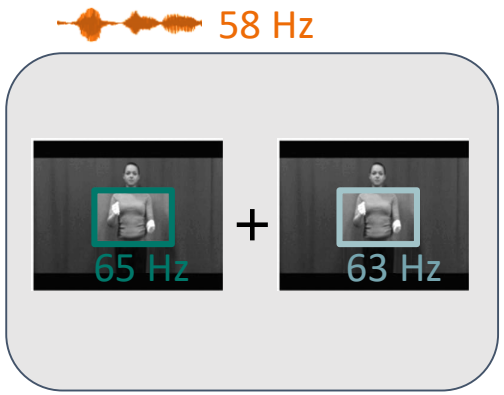
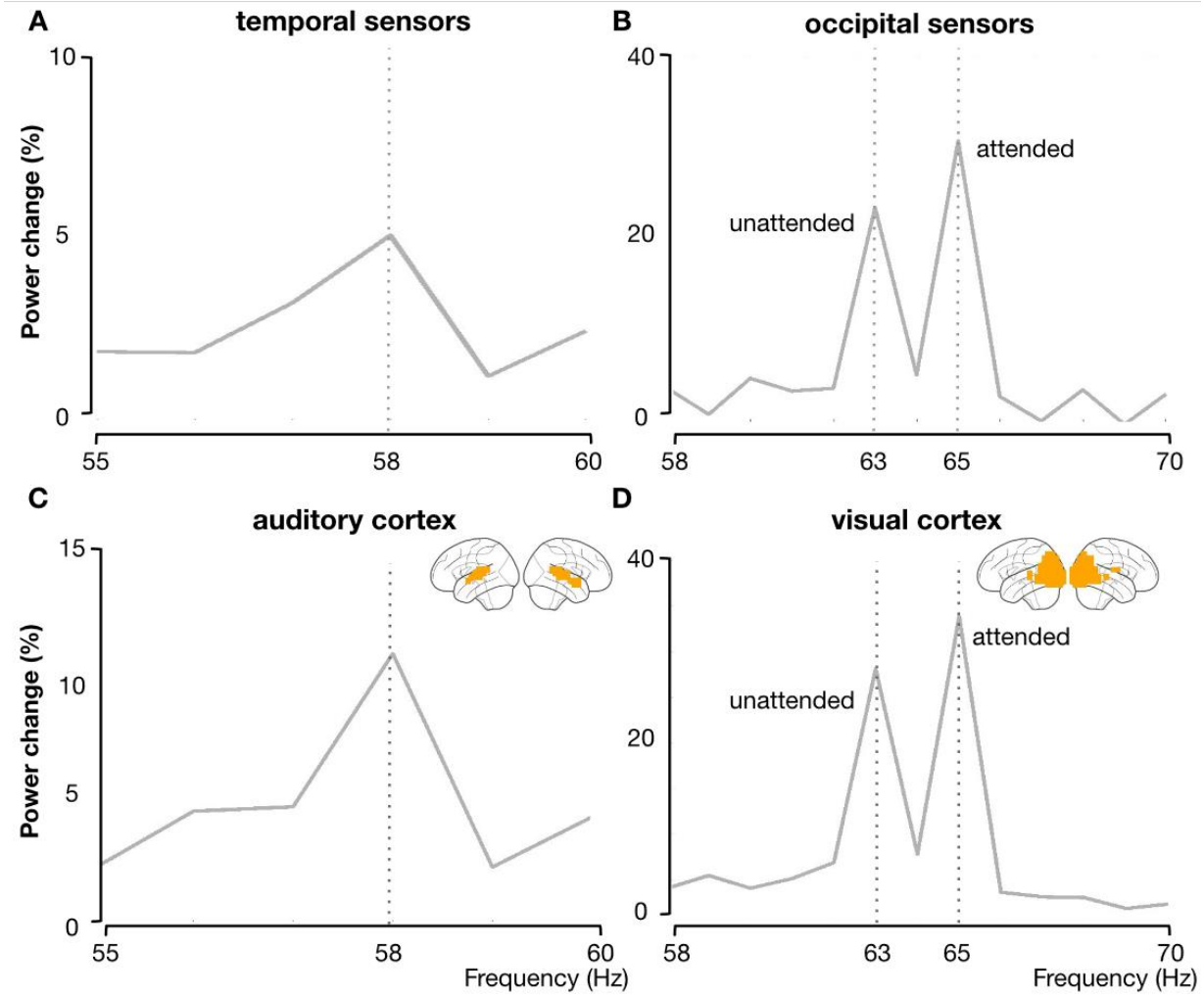
Modulated by attention





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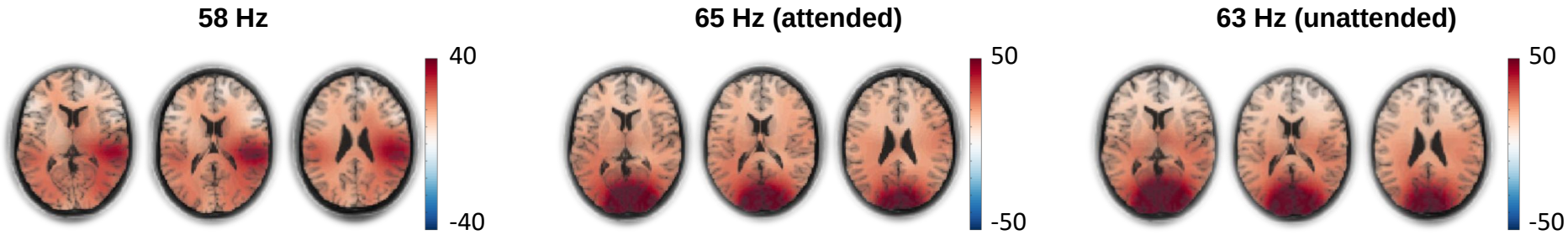
Neural sources of the tagging signals



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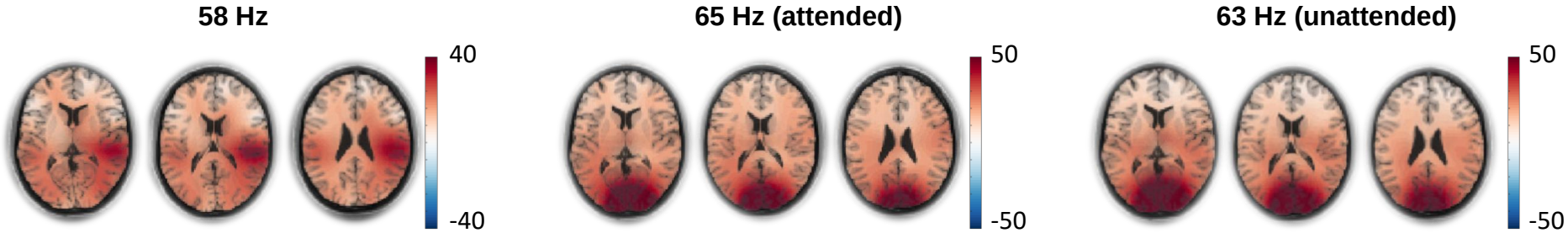
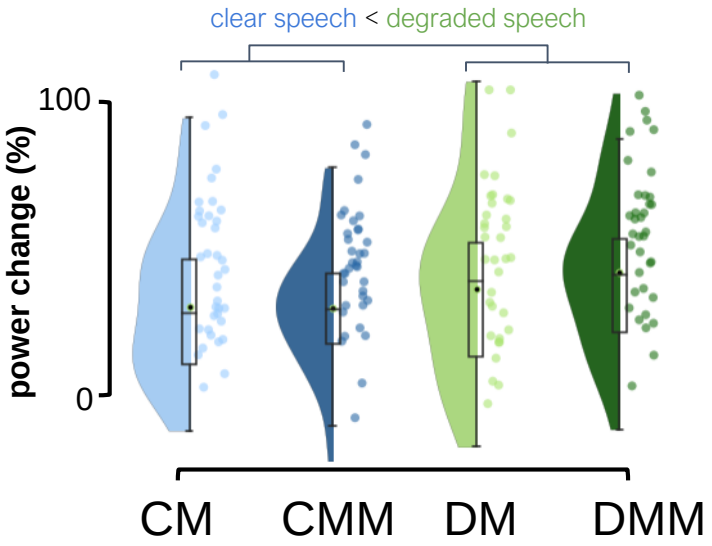
Neural sources of the tagging signals





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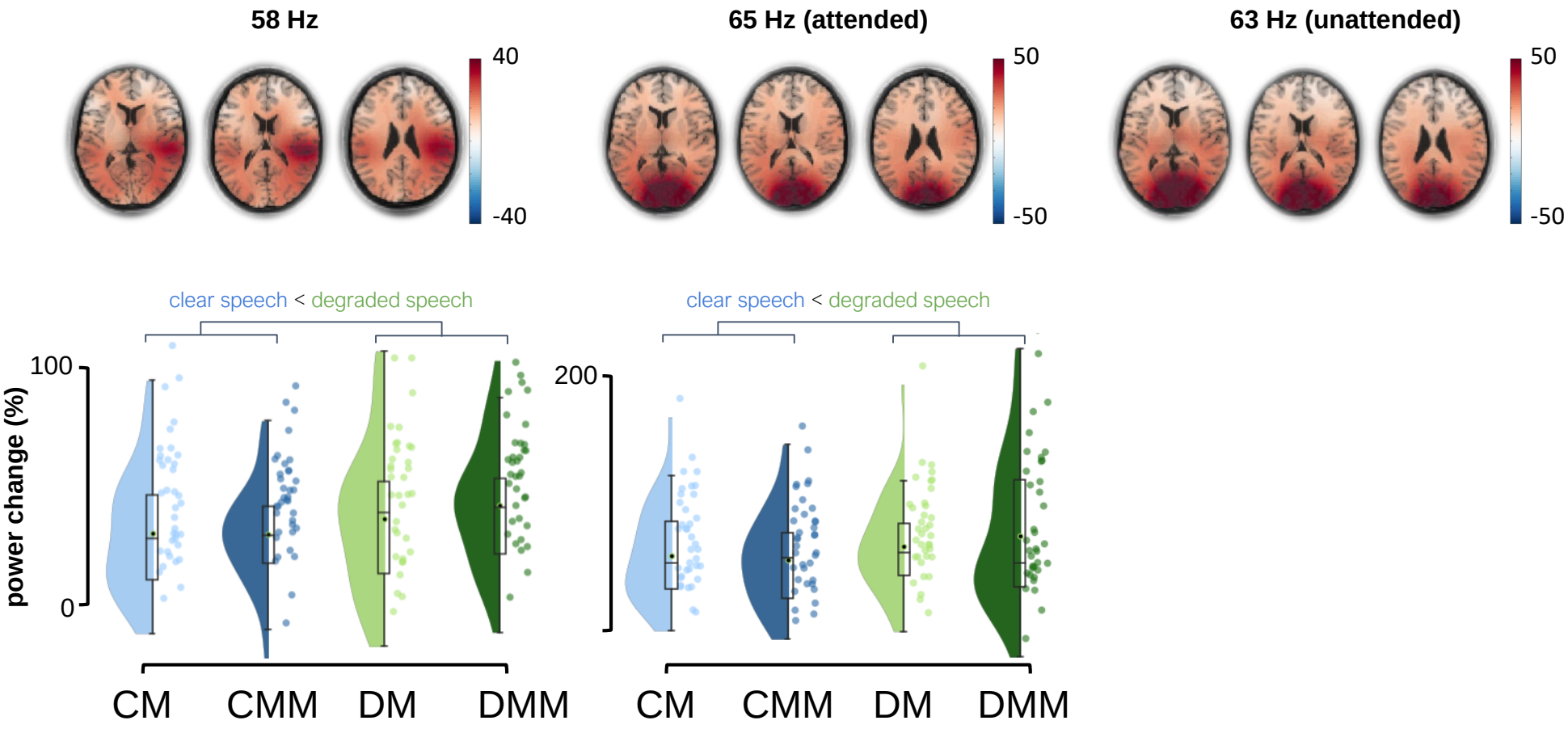
Neural sources of the tagging signals



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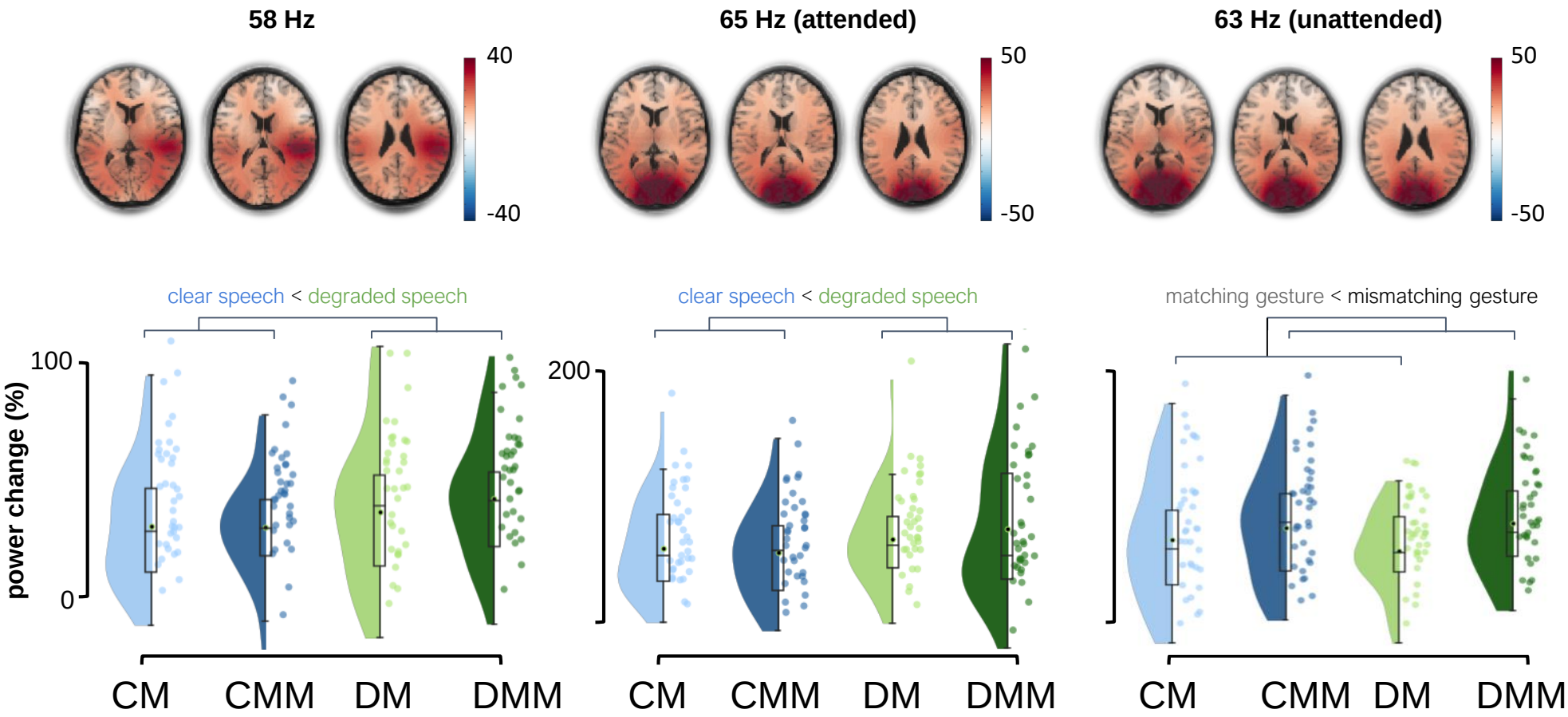
Neural sources of the tagging signals



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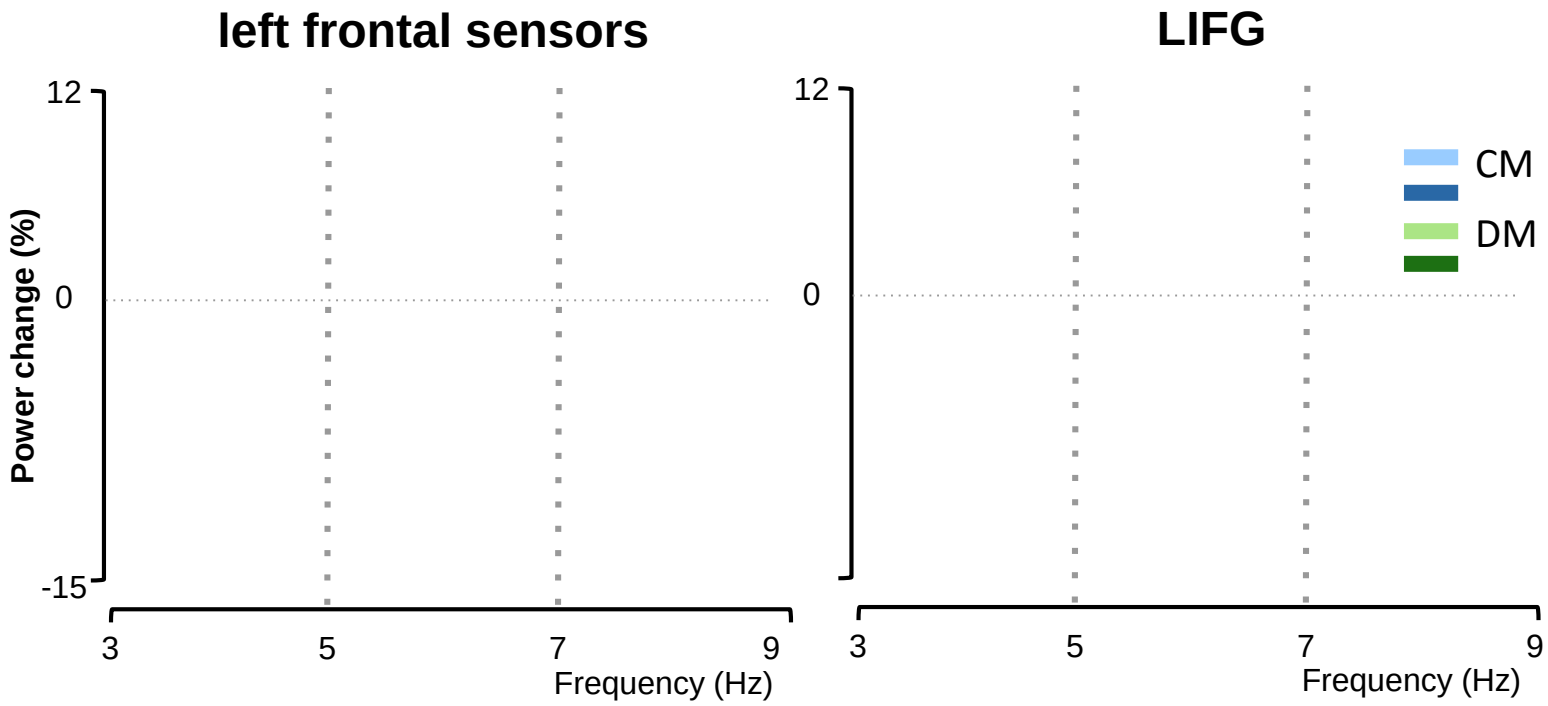
Interim results

- ✓ Degraded speech enhances auditory attention to speech information
- ✓ Degraded speech enhances visual attention to cued gestural information
- ✓ Mismatching gestures enhances visual attention to non-cued gestural information
  - ✓ Due to overall disengagement? (to be tested)

Intermodulation frequencies



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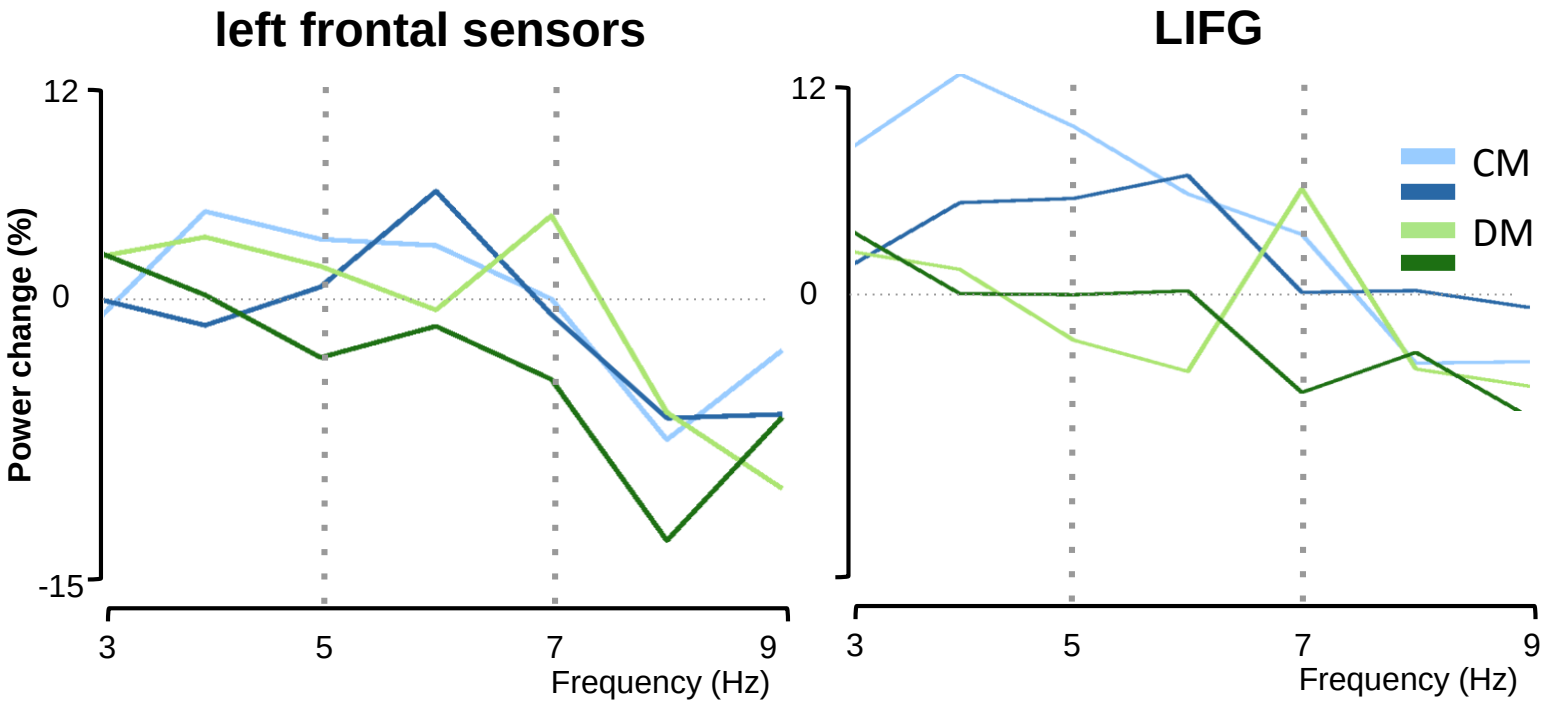
Intermodulation frequencies



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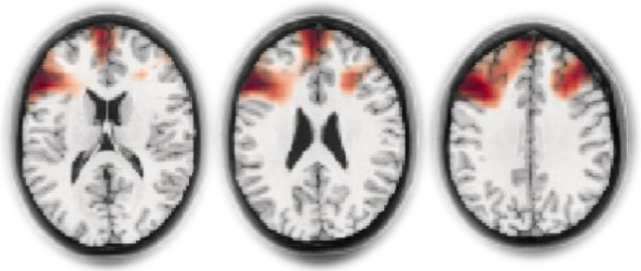
Neural sources intermodulation frequencies

7 Hz (attended)



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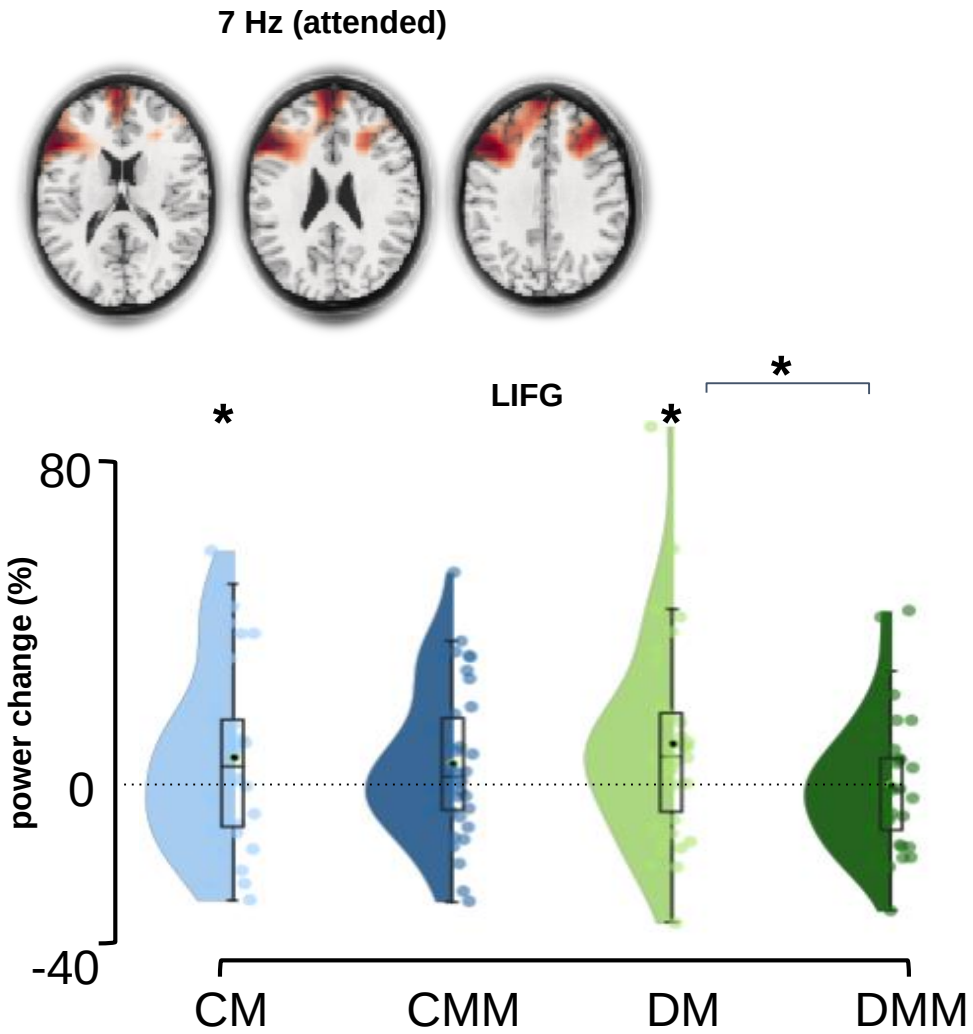
Neural sources intermodulation frequencies



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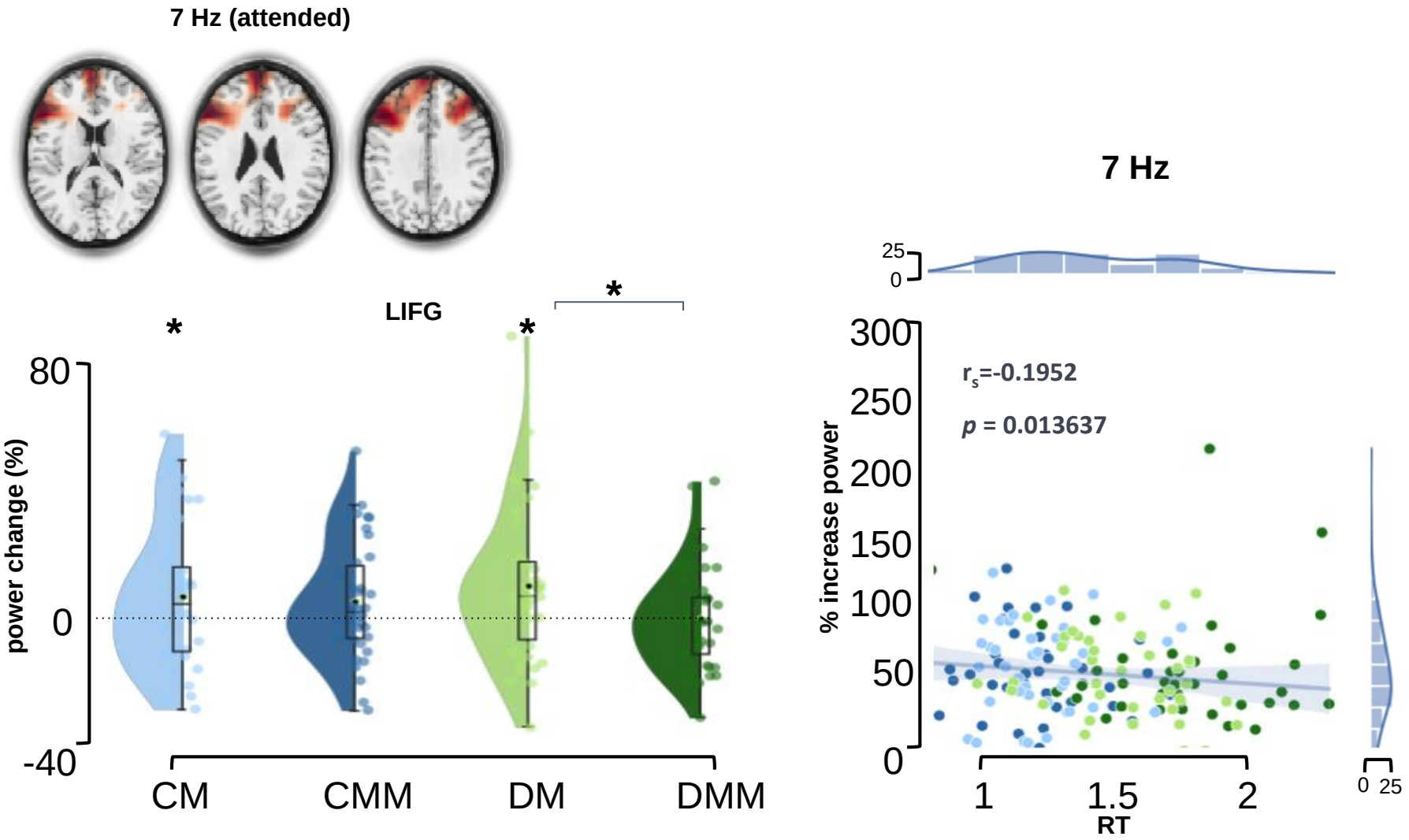
Speed of integration



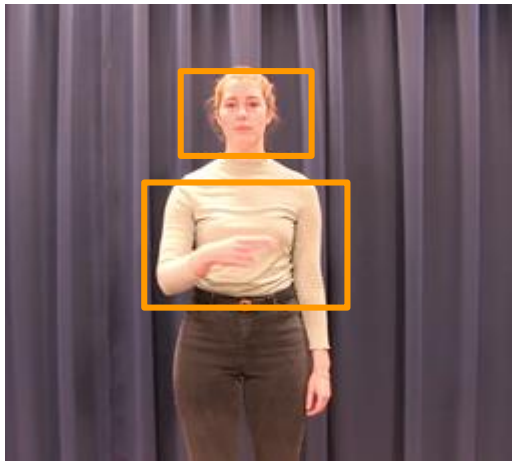
Interim results

- ✓ The auditory tagged speech signal and attended gestural information interact in frontotemporal and frontal regions
- ✓ Focusing on LIFG, this enhancement was specific for the attended information, for those trials that benefitted from integration
- ✓ Higher power at this intermodulation frequency was related to faster reaction times

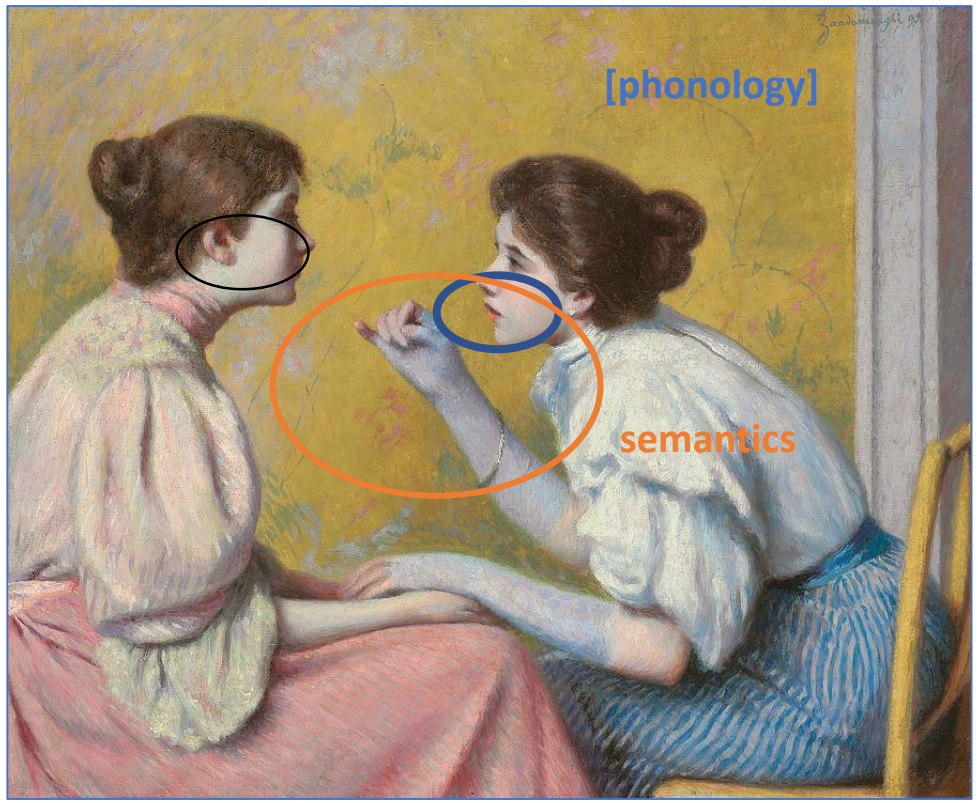
Summary & next steps

- Rapid Invisible Frequency Tagging as a means to investigate sensory processing without interfering with it, i.e. to “wiretap” perceptual processing

- How do we integrate information from multiple sources? How do we decide *what* is relevant *when?*

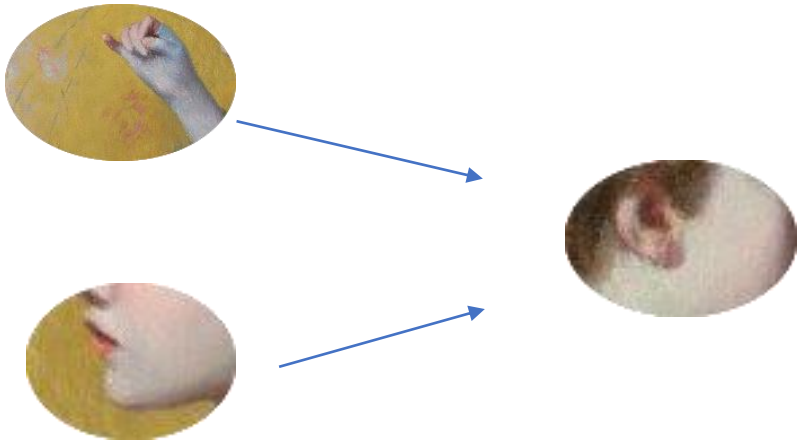


Is the strength of the intermodulation frequency dependent on the informativeness of visual signals?



Interesting conversation
(Federigo Zandomeneghi, 1895)

Is attention allocation and signal **integration**



1) altered by informativeness of gestures and visual speech?
2) is this dependent on semantic and phonological fluency scores of the participant?

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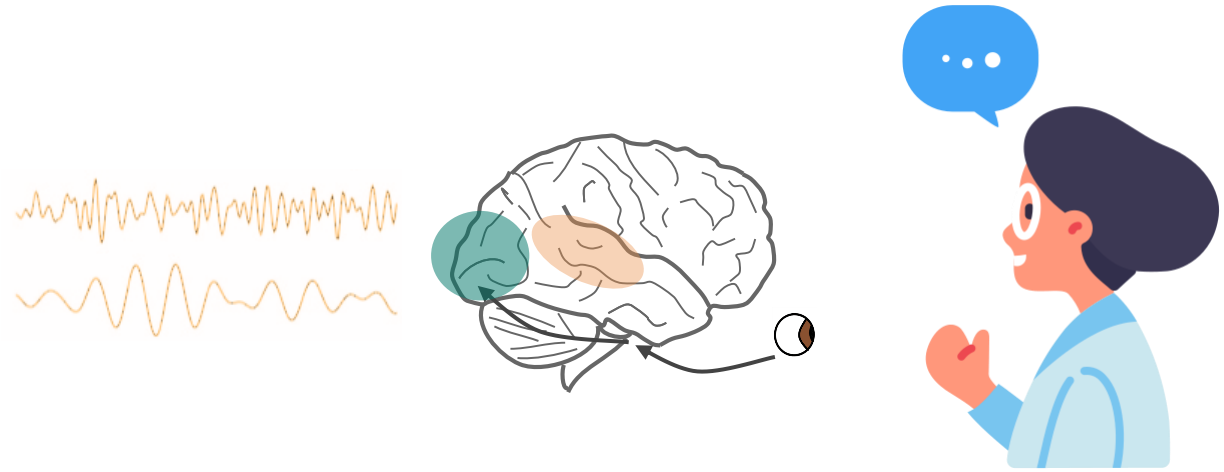
What is the role of low-frequency oscillations in sensory processing and audiovisual (speech-gesture) integration?

RIFT leaves low-frequency oscillations unperturbed and open for investigation



Multimodal communication within brains

within one brain

How do we integrate information from multiple conversational partners? How do we decide *what* is relevant *when?*

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Multimodal communication within brains

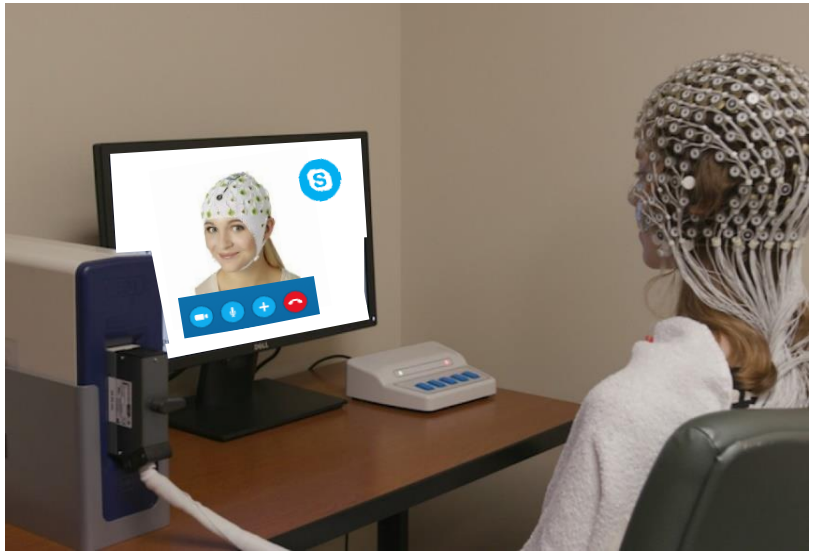
within one brain

How do we integrate information from multiple conversational partners? How do we decide *what* is relevant *when?*

within one brain

Attention allocation to speech comprehension and planning?

Multimodal communication between brains



between brains

Is integration easier
when we are more in sync?

dual-EEG + dual-RIFT

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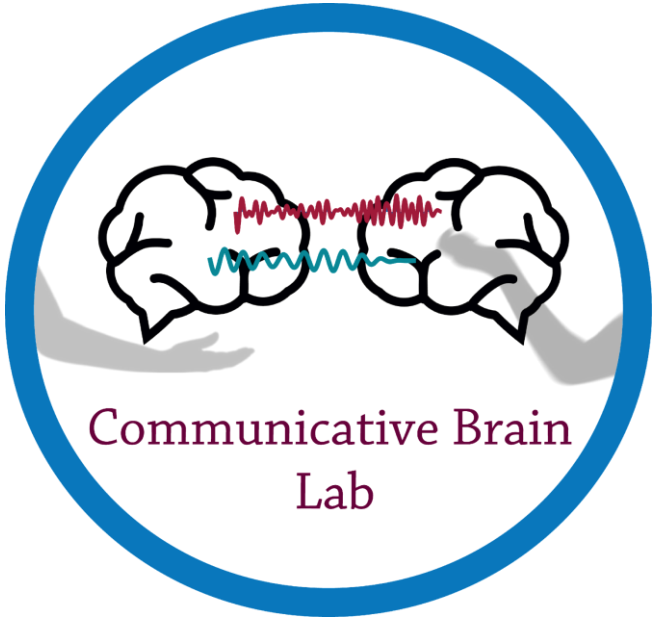
Thank you for your attention!

- Rapid Invisible Frequency Tagging as a means to investigate sensory processing without interfering with it, i.e. to “wiretap” perceptual processing

- How do we integrate information from multiple sources? How do we decide *what* is relevant *when?*



- Informativeness of the sensory information?
- Individual differences?
- Role of lower frequency oscillations?
- Within and between brains?
- Towards more naturalistic paradigms

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