Neuromagnetic responses to gaps in tones: within-channel and between-channel conditions

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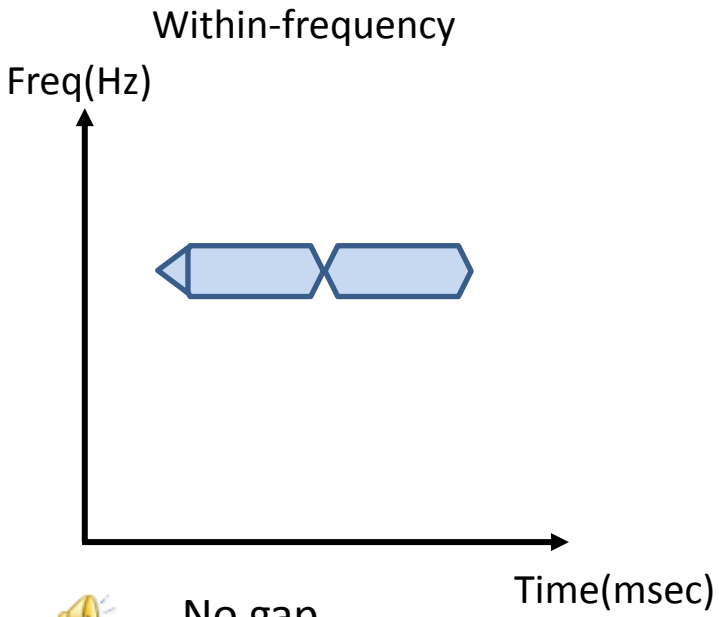
Gap detection

(Phillips, et al., 1997)

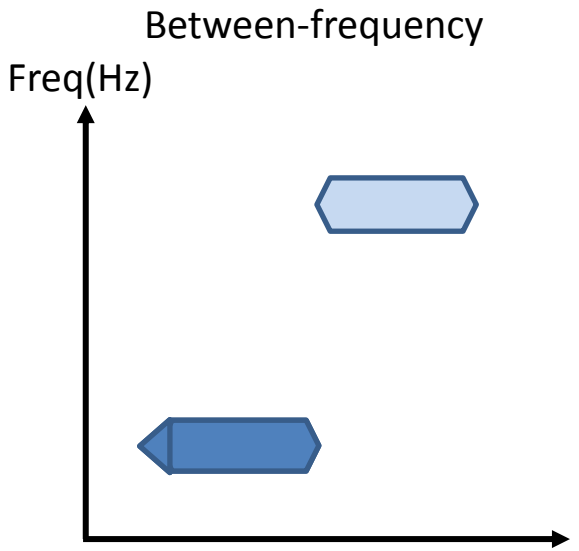
becomes dramatically difficult when the frequency of the sounds before or after the gap differs.



No gap

Gap 30

Gap 80

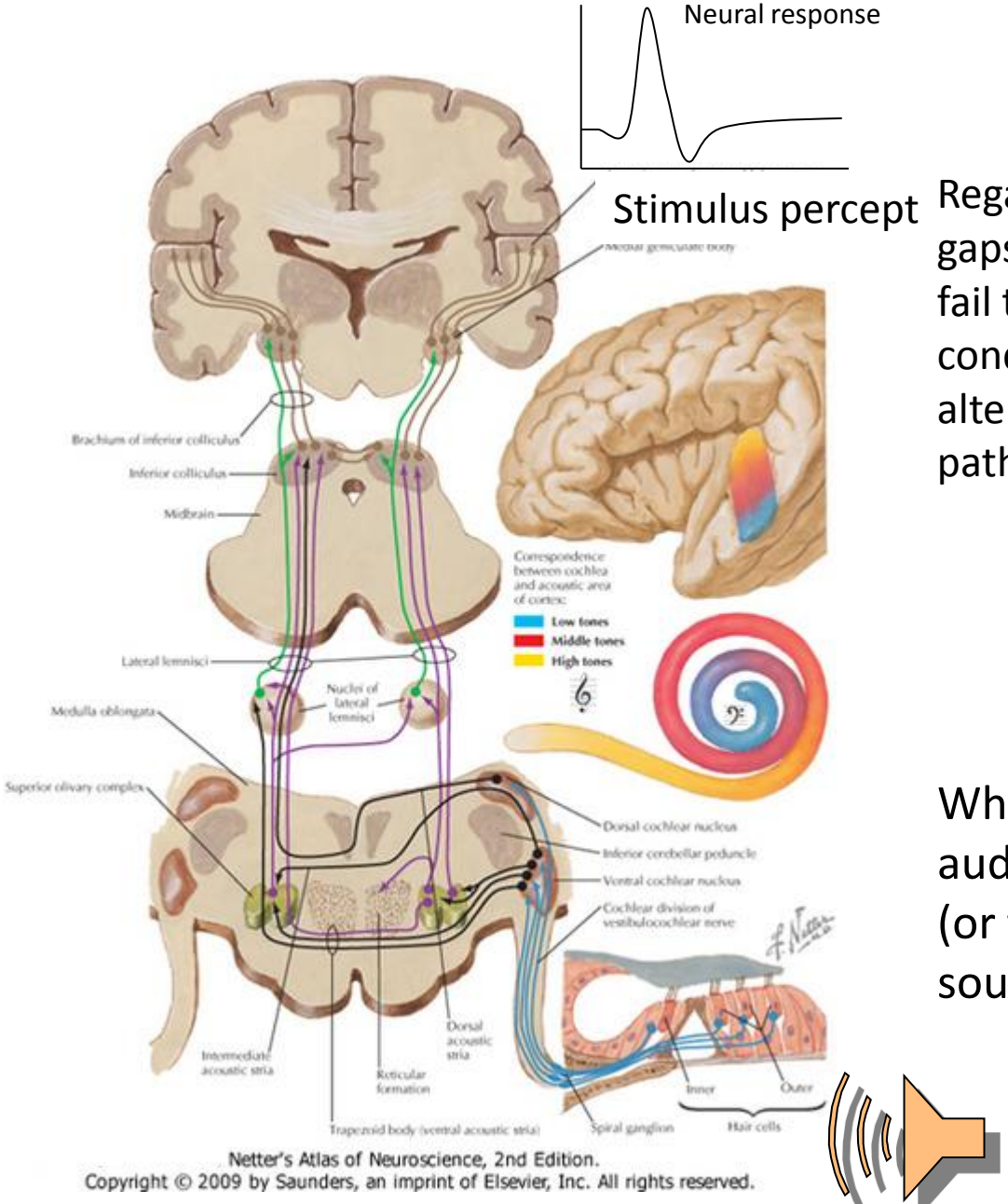


No gap

Gap 30

Gap 80

Why gap detection is so difficult when the frequency of the sounds before or after the gap differs?



Regardless of the existence of physical gaps during the sounds, we sometimes fail to perceive the gap at the certain condition. It means the information alters somewhere in the auditory pathway.

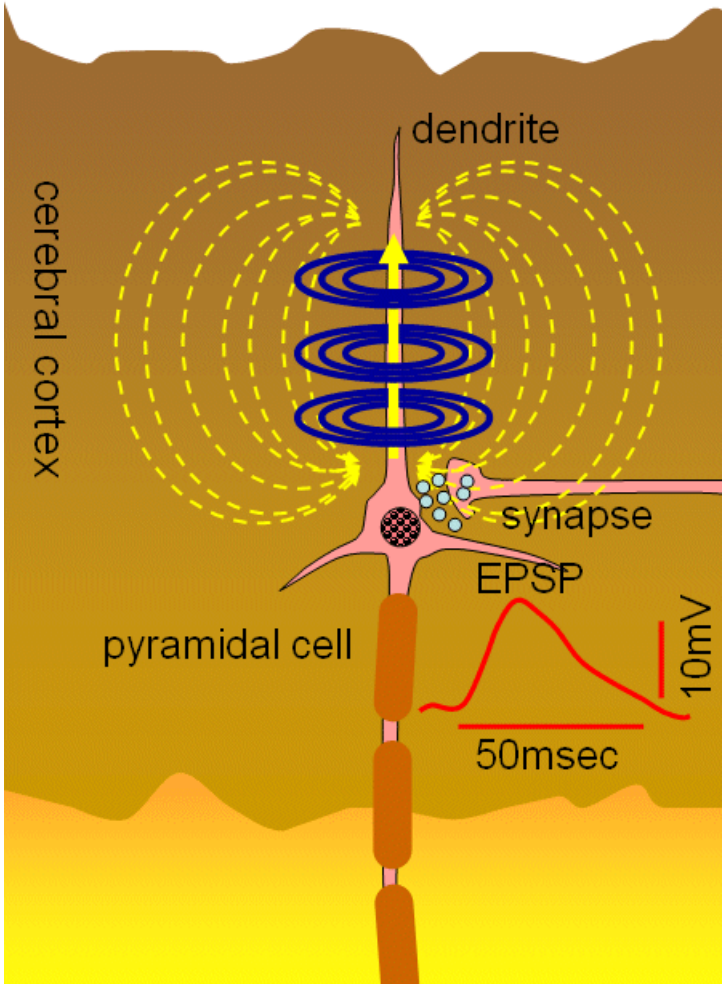
What is going on in the human auditory system when we perceive (or fail to perceive) the gaps in the sounds?

Stimulus input

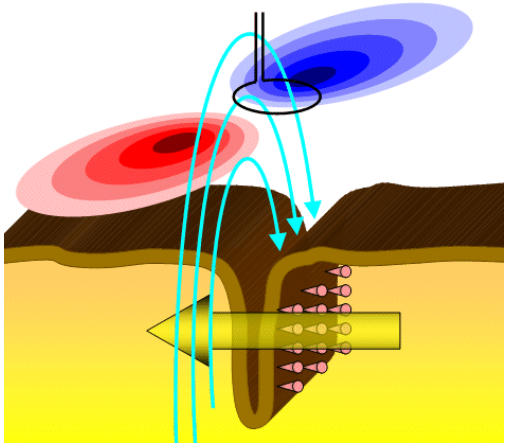
Research Aim

To investigate time-frequency profiles to the gaps in tones by using within-frequency and between-frequency stimulus patterns.

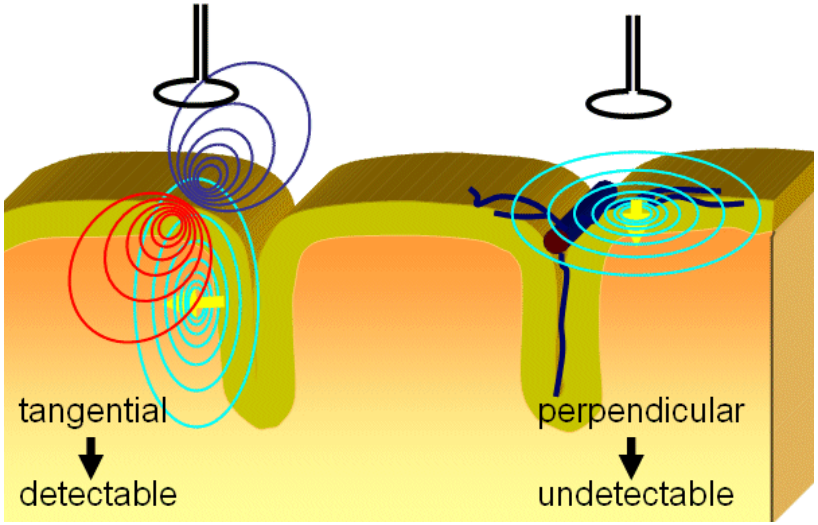
What MEG reveals



Excitatory PostSynaptic Potential (EPSP)
in the pyramidal cells



Measures the potentials of tangential direction toward the coils



Cannot detect the response at the brain gyrus

http://meg.aalip.jp/

Previous MEG researches

- Witton, et al. (2012) NeuroImage. 63(3), 1249–1256.

  "MEG stimulus was a continuous broadband, white Gaussian noise, lasting 348 s."

- Bernhard, et al. (2010) PLoS ONE. 5(4): e10101.

  "Stimuli were 1-kHz pure tones with the envelope shaped by Gaussian pips with standard deviation of 0.5."

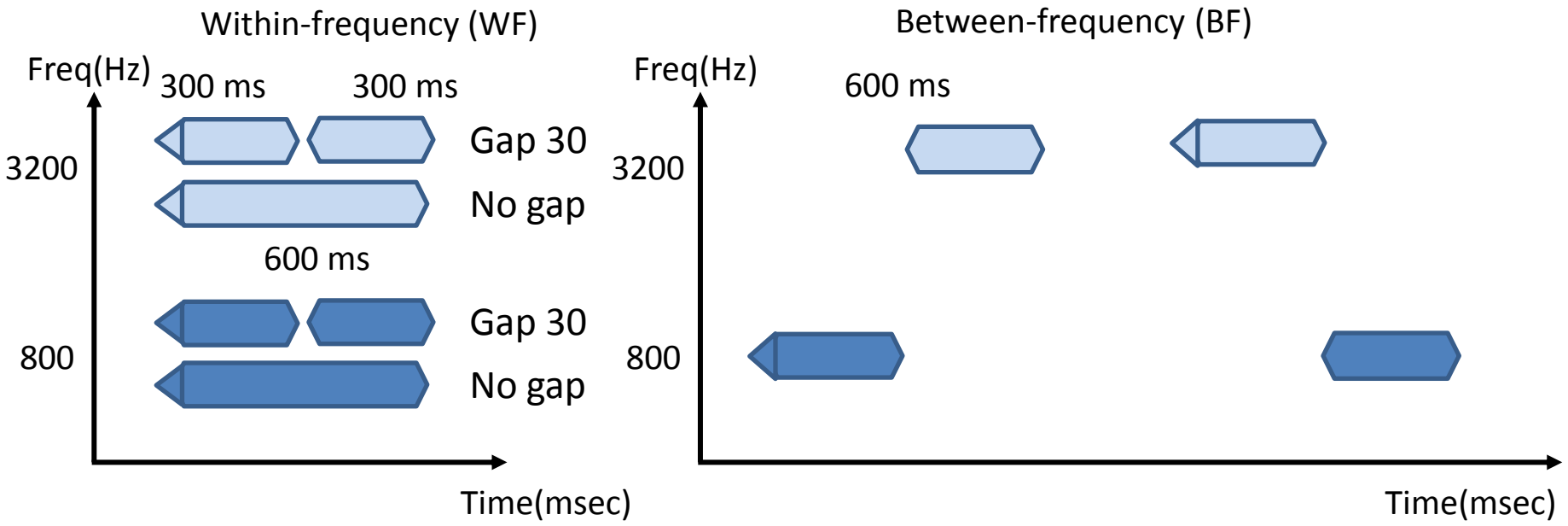
No study had examined about the gap detection processing with 'between frequency' stimuli.

magnetoencephalogram recording

- Participants
  - Four right handed healthy volunteers (age range 26-36 years, all female)
- Stimuli
    - Leading/trailing markers; 800 or 3200Hz pure tones, both are 300 msec (leading marker: rise time 20 ms/fall time 3 ms, trailing marker: rise/fall time 3 ms)
  - Frequency
    - Within frequency: 800-800 3200-3200, Between frequency ：800-3200, 3200-800
  - Gap
    - 30 ms (sub-threshold), 80 ms (supra-threshold), and no-gap
  - SOA 1500～1800 ms
- magnetoencephalogram recordings
  - Recording: 306-channel Neuromag
  - Sampling freq 1000 Hz
  - Digital Filtering 1-30 Hz

306-channel Neuromag Vectorview MEG (Elekta).

Stimulus patterns



Gap…30 ms(sub-threshold), 80 ms(supra-threshold)

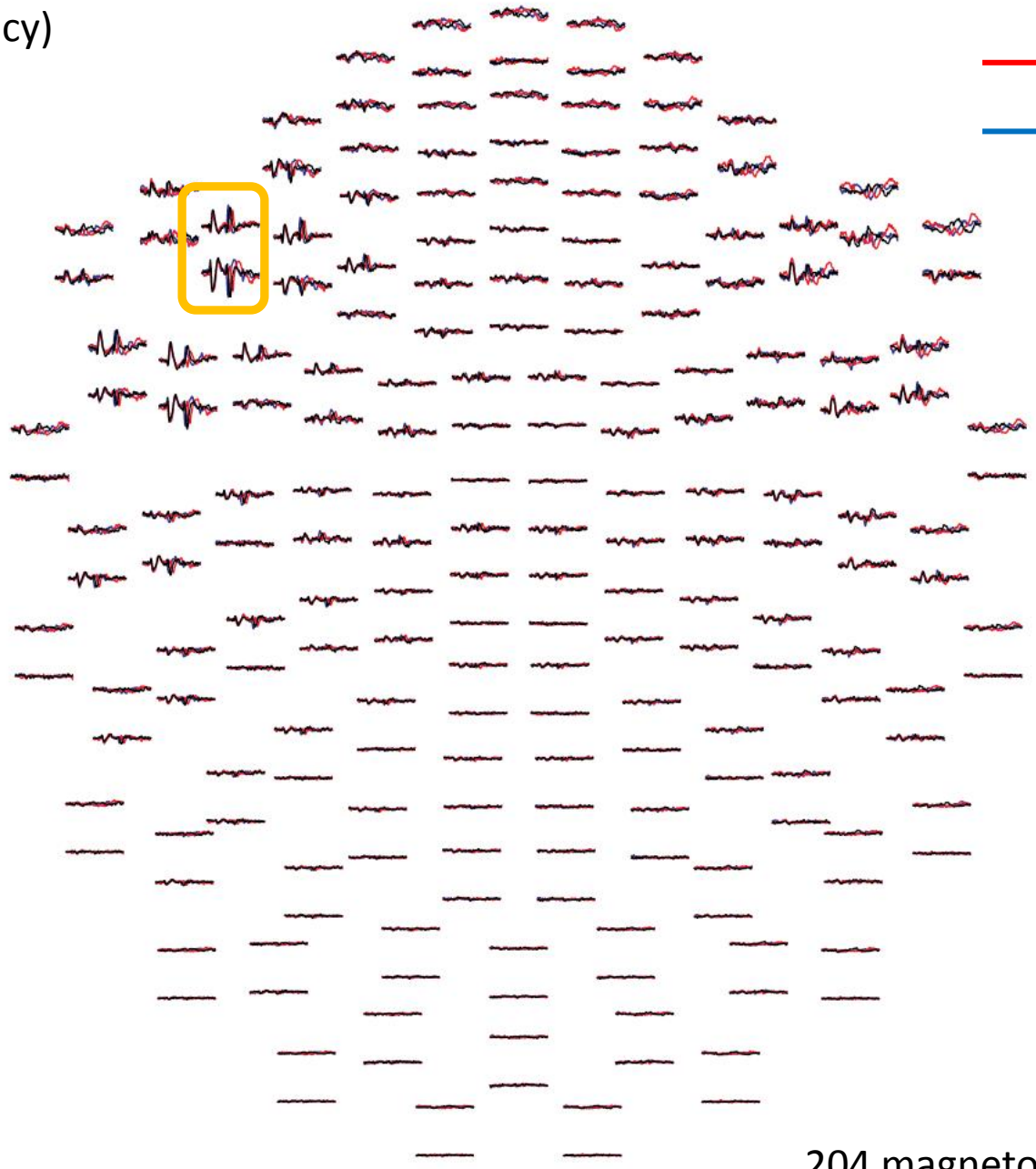
No gap…600 ms

Leading marker: 20 ms rise/ 3ms fall time

Trailing marker: 3 ms rise/fall time

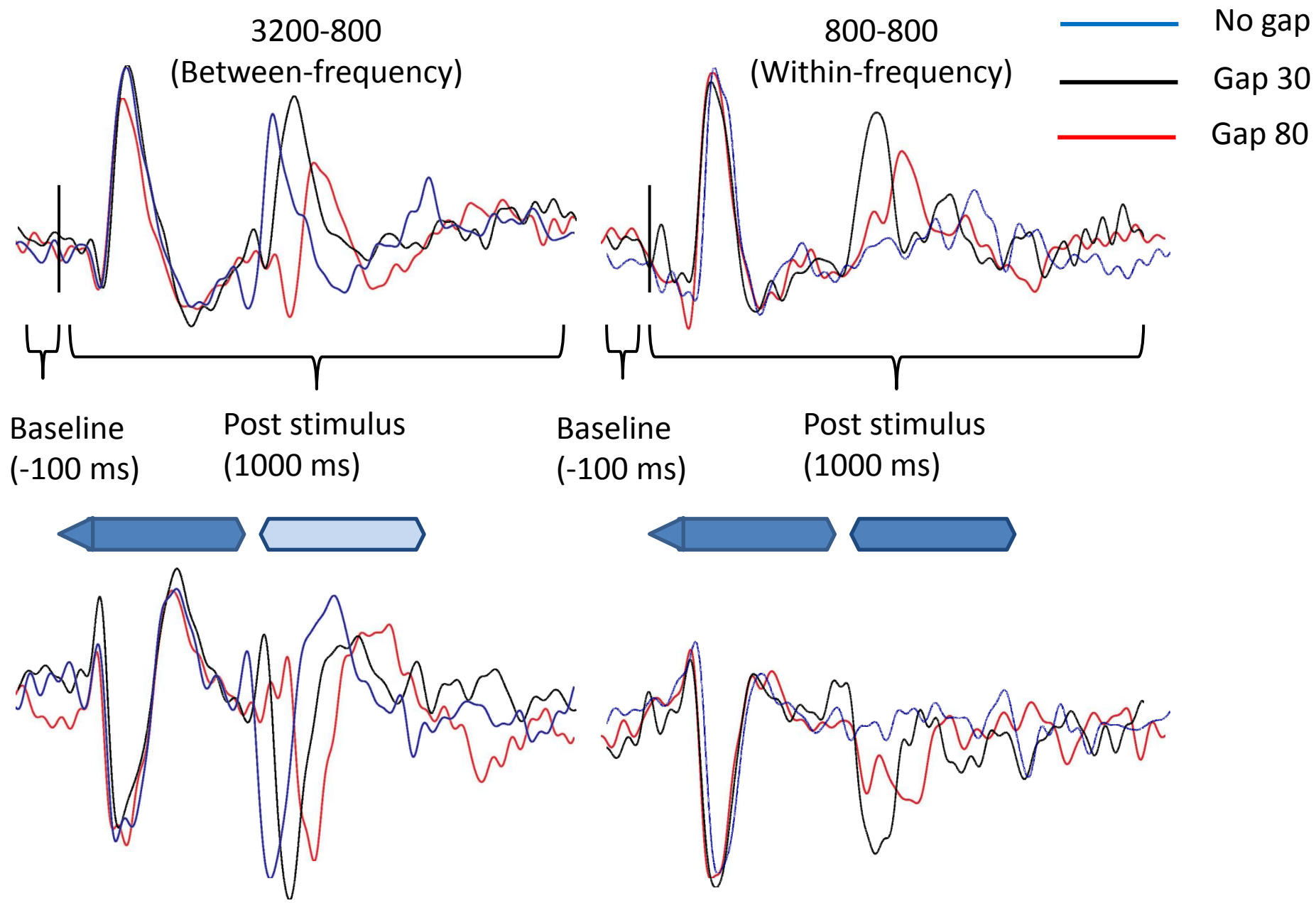
Averaged waveforms

3200-800
(Between-frequency)



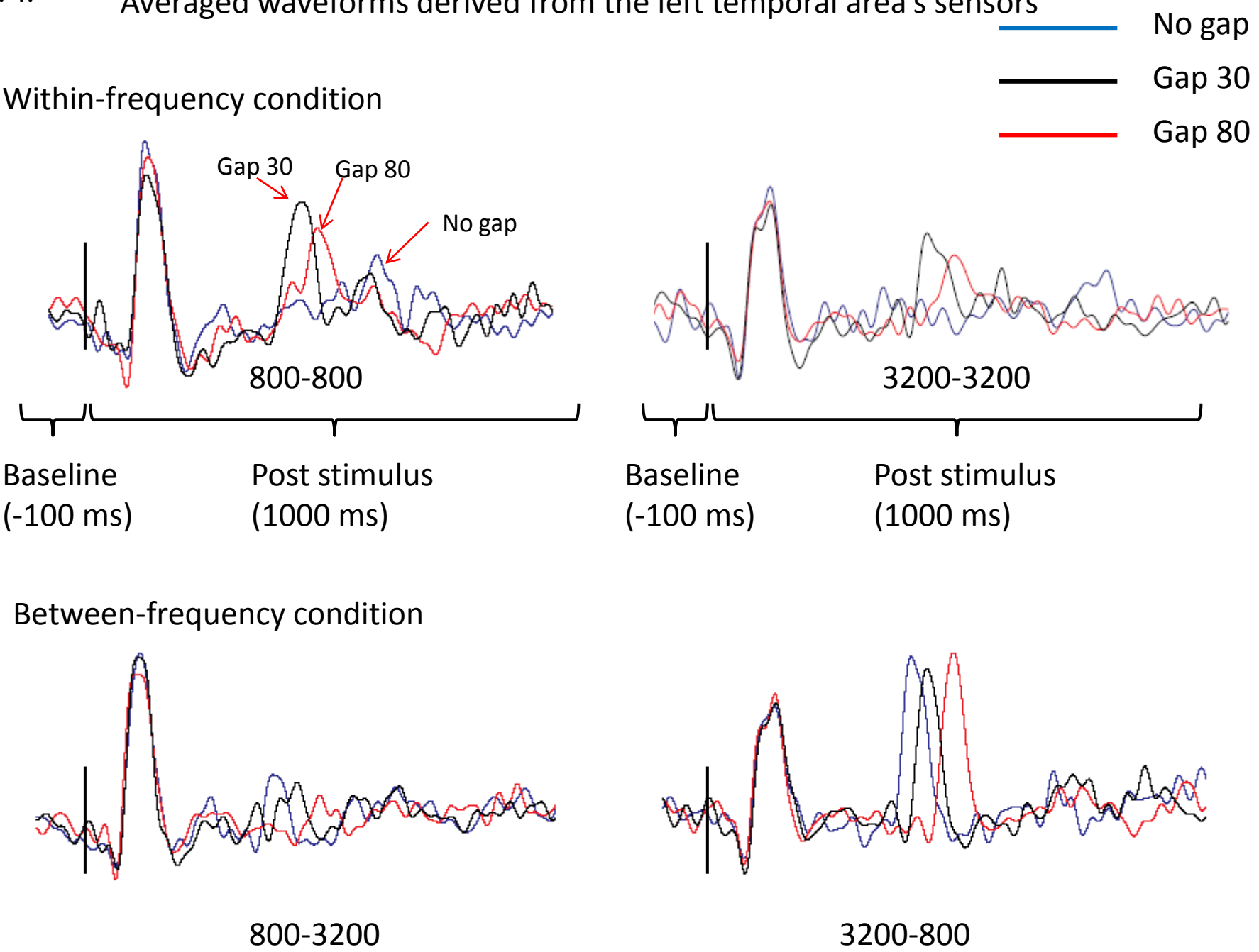
Gap 30
Gap 80
No gap

204 magnetometer sensors


3200-800
(Between-frequency)
800-800
(Within-frequency)
No gap
Gap 30
Gap 80
Baseline
(-100 ms)
Post stimulus
(1000 ms)
Baseline
(-100 ms)
Post stimulus
(1000 ms)

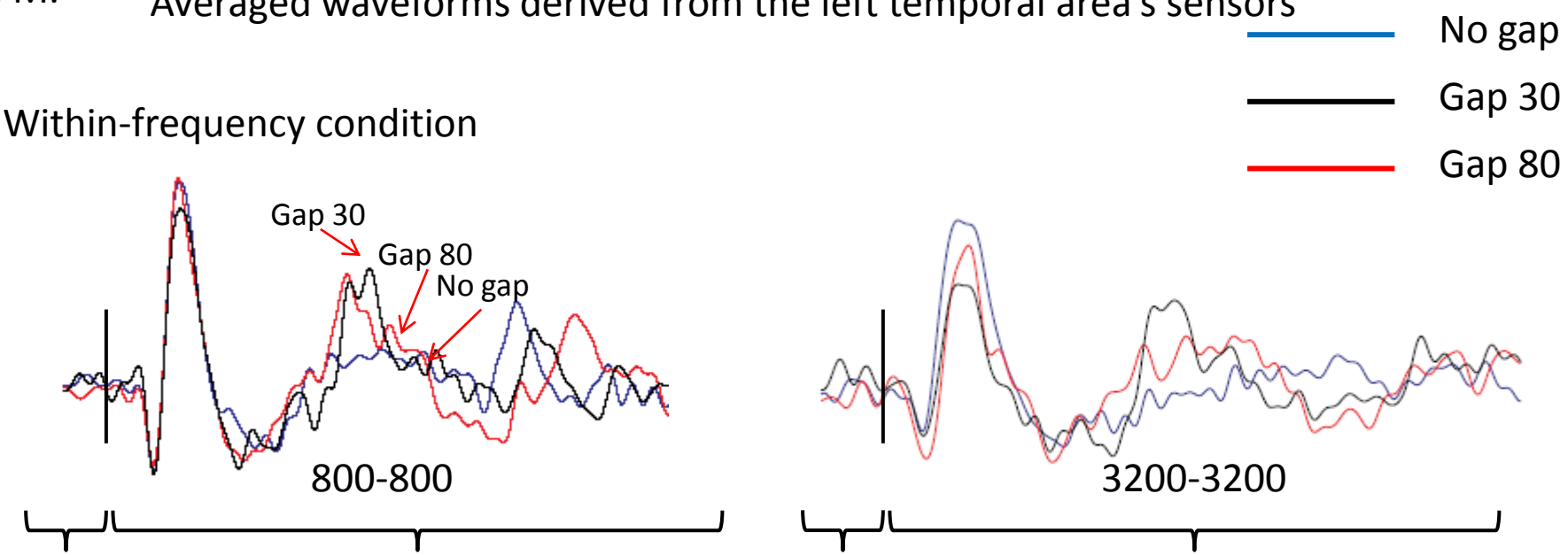
E. Y.

Averaged waveforms derived from the left temporal area's sensors

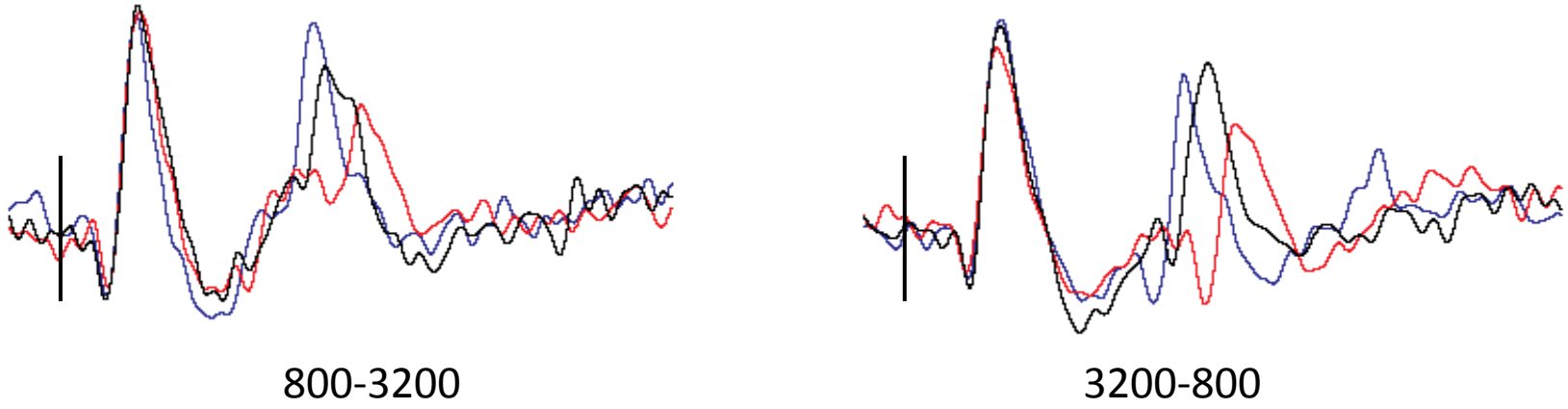


T. M.

Averaged waveforms derived from the left temporal area's sensors

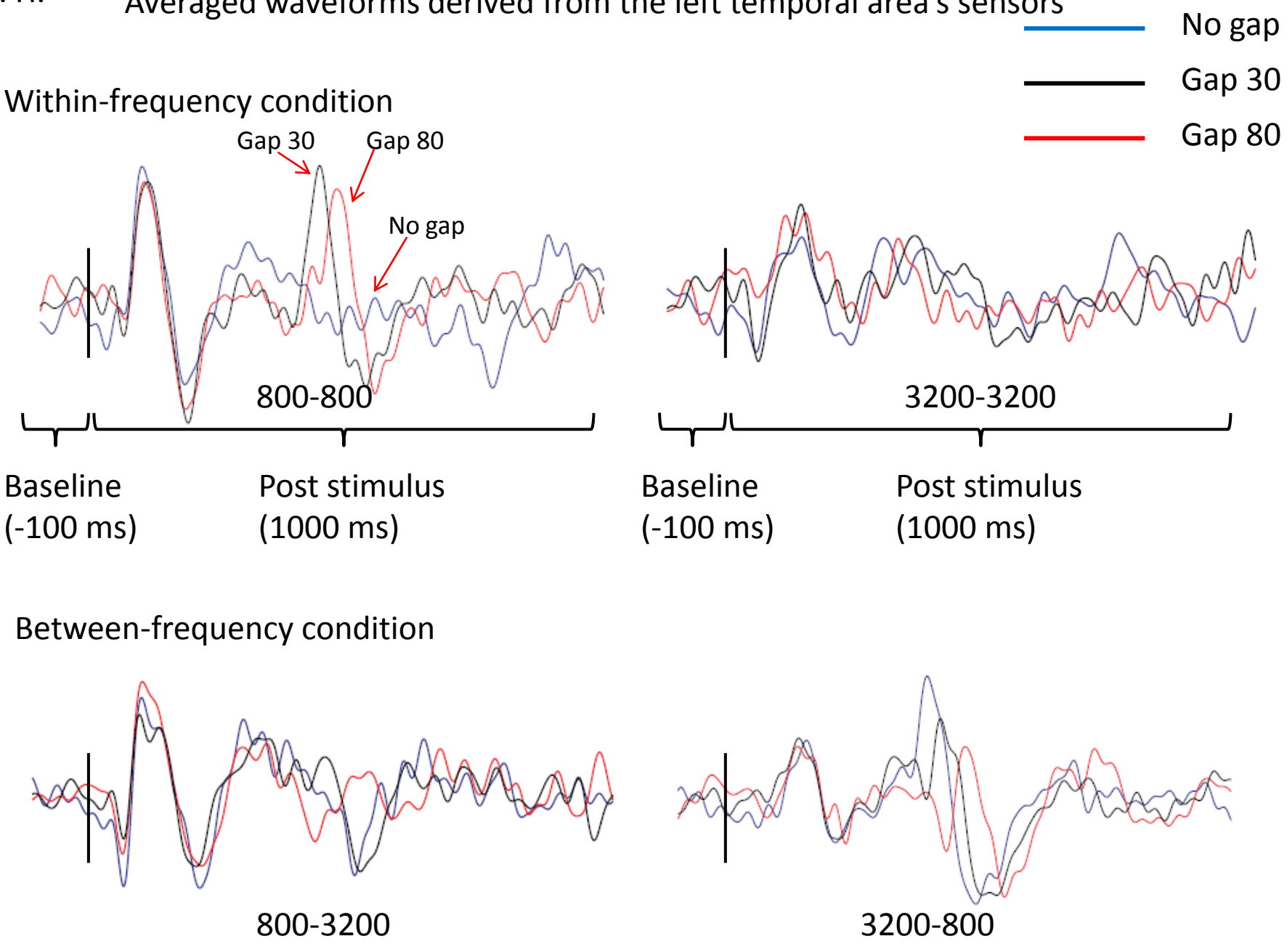


Between-frequency condition



E. H.

Averaged waveforms derived from the left temporal area's sensors



Summary of the results (1)

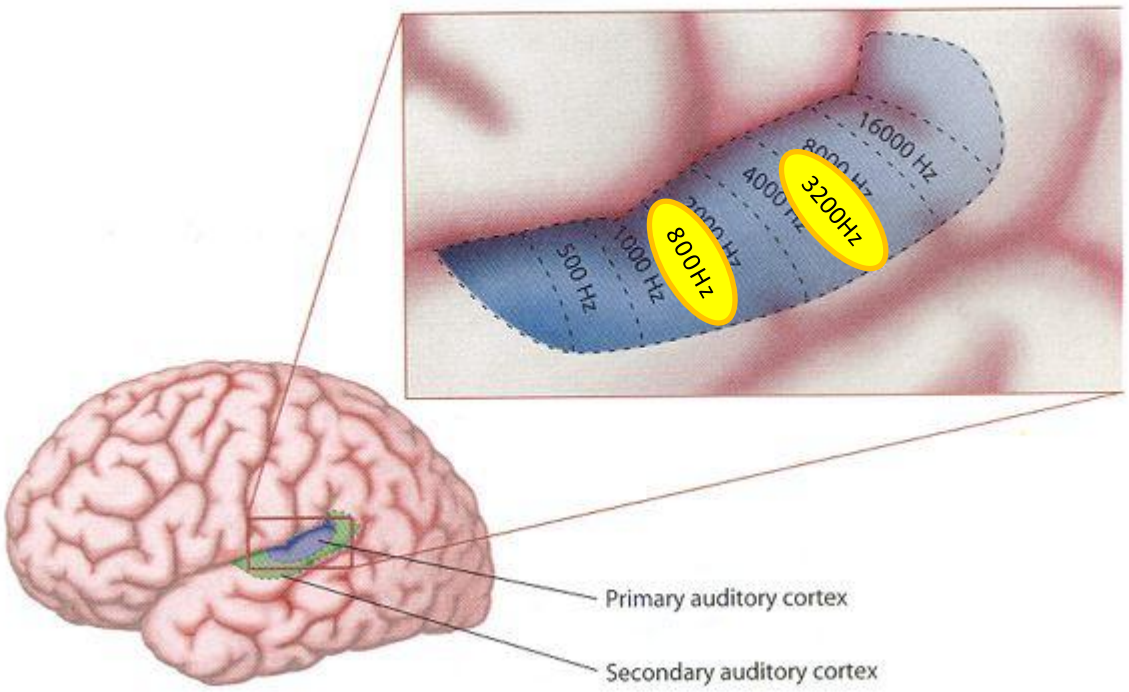
Auditory MEG activities appeared in response to the onset of the leading and the trailing markers.

For within-frequency conditions, no peak responses were observed after the onset of the trailing markers when the stimuli had no gaps, whereas for between-frequency conditions, apparent N1ms were observed even the stimuli had no gaps.

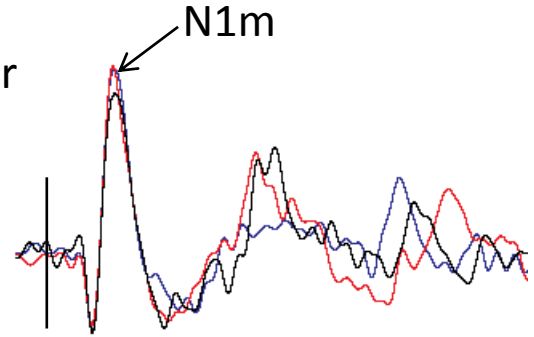
Tonotopic organization

Cortical tonotopy

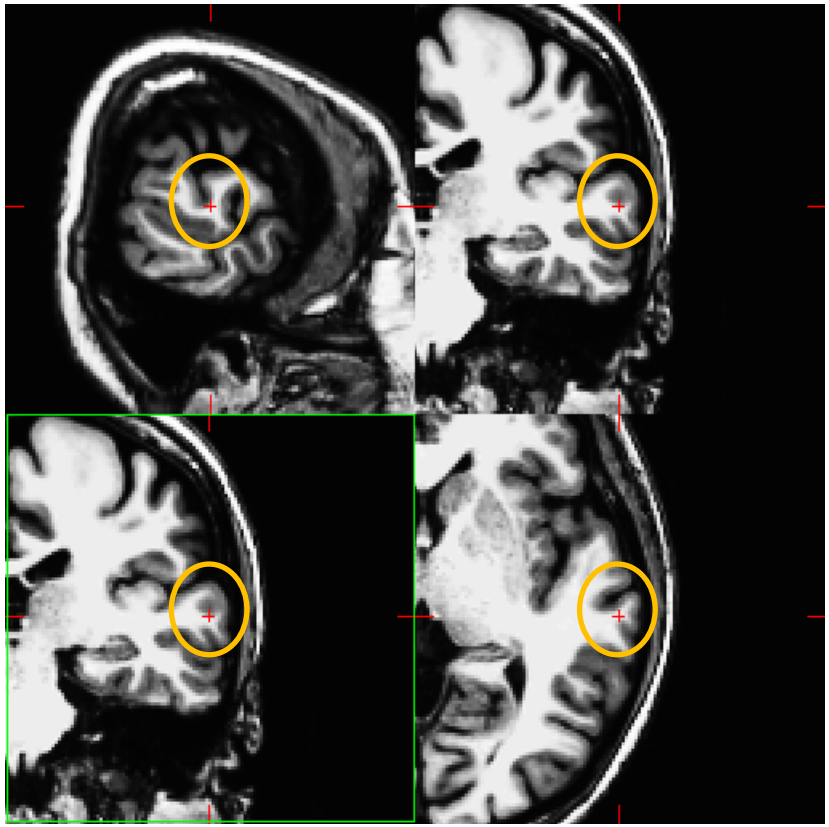
In human auditory cortex, frequency is encoded as place information.



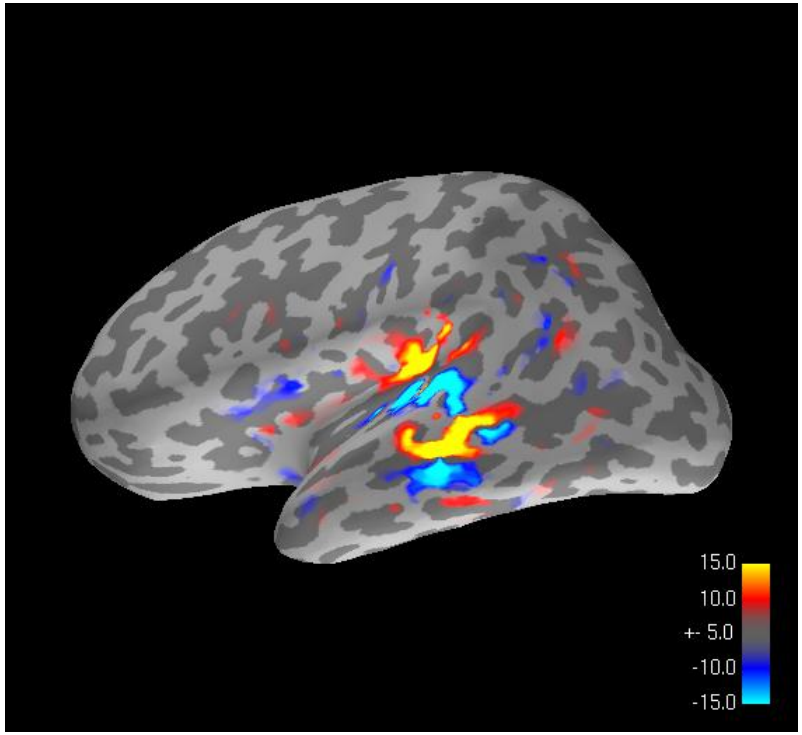
Source localization of the N100m for the leading marker



Dipole Estimation（800_800_no gap）

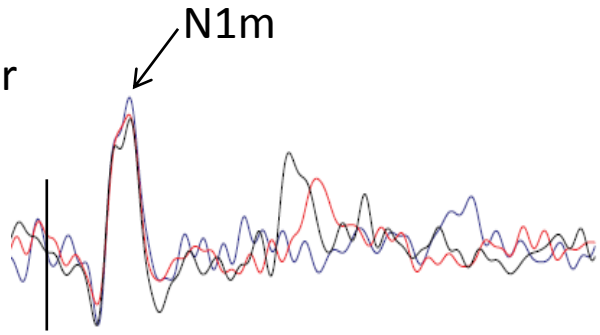


MNE result

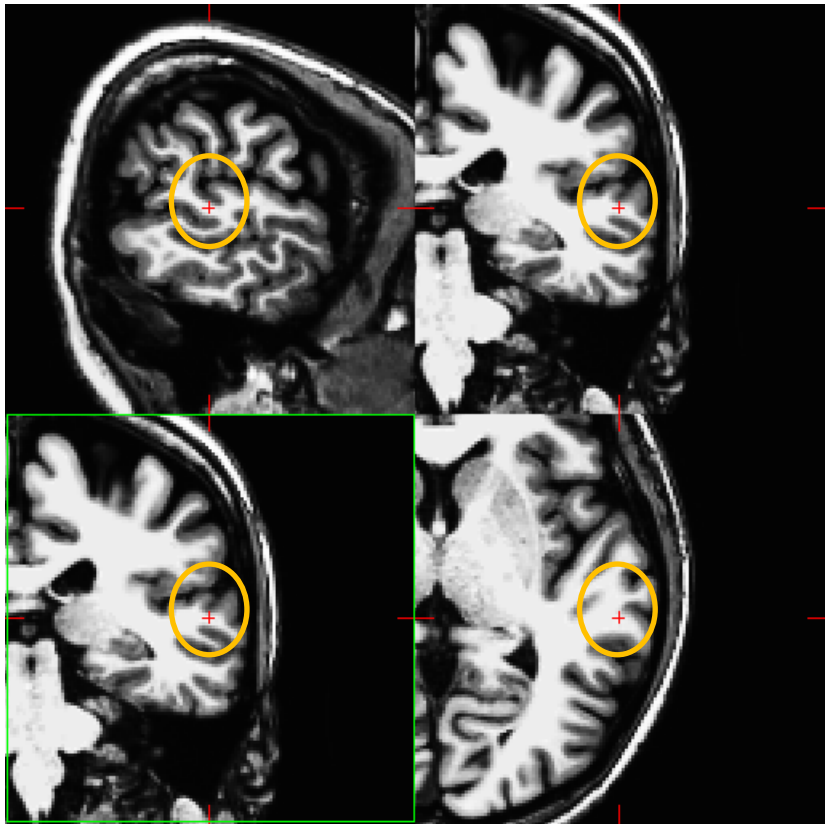


(x, y, z) = (-56.3, 0.2, 50.5) g = 98.2 %

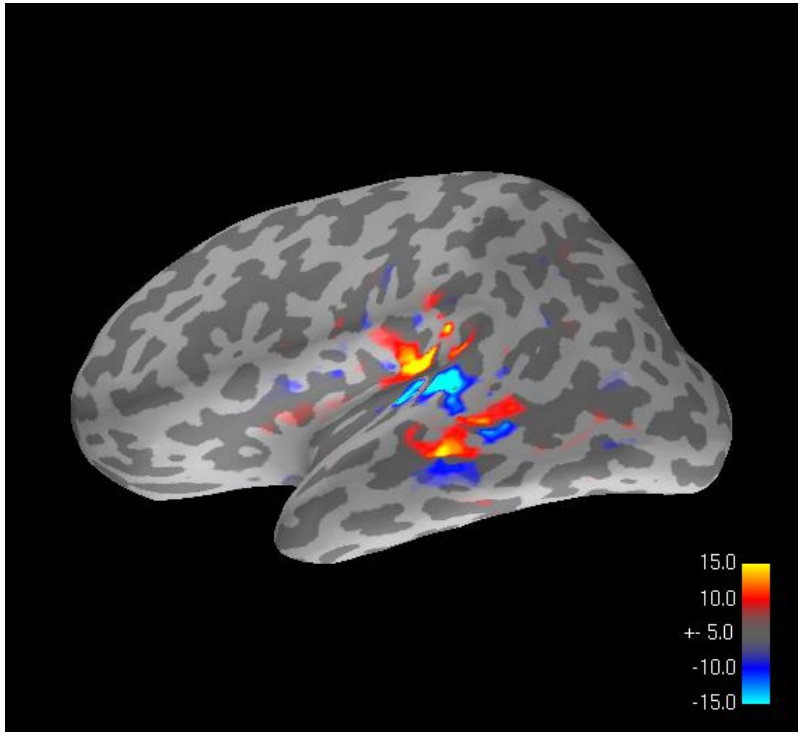
Source localization of the N100m for the leading marker



Dipole Estimation（3200_3200_no gap）

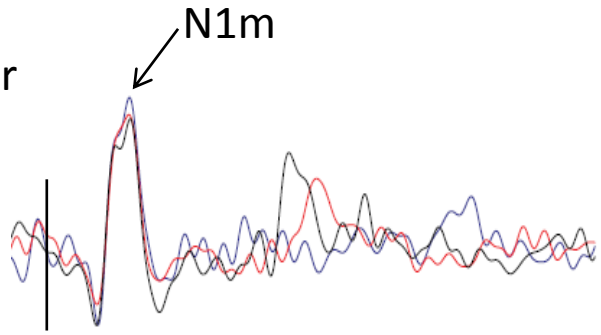


MNE result

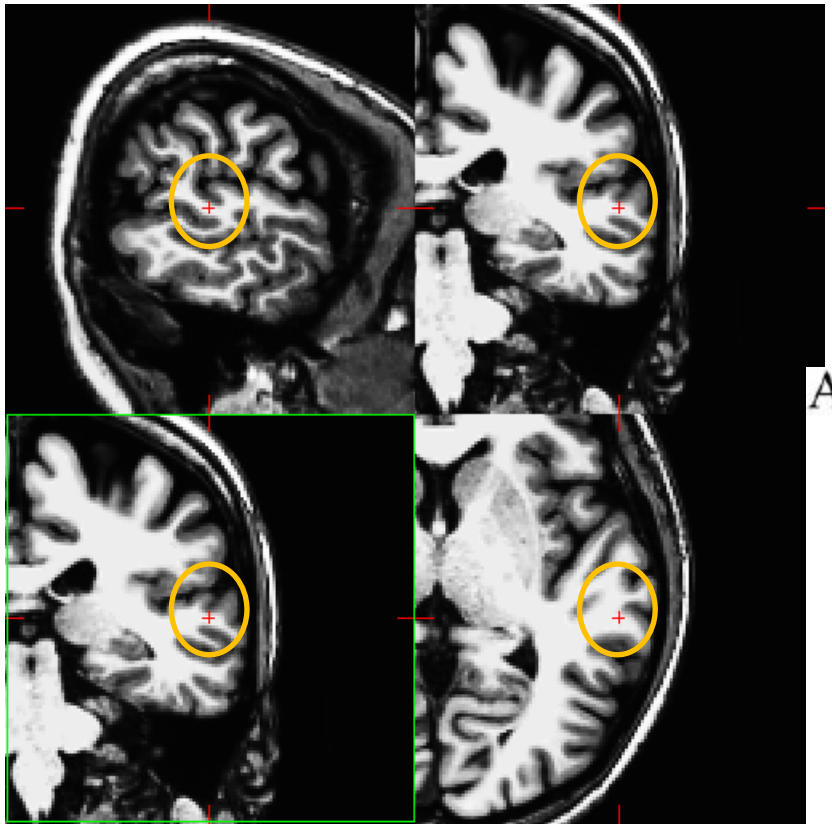


(x, y, z) = (-58.5, -4.9, 54.3) g = 97.5%

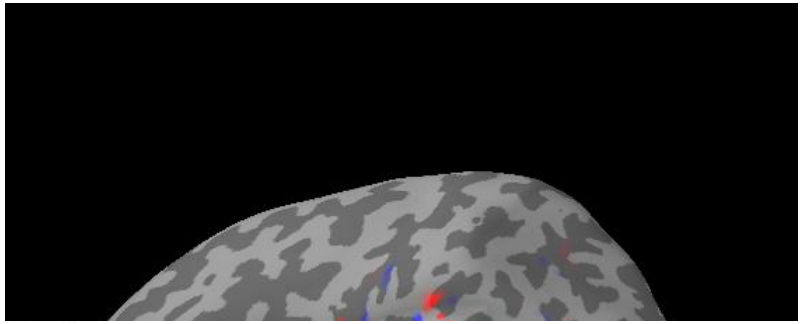
Source localization of the N100m for the leading marker

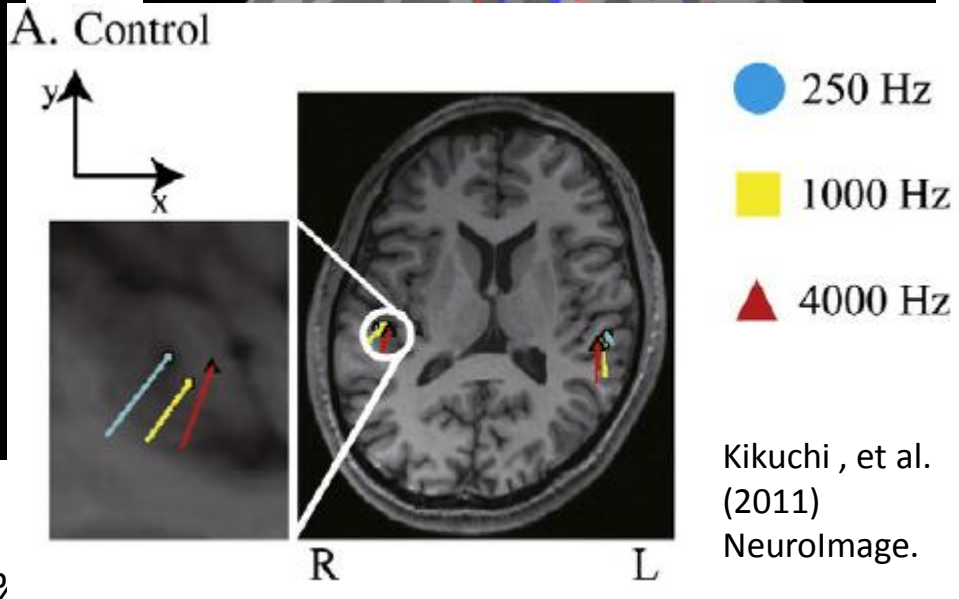


Dipole Estimation（3200_3200_no gap）



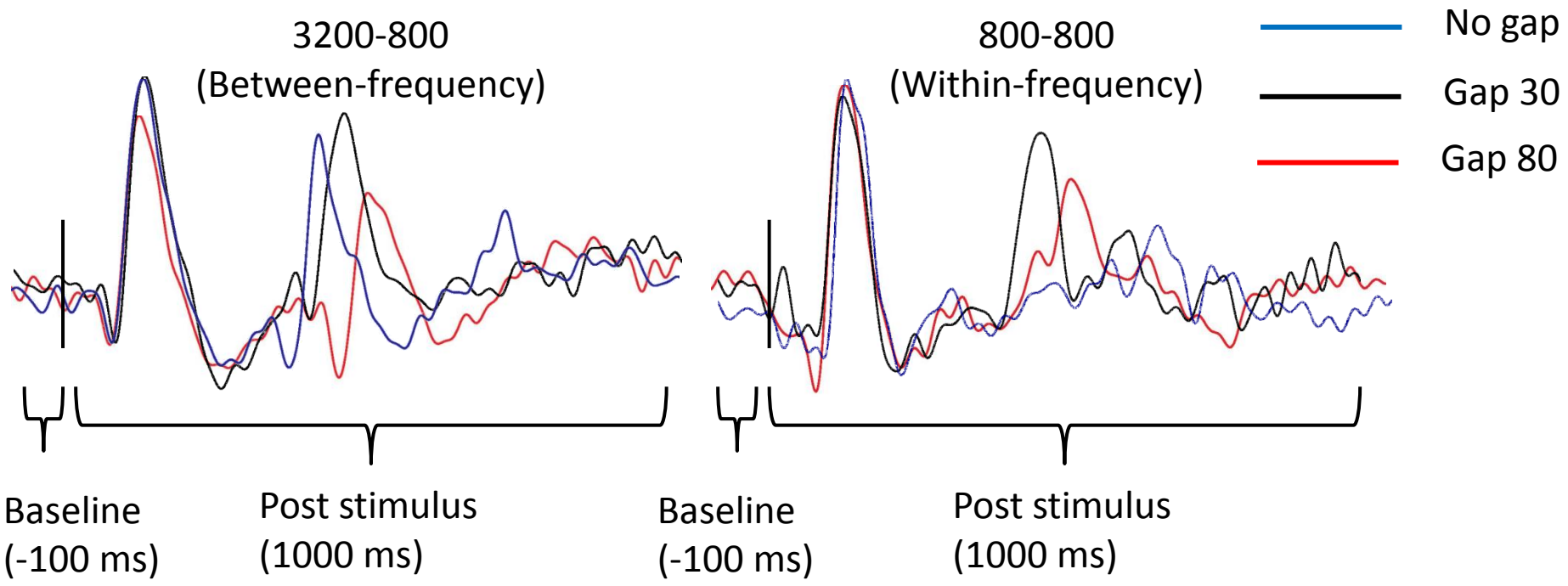
MNE result





Kikuchi , et al. (2011) NeuroImage.

(x, y, z) = (-58.5, -4.9, 54.3) g = 97.5%



Within-frequency condition → Onset response to the trailing marker

Between-frequency condition → Onset response to the trailing marker and Detection to the frequency changes

Summary of the results (2)

Tonotopic organization shows that the areas which process different frequencies may spatially vary in the brain.

In within-frequency condition, the auditory system is just required to detect the gaps in the tone, whereas in between-frequency condition, it is required to detect the frequency changes as well as the gaps.

These evidence could be one of the reasons for the difficulty of gap detection in the between-frequency condition.

The within-frequency and between-frequency patterns can elucidate time-frequency information process of auditory system.

Thank you for your attention.
Give me comments and advice
as much as possible.