Neuroanatomical and functional brain properties of tinnitus

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Dave Langers

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Overview

- Introduction: why care about brain imaging?
- VBM: More gray matter in tinnitus patients
- fMRI: Lack of tonotopic reorganization in tinnitus

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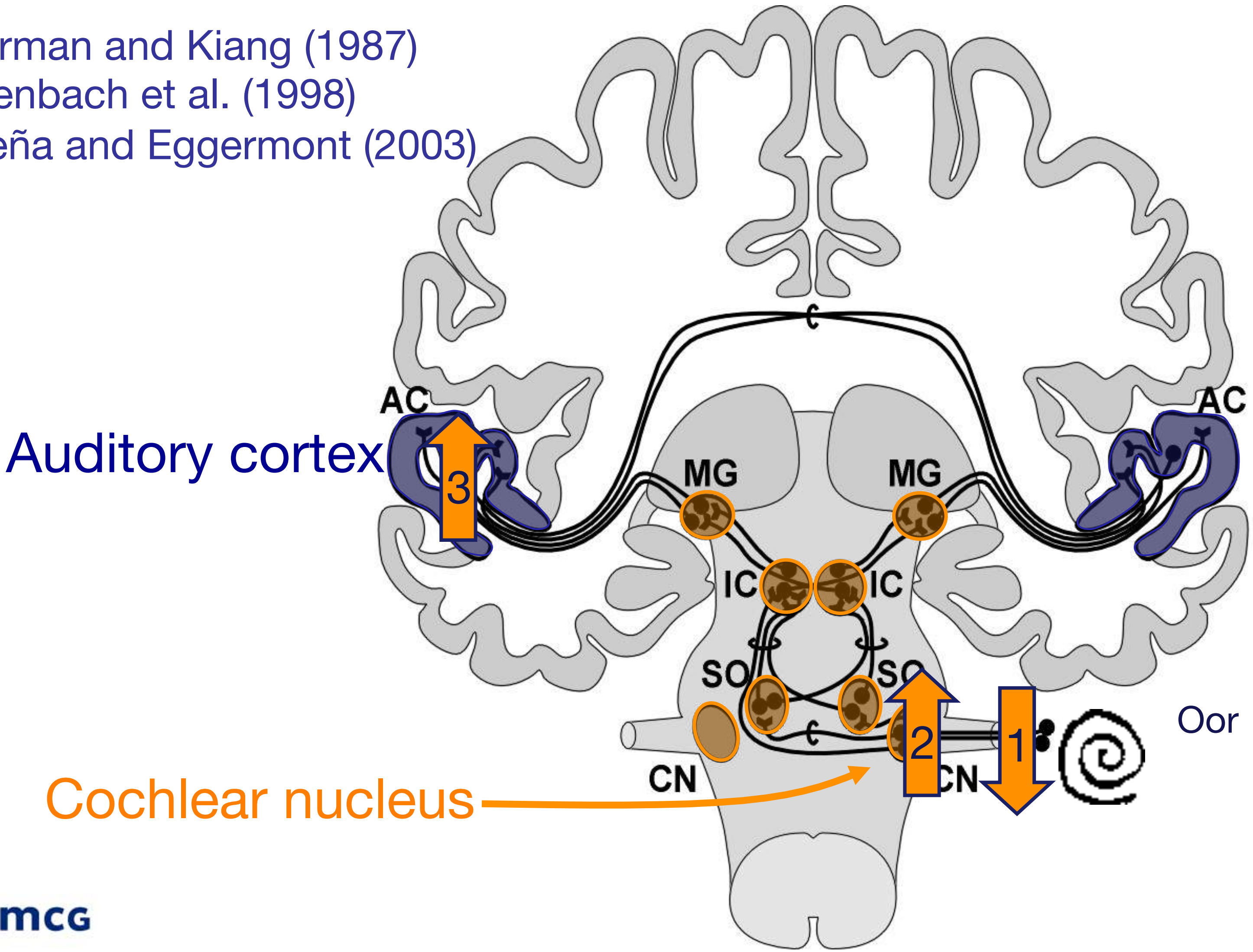
Noise-induced hearing loss and spontaneous neural activity

1. Liberman and Kiang (1987)
2. Kaltenbach et al. (1998)
3. Noreña and Eggermont (2003)



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Research questions

Is there a difference between the brains of subjects **with** and **without** tinnitus, respectively, that may explain why some people develop tinnitus, while others do not?

1. Are there neuroanatomical differences related to tinnitus (e.g. gray matter differences)?
2. Are there functional differences related to tinnitus (e.g. tonotopic map differences)?

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Structural and functional study of tinnitus

- Three subject groups
  - Normal hearing, n=24, age=58 (sd 6) yrs
  - Hearing impaired, n=16, age=63 (sd 10) yrs
  - Hearing impaired with tinnitus, n=31, age=56(sd 9) yrs
- Age-matched
- Hearing loss matched
- Tinnitus Handicap Inventory (THI): 4-72, average=29 *(Husain et al: 10-26, average 17)*

- Structural MRI, with voxel-based morphometry, quantify gray matter

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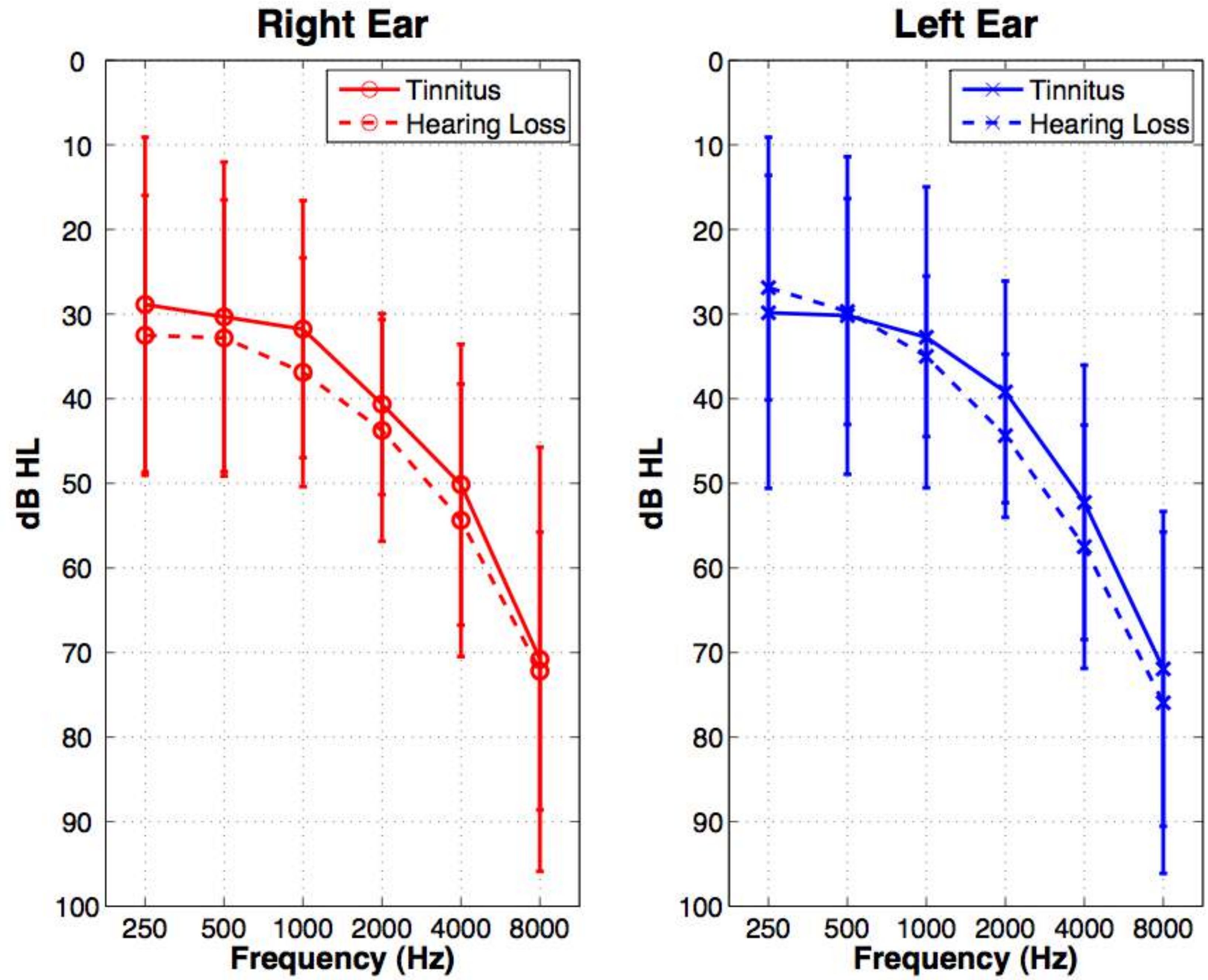
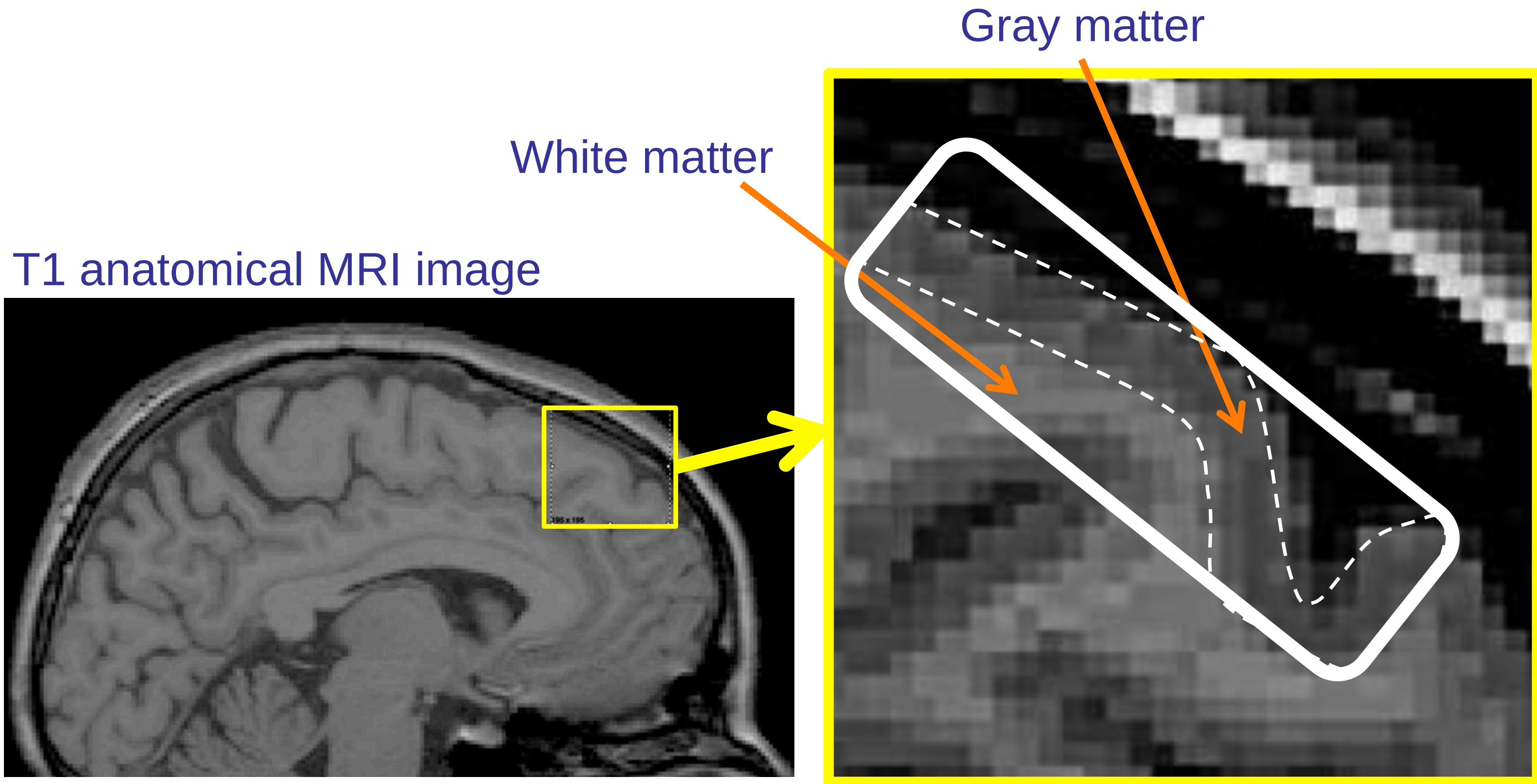


Right Ear
Tinnitus
Hearing Loss
dB HL
0
10
20
30
40
50
60
70
80
90
100
250
500
1000
2000
4000
8000
Frequency (Hz)
Left Ear
Tinnitus
Hearing Loss
dB HL
Frequency (Hz)

Voxel-based morphometry (VBM)



Total gray matter

*

Hearing loss + tinnitus

Controls

Hearing loss

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Total gray matter volume

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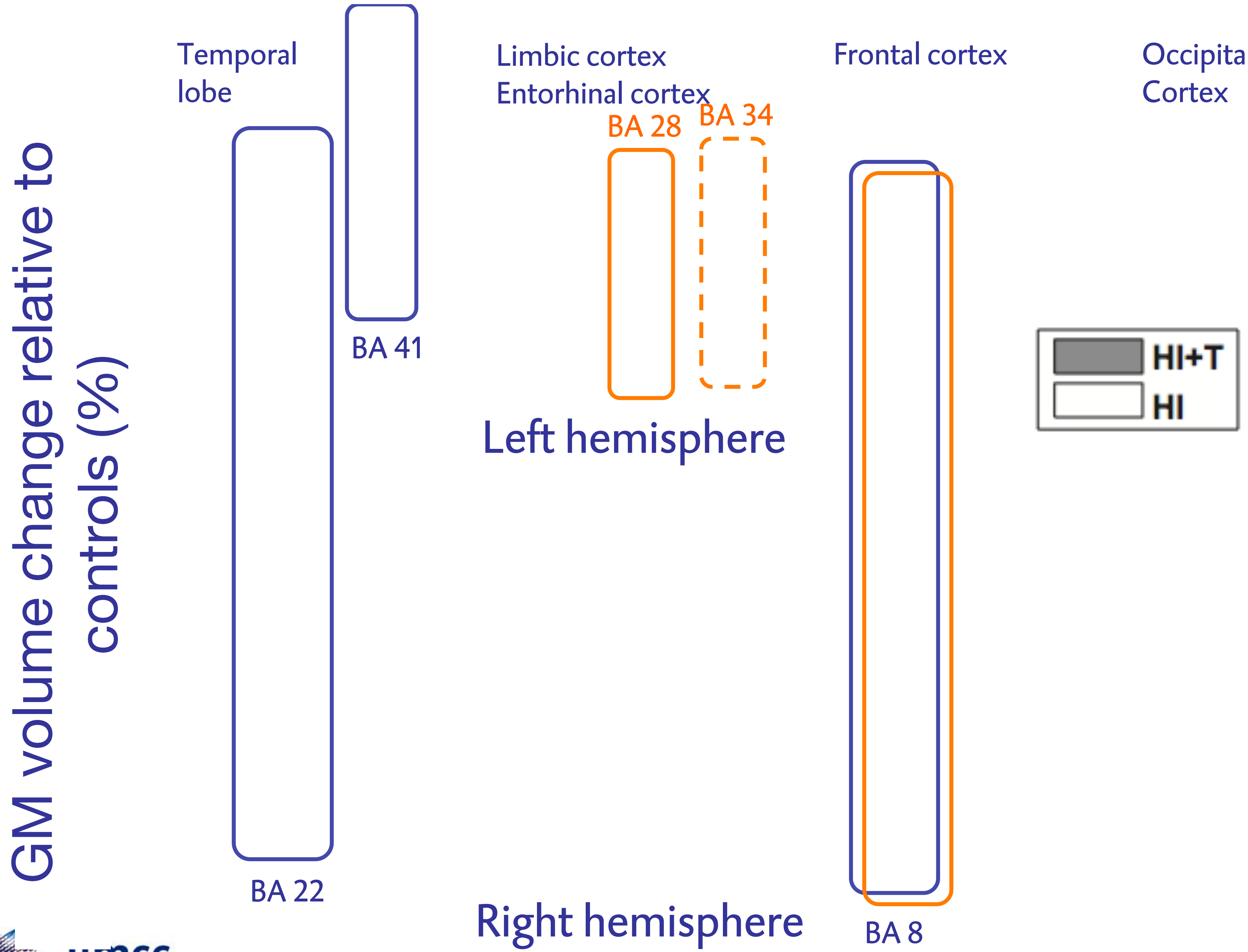
THI score


GM volume change relative to controls (%)
Temporal lobe
BA 41
BA 22
Limbic cortex
Entorhinal cortex
BA 28
BA 34
Left hemisphere
Right hemisphere
Frontal cortex
BA 8
Occipital Cortex
HI+T
HI

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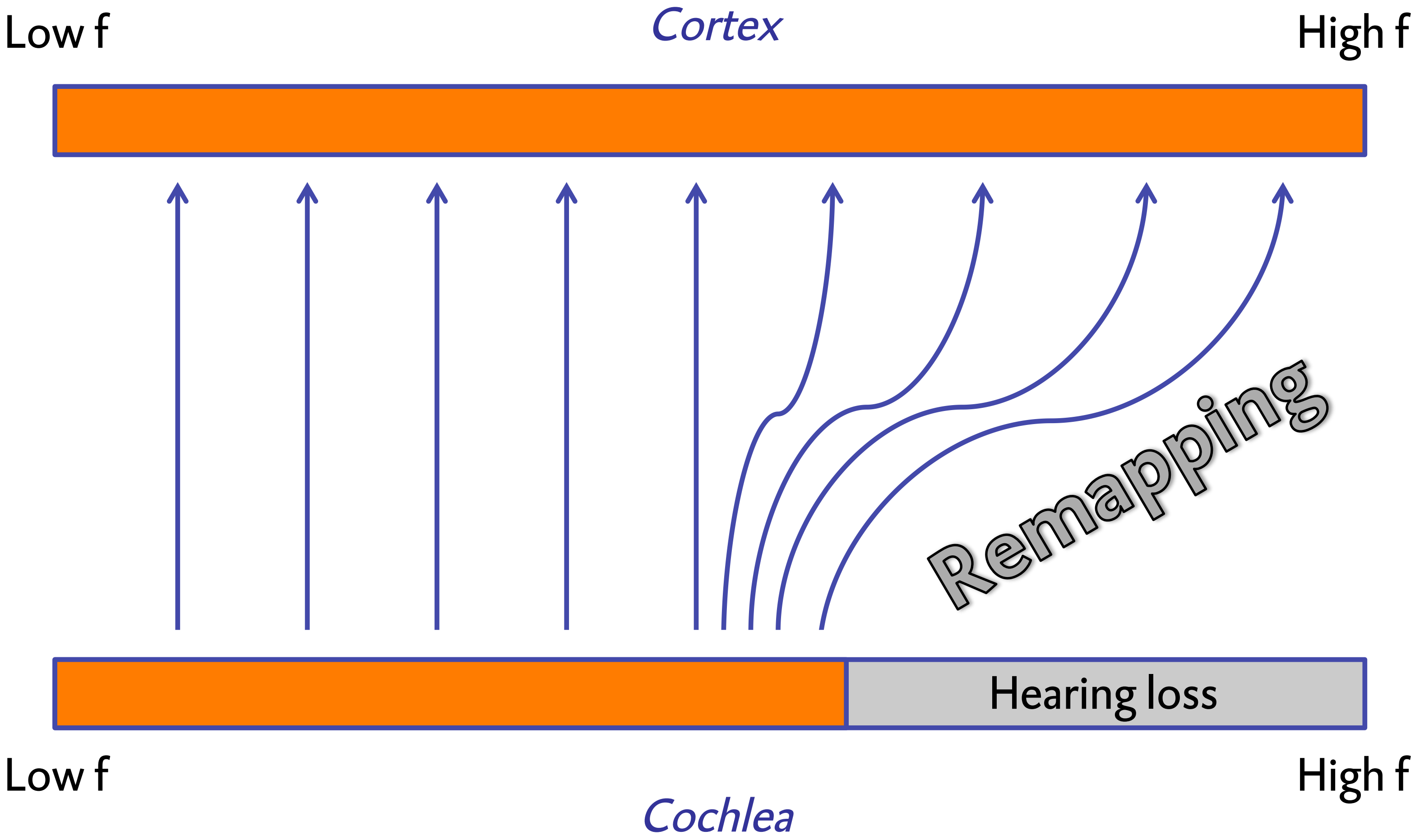
Tinnitus model 1:
Tonotopic reorganisation



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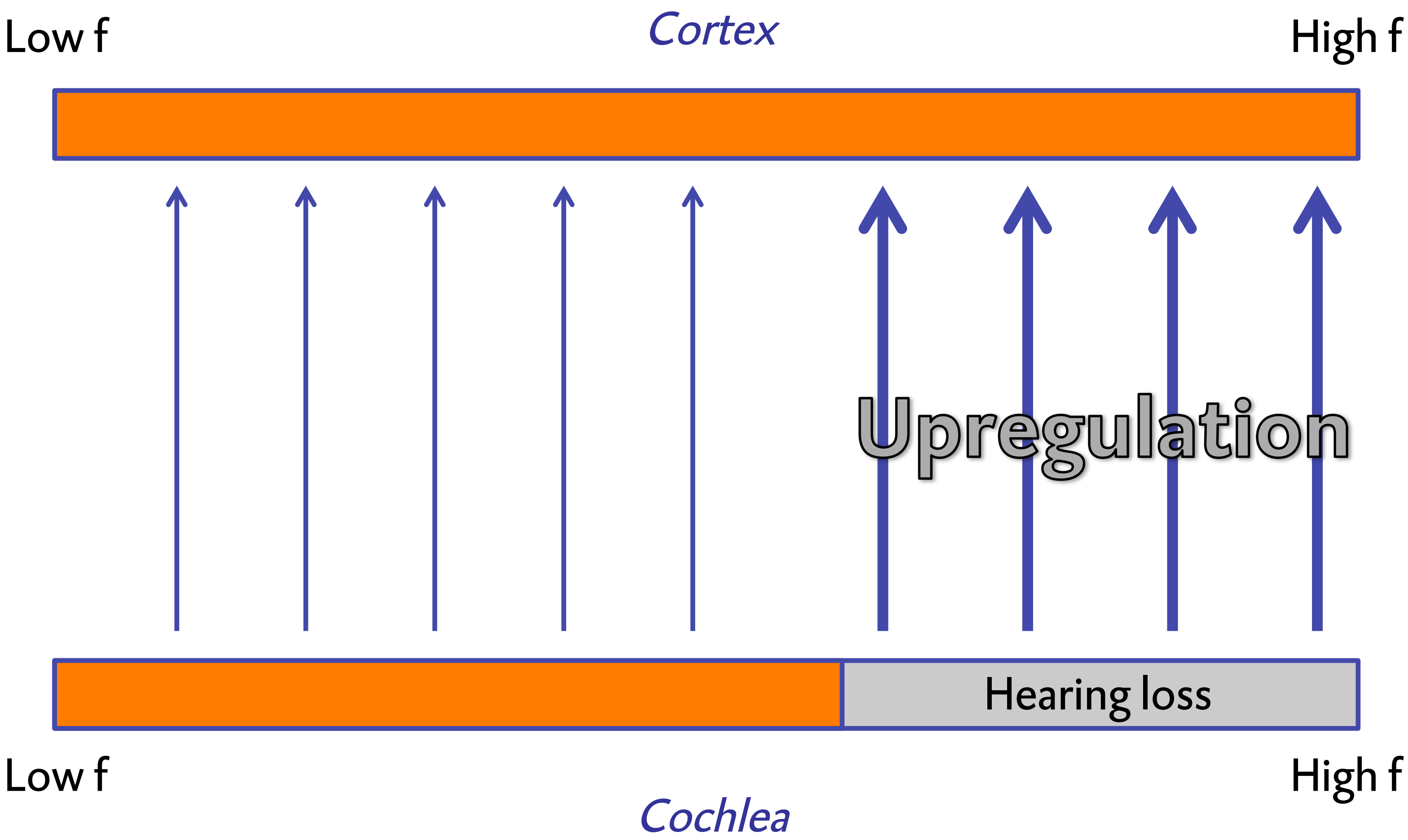
Tinnitus model 2:
Homeostatic reorganization



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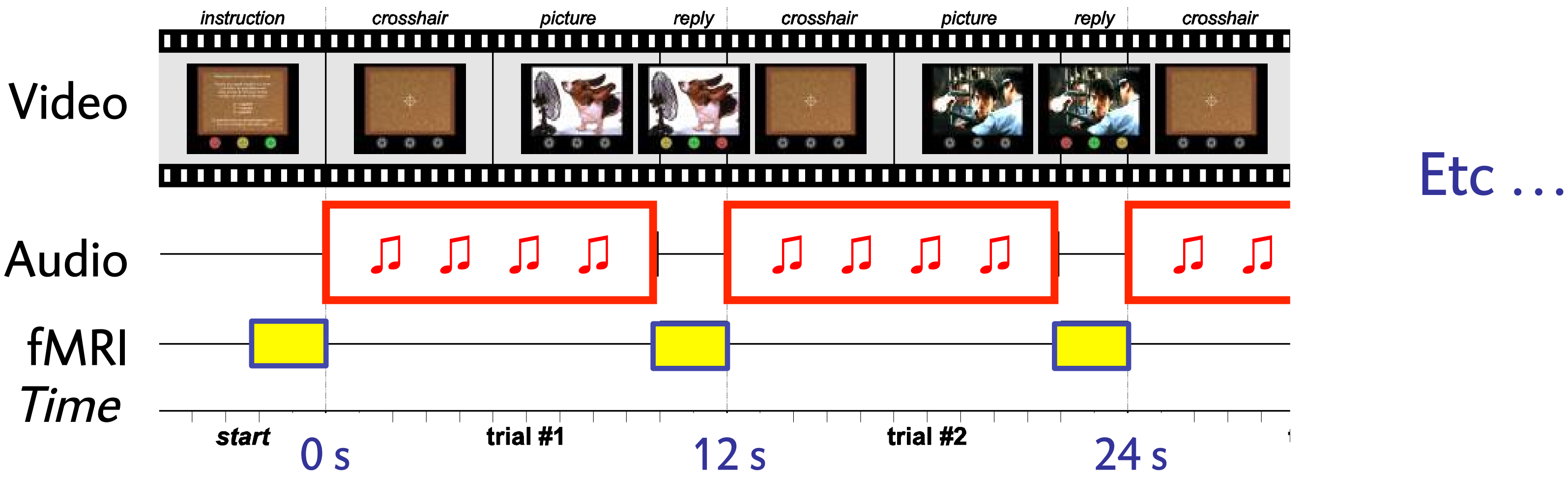
fMRI paradigm tonotopy study

- fMRI paradigm:
  While subjects performed three 8-minute blocks of a controlled visual/emotional task, 100-ms tones (250-8000 Hz) were presented at a 5-Hz rate



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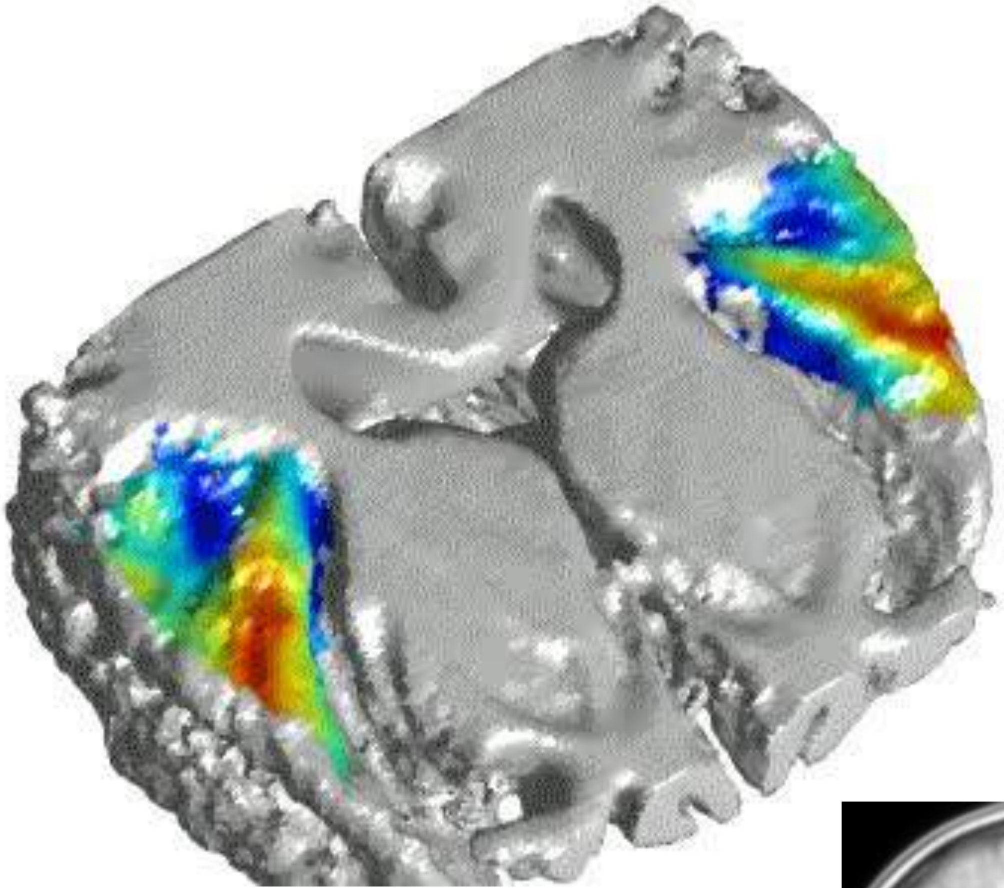
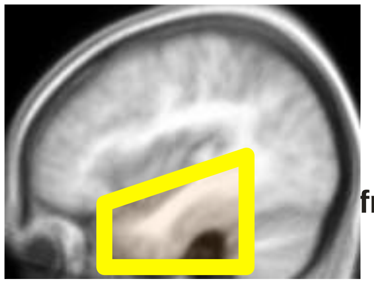
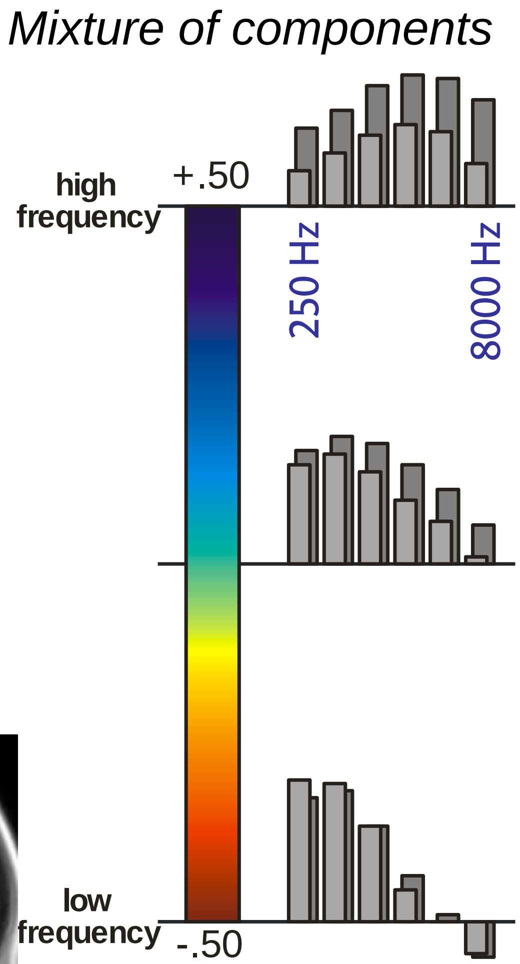
Results: principal component analysis







Langers & Van Dijk, Cereb. Cortex 2011

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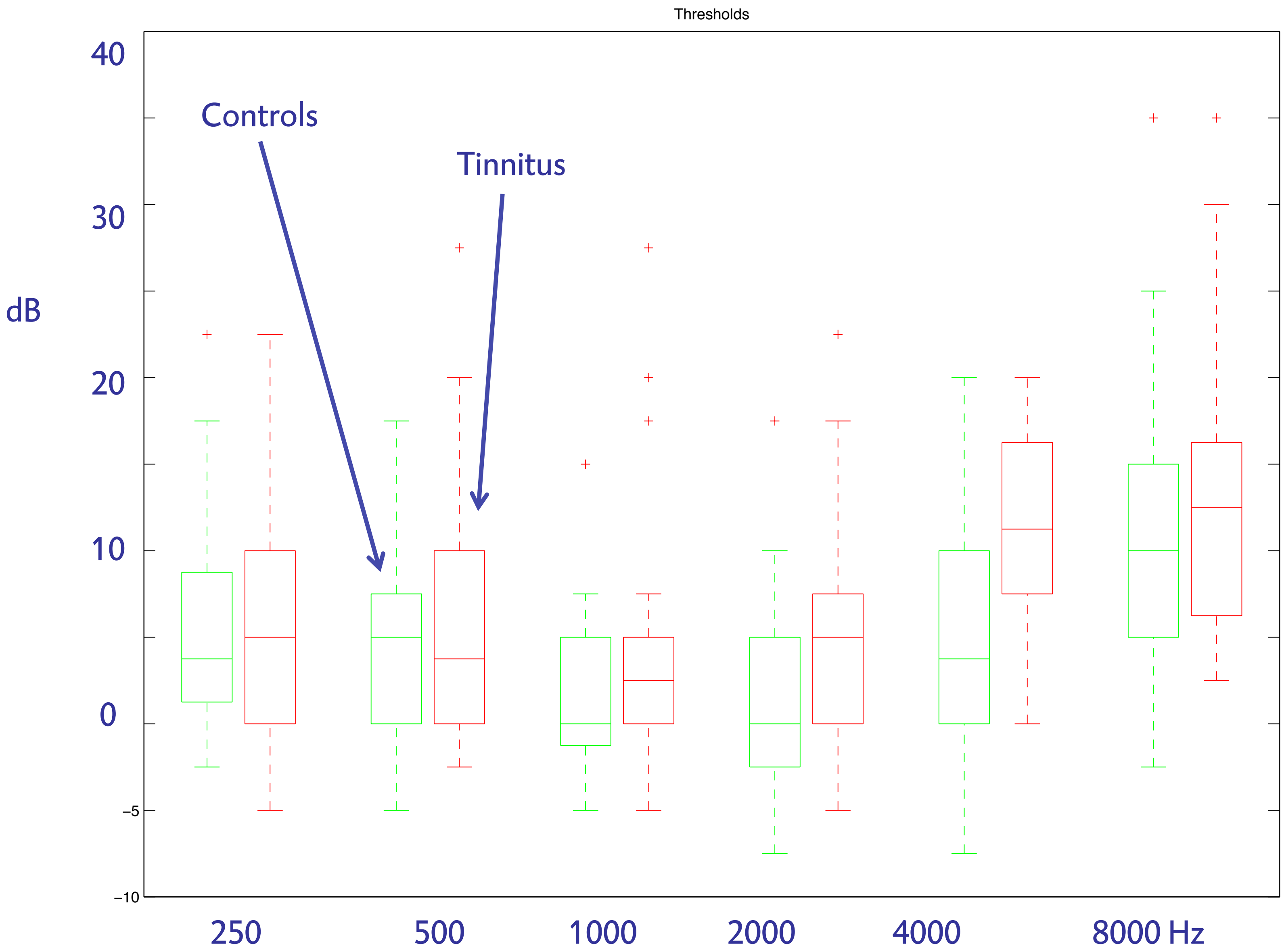
Thresholds
40
30
20
10
0
–5
–10
dB
Controls
Tinnitus
250
500
1000
2000
4000
8000 Hz

All | Controls | Tinnitus

High f

Low f

High f

Conclusion

- Tinnitus is associated with gray matter differences, in temporal, limbic, frontal brain and occipital areas
- Most robust changes are present in the temporal and frontal lobes
- Total gray matter volume positively correlates with tinnitus severity
- Understanding the causality in these correlations will be an important next step

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Conclusion (2)

- There was no evidence for remapping of tonotopy in tinnitus
- In other words: these data do not support the remapping hypothesis of tinnitus
- Future treatment may need to focus on reversing unwanted homeostatic plasticity

But:

- These conclusions may only apply to the tinnitus (sub)groups we investigated

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