Lateralization of Language could start in auditory cortex

Simultaneous MEG and Depth Recordings

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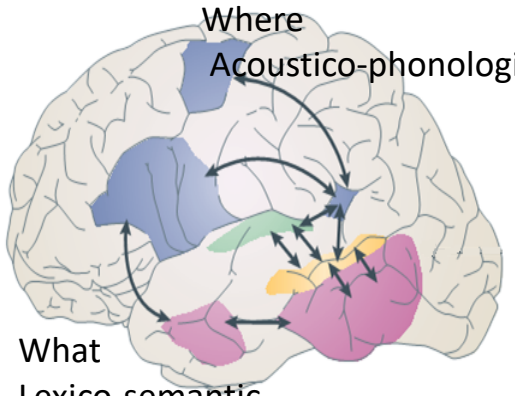
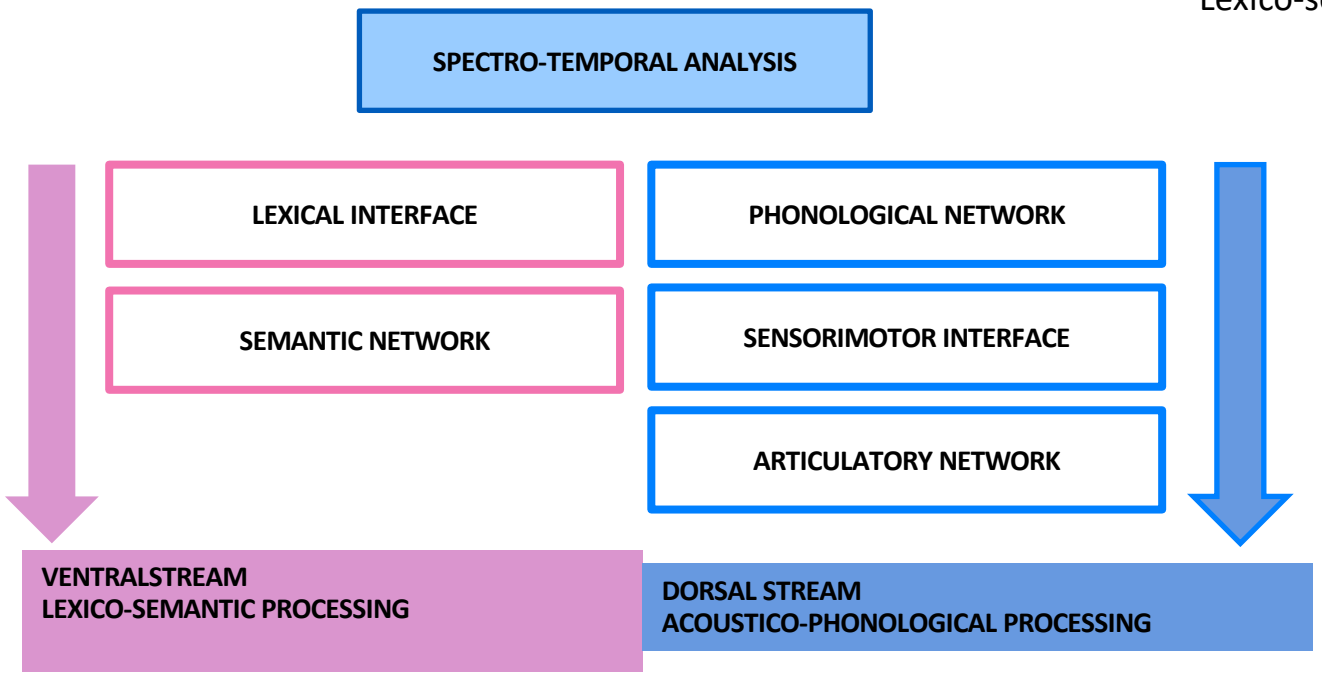
Cleveland Clinic

Dual stream model of speech processing

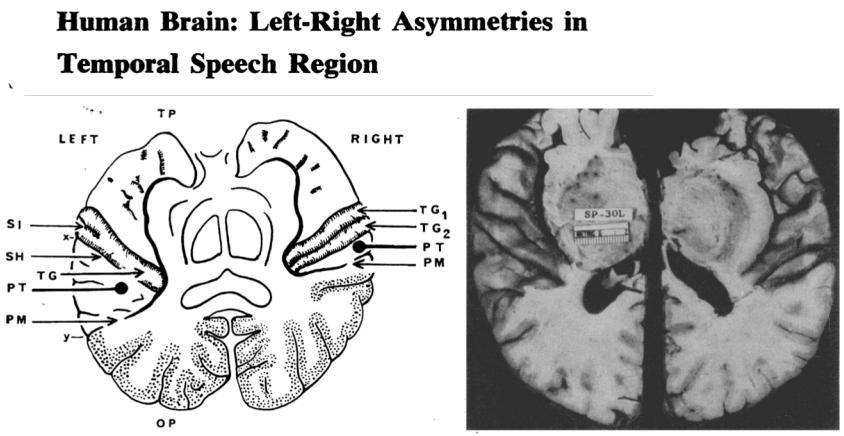


Hickok and Poeppel 2007

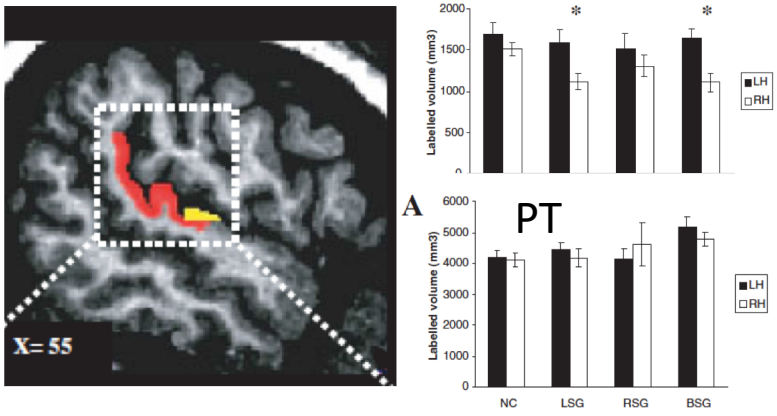


A POSSIBLE SENSORY ORIGIN OF LEFT DOMINANCE FOR LANGUAGE ?

Anatomical foundations



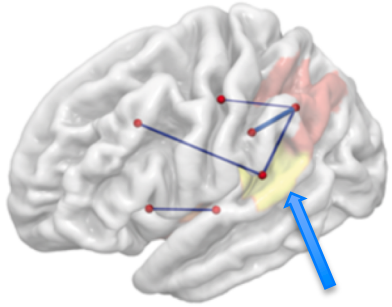
Geswind &Levitsky, 1968



Dorsaint –Pierre, 2006

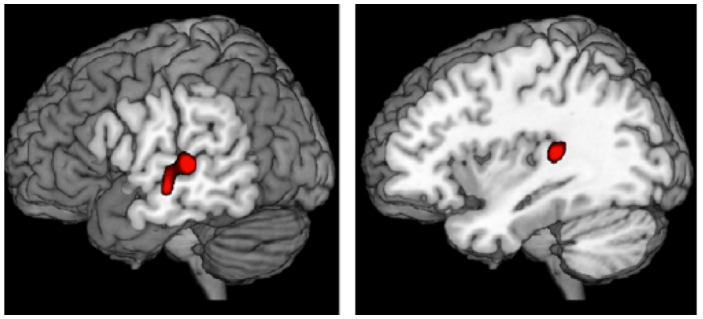
Functional foundations

One of the main deficits in patients with Wernicke's aphasia is the auditory verbal comprehension partly due to a phonemic acoustic deficit.



Syll. discrimination *Fridriksson et al, 2018*

Syll. identification



Saetrevik and Specht, 2012

Asymmetric Sampling in Time (AST) Theory

Right auditory cortex

Sampling acoustic signal through ~200 ms time window

Insensitive to phonetic contrasts

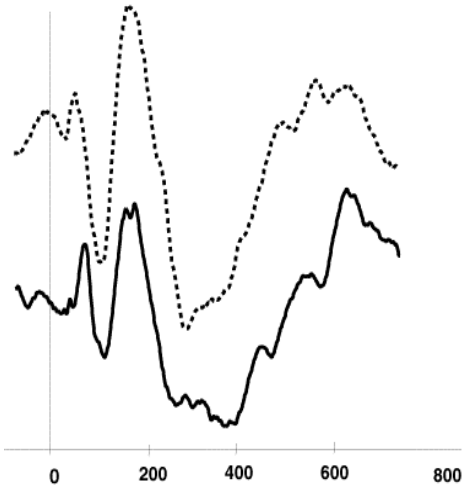
Left auditory cortex

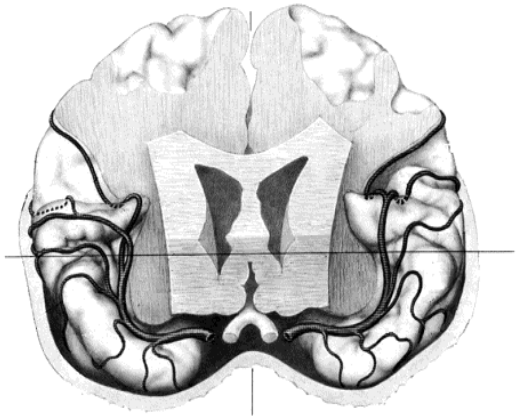
Sampling acoustic signal through ~20 ms time window

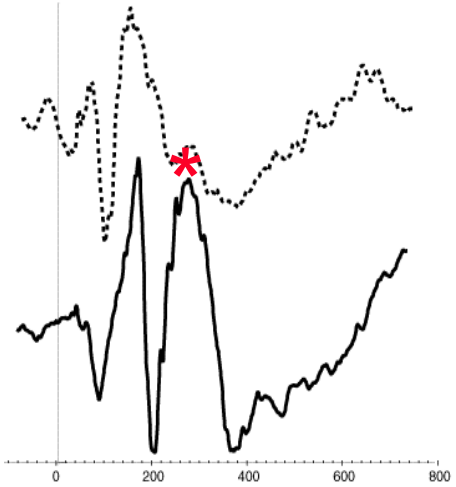
Sensitive to phonetic contrasts

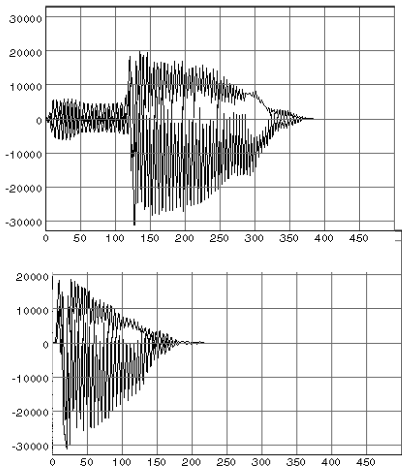
Poeppel, 2003

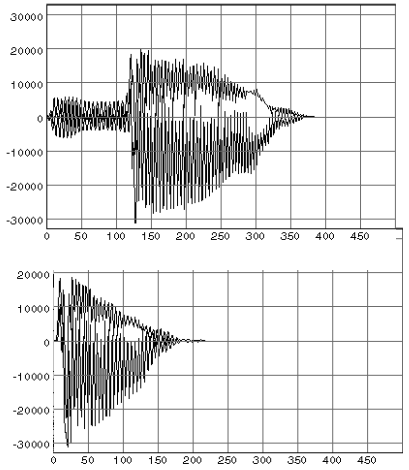
AST evidenced by syllables processing in Heschl's gyrus and Planum Temporale





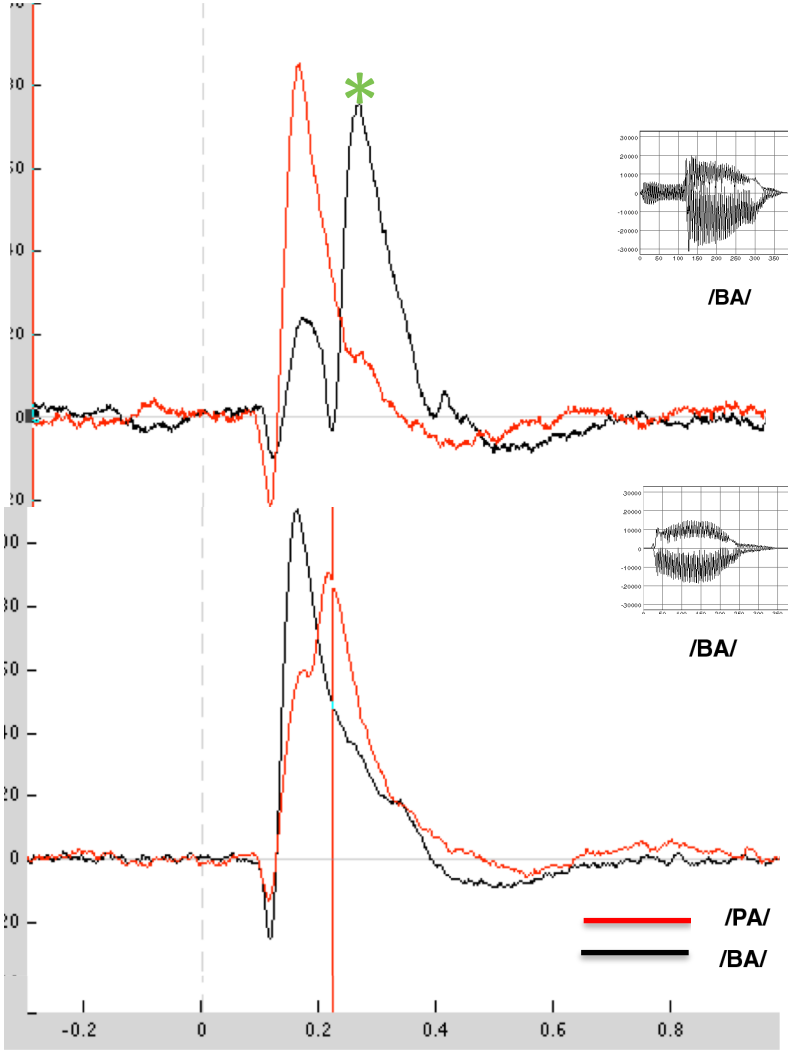


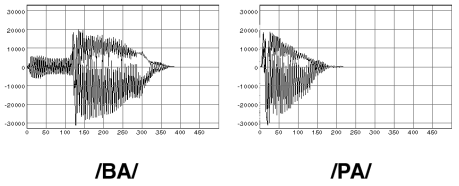




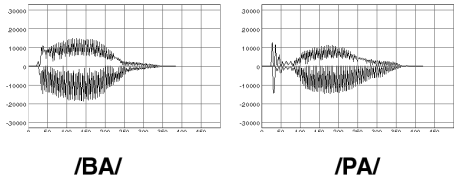
Liégeois-Chauvel et al., 1999

Processing of acoustical information in left Heschl's gyrus



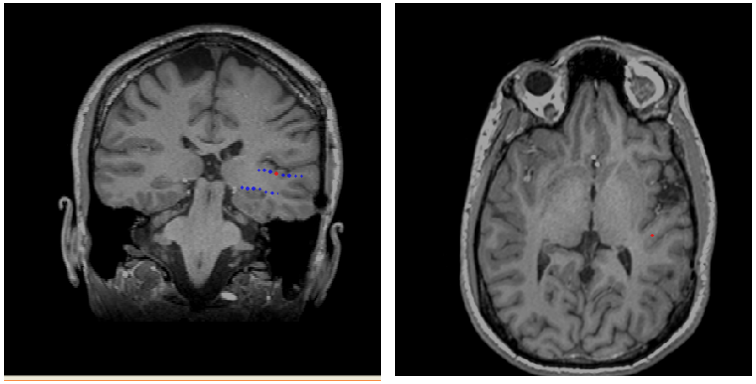


French

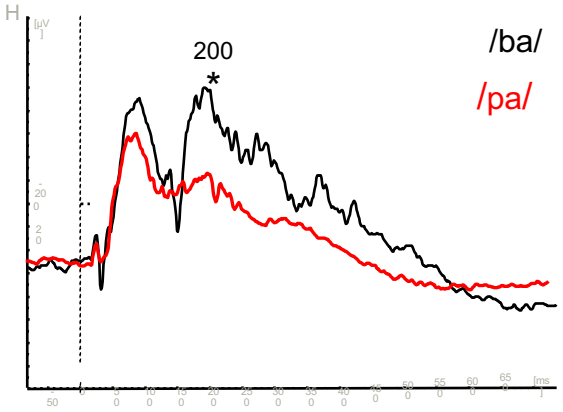


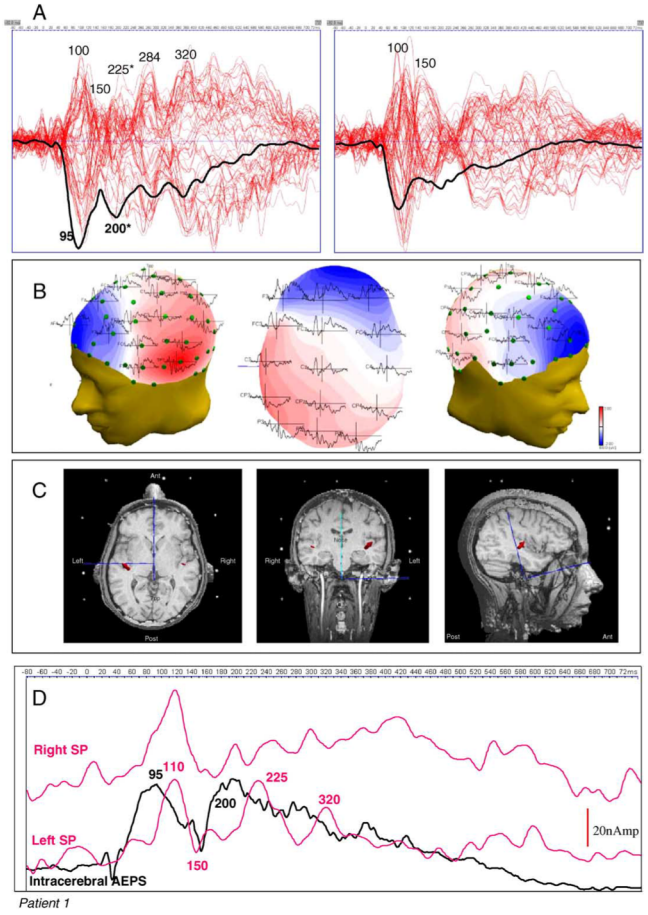
English

American Native Speaker



Comparison of HR EEG and depth recordings in left Heschl's gyrus

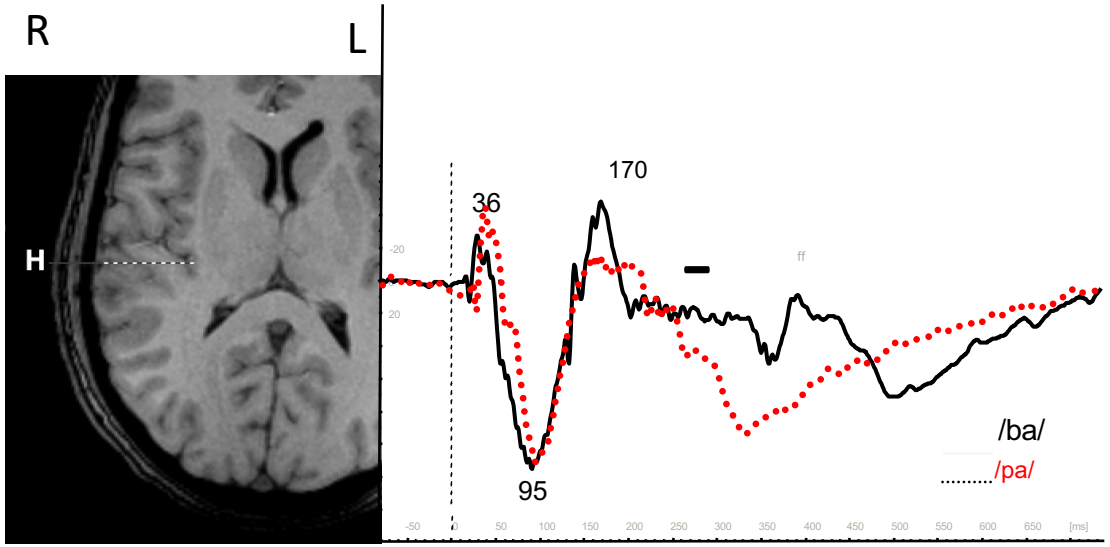


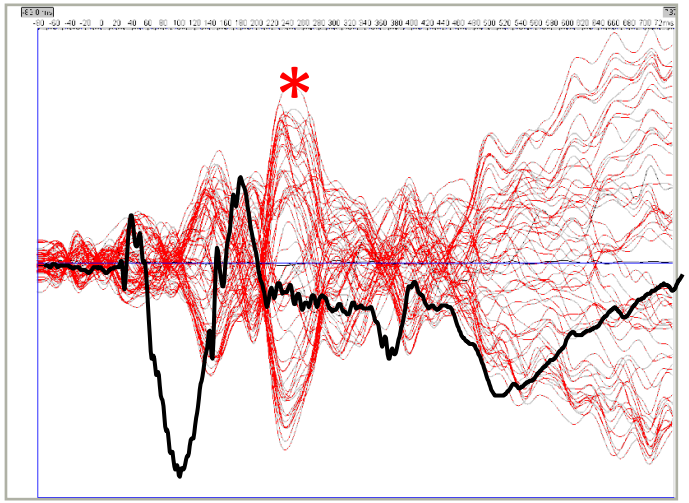


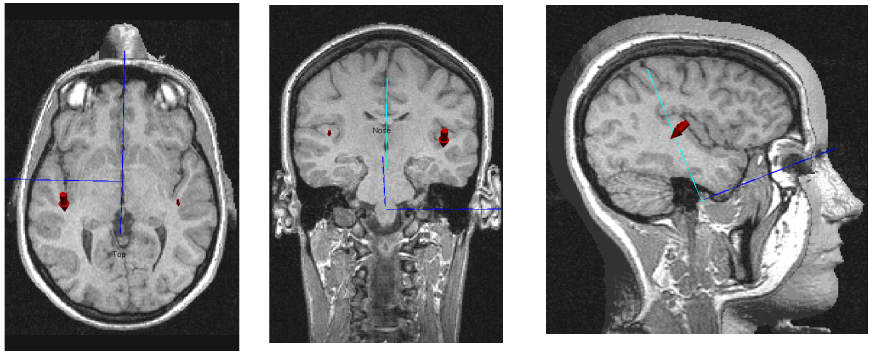
Right handed patient:
left dominance for language (WADA)

Trébuchon et al, 2005

Comparison of HR EEG and depth recordings in right Heschl's gyrus



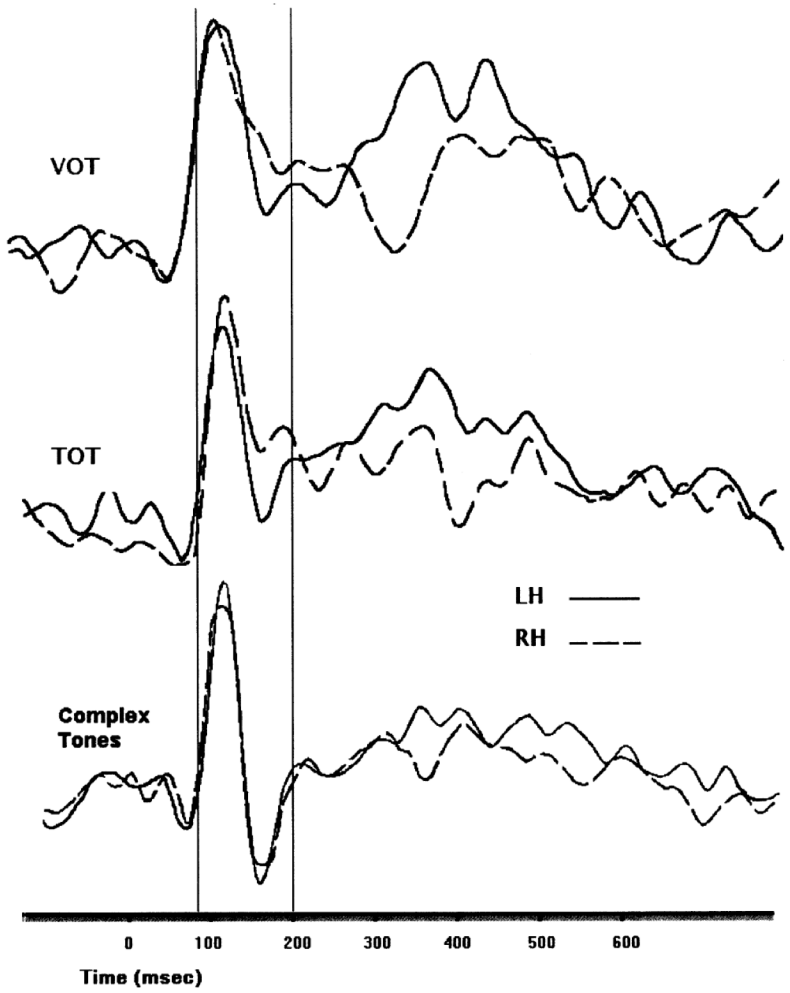


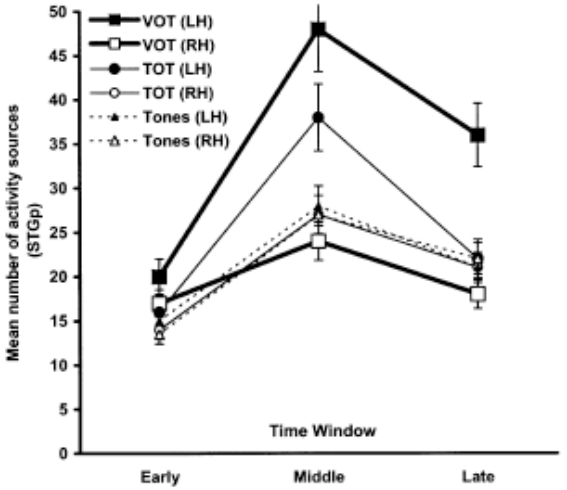


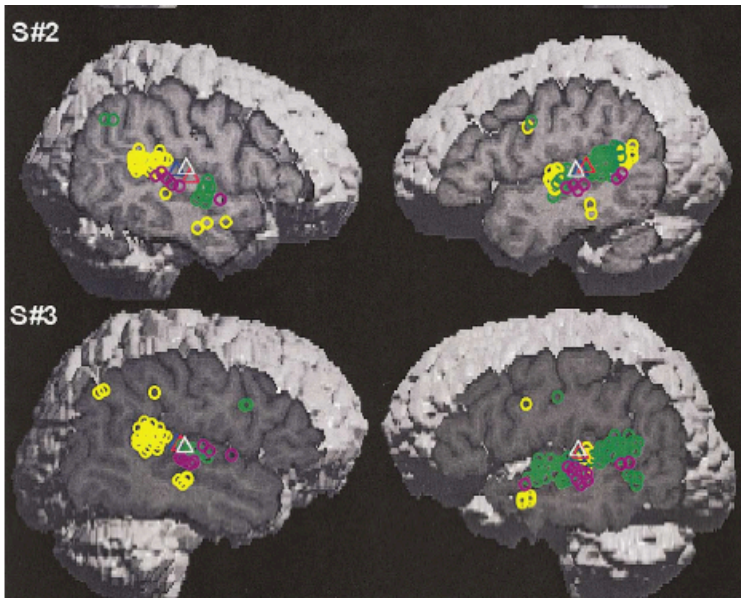
Right Handed Patient-
Left dominance for language

Trébuchon et al, 2005

Superiority of left hemisphere for VOT processing







Papanicolaou et al, 2003

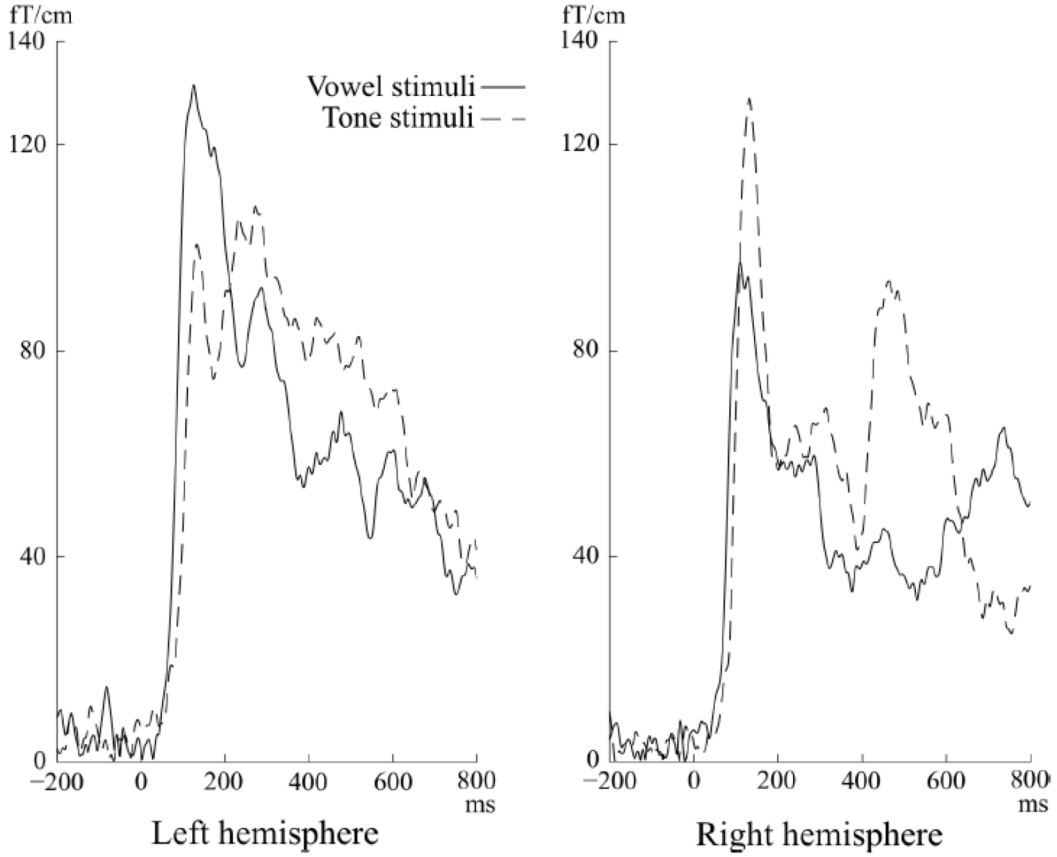
Superiority of left hemisphere for vowel processing

PLOS ONE

RESEARCH ARTICLE

A simple magnetoencephalographic auditory paradigm may aid in confirming left-hemispheric language dominance in epilepsy patients

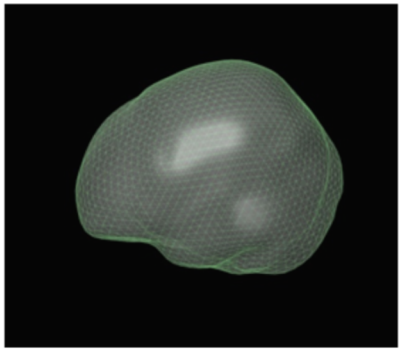
Juha Wilenius[1]*, Henri Lehtinen[2], Ritva Paetau[1,2], Riitta Salmelin[3], Erika Kirveskari[1]



Simultaneous recording MEG-SEEG

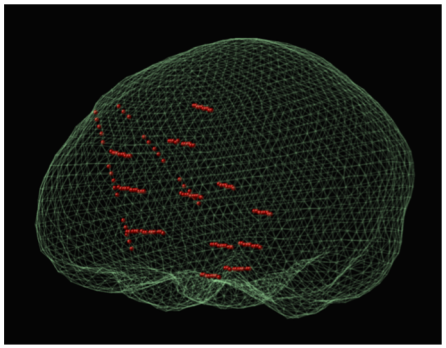
Reconstruction of virtual electrode

1



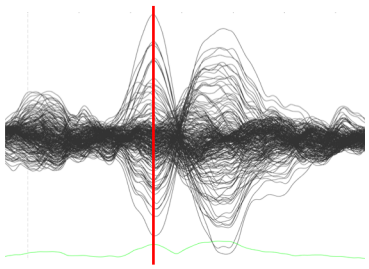
Media model: construction of a biophysical model of the Head

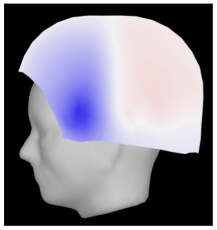
2

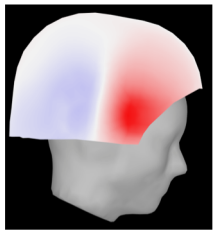


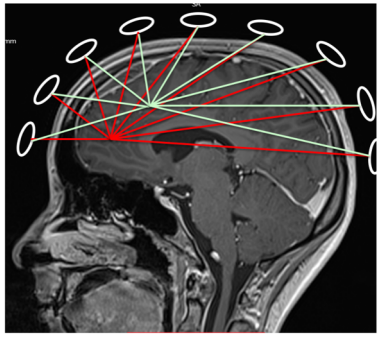
Source model: Virtual electrodes for each contact of the depth electrodes

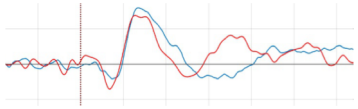
3





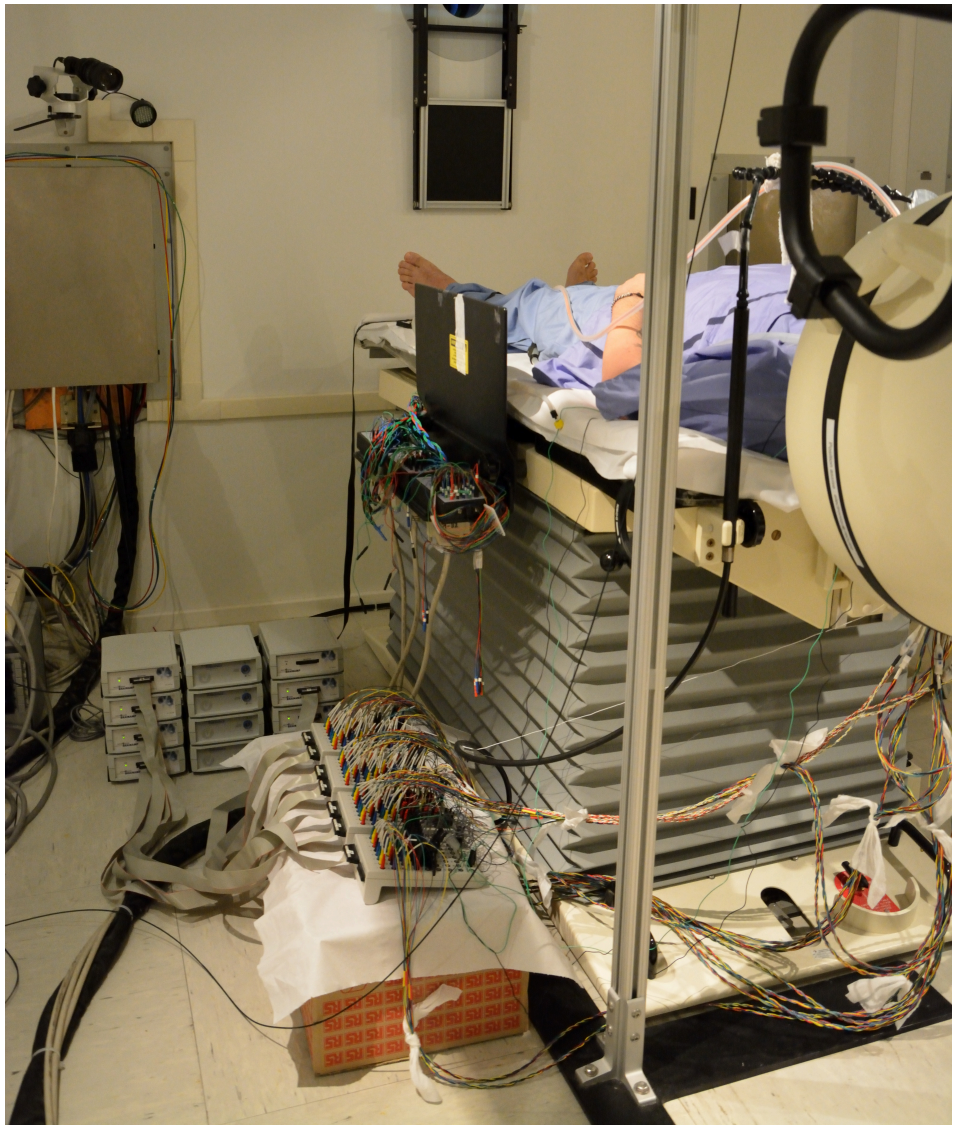


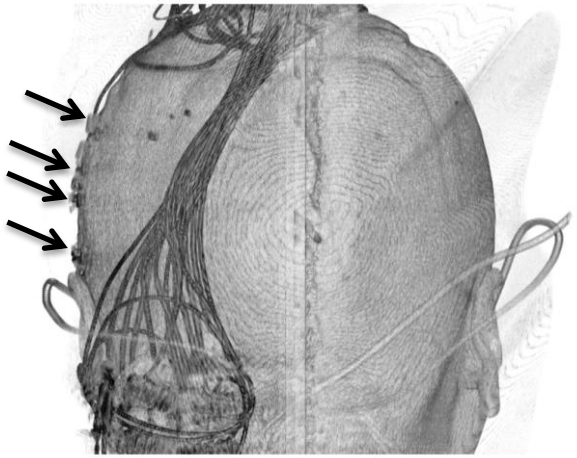




Reconstruction of the temporal time course of the virtual electrode by spatial filtering.
This uses the source model and the information coming from the time course of each epoch

Simultaneous recording for validation





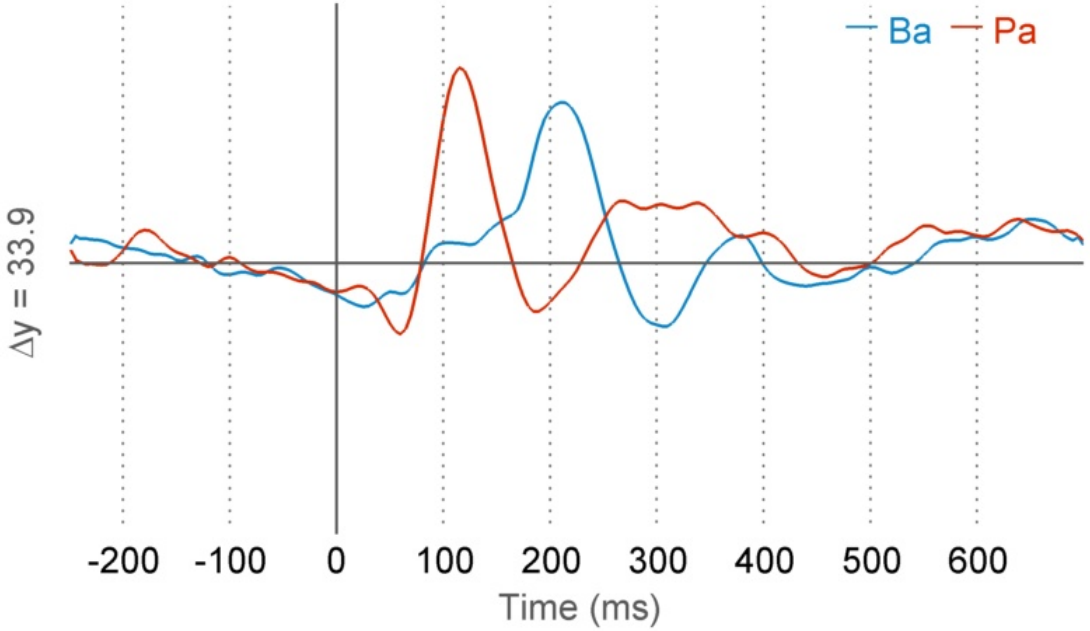
C

- Low profile for electrode support
- 248 magnetometers. 3600WH 4D Neuroimaging MEG
- 256 channel Brainamp EEG
- Optically insulated
- Battery operated amplifiers

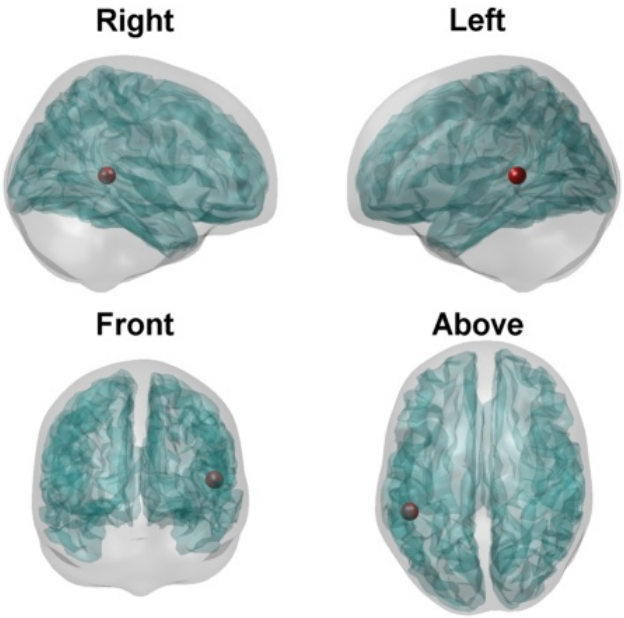
Dubarry et al. 2015. Badier et al. 2017

Source reconstruction by spatial filtering (LCMV)

Language lateralization from MEG data



Auditory stimulation /Ba/ and /Pa/

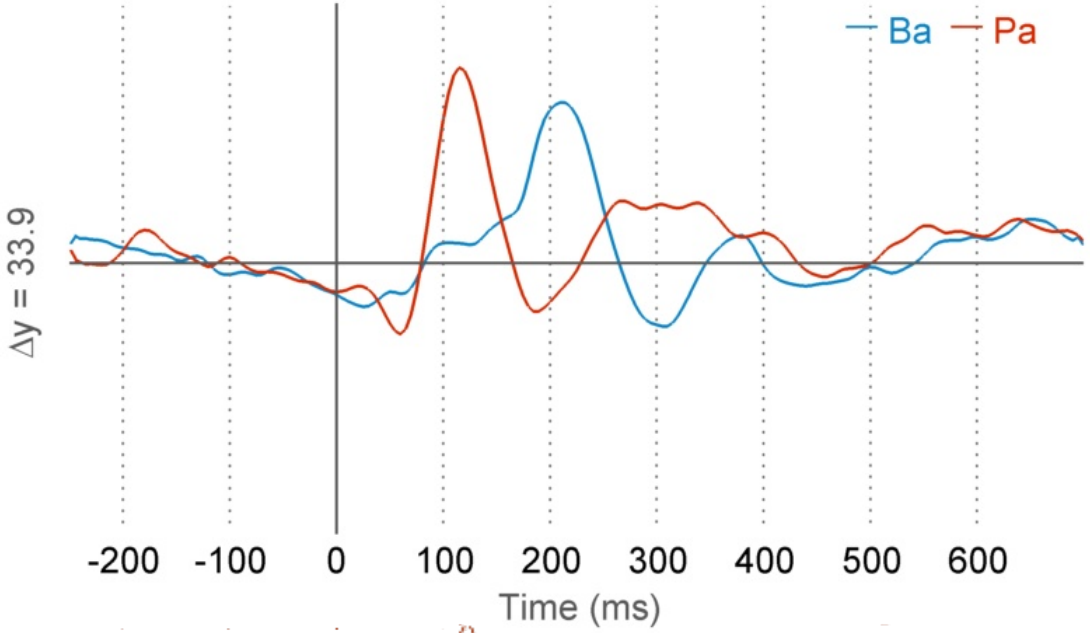


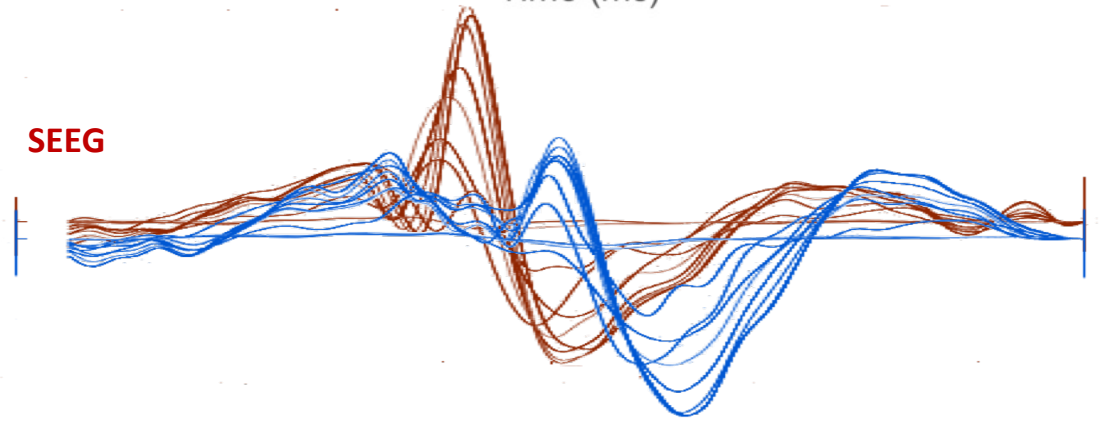
Source location

Zielinski et al. In prep

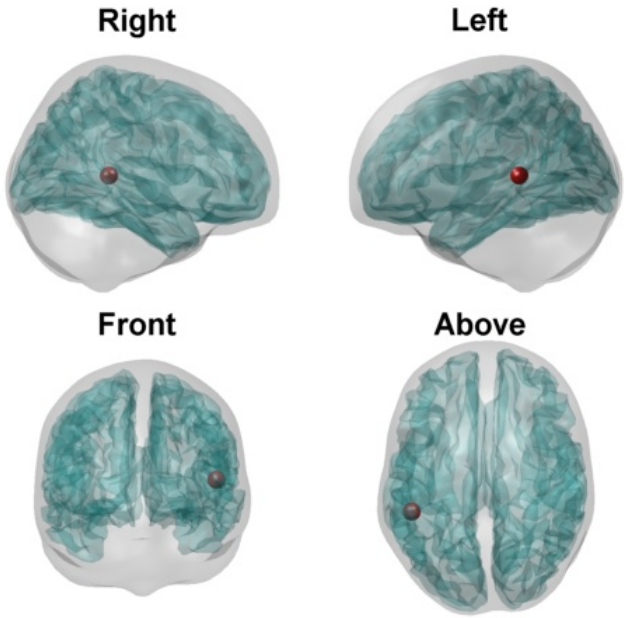
Source reconstruction by beamforming (LCMV)

Language lateralization from MEG data





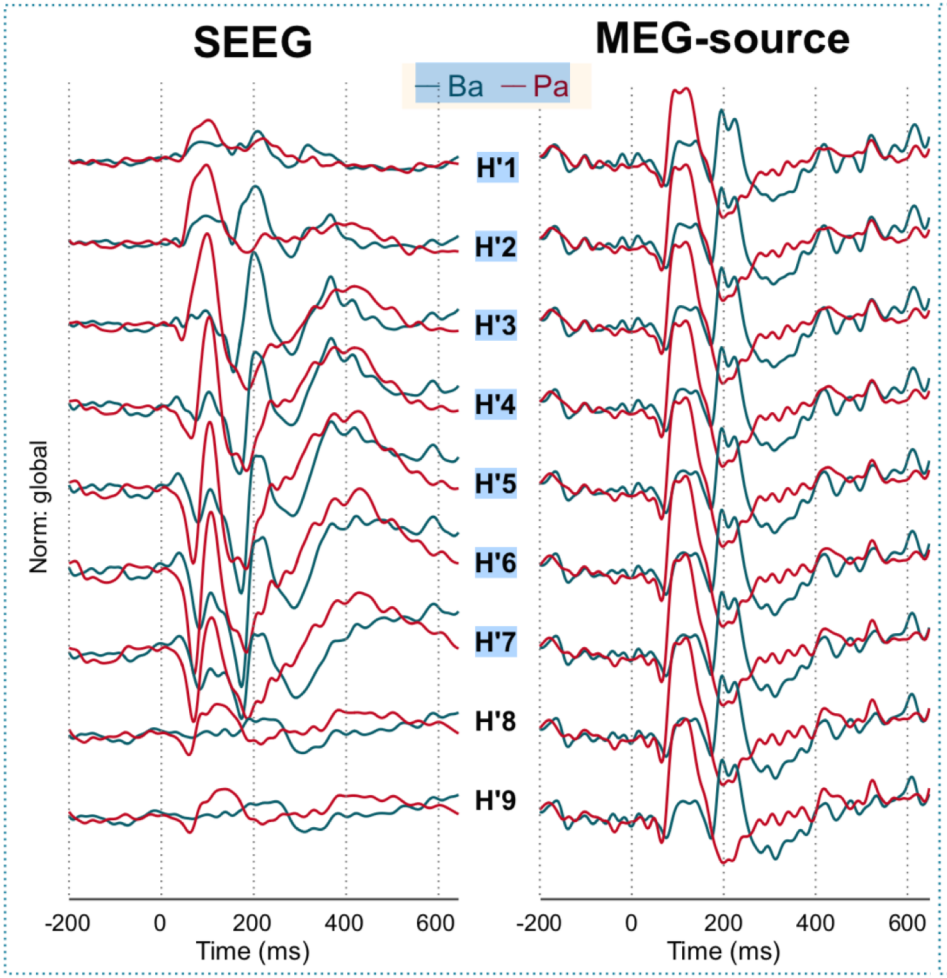
Auditory stimulation /Ba/ and /Pa/

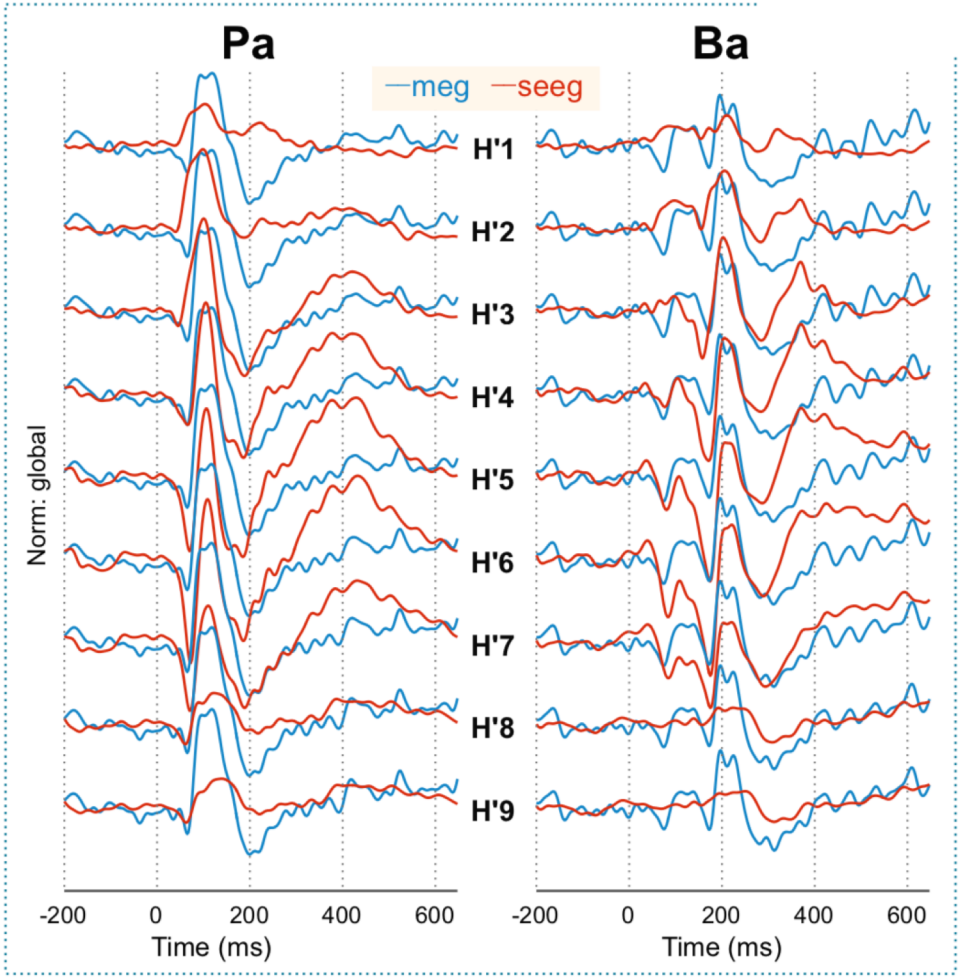


Source location

Zielinski et al. In prep

MEG – SEEG





Good time course reconstruction

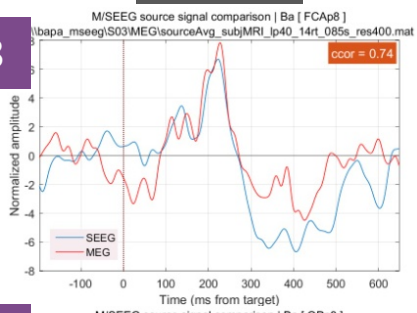
Spread of response: leakage effect

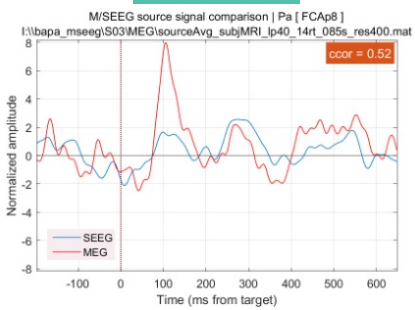
SEEG vs MEG in other areas

Ba

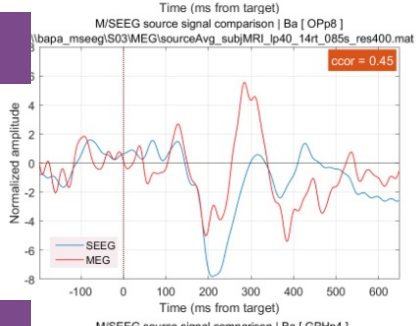
Pa

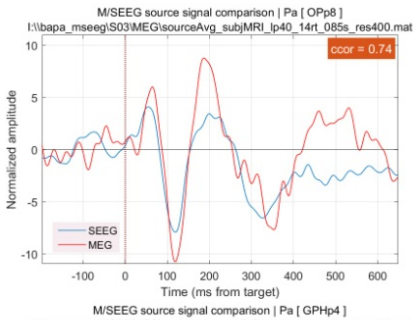
FCAp8



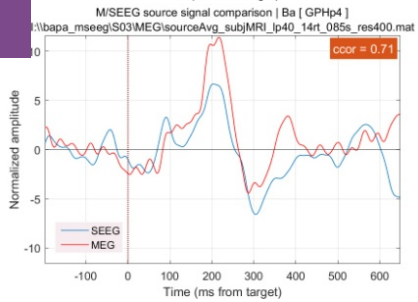


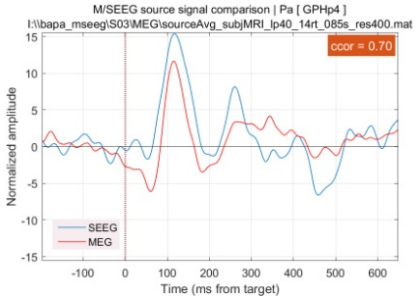
OPp8



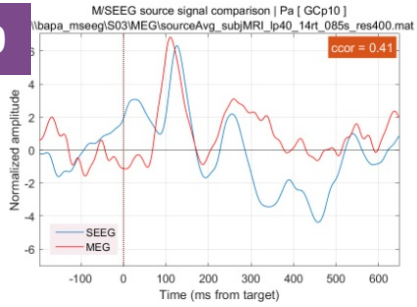


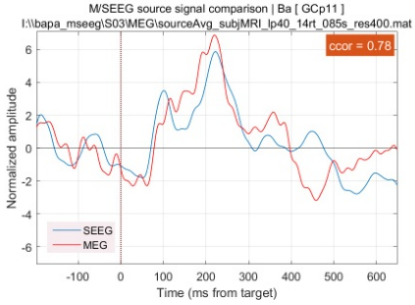
GPH4





OCP10

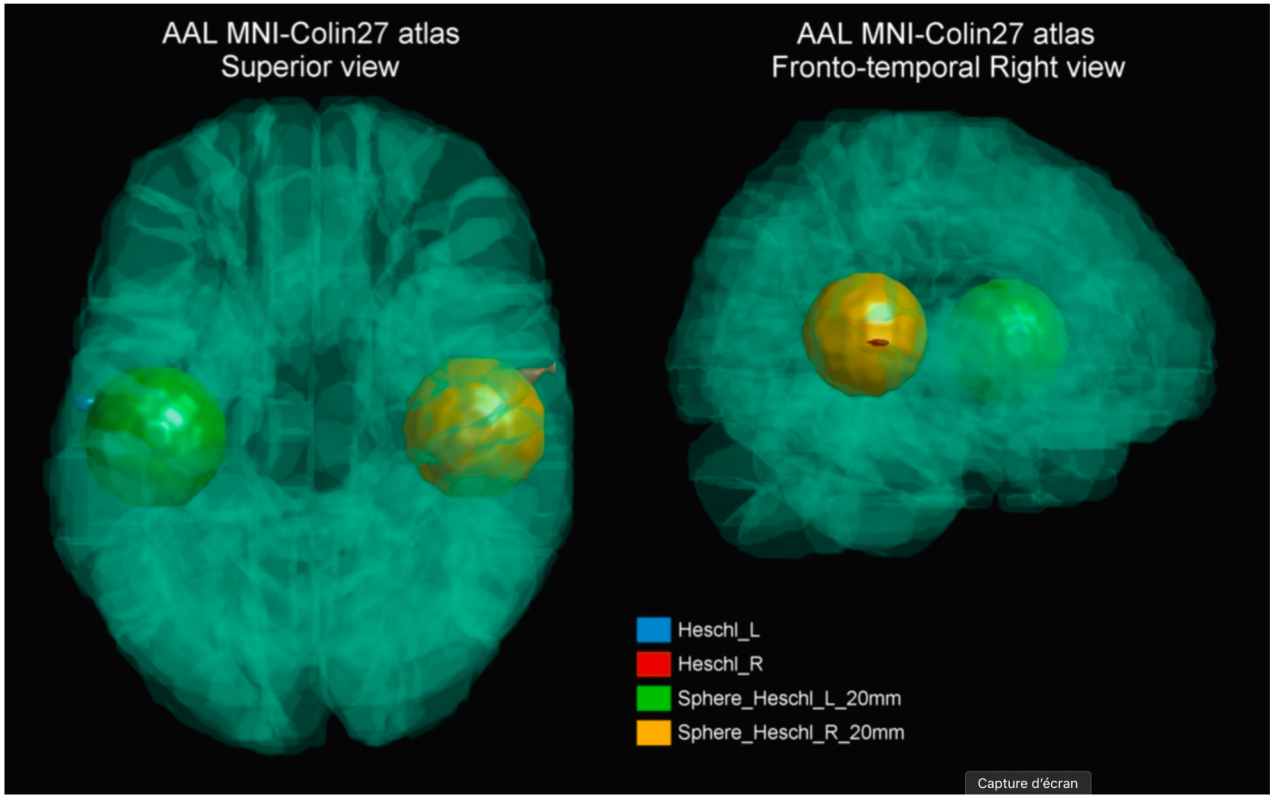


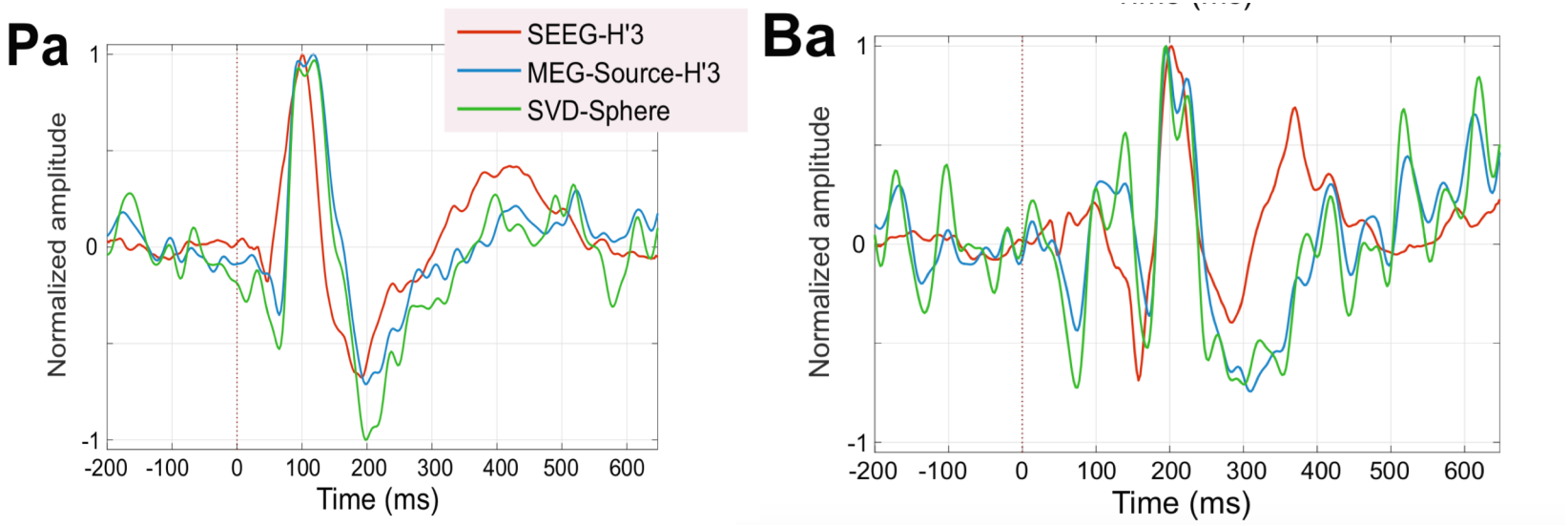


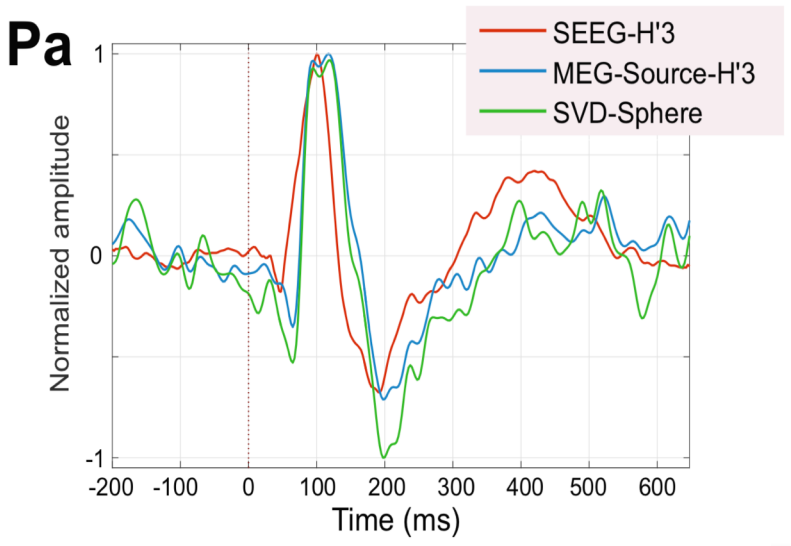
SEEG vs MEG

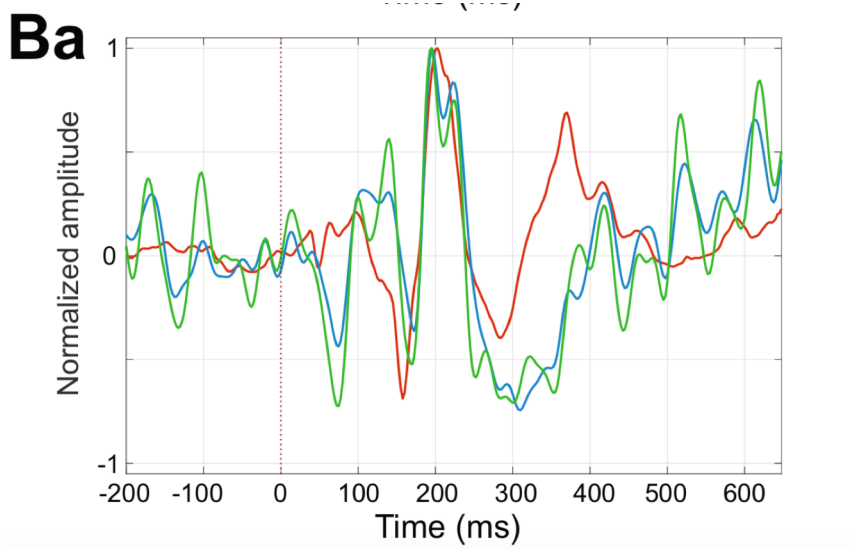
Without MRI ?

- Head model: template (Colin 27)
- Source model: 3D grid of dipole uniformly spaces of 10 mm. The dipole retains are the one contained on a sphere (one for each side) centered around Heschl gyrus (104 dipoles).
- The first component of the resulting singular value decomposition (SVD) of the 104 dipoles is taken as the reconstruction.

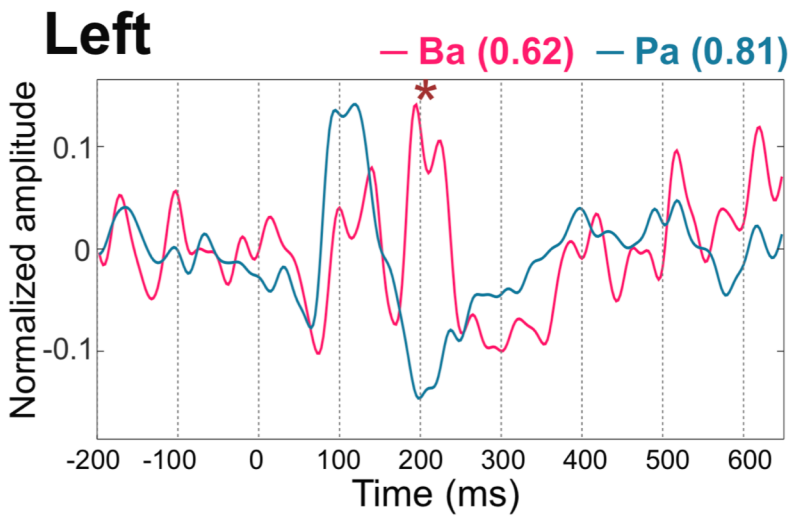


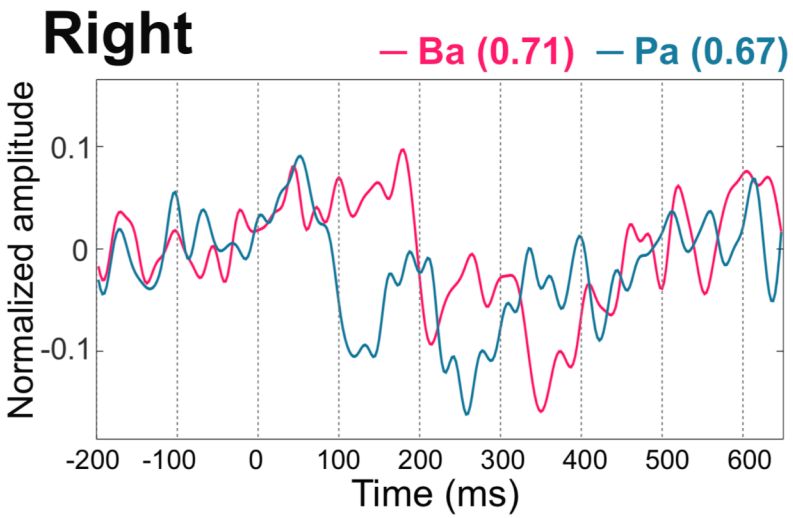

Pa
SEEG-H'3
MEG-Source-H'3
SVD-Sphere
Normalized amplitude
1
0
-1
-200
-100
0
100
200
300
400
500
600
Time (ms)
Ba
Normalized amplitude
1
0
-1
-200
-100
0
100
200
300
400
500
600
Time (ms)





Evoked responses for MEG-SVD-Sphere





Functional mapping by MEG

- Accurate reconstruction of the time courses
- Reconstruction for both hemisphere
- Spatial resolution limited by the « leakage » effect. Sources appear to be more extended that seen by the SEEG recording
- Application to other cortical areas/cognitive processes (somatosensory responses, memory, reading…)
- Reconstruction of activities from depth structure to be validate
- Possibility to obtain similar results without MRI

Conclusion

1- Hemispheric lateralization for speech could result from an asymmetry of cortical tuning with the left and right auditory areas differentially sensitive to spectro-temporal features of speech.

2- The auditory cortex (Heschl's gyrus and PT) in the dominant hemisphere is crucial to the phonemic acoustic perception.

3- Language lateralization could be seen as a continuously graded rather than an all-or-none phenomenon, with relative degrees of dominance rather than distinct categories.

4- MEG is a reliable tool to assess Hemispheric dominance

Thank you for your attention

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