Auditory Functional Mapping. Validation by simultaneous depth and MEG recordings
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Introduction

Epilepsy surgery requires the functional mapping of brain functions that might be affected. Recordings of evoked potentials during pre-surgical exploration by intracranial electrodes give very accurate information. These activities can also be obtained from non-invasive measurements (EEG or MEG). However, reconstructing the activity of a given cortical region requires the use of methods and models that are still discussed.

In this study, we recorded simultaneously from intracranial electrodes and MEG sensors the activities evoked at the level of the auditory cortex in response to verbal sounds /ba/ and /pa/ and the electro-physiological index of hemispherical lateralisation (Lêgeois-Chauvel et al. 1999²). Trébuchon et al. 2005[5]. We used a spatial filtering technique to obtain, from the MEG measurements, the temporal time course of the evoked activities at the level of virtual electrodes defined at the location of the contacts of the intracranial electrodes - thus allowing the comparison between these reconstructed responses and those coming from the intracranial measurements.

Methods

Patient
- Women 43 years old suffering for a left frontal lobe epilepsy
- SEEG: 13 electrodes in the left frontal and temporal lobes, 1 electrode in the right frontal lobe. The reconstructions are given here for the two electrodes exploring the left auditory cortical areas (electrode H').

Acquisition
- Simultaneous MEG/SEEG detail protocol in Dubarry et al., 2014[8] and Badier et al., 2017[10]
- MEG: 248 full magnetometer system (3600WH 4D Neuromaging). Sampling frequency 2034.51 Hz
- SEEG: 219 channels (BrainAmp®). Sampling frequency 2500 Hz.
- MEG and SEEG are synchronized through the stimulation triggers.
- /ba/ and /pa/ displayed in random order, N=250 each, ISI 0.8-1.2 s.
- Fiducial points (supraorbital 1 and 2, external angles of the eyes, ear tragus) for the registration of the MEG (digitization 0.95 mm).
- Source model: 3D grid of dipole uniformly spaced of 10 mm. The SVD of the 104 dipoles is taken as the reconstruction.
- Source reconstruction (inverse solution) by spatial filtering (LORETA[15])
- The spatial filter provides the evoked response estimated for each SEEG contact from the MEG recordings: virtual electrodes

Data analysis
- Preprocessing(MEG & SEEG)
  - filtering 0.5 - 40 Hz
  - resampling 400 Hz
  - epoching -200 to 650 ms
  - averaging for MEG sensors and SEEG recordings

Supplementary analysis
- Head model: anatomical registration between MEG and MRI by fiducial points and head surface matching.
- Determination of the SEEG contact coordinates (Epitools[13]).
- Estimation of the SEEG contact coordinates (Epitools[13]).
- Source reconstruction (inverse solution) by spatial filtering (LORETA[15]).
- Spatial filter provides the evoked response estimated for each SEEG contact from the MEG recordings: virtual electrodes

Results and discussion

BA vs PA
- SEEG vs MEG virtual electrode reconstructions

Norm: global
- For comparison purpose a normalization based on the maximum amplitude for each modality have been performed.

Evoked response for the different modalities
- MEG-source
- SEEG-H'3
- SEEG-H'4
- SEEG-H'5
- SEEG-H'6
- SEEG-H'7
- SEEG-H'8
- SEEG-H'9
- SEEG-O'C

Evoked response for the different modalities
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The temporal responses of the virtual sources obtained by spatial filtering of MEG data are similar to those obtained by SEEG data both in the primary auditory cortex region and for more distant regions.

The responses obtained in SEEG remain more focused than those obtained in MEG, which confirms the phenomenon of "source leakage" which tends to show a less punctual localization than expected and is due to the properties of the gain matrix.

The answers obtained in MEG are able to allow a functional mapping of the auditory cortex areas. It is possible to obtain close results without the contribution of the MNI of the patient (c supplementary analysis)