Magnetoencephalography as a powerful tool in clinical research: approaches to improve the signal/noise ratio in clinical environments

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Introduction

Magnetoencephalography (MEG) is a noninvasive functional imaging technique that is able to detect the very feeble magnetic fields generated by neuronal activity with a good spatial resolution (<1 cm) and an excellent temporal resolution (msec). Compared to EEG, MEG offers a better source localization, due to the reduced signal distortion. Nowadays, MEG is used in some clinical conditions such as preoperative assessment of brain tumors and intractable epilepsy. More recently, MEG has been applied to other neurological conditions such as neurodegenerative diseases, multiple sclerosis, migraine, and to study recovery after stoke. However, in the clinical practice the high sensitivity of the system poses challenges to keep a low signal – to – noise ratio as the hospital environment is magnetically noisy.

Objectives

In order to use MEG in clinical environments it is mandatory to set up strategies and methods to improve the signal/noise ratio[1]. To this aim we used an approach based on principal and independent component analysis (PCA, ICA).

Material and Methods

Our MEG system has been developed by the CNR Institute of Applied Sciences and Intelligent Systems "E. Caianiello" and is located in the clinic Hermitage Capodimonte in Naples. The sensor array consists of a 154 magnetometers covering the whole head. Three additional triplets are used as references. The device is operating inside a magnetically shielded room.

In order to remove artifacts from the signals and improve the signal/noise ratio a preprocessing was carried out. Environmental noise has been removed subtracting the signal recorded by reference sensors. ICA has been used to identify and remove blinking and cardiac artifacts.

Results

Our approach is able to significantly reduce the environmental noise improving the signal/noise ratio. More specifically, it is able to remove the noise deriving from mechanical vibrations and biological artifacts, at frequencies of biological interest.

Discussion

When MEG device is located in a clinical environment, many sources of external disturbs may be present. Artifacts may arise by environmental noise due to mechanical (vibrations) or electromagnetic (monitors, air conditioning, elevators) origin. The magnetically shielded room generally reduces efficiently the electromagnetic noise. ICA represents a powerful approach to reduce the noise derived by biological artifacts, while the reference cleaning through PCA allows to minimize interferences caused by micro-vibrations, thereby obtaining a reliable MEG signal.

Conclusions

Approaches to cut the interference of mechanical origin are expensive and hard to apply. This relatively simple and cheap approach might help introducing MEG in settings otherwise not suitable for these studies.

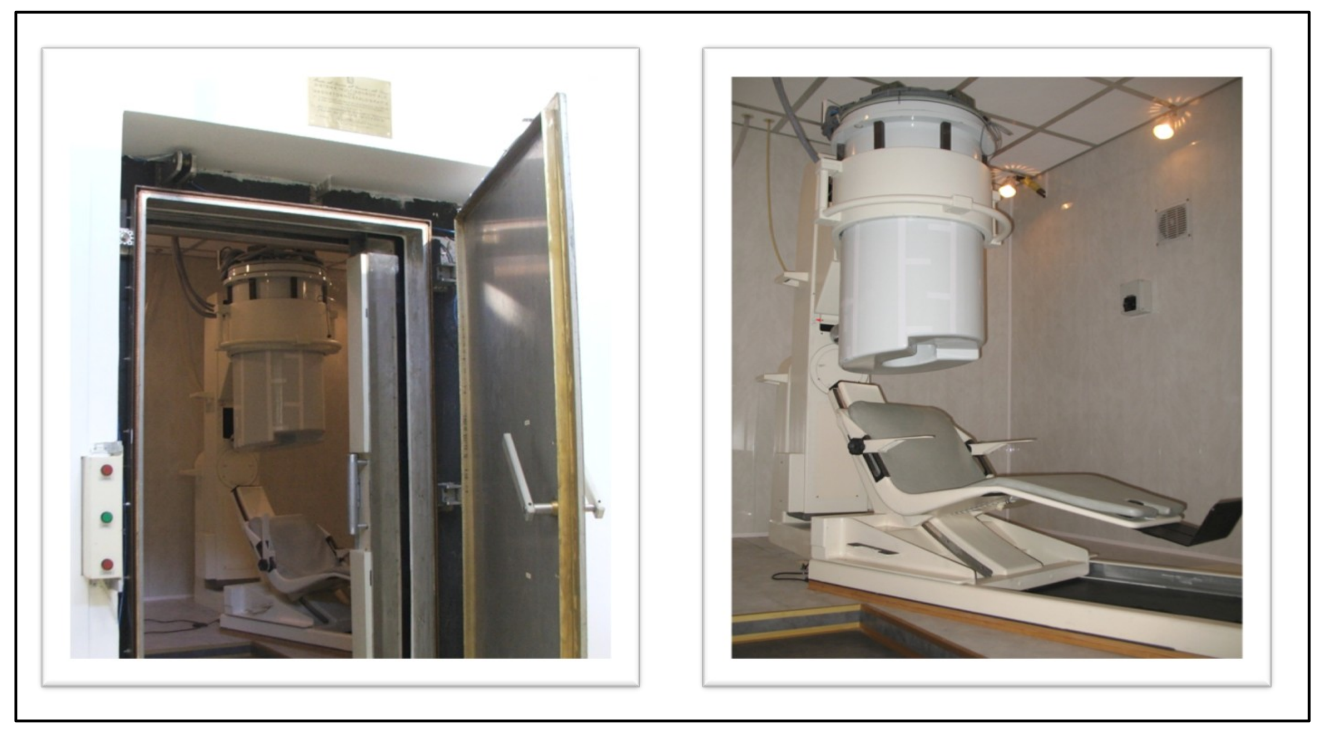

Figure 1 – Magnetoencephalography inside a magnetically shielded room

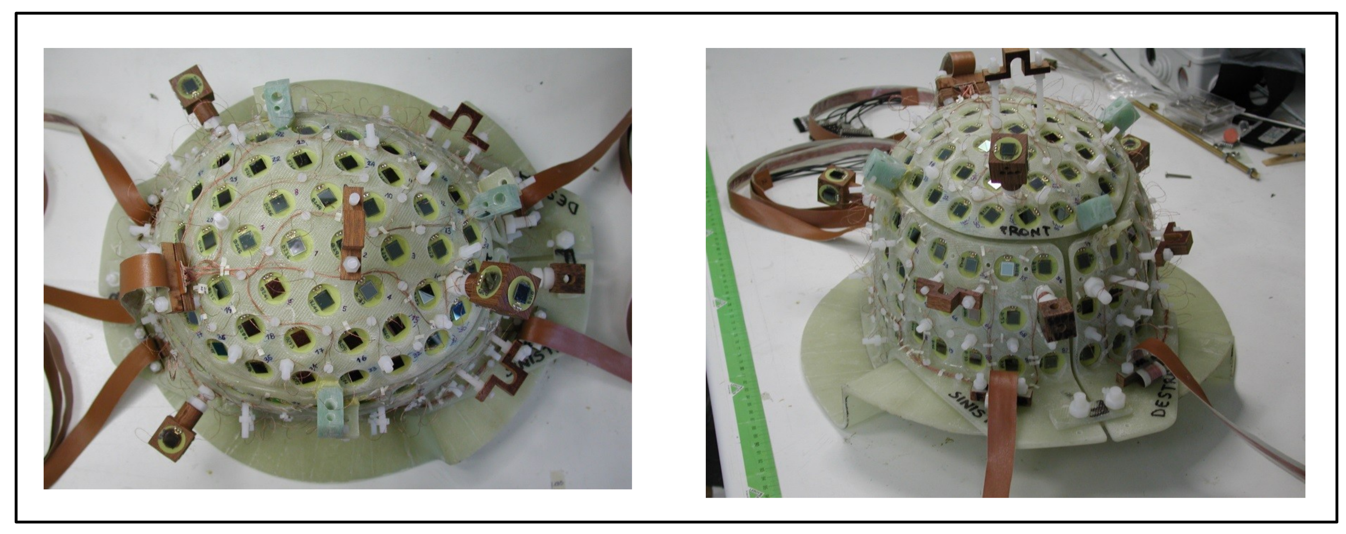

Figure 2 – Helmet shaped sensor array

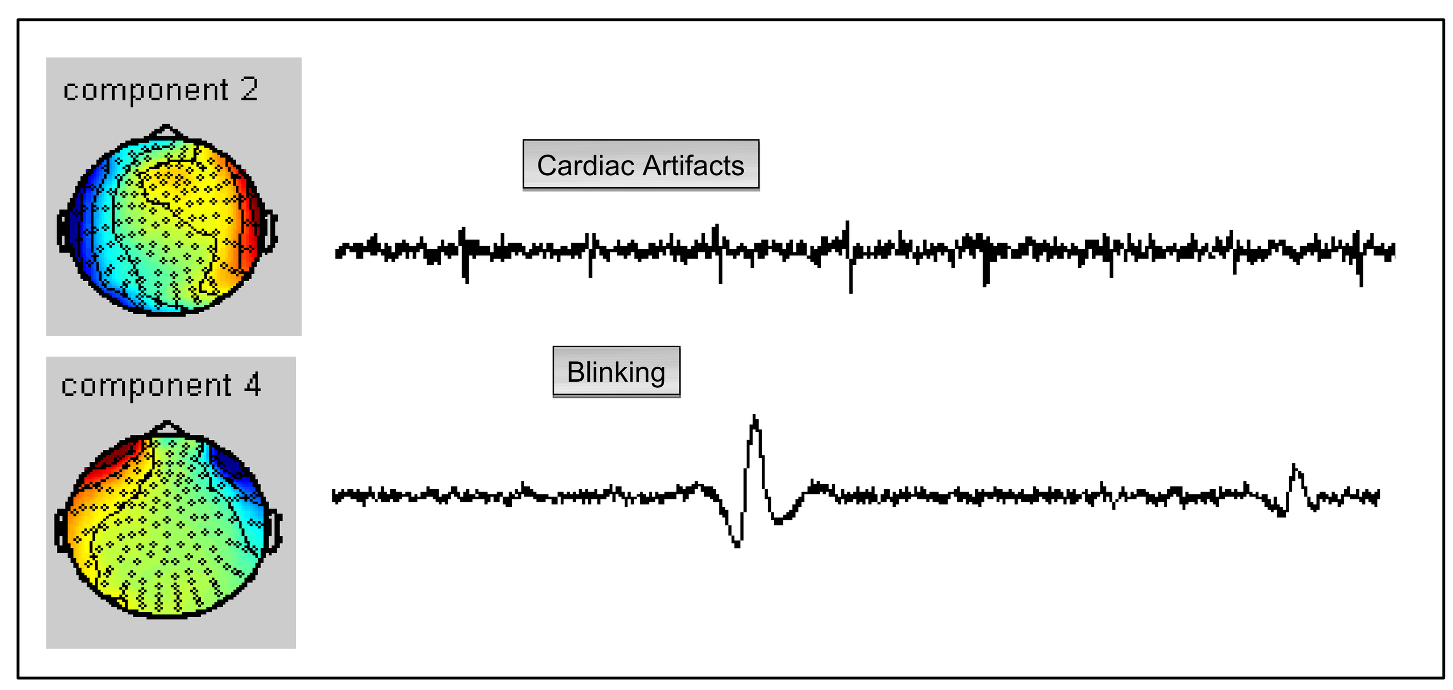

Figure 3 – Physiological artifacts

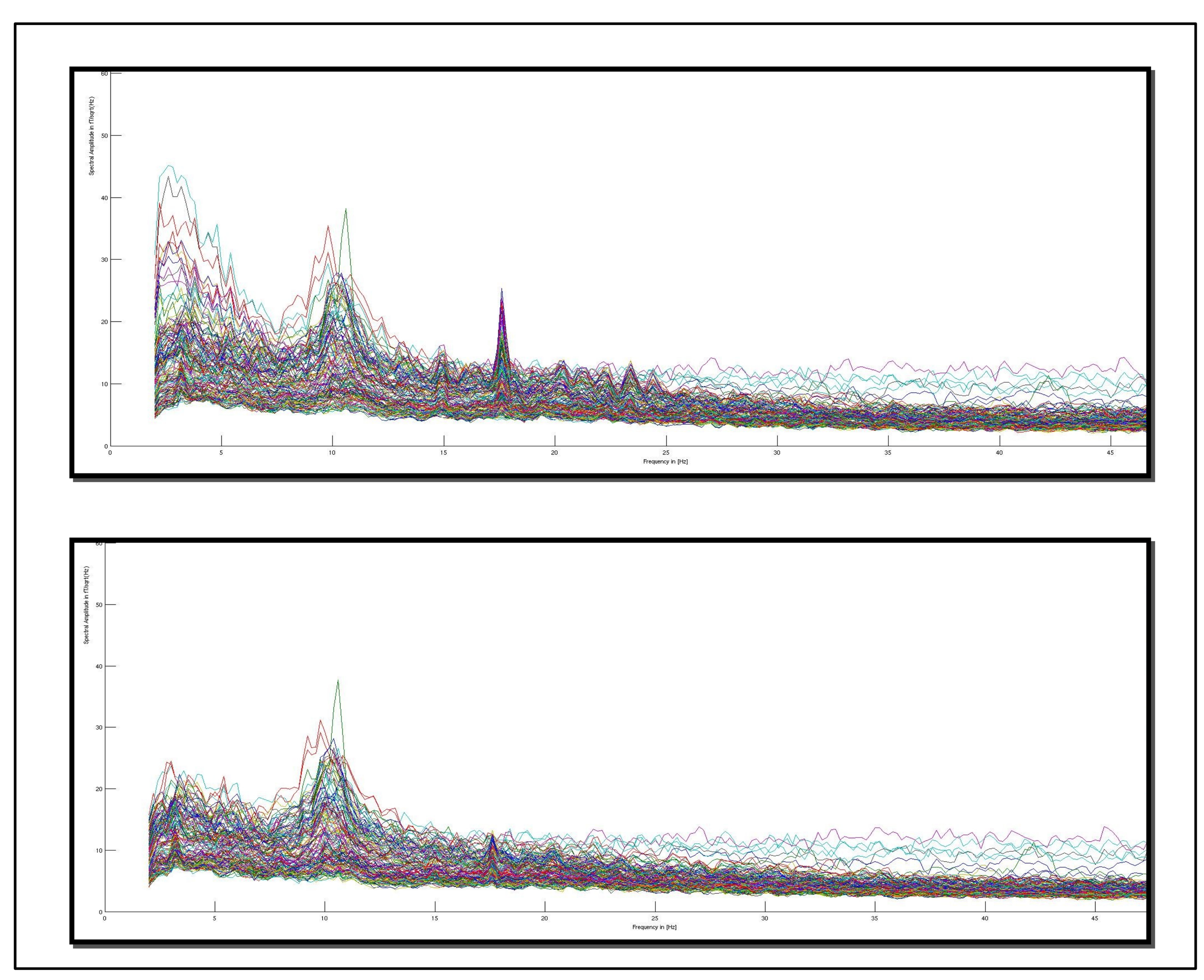

Figure 4 – Power Spectrum of rhythm alpha [8-10Hz] pre and post cleaning with PCA

References

Gross J, Baillet S, Barnes GR, Henson RN, Hillebrand A, Jensen O, Jerbi K, Litvak V, Maess B, Oostenveld R. *Good practice for conducting and reporting MEG research.* Neuroimage. 2013;65:349-63.

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