

SPM COURSE ADVANCED EEG: EEG/fMRI

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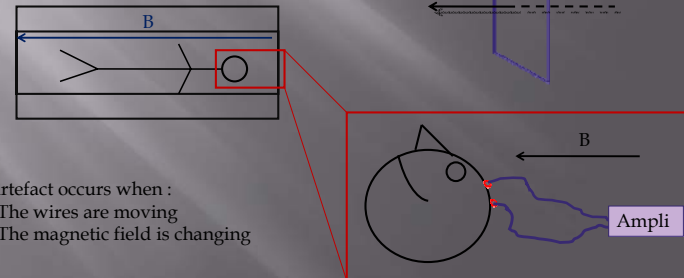


Why is there artefacts in EEG recorded during fMRI acquisition ??

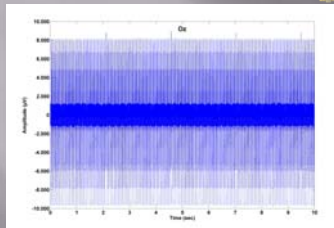
Faraday's Law: $\mathcal{E} = - \frac{d\Phi_B}{dt}$

Electromotive Force
Variation of magnetic flux

Ok... But what does it mean practically ?



Artefacts introduced in EEG during fMRI use

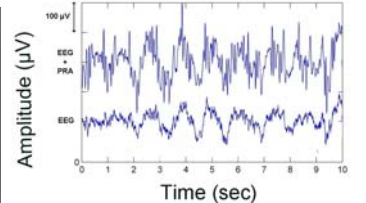


Gradient Related Artefact (GRA) :

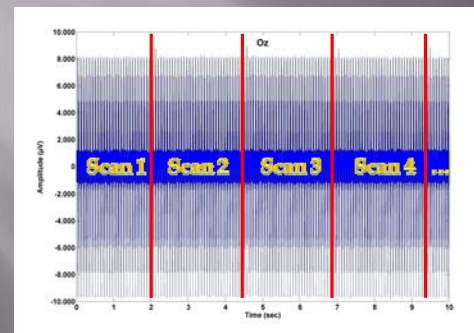
Large artefact induced by the variation in the magnetic field required for a fMRI acquisition.

Pulse Related Artefact (PRA) :

Slight movement of the human body and pulsatile movement of the scalp arteries at each heartbeat are the causes of the PRA.



GRA Rejection : Average Artefact Subtraction (AAS)



Methods

- 1) Compute a GRA template using the mean of the n last scan.
- 2) Subtract the GRA template from the current EEG.

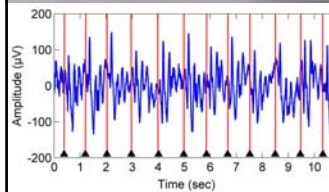
Results

Rejects efficiently the GRA both on- and off-line.

Need to have the **PRECISE** timing of scans !
⇒ Synchronize EEG & fMRI clocks.

PRA Rejection: classic approaches

A) Channel-Wise Methods



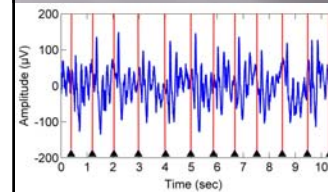
AAS method:

Same idea than Allen's AAS Rejection for GRA : for each channel, the mean of the n last occurrence of the PRA is subtracted from the EEG.

Limitation: Does not capture the beat to beat changes in the artefact.

PRA Rejection: classic approaches

A) Channel-Wise Methods



AAS method:

Same idea than Allen's AAS Rejection for GRA : for each channel, the mean of the n last occurrence of the PRA is subtracted from the EEG.

Limitation: Does not capture the beat to beat changes in the artefact.

- PCA method:**
- 1) For each EEG channel, a matrix S is formed: each row is filled by an artefact occurrence.
 - 2) A PCA is performed on S and the 3 first PC's are retained.
 - 3) These PC's are fitted to the original signal and the fitted signal is subtracted.

Limitation: Sometimes suppresses some part of the true underlying EEG signal

PRA Rejection: classic approaches

B) ICA Methods

- Classic ICA method:**
- 1) Each EEG channel is considered as a mixture of sources.
 - 2) The algorithm looks for a demixing matrix allowing to compute the *independent* sources from the channels.
 - 3) The artefacted sources are identified and suppressed. The sources are projected back in the signal space.

Limitation:

- Non robustness of the algorithm. (random initialisation)
- The choice of the sources to suppress is a problem.

PRA Rejection: classic approaches

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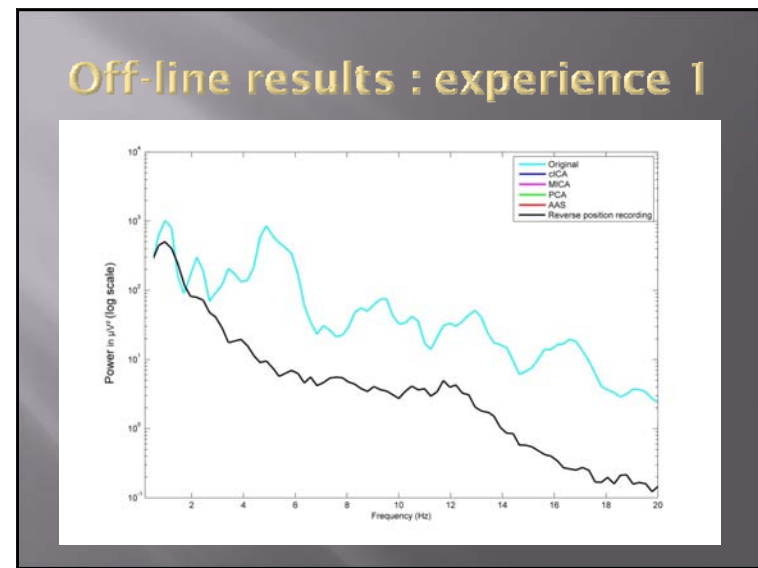
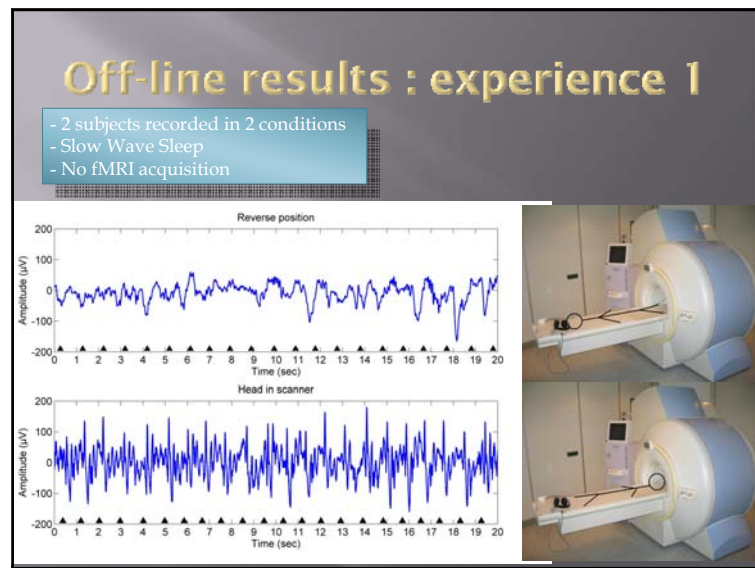
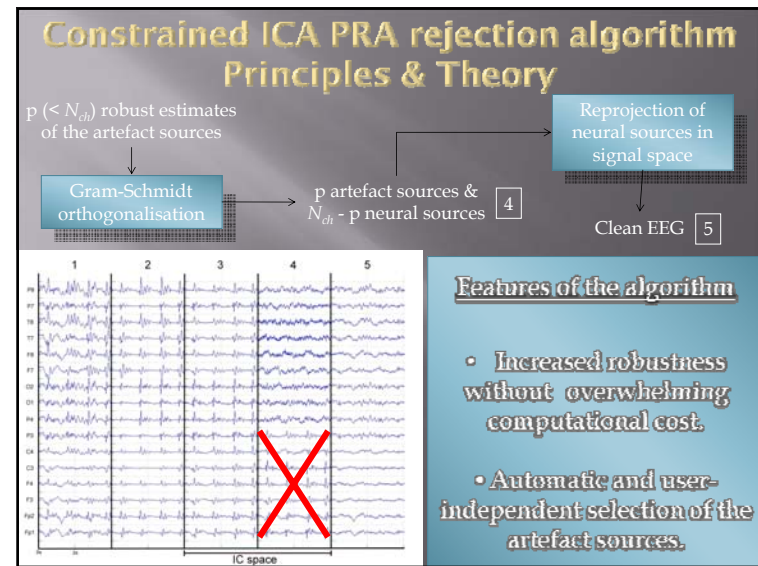
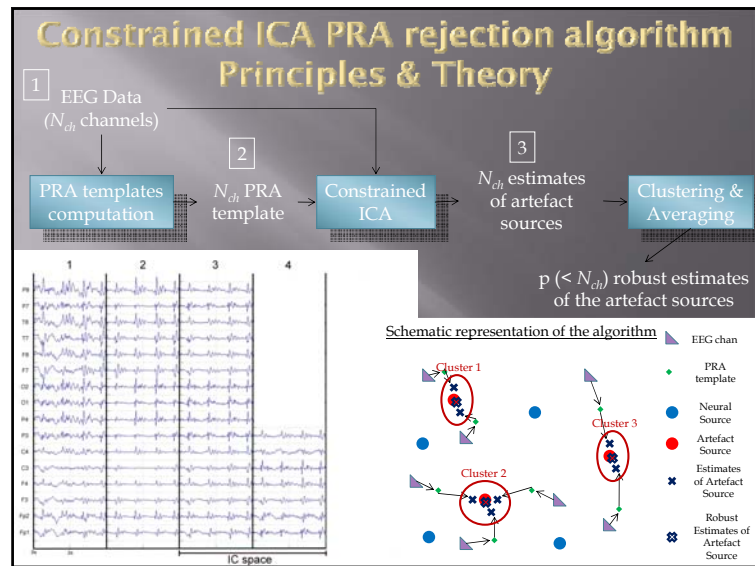
Limitation:

- Non robustness of the algorithm. (random initialisation)
- The choice of the sources to suppress is a problem.

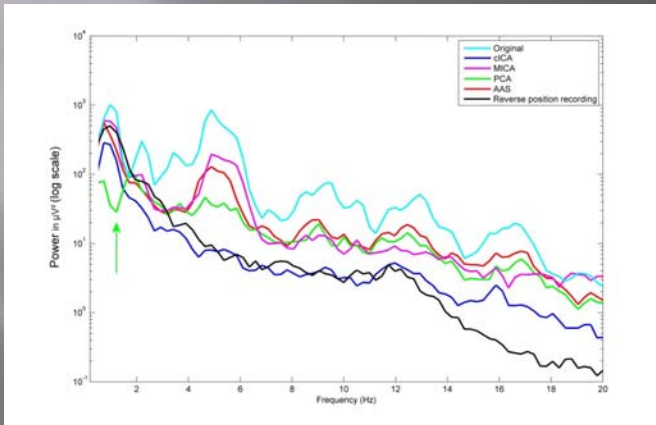
- Multi-ICA method:**
- 1) ICA solutions are computed n times
 - 2) The mean of the n corrected signals are computed.

Limitation:

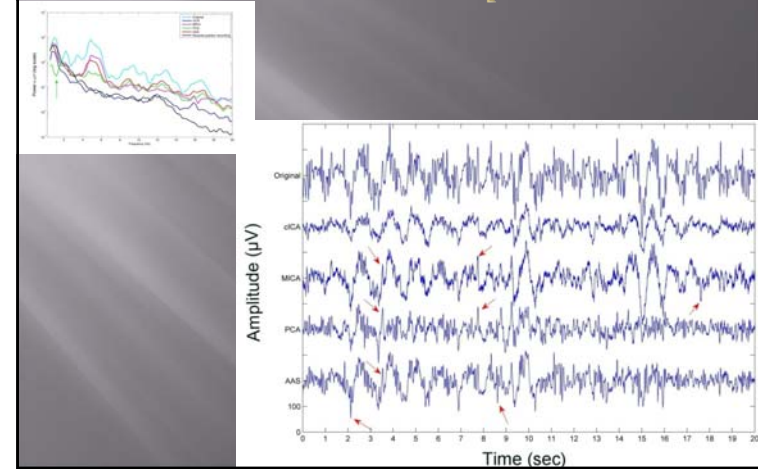
- Computational cost.
- The choice of the sources to suppress is a problem.



Off-line results : experience 1

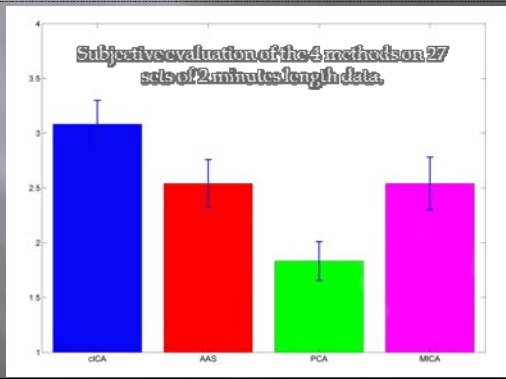


Off-line results : experience 1

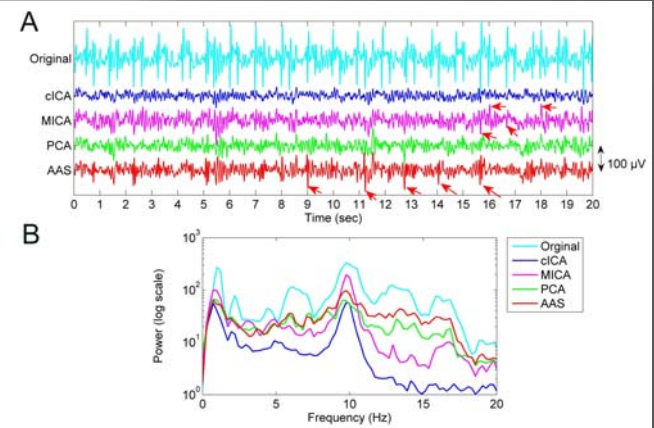


Off-line results : experience 2

- 9 subjects
- 3 states of consciousness : awake, stage 2 sleep and slow wave sleep

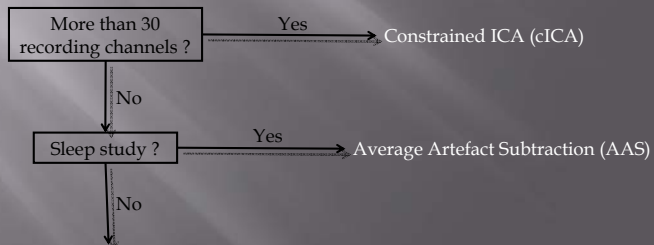


Off-line results : experience 2



Matlab/FASST practical Demo

- First suppress the gradient artefact.
- Then suppress the pulse (or BCG) artefact using the appropriate method.



Principal Component Analysis (PCA)

EEG-fMRI integration

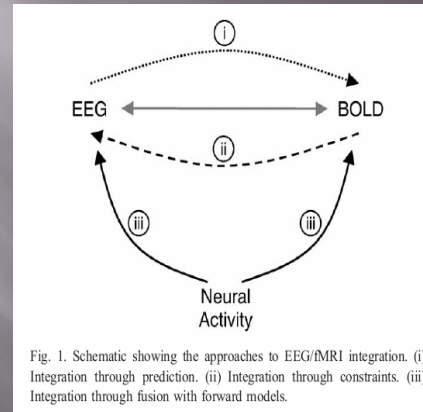
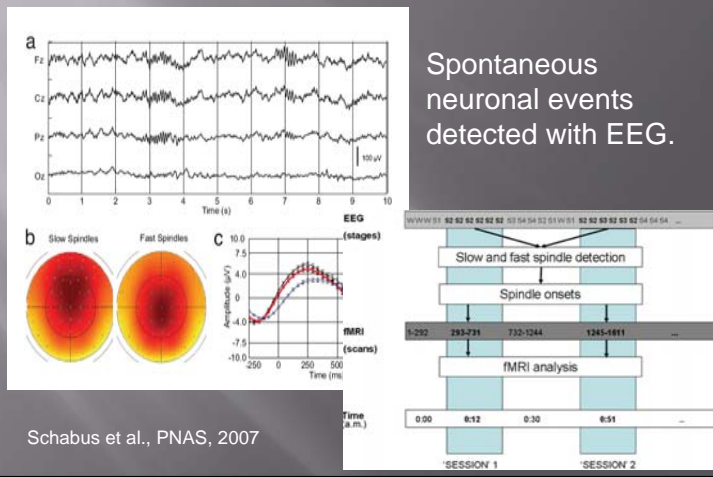


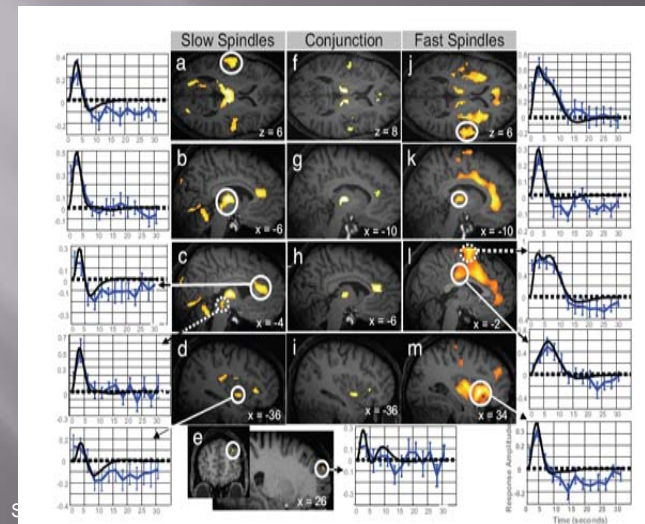
Fig. 1. Schematic showing the approaches to EEG/fMRI integration. (i) Integration through prediction. (ii) Integration through constraints. (iii) Integration through fusion with forward models.

Kilner et al. NeuroImage, 2005.

Application example 1



Schabus et al., PNAS, 2007



Acknowledgement & references

Acknowledgement:

Christophe Phillips
Pierre Maquet
Mannel Schabus
Thanh Dang-Vu
Evelyne Balteau
Laura Mascetti
Arlane Forêt

Audrey Vanhaudenhuysse
Julien Grandjean
Emeline Verdin
Virginie Sterpenich
Christina Schmidt
Quentin Noirhomme

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