ICA Application

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EEGLAB Workshop 2007

Outline

- Why use ICA?
- Results from ICA analyses
  - Frontal midline theta in working memory
  - Visual cueing and discrimination task
  - Spectral changes during emotional imagery

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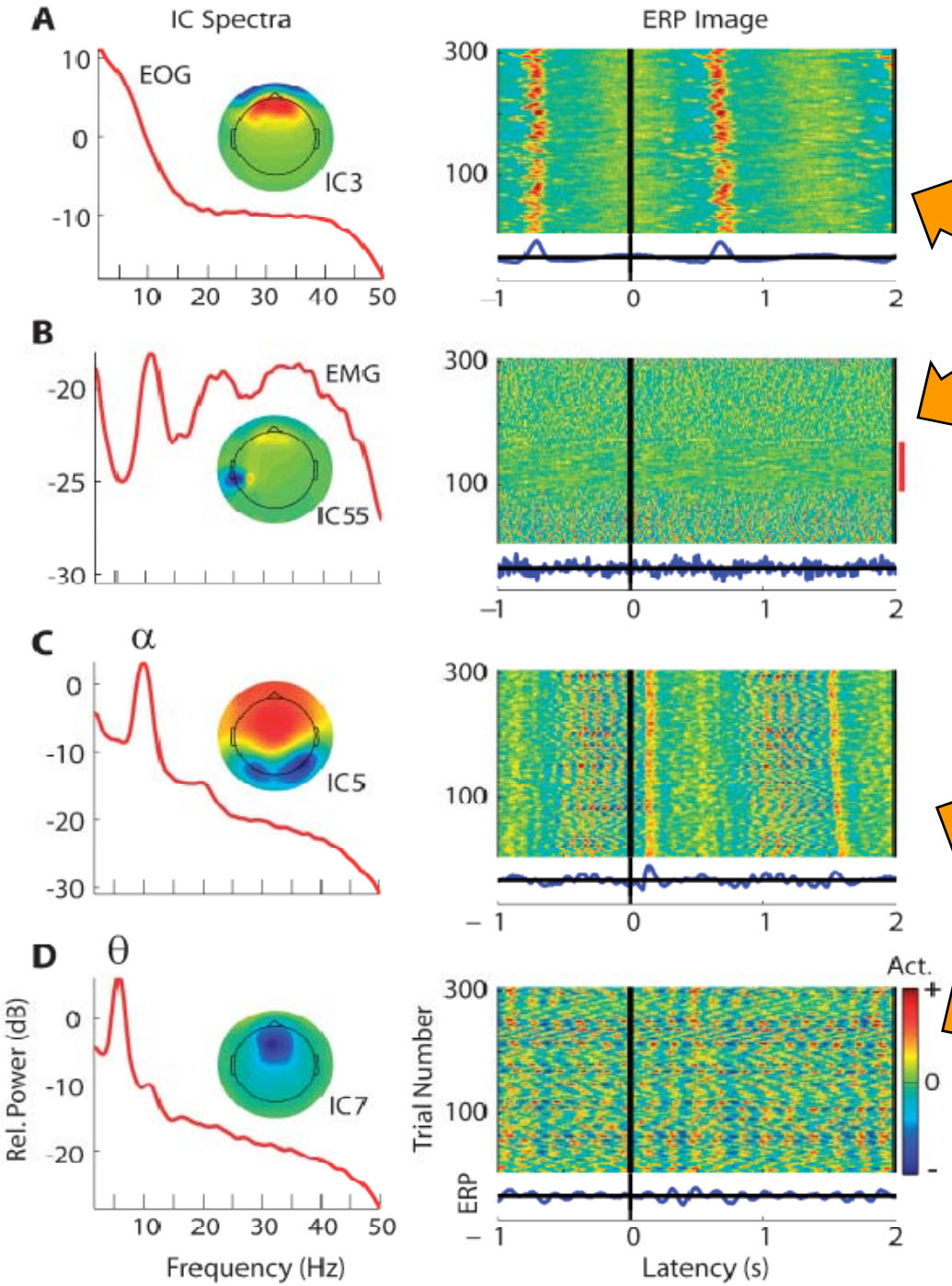
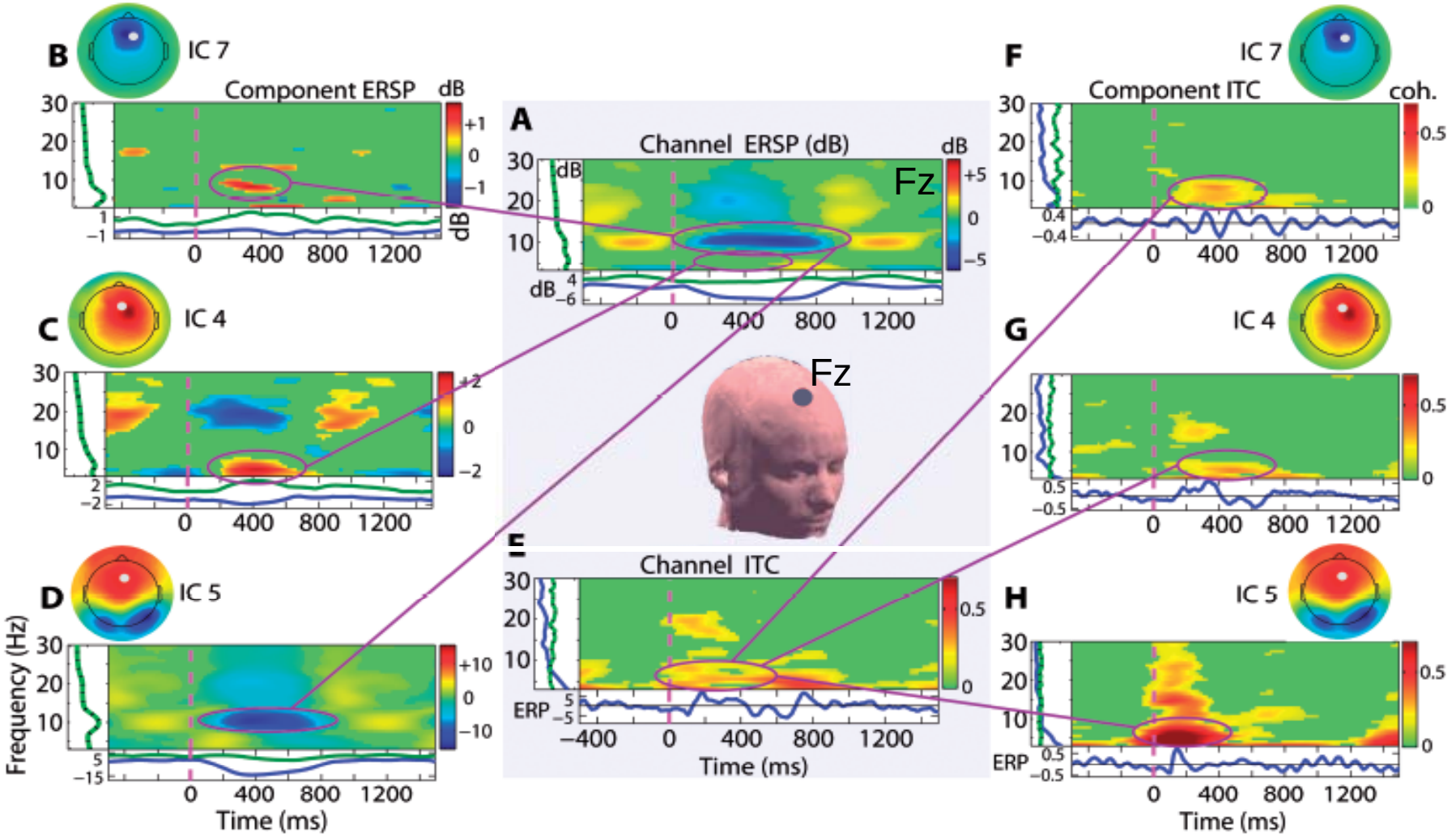


ICA can help filter out artifacts

ICA can also isolate brain sources

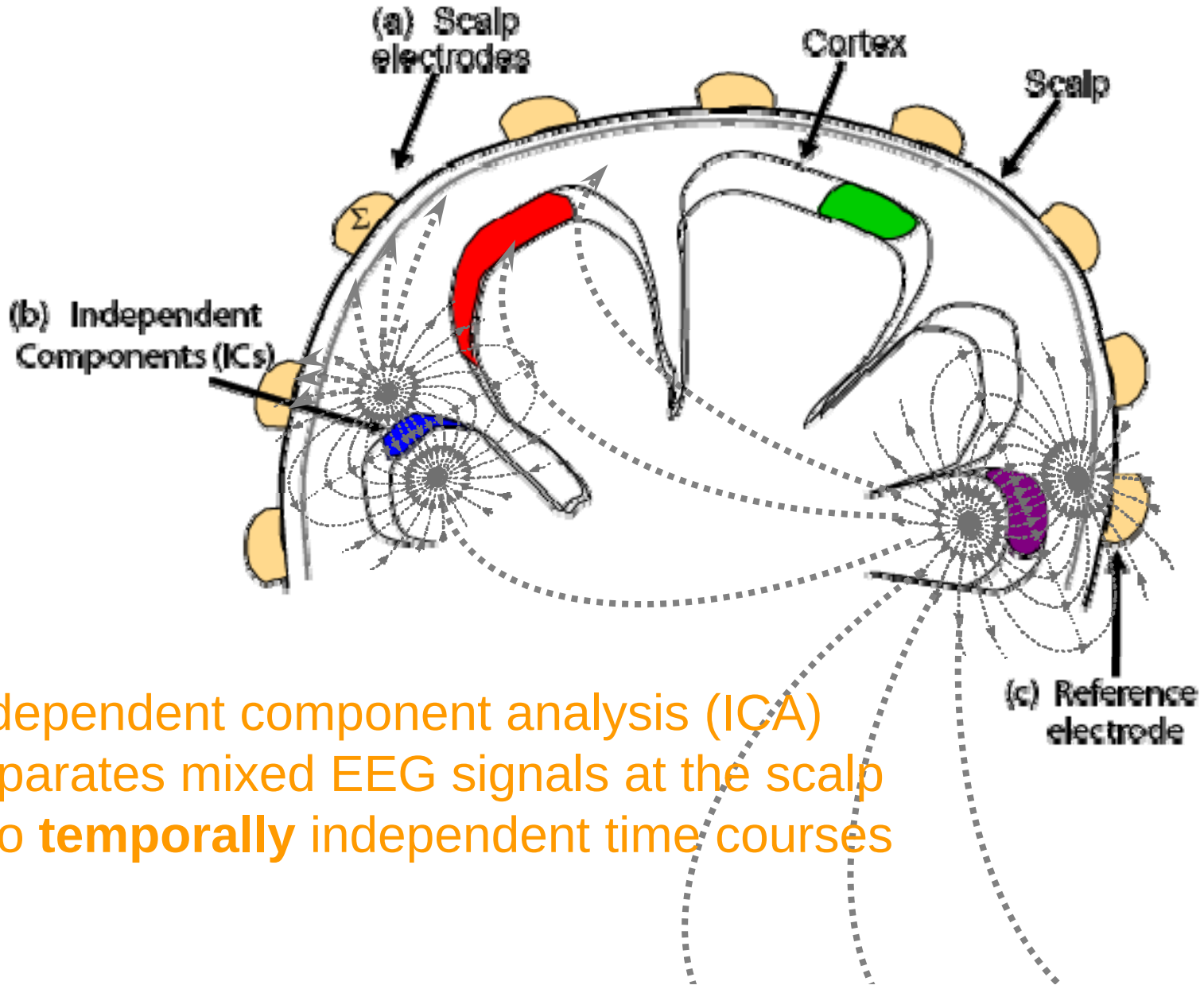
Onton and Makeig, Prog. Brain Res. (2006)

Why analyze source activity instead of channels?



Onton and Makeig, Prog. Brain Res. (2006)

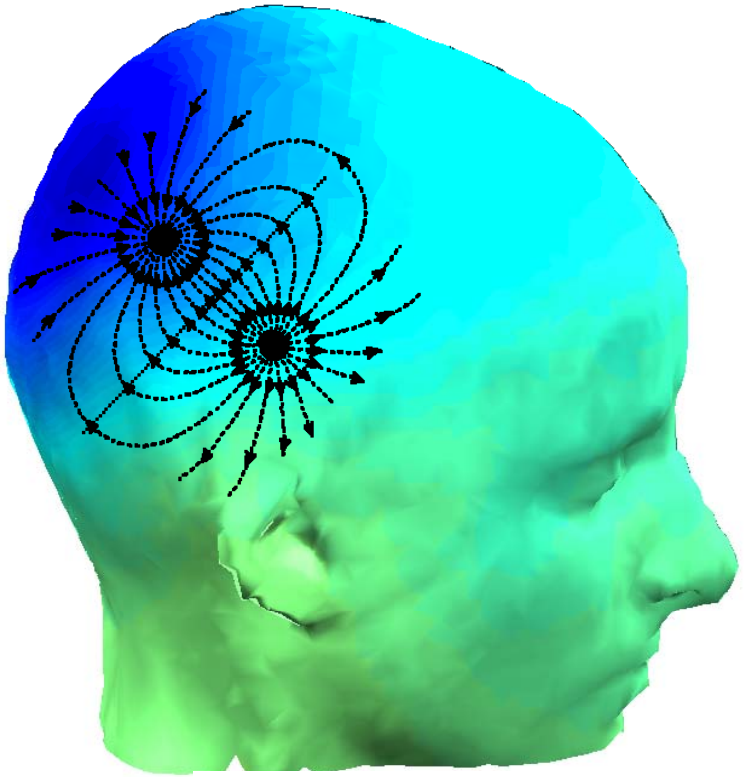
Separating EEG source activities

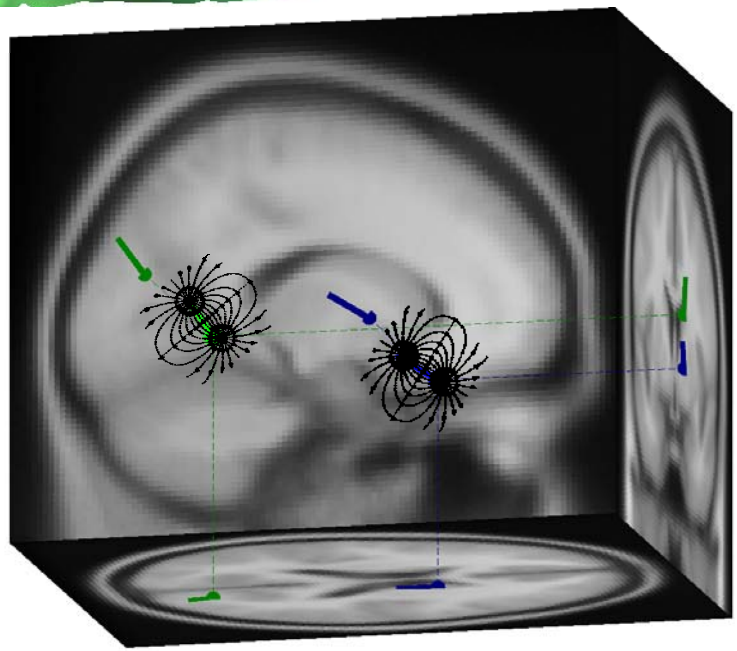


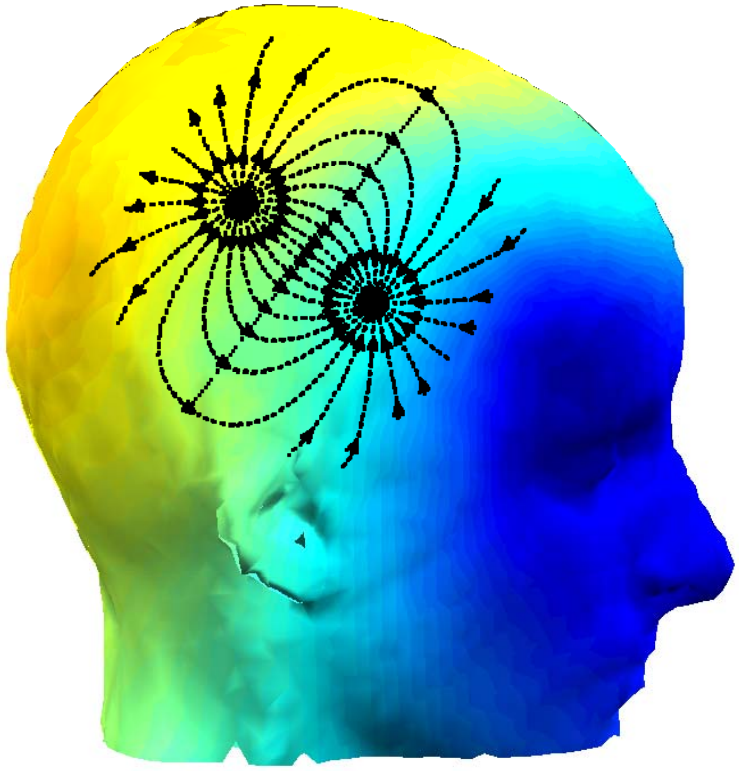
Independent component analysis (ICA) separates mixed EEG signals at the scalp into **temporally** independent time courses

Dipolar Scalp Projections

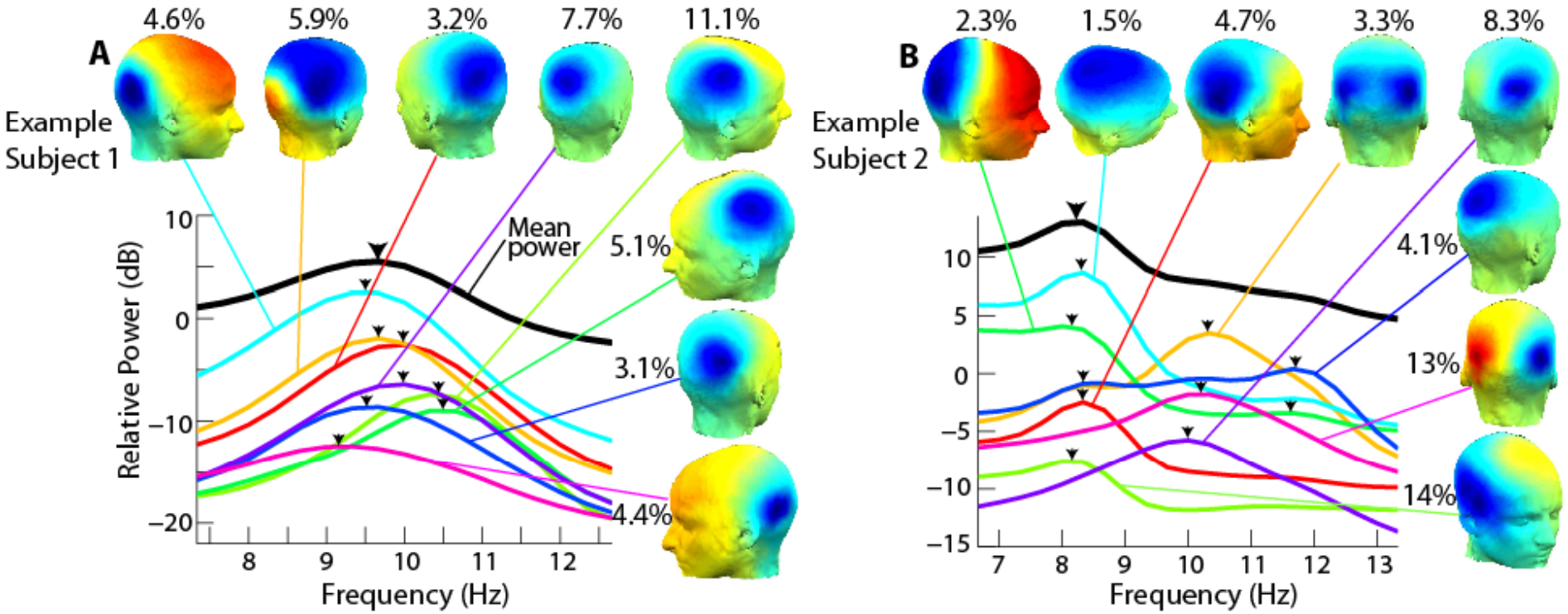
ICA creates a **spatial** filter for each **temporally** independent source



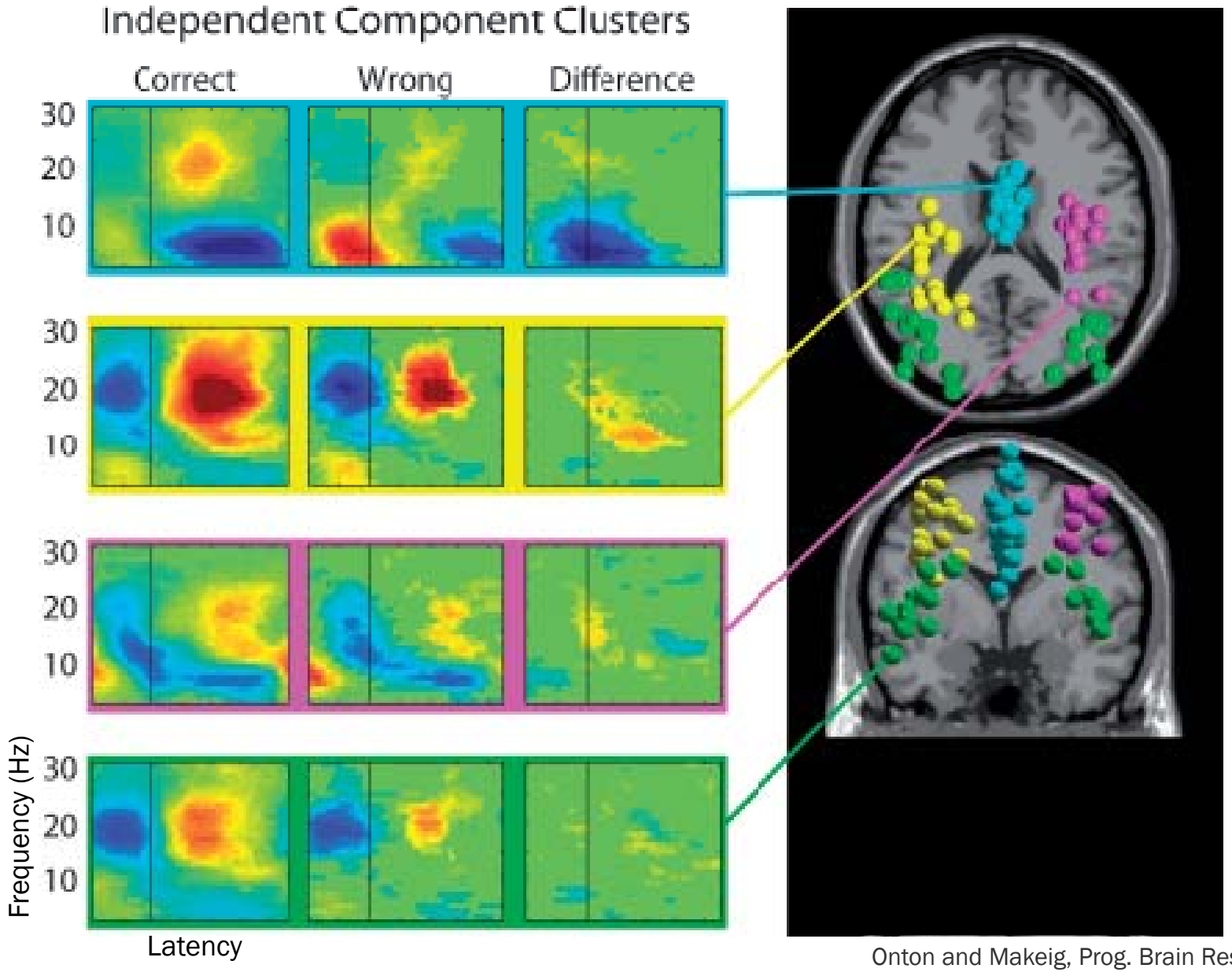




Various 'alpha' frequencies WITHIN subject



Goal: to cluster matching ICs across subjects



Onton and Makeig, Prog. Brain Res. (2006)

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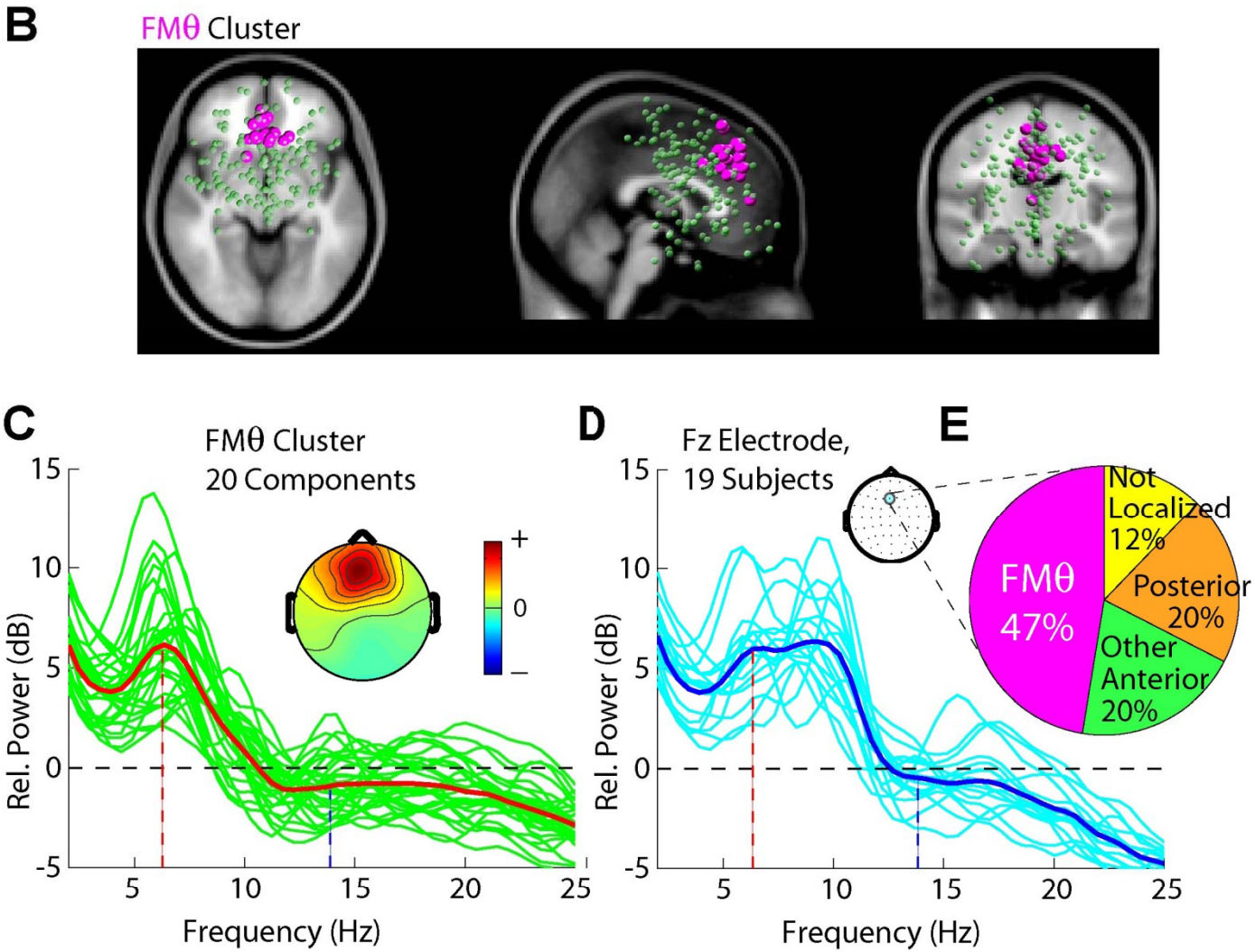
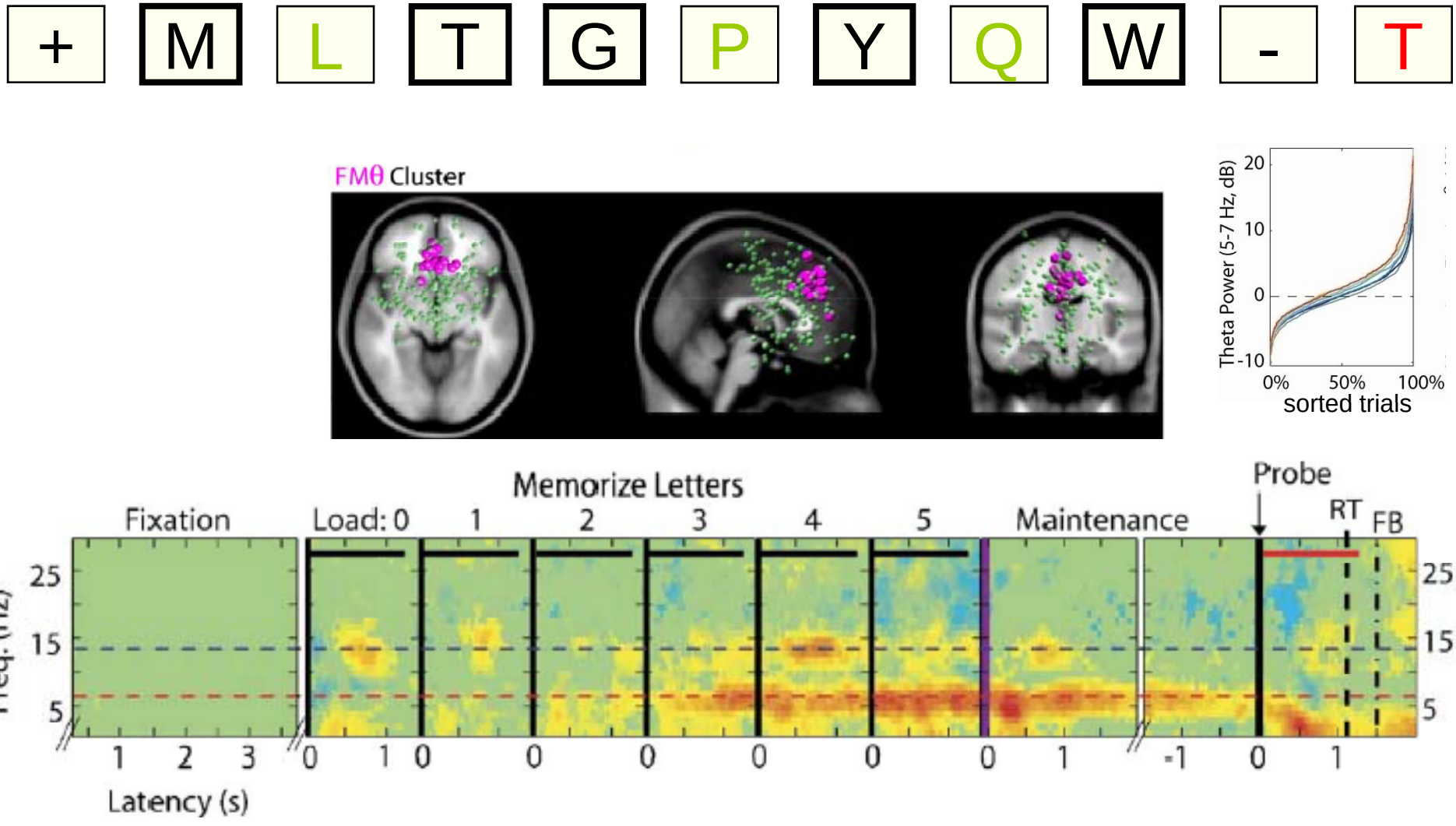
Frontal midline theta cluster



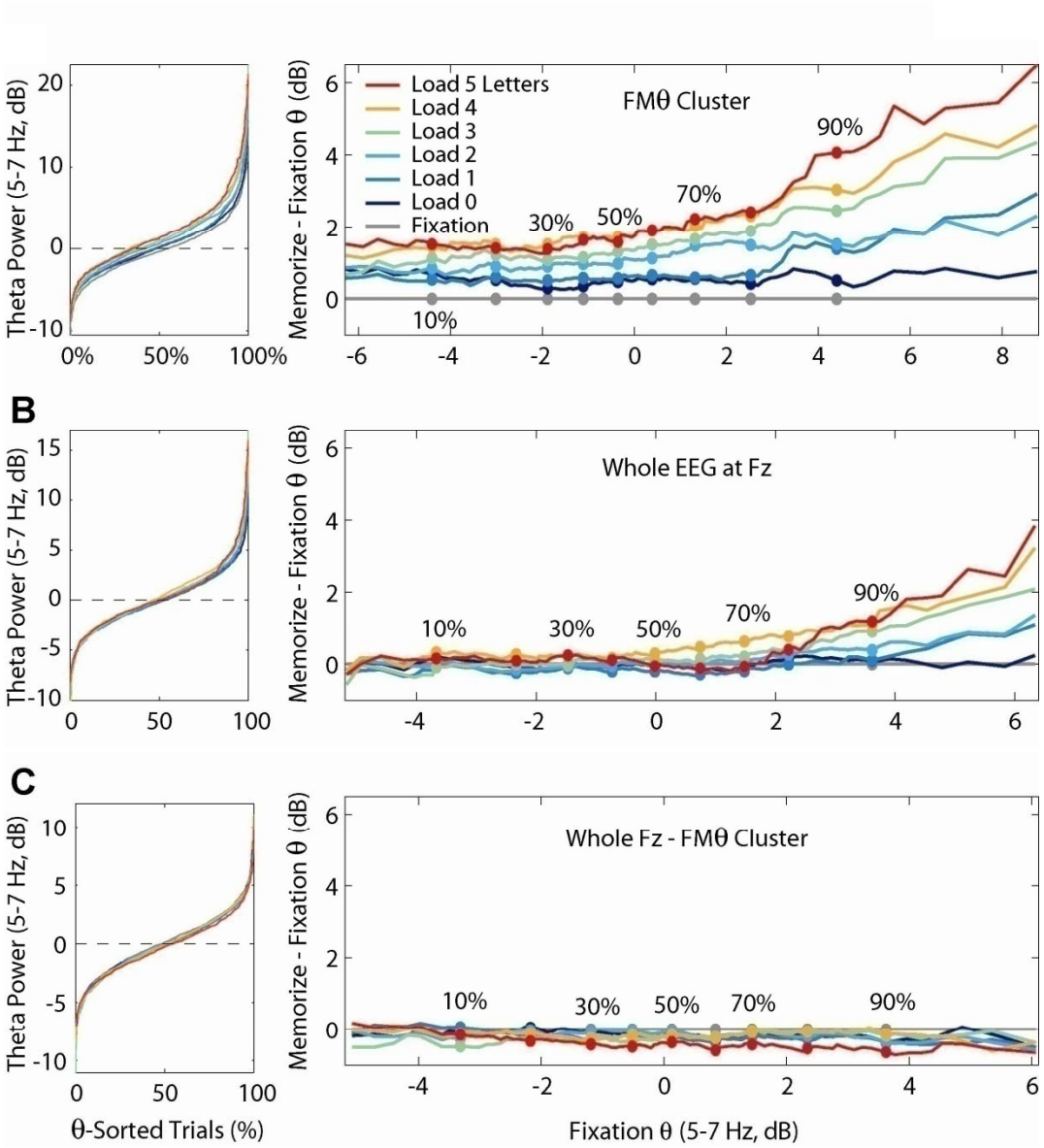
Onton et al., NeuroImage 27 (2005) 341 - 356

FMθ: average time/frequency power



Onton and Makeig, NeuroImage (2005)

Theta power across trials



All load-related theta power from frontal midline cluster!

Onton et al., NeuroImage 27 (2005) 341 - 356

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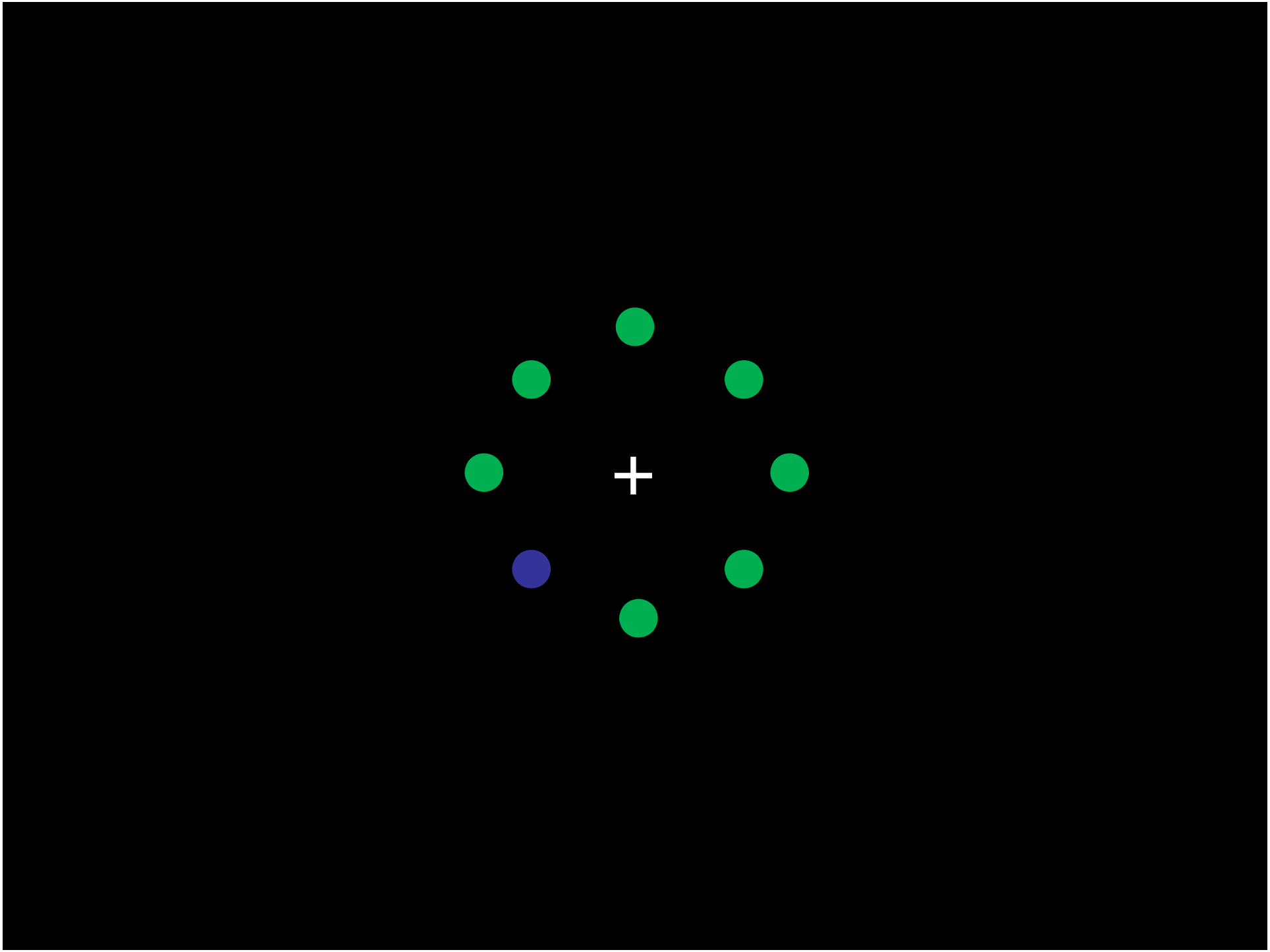
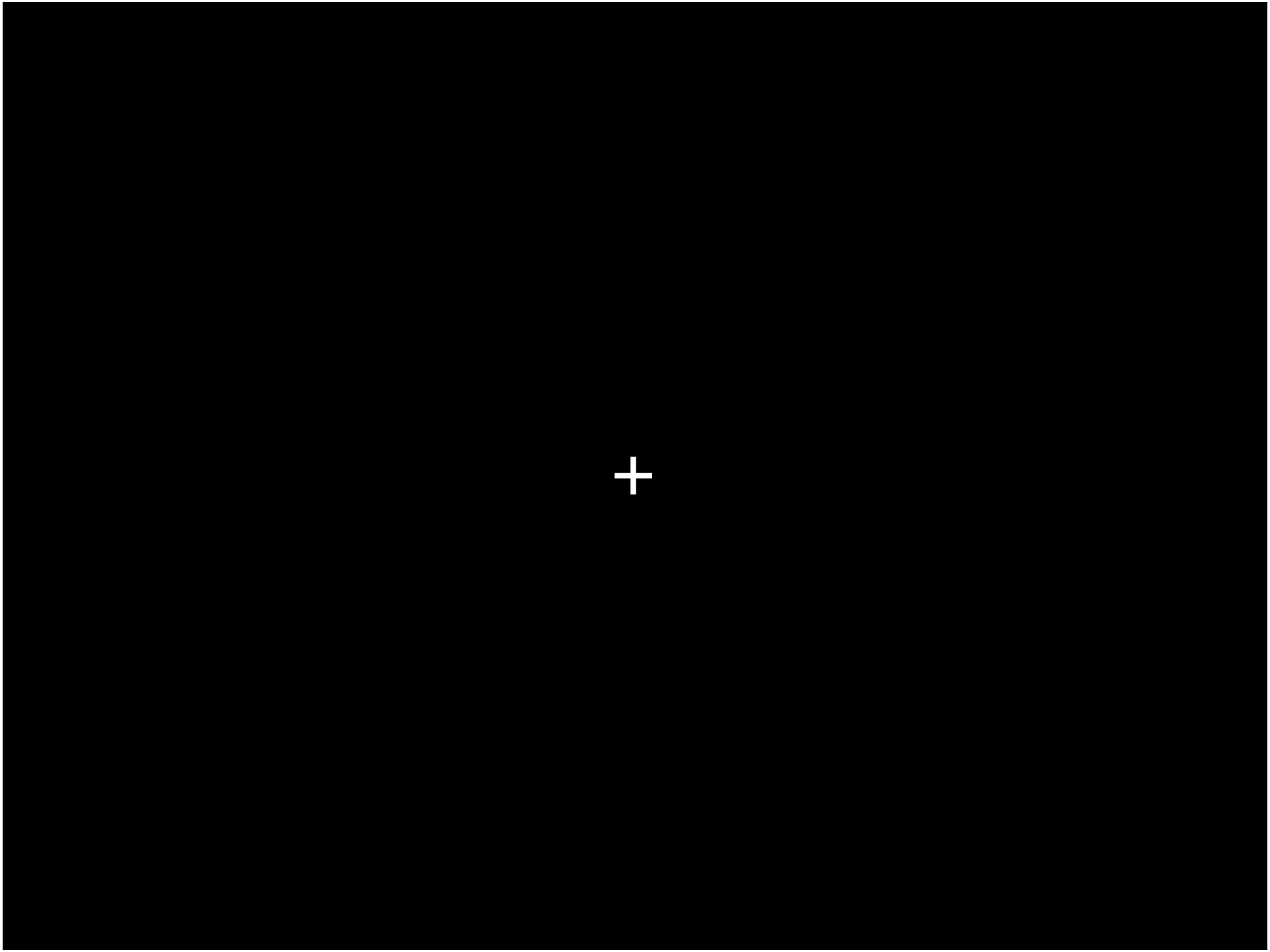
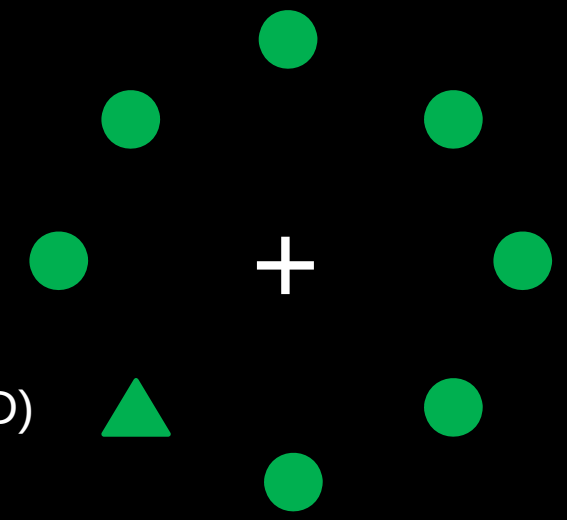
Visual Cueing Task:

Does the target differ in shape or color?

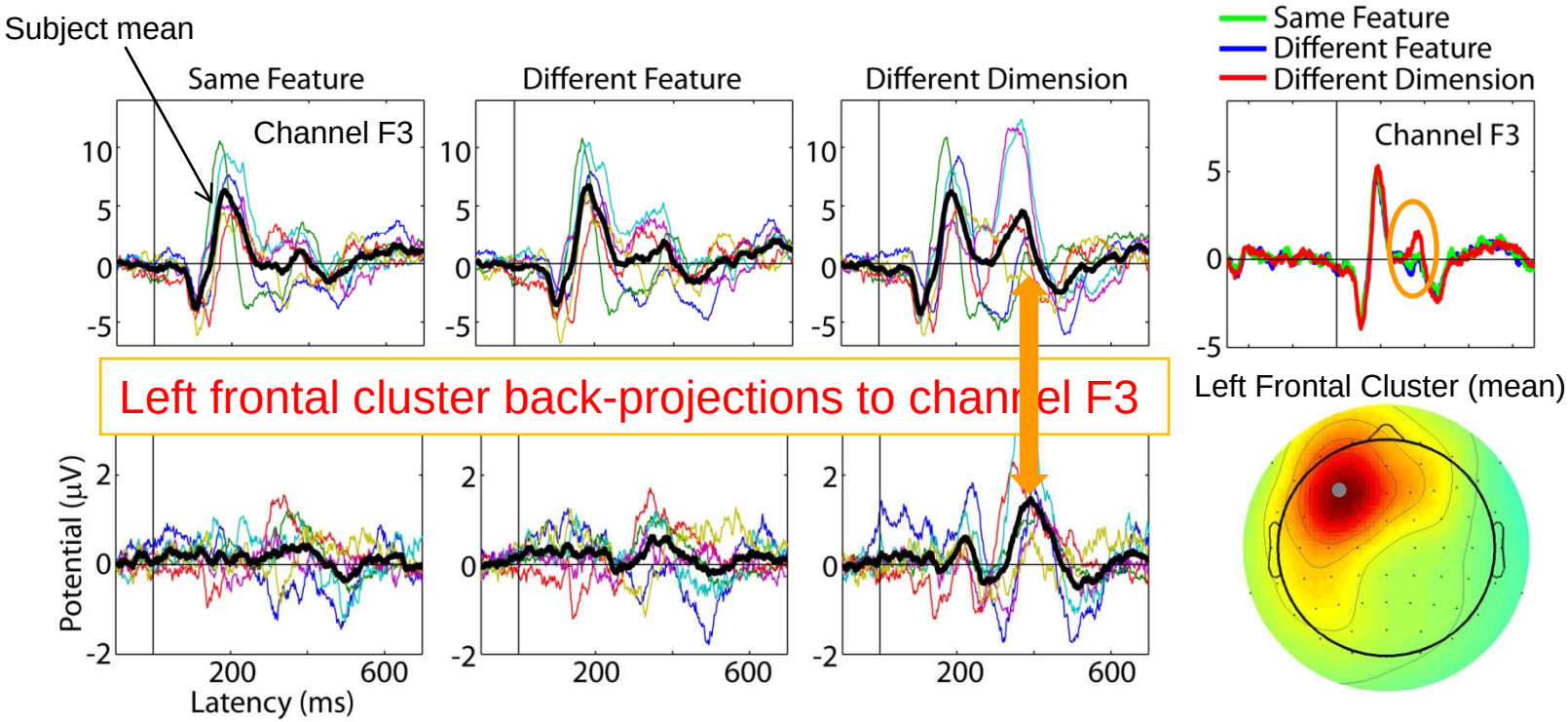


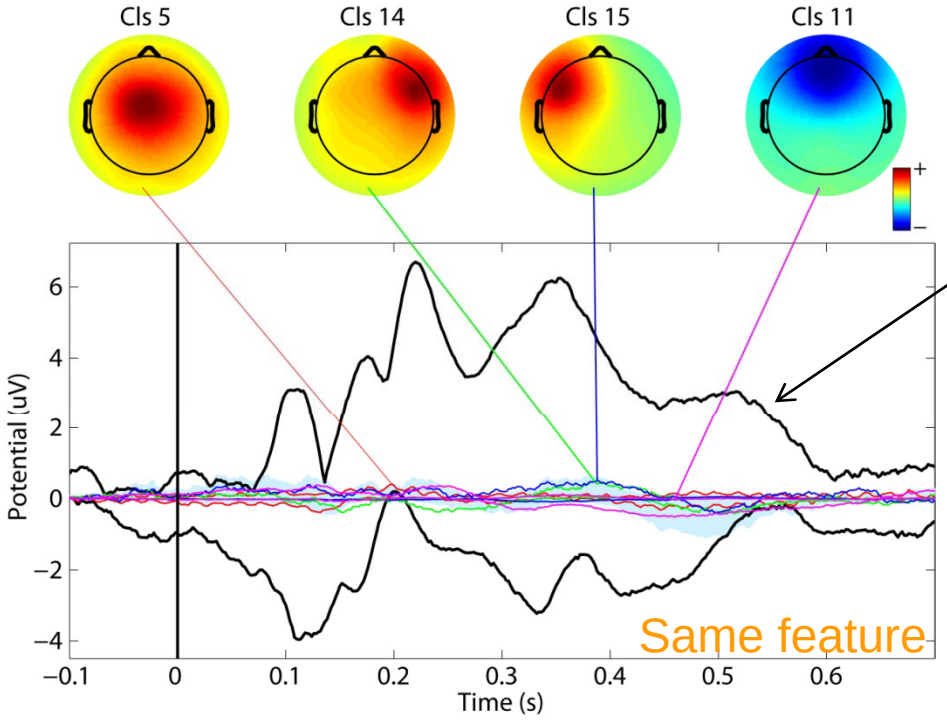


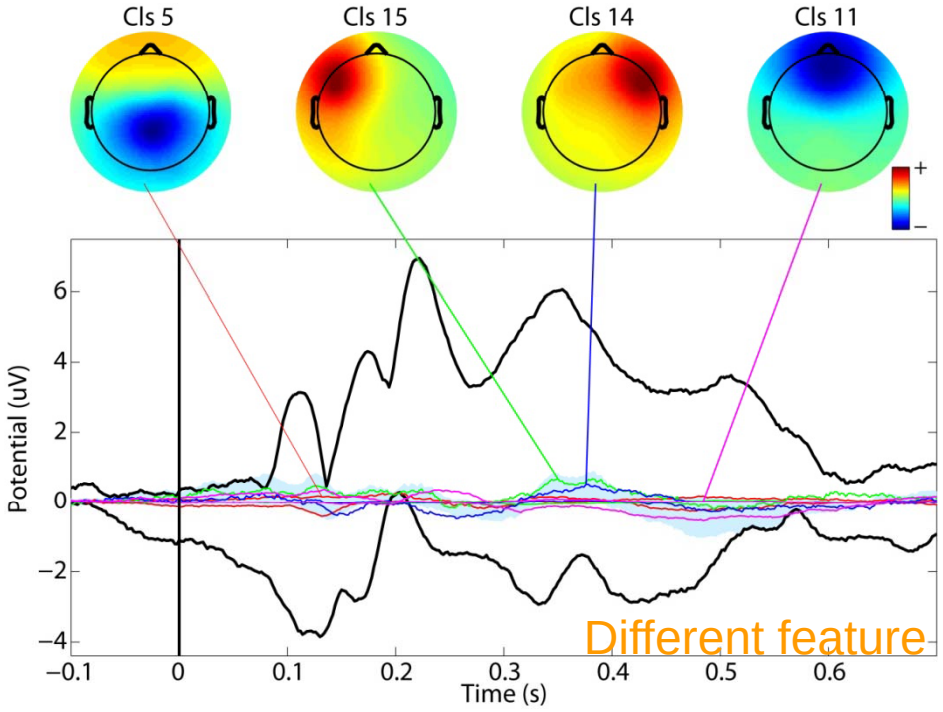
Different Dimension (dD)



Enhanced Frontal ERP for dD Trials

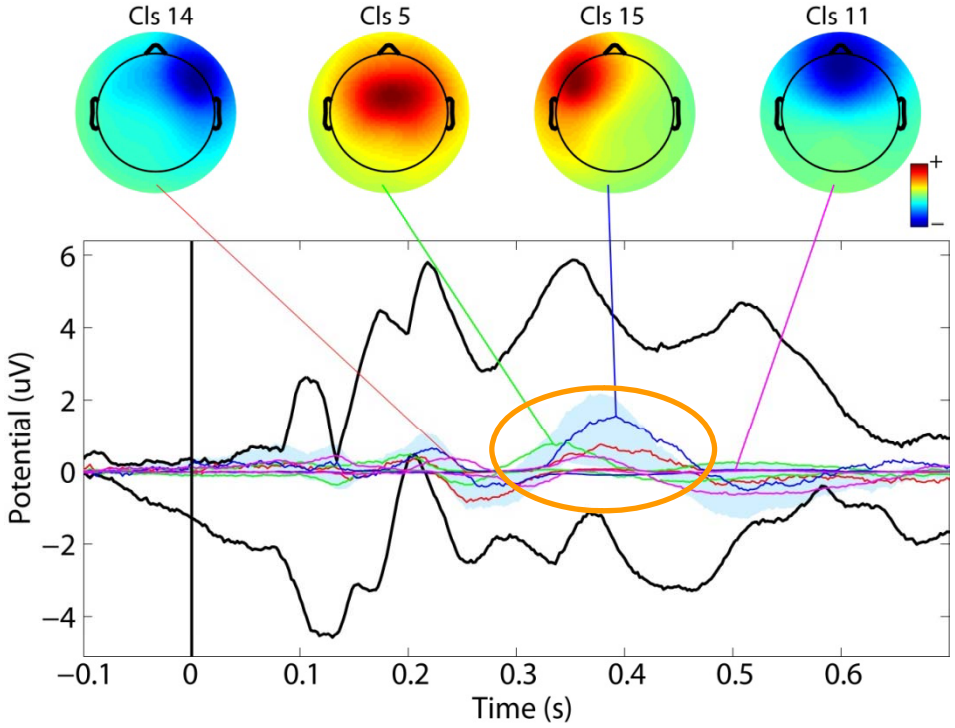


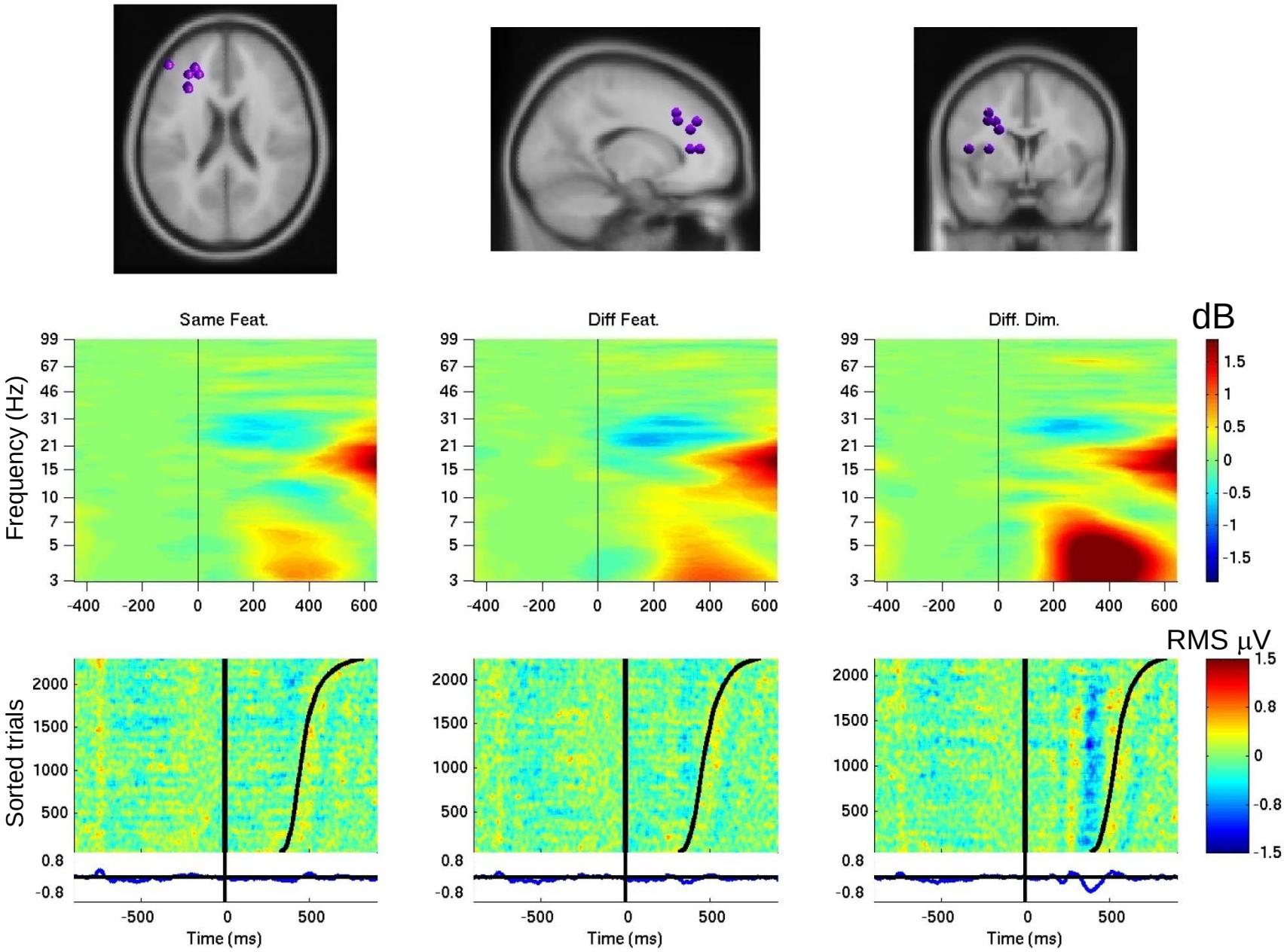




Back-projection of all clusters

Different dimension




Same Feat.
Diff Feat.
Diff. Dim.
dB
Frequency (Hz)
99
67
46
31
21
15
10
7
5
3
-400
-200
0
200
400
600
1.5
1
0.5
0
-0.5
-1
-1.5
RMS μV
Sorted trials
2000
1500
1000
500
0.8
-0.8
-500
0
500
Time (ms)

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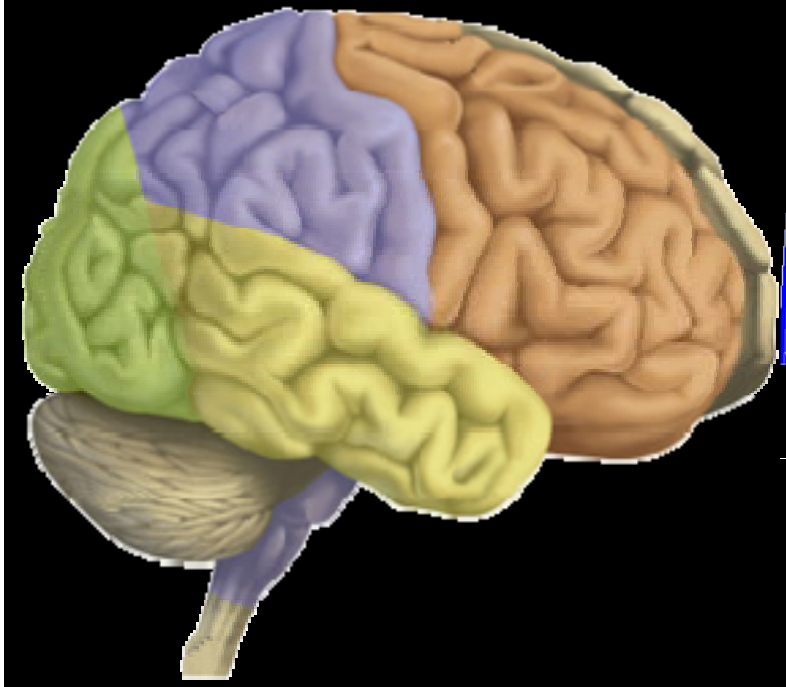
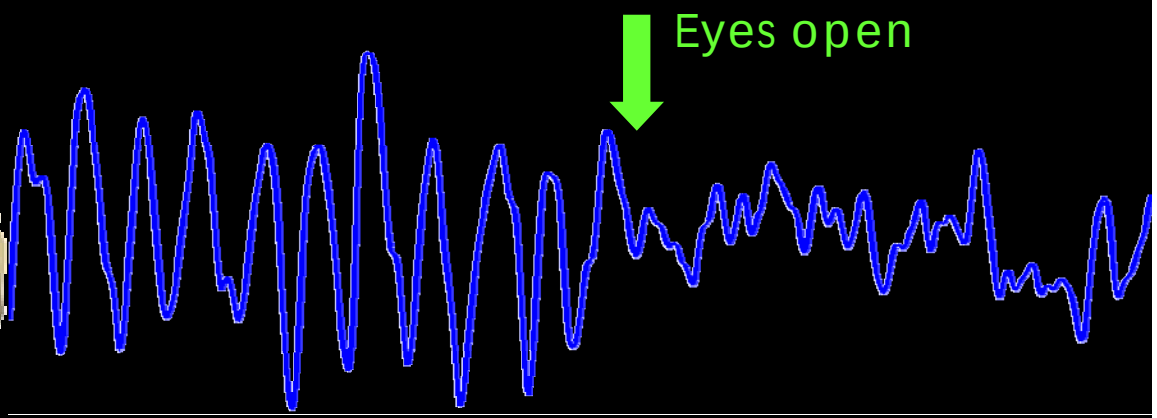
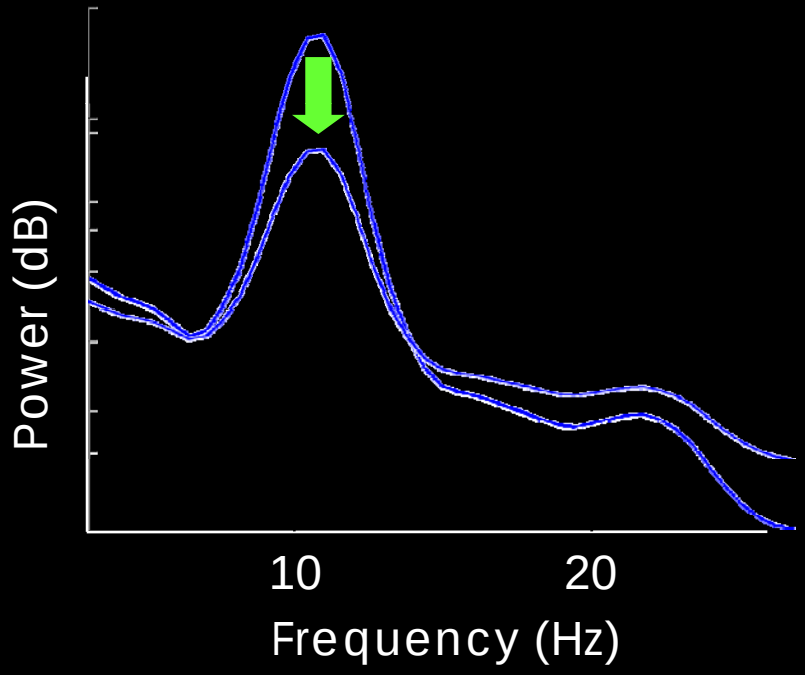
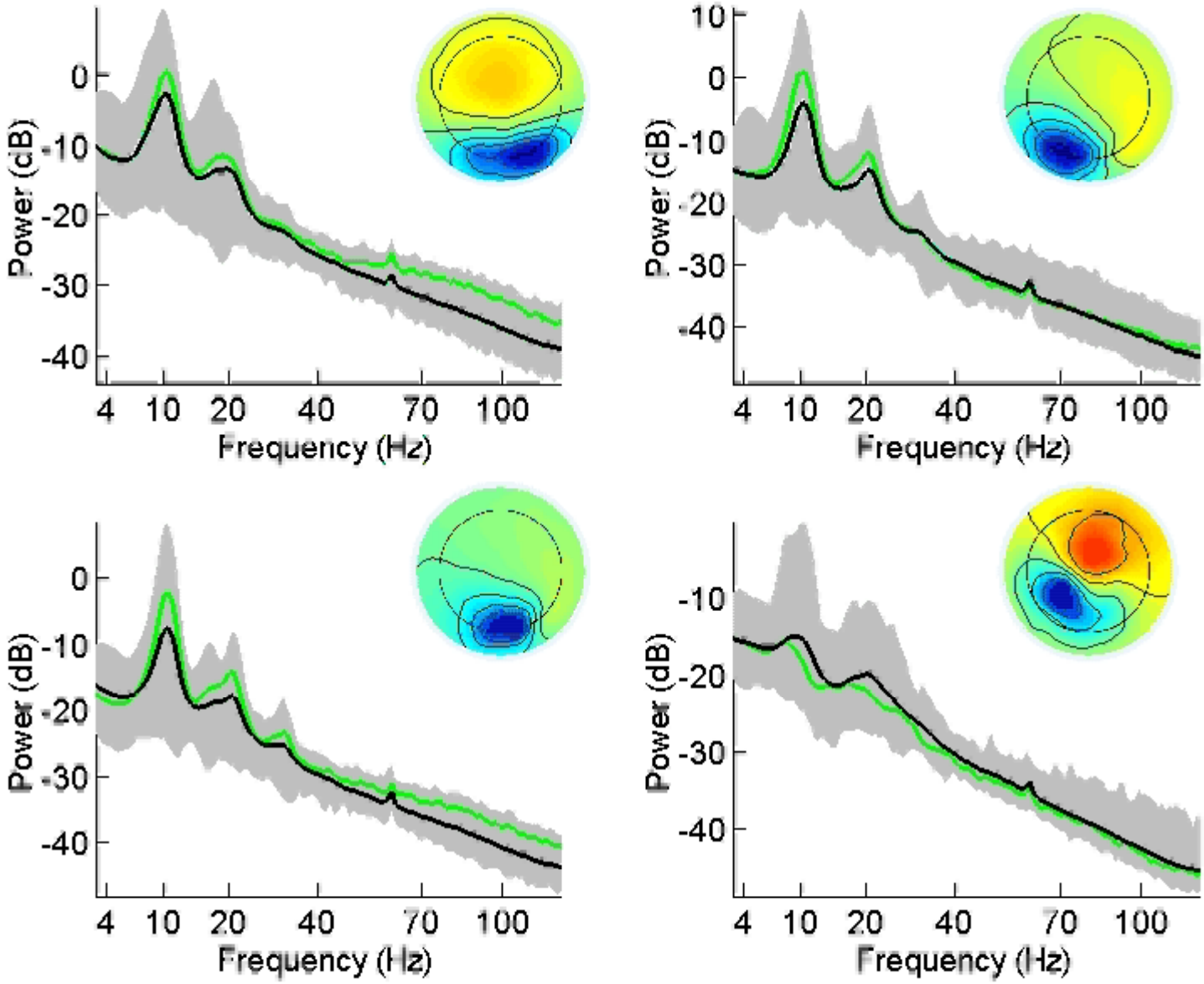






What is spectral instability?

Change in frequency power over time


Power (dB)
0
-10
-20
-30
-40
4
10
20
40
70
100
Frequency (Hz)
Power (dB)
10
0
-10
-20
-30
-40
4
10
20
40
70
100
Frequency (Hz)
Power (dB)
0
-10
-20
-30
-40
4
10
20
40
70
100
Frequency (Hz)
Power (dB)
-10
-20
-30
-40
4
10
20
40
70
100
Frequency (Hz)

What causes spectral instability?

Thalamocortical loops

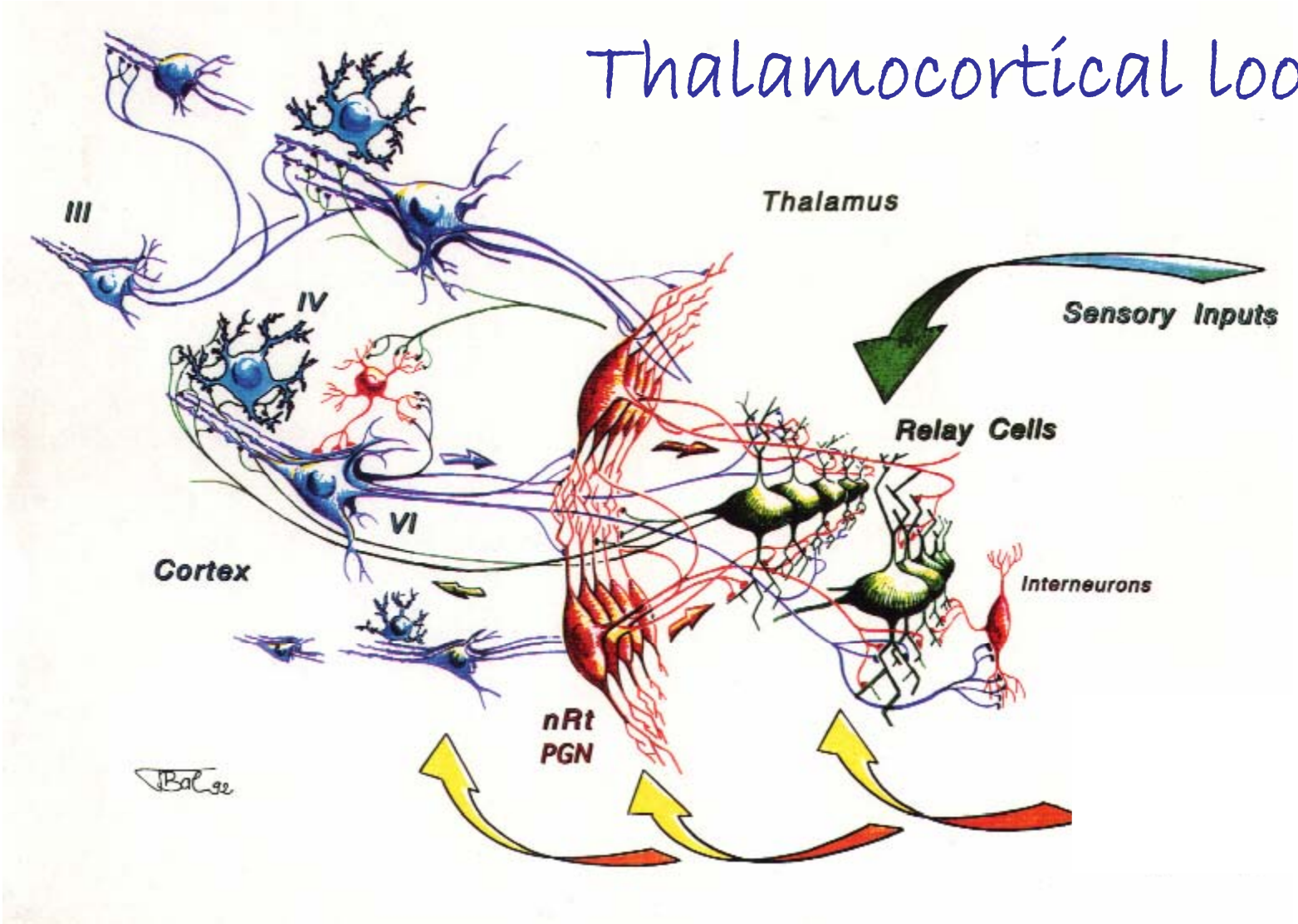
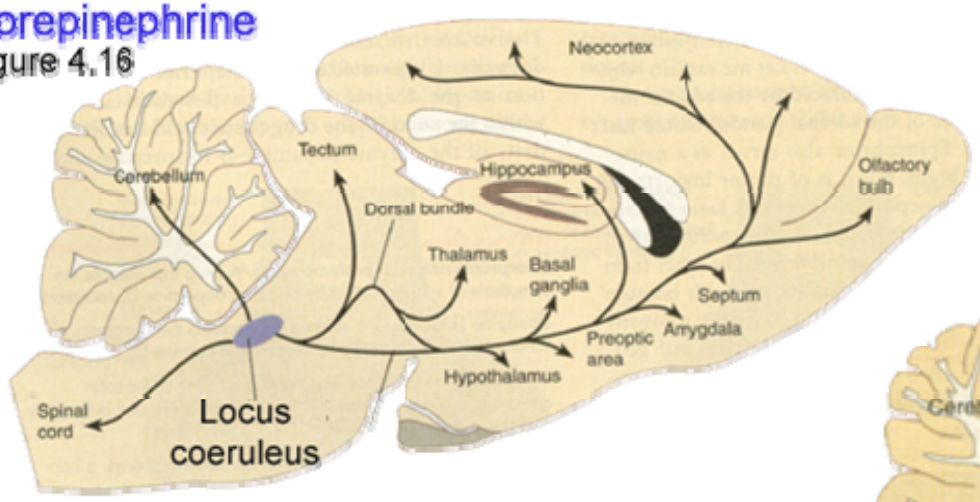


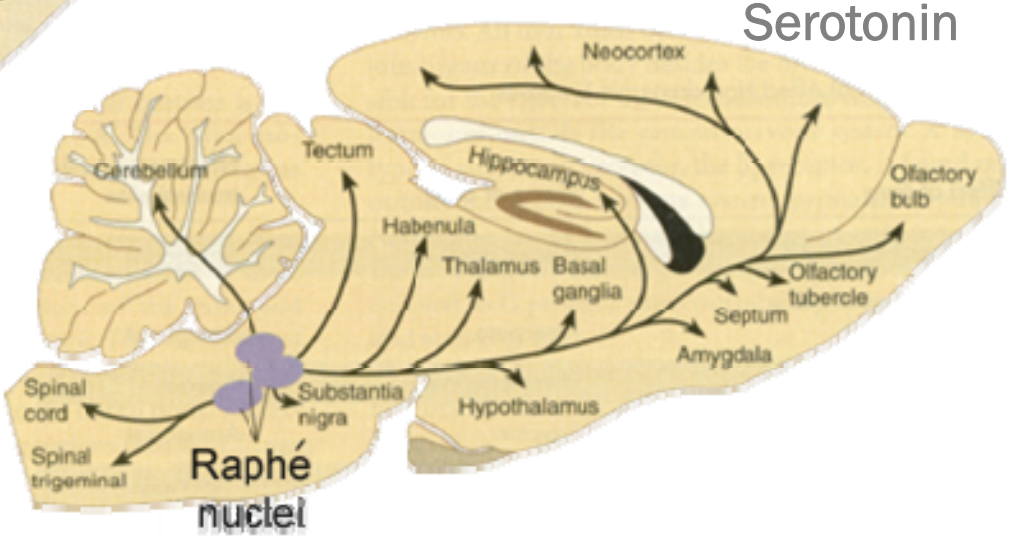
Figure drawn by Thierry Bal

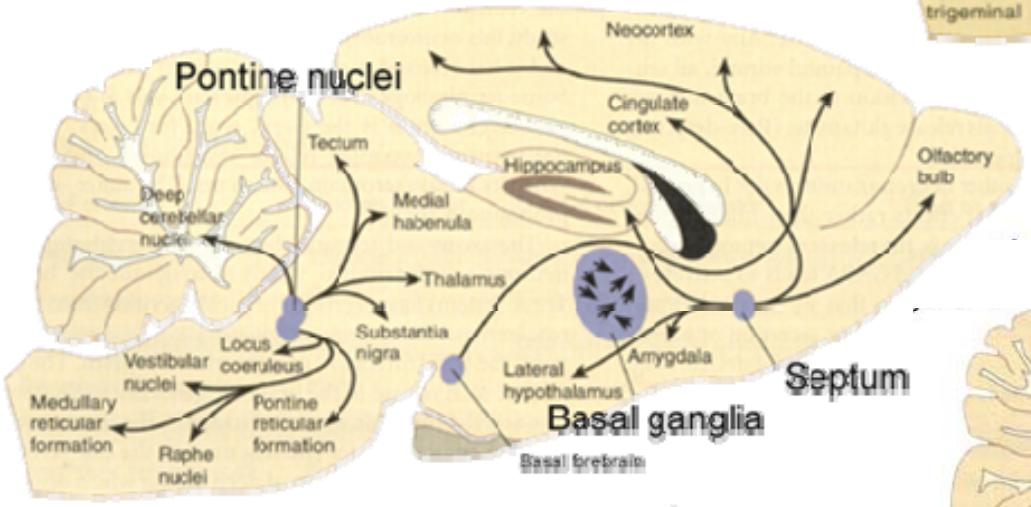
Norepinephrine

Figure 4.16



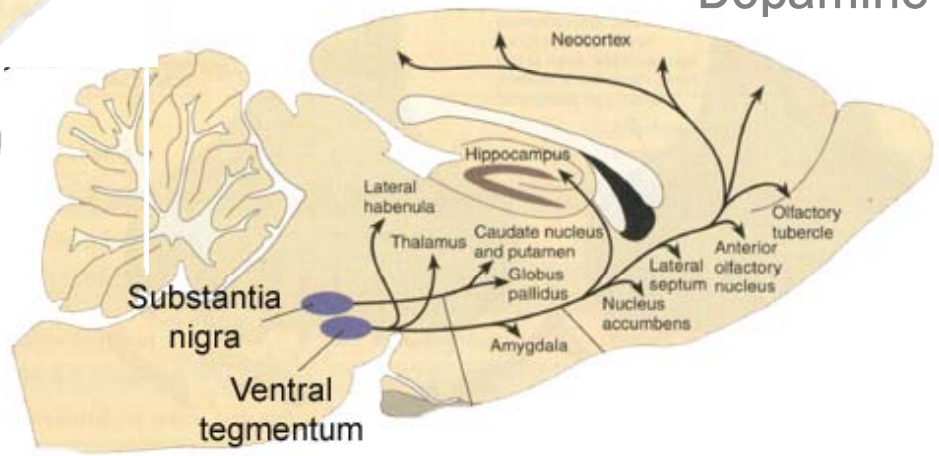
Serotonin

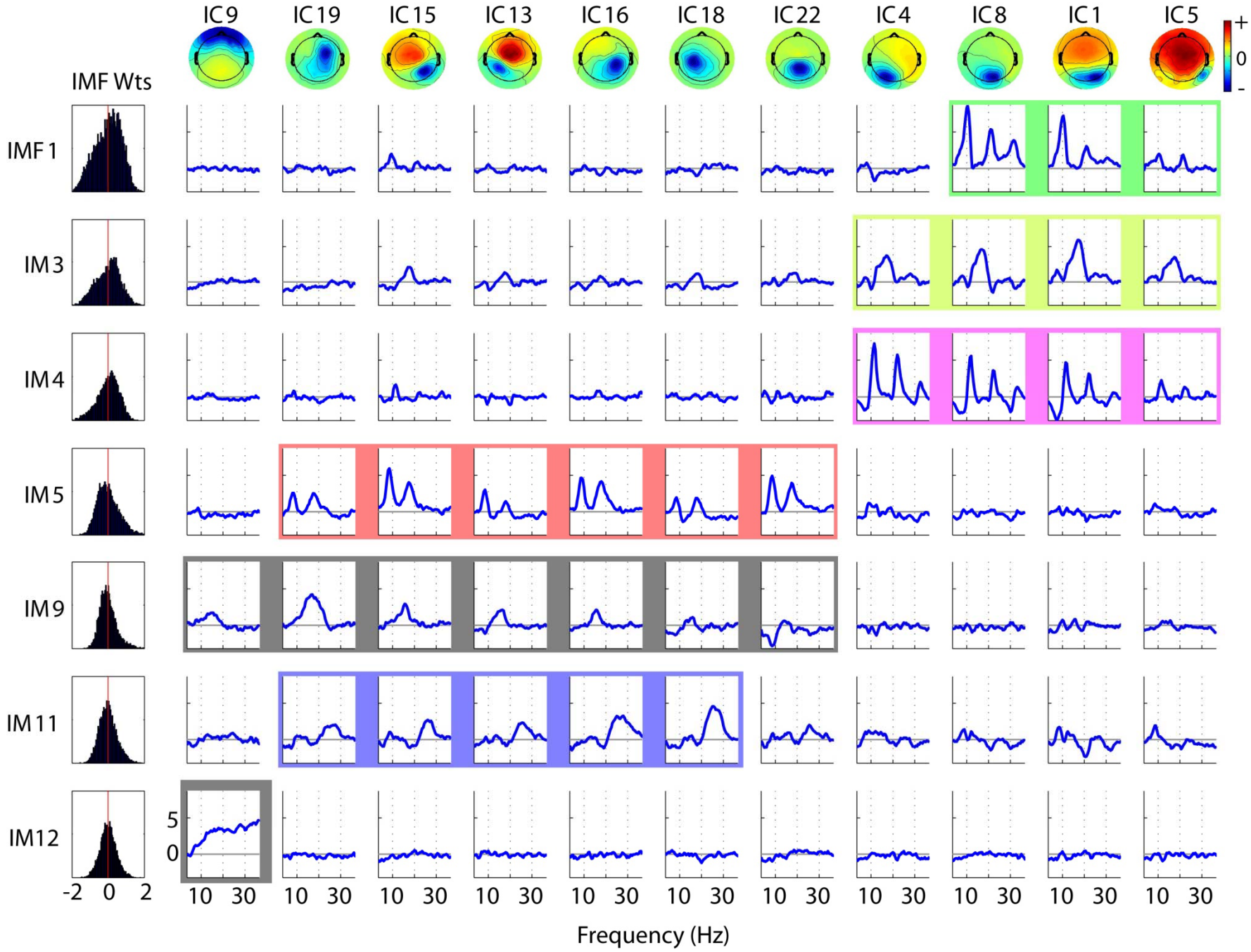




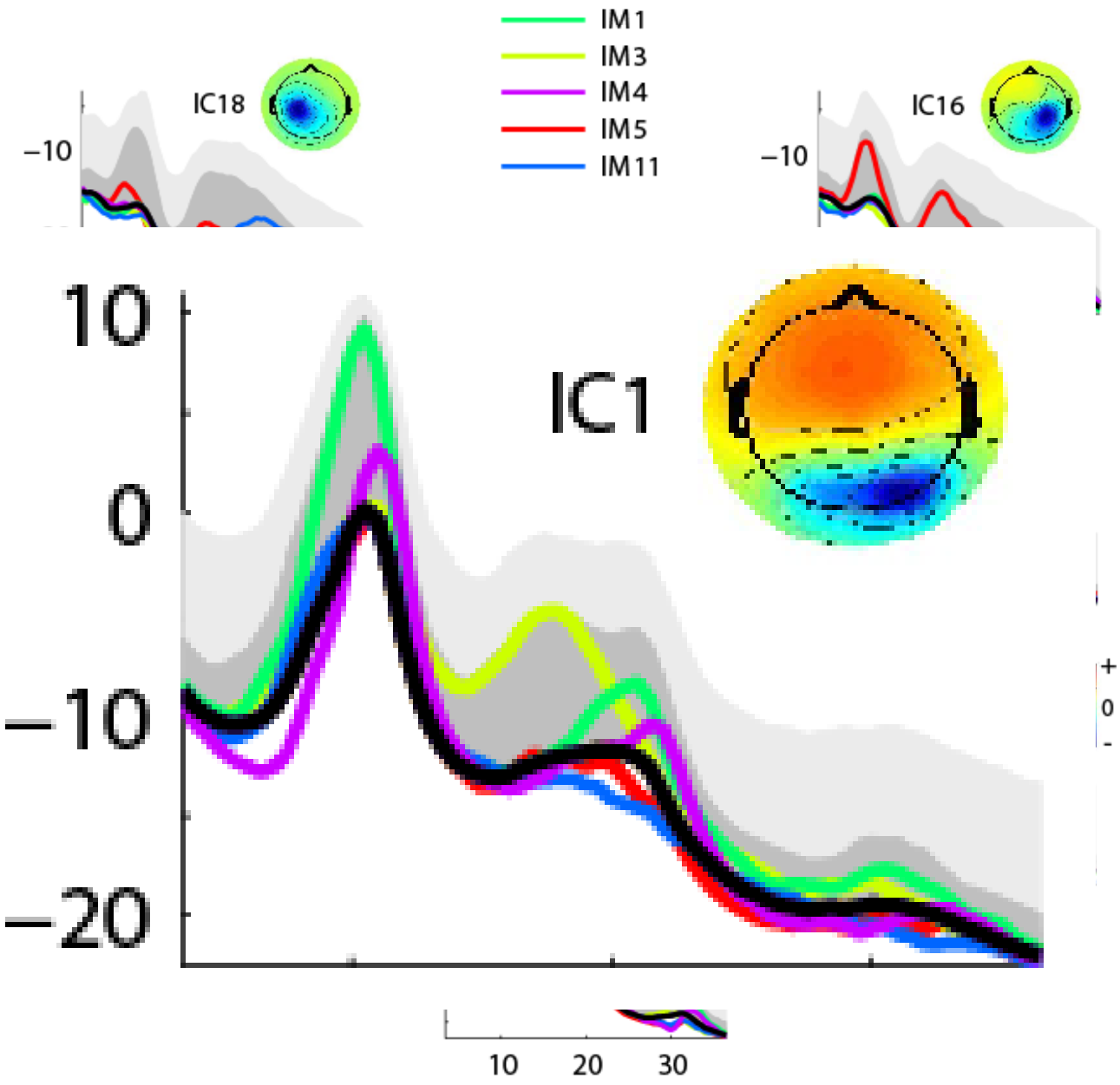
Acetylcholine

Dopamine

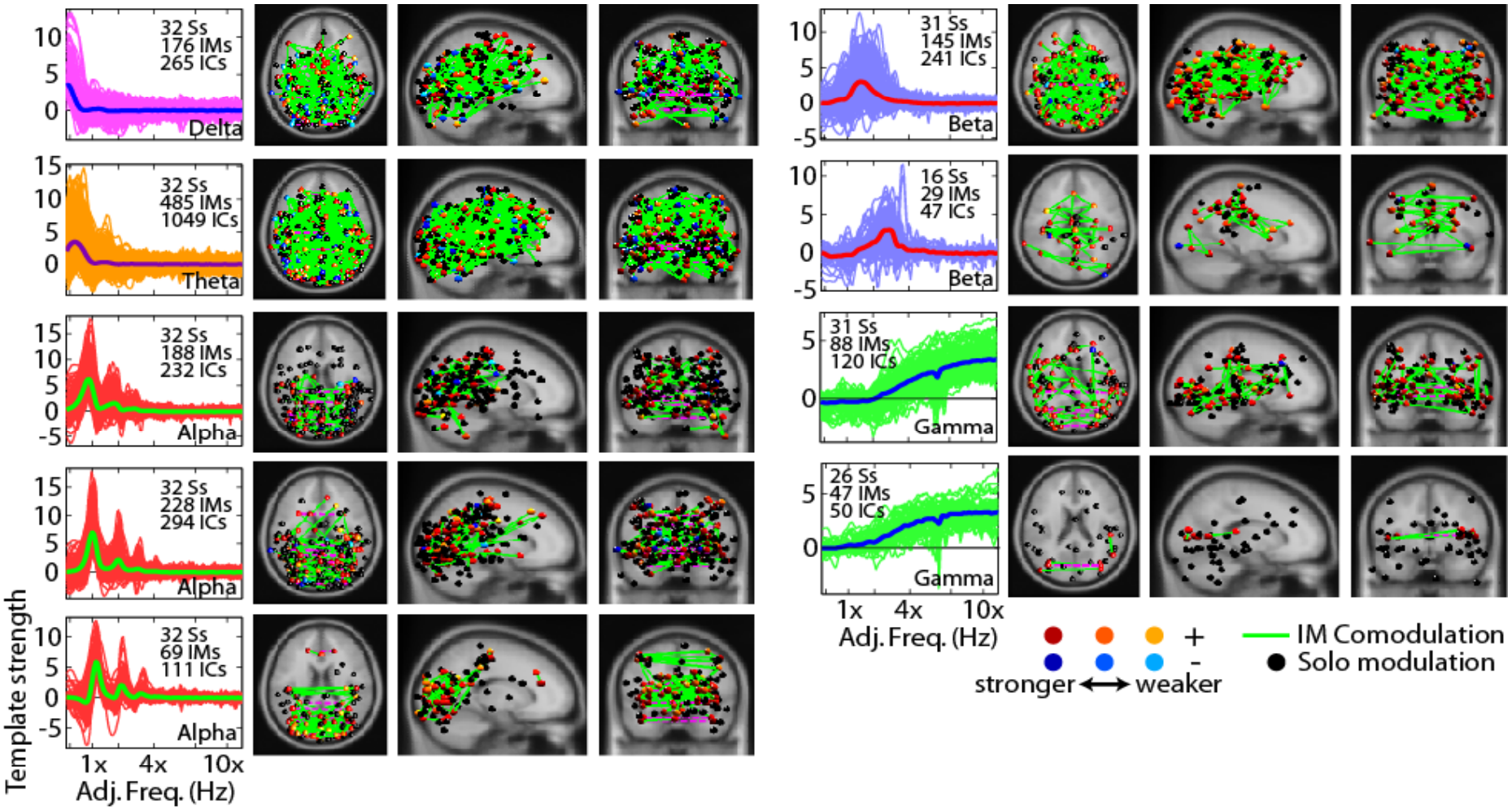



IC9
IC19
IC15
IC13
IC16
IC18
IC22
IC4
IC8
IC1
IC5
+
0
-
IMF Wts
IMF 1
IM3
IM4
IM5
IM9
IM11
IM12
-2 0 2
5
0
10 30
Frequency (Hz)

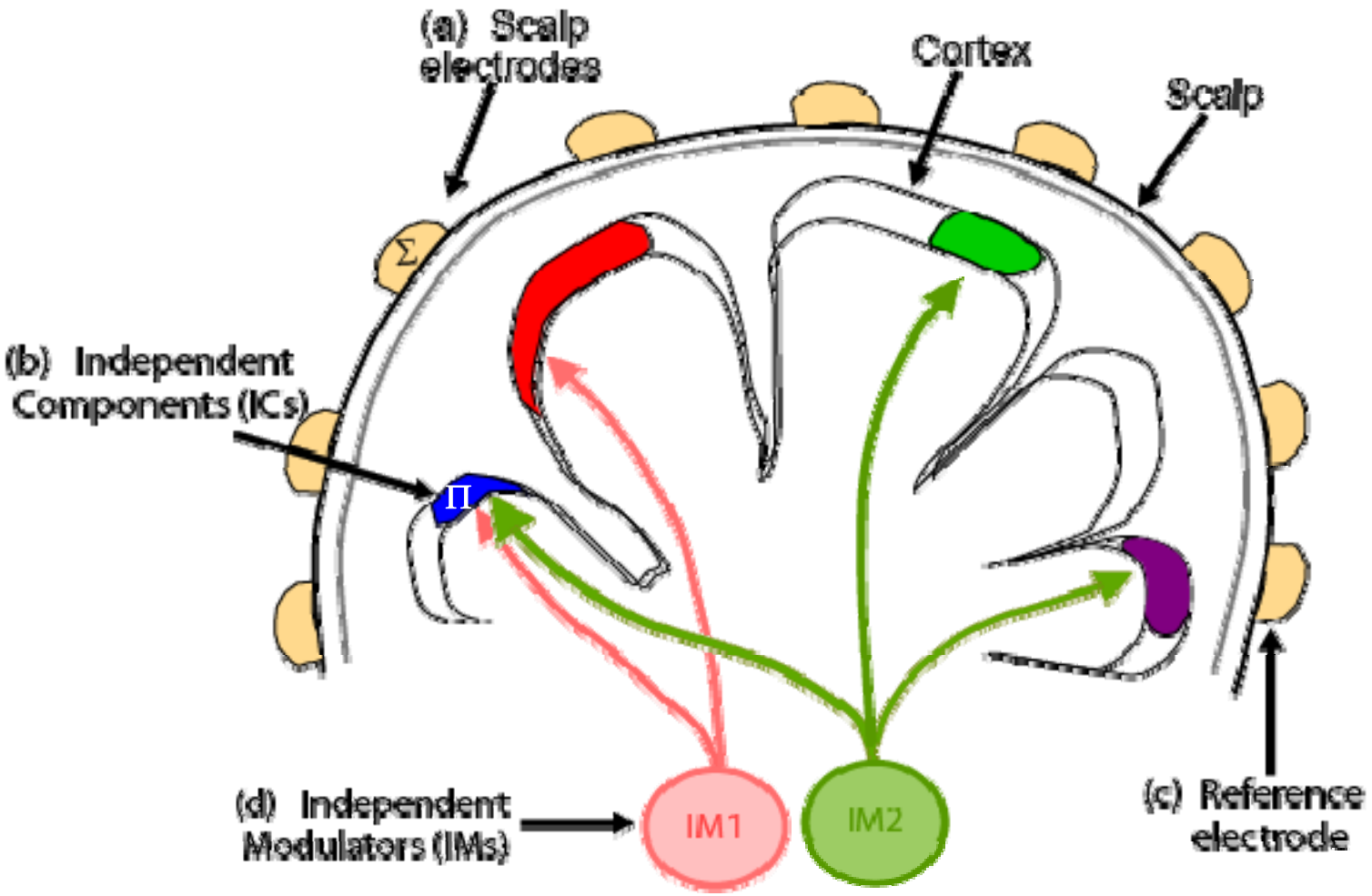
Spectral modulation envelopes



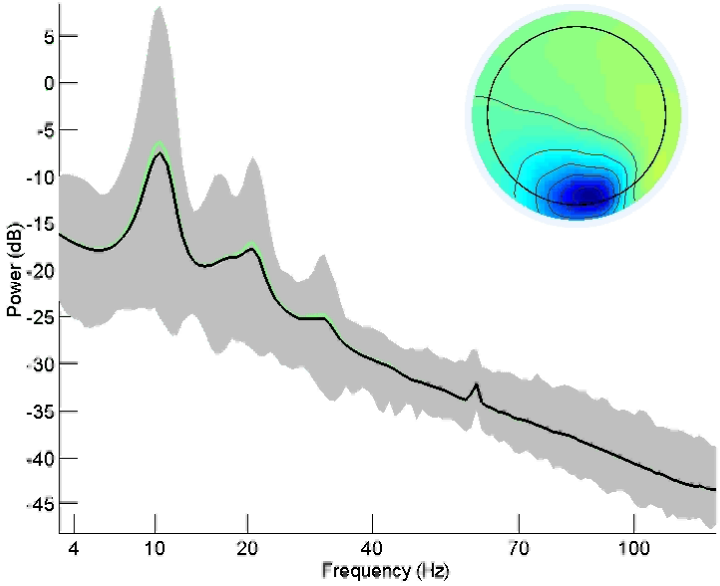
Clusters of spectral modulators



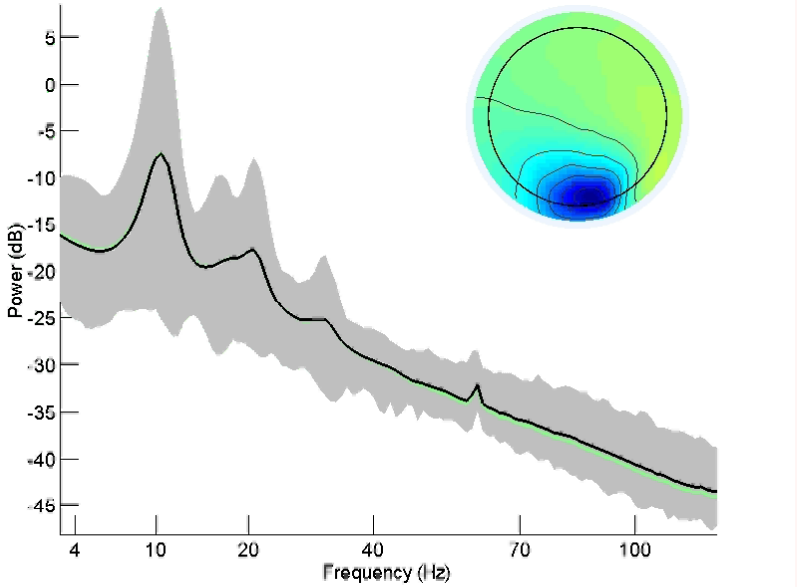
Independent (Co-)Modulators of EEG Source Activities



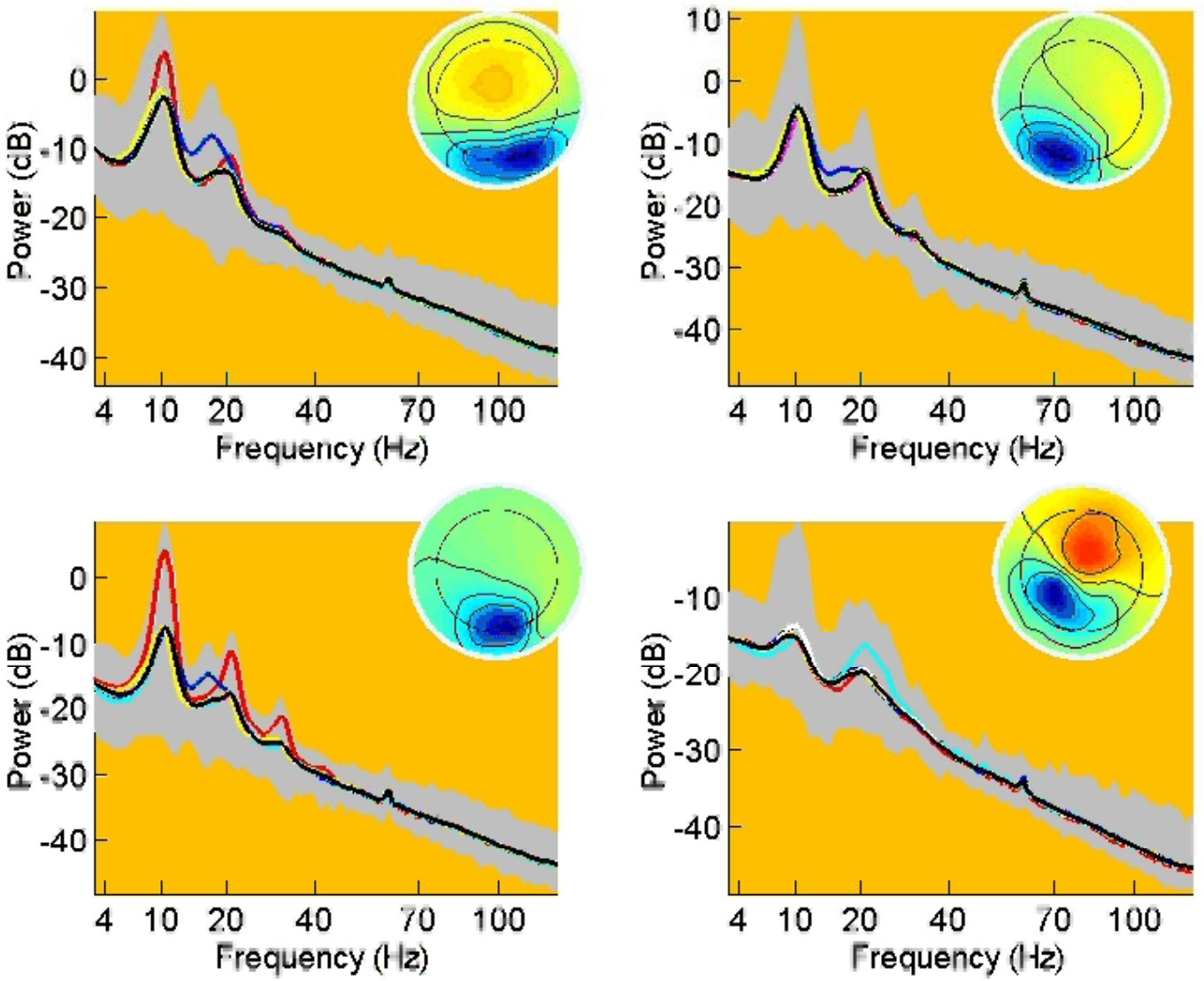
Alpha (+ harmonic) modulation



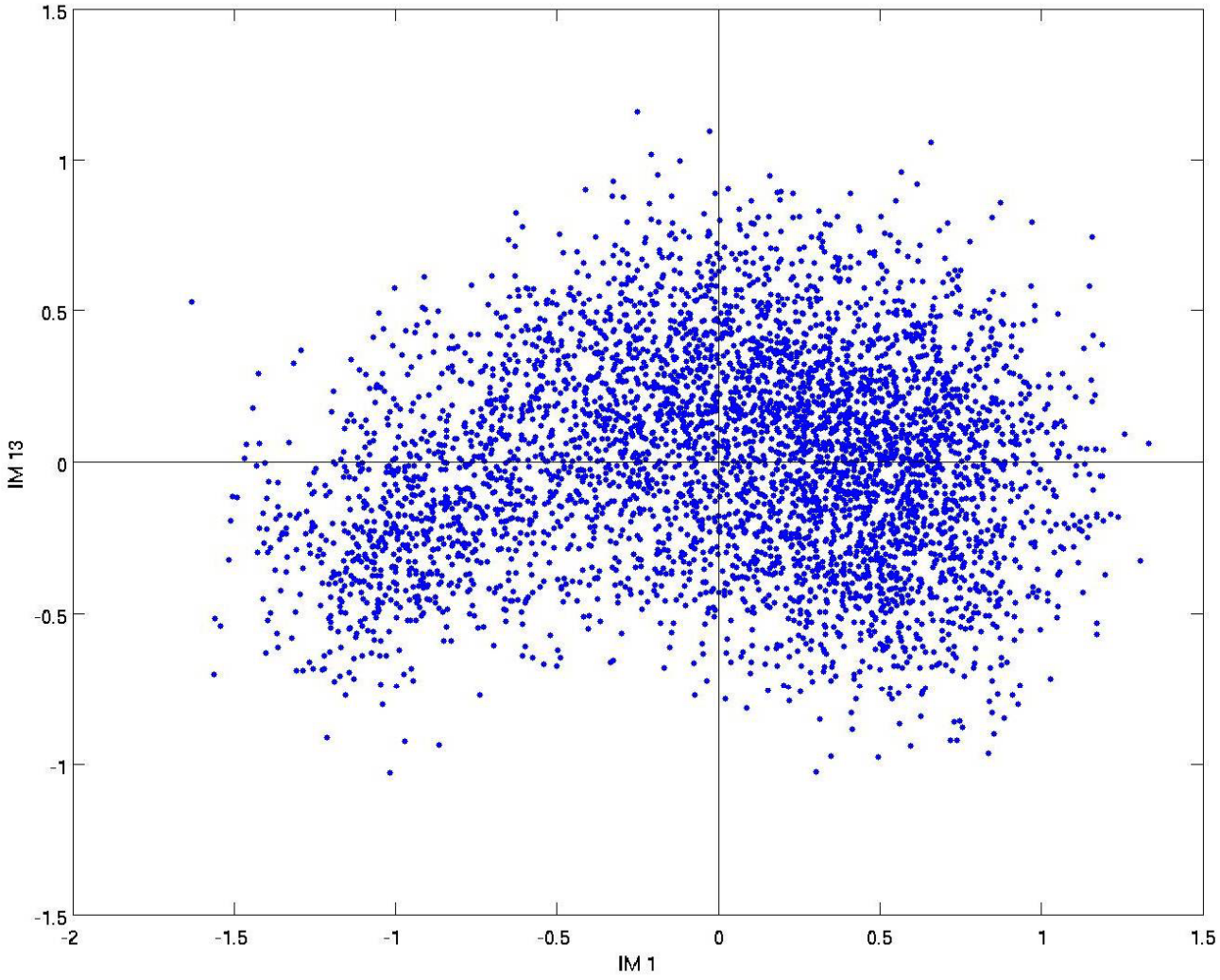
High frequency modulation



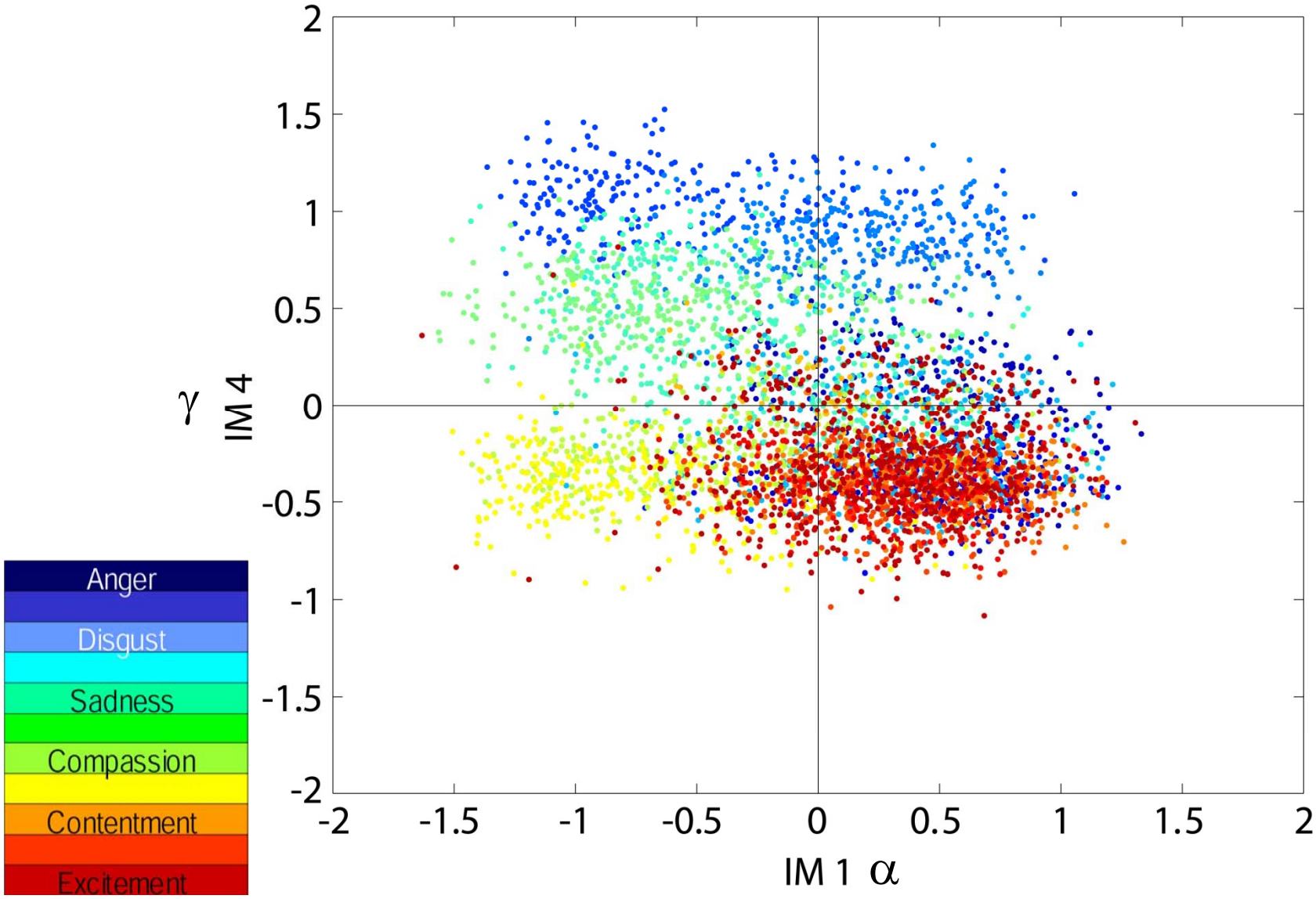
Many ICs, many IMs…



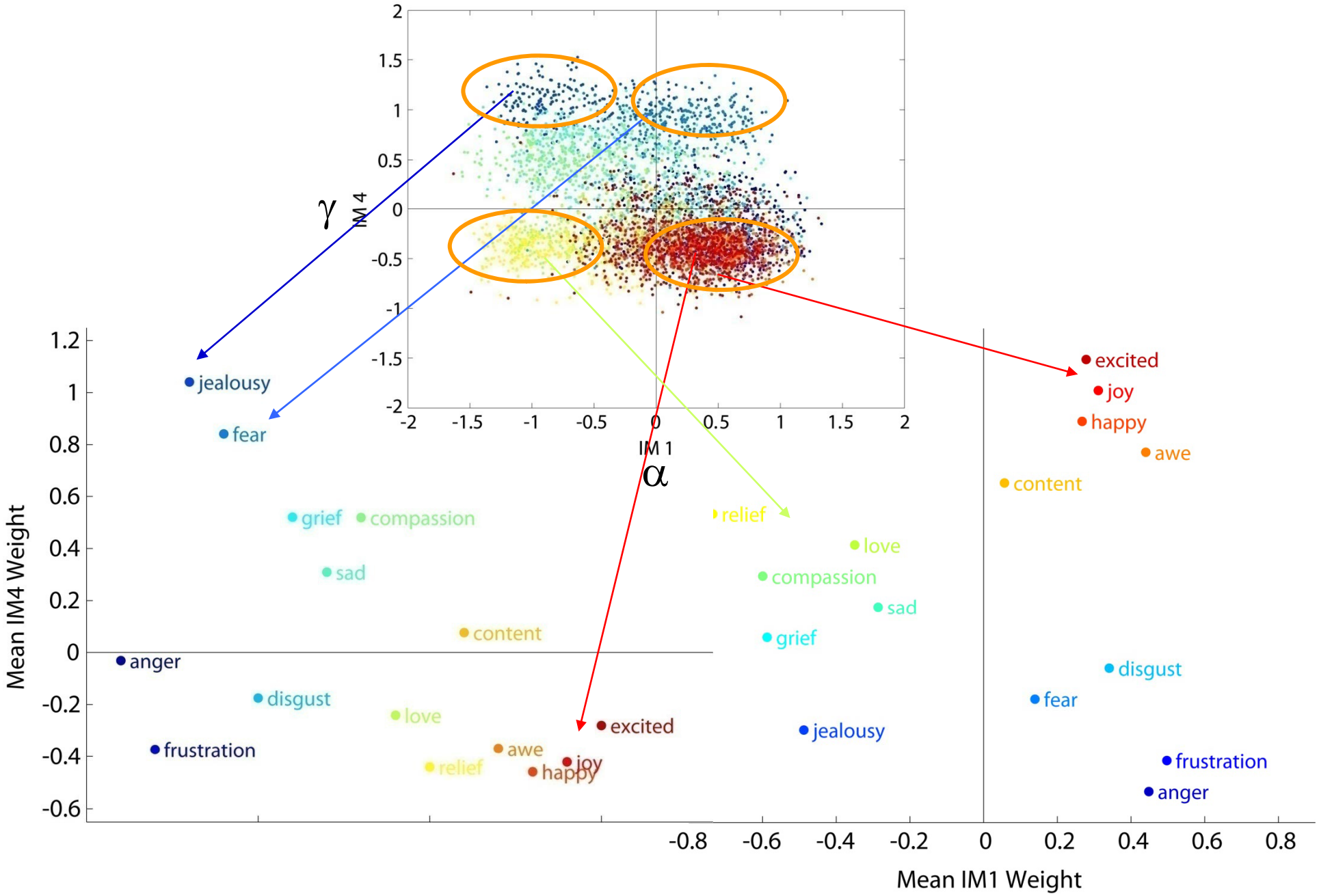
IM weight correlation



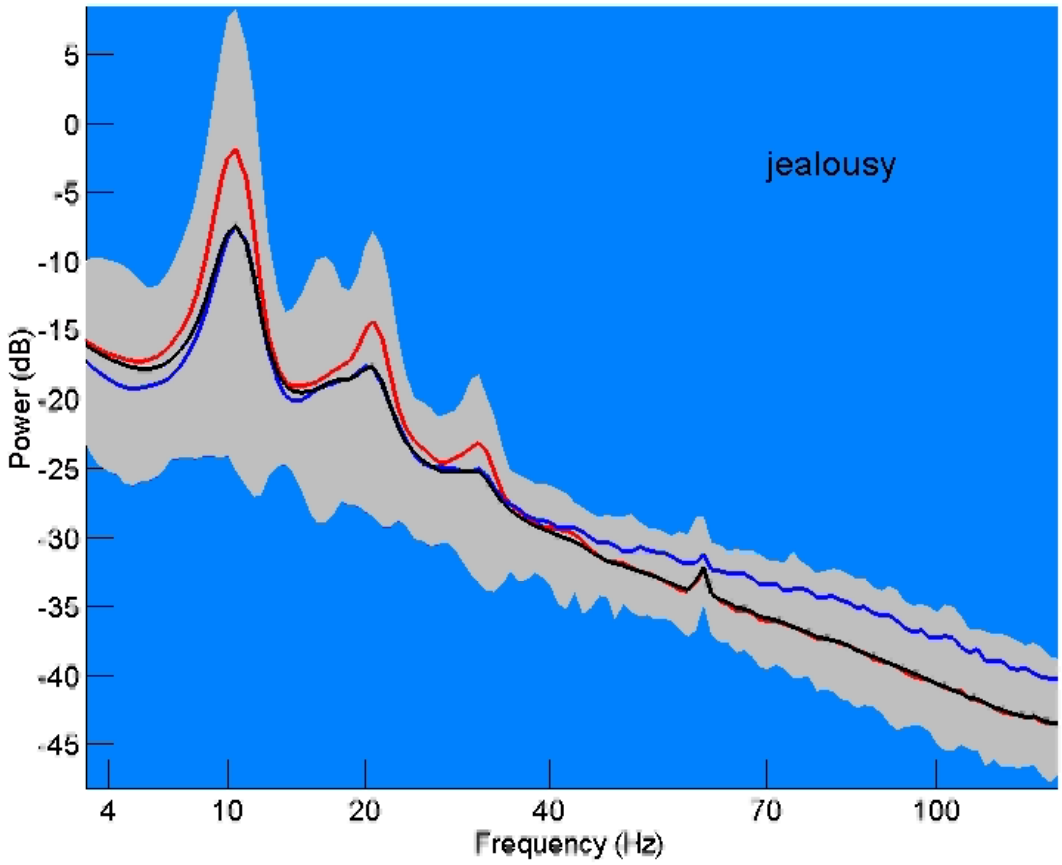
IM weight interactions



Mean weight for each emotion



IM interactions during emotional imagery



Conclusions

- Why use ICA?... Why NOT??!!
- Advantages of using ICA
  - artifact rejection
  - isolates specific brain processes
- Other applications
  - ICA decomposition of spectral modulations