EEG spectral modulations during emotional imagery

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Outline

- ❒ Emotional imagery experiment
- ❒ Unmixing power modulations with ICA
- ❒ Broadband high frequency modulations
- ❒ Power modulations during emotional imagery
- ❒ Emotion classification using power modulations

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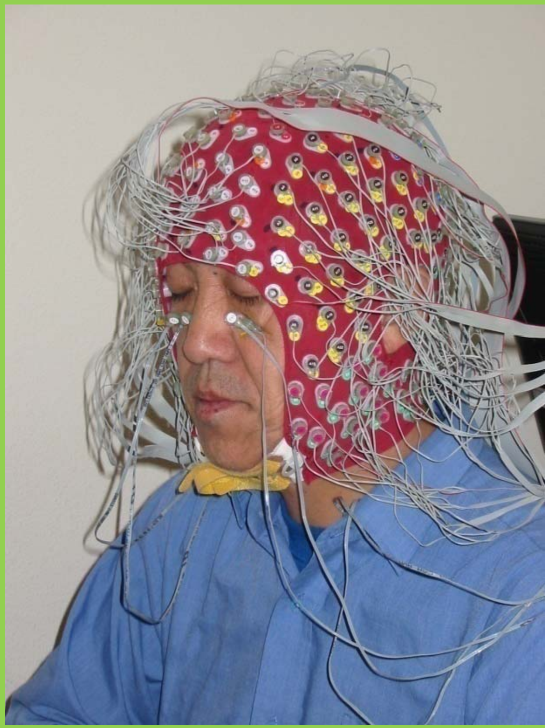
Experimental procedure

- Pre-session eyes closed baseline
- Guided relaxation (~5 min)
- 15 emotions
  - balanced positive and negative valence
  - introduced verbally via headphones
  - self-paced emotional experience
- Subject pressed a button when feeling became intense
- Instructed to image for ~4 min
- Post-session eyes closed baseline



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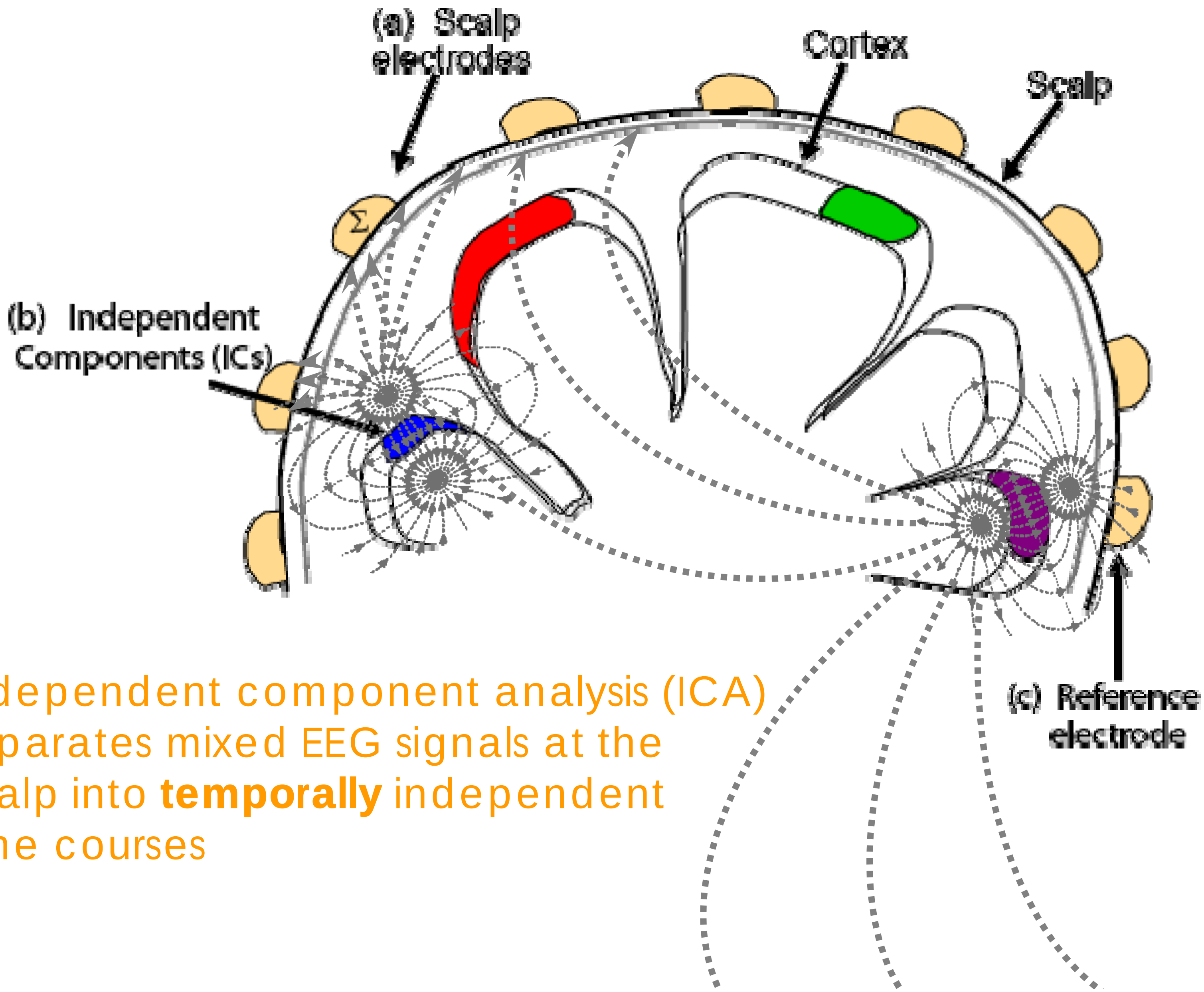
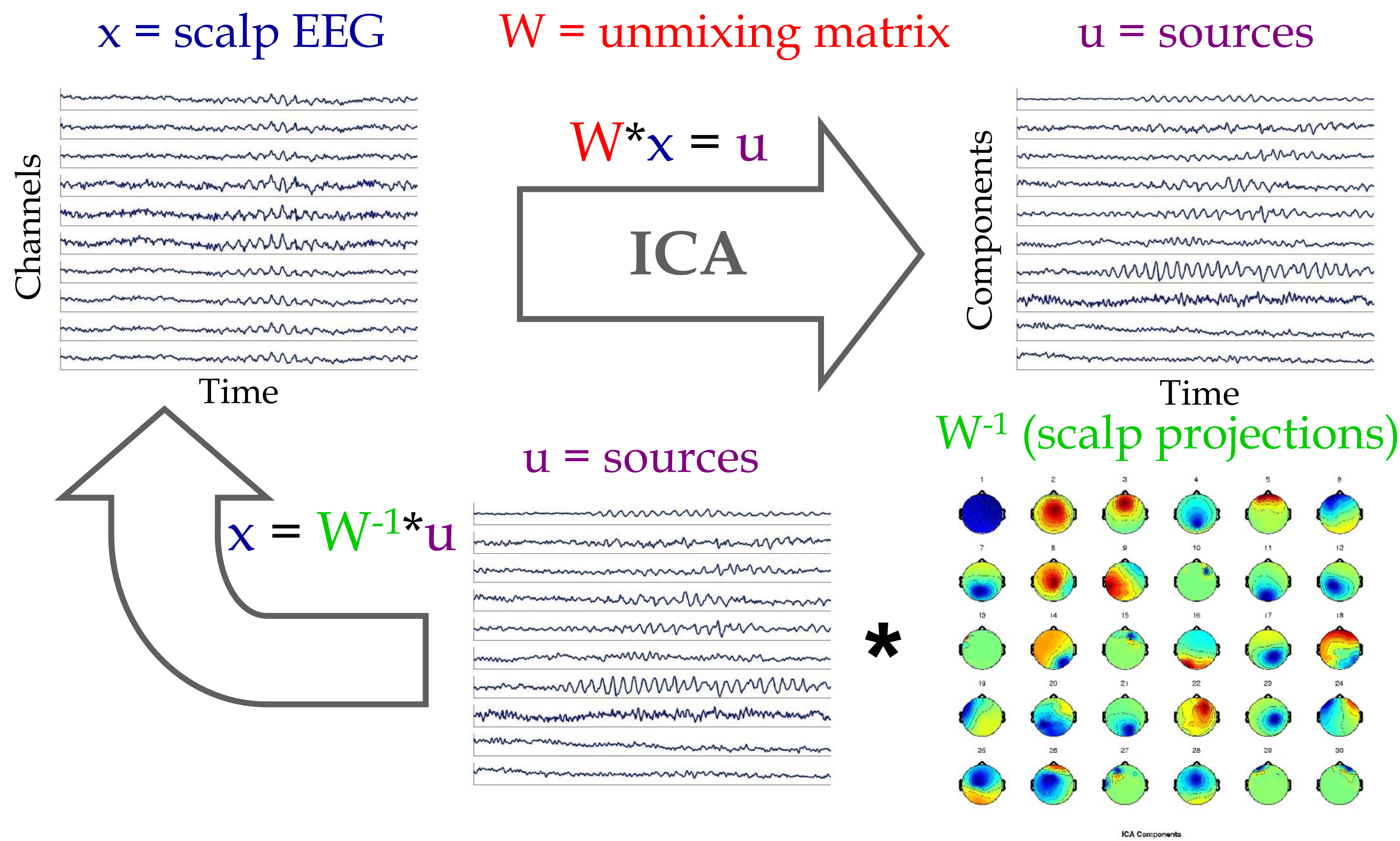
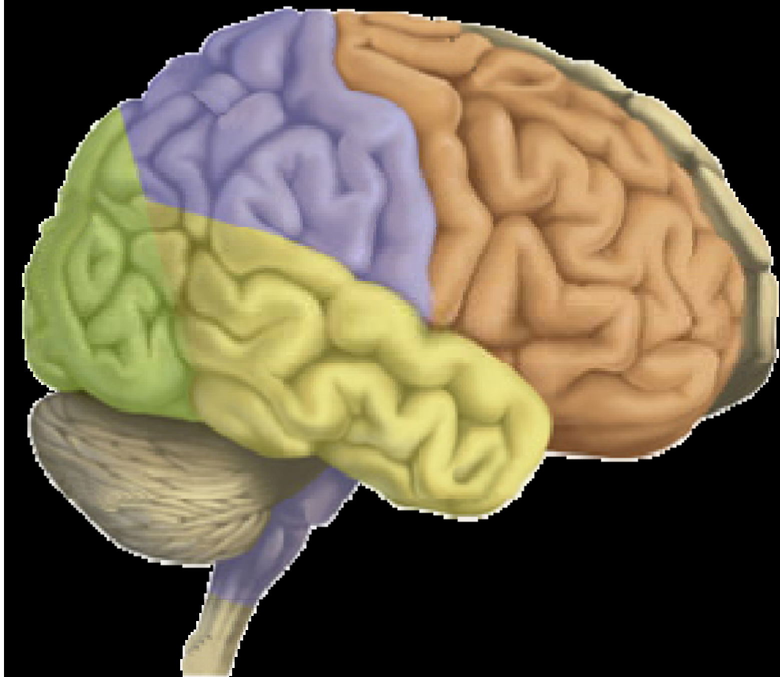
Separate mixed source activities

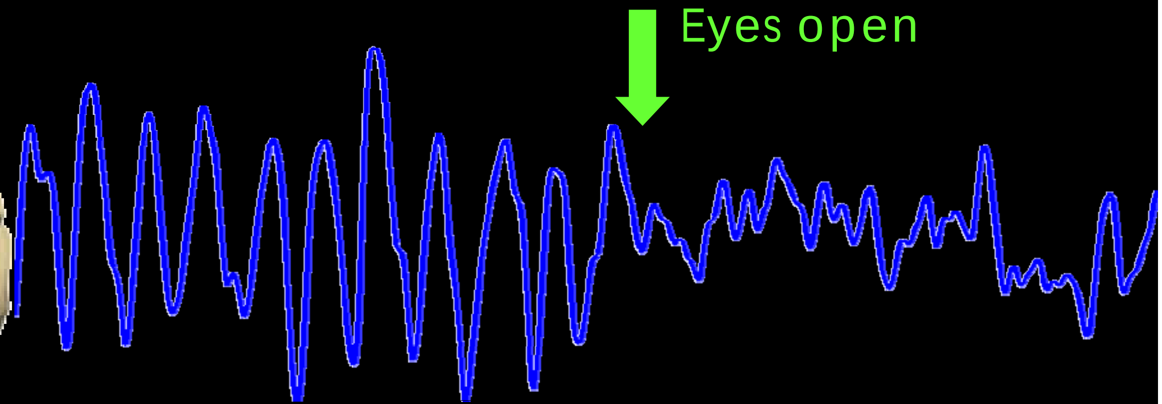


Independent component analysis (ICA) separates mixed EEG signals at the scalp into **temporally** independent time courses

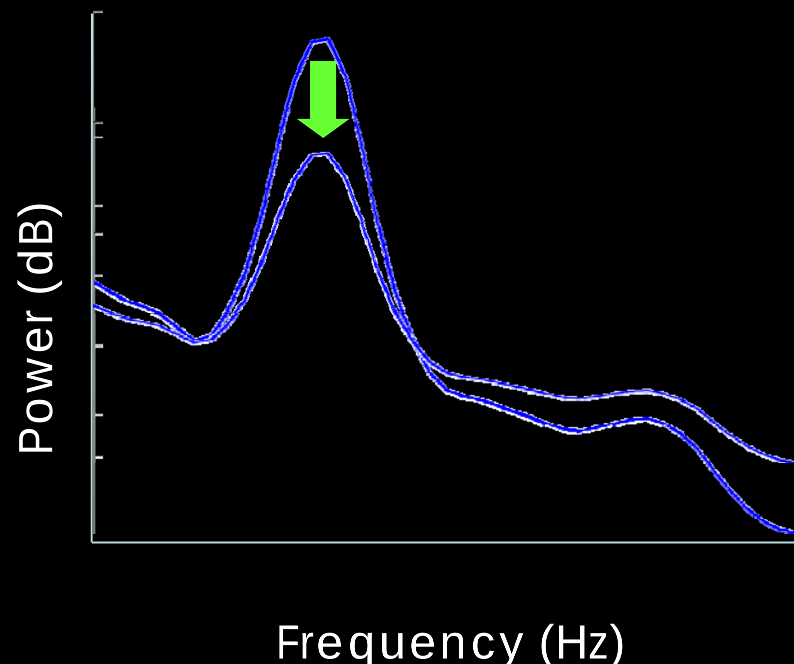
Independent component analysis (ICA)



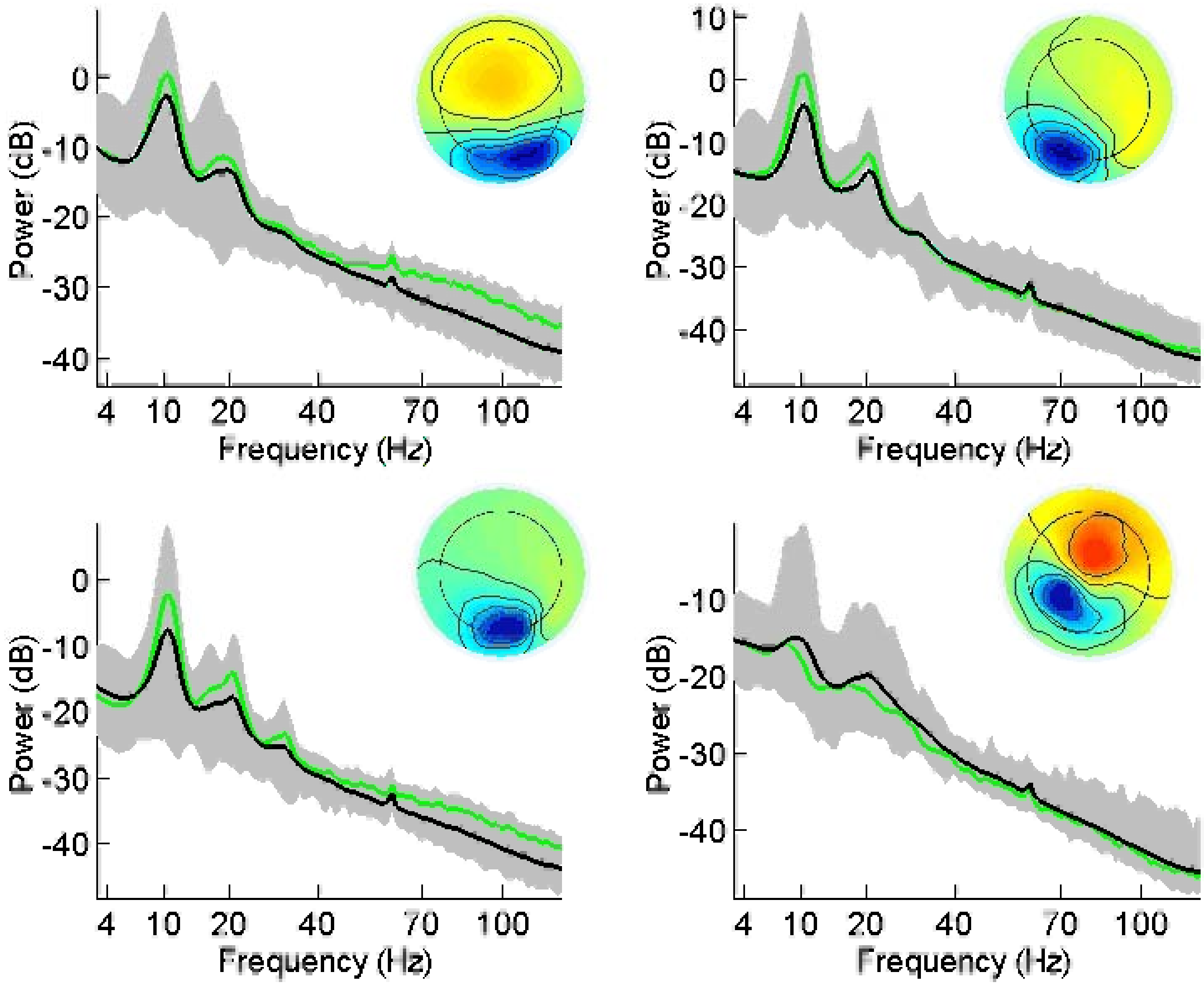




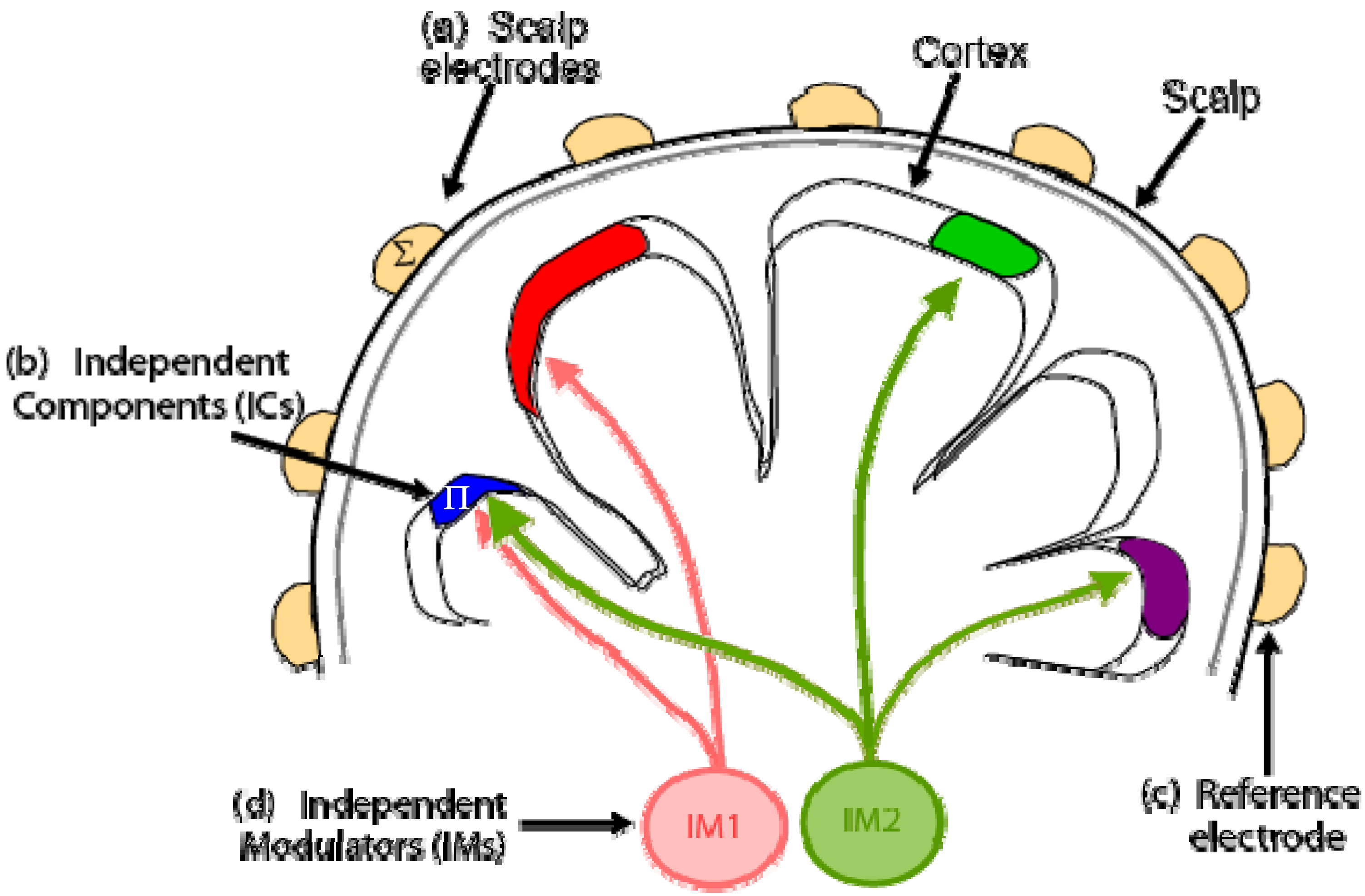
Dynamic changes in frequency power over time



Complexity of on-going EEG spectral power

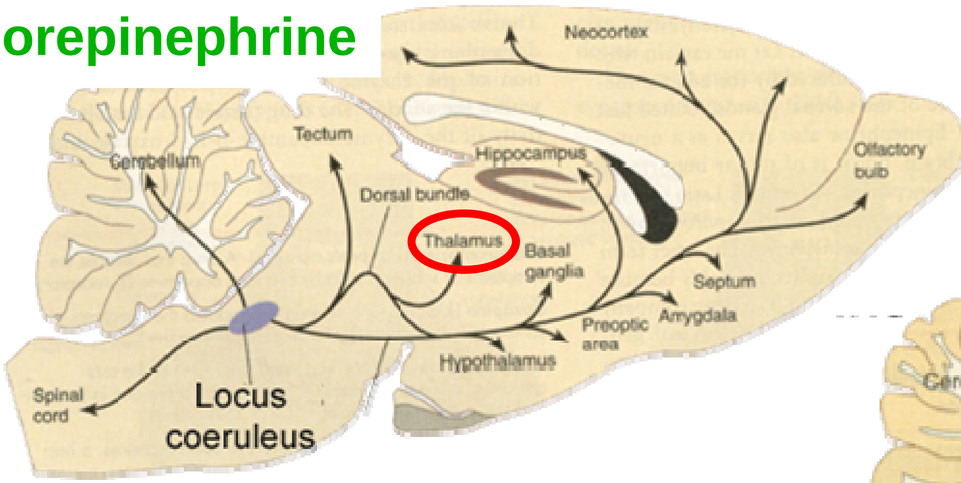


Independent (Co-)Modulators of EEG Source Activities

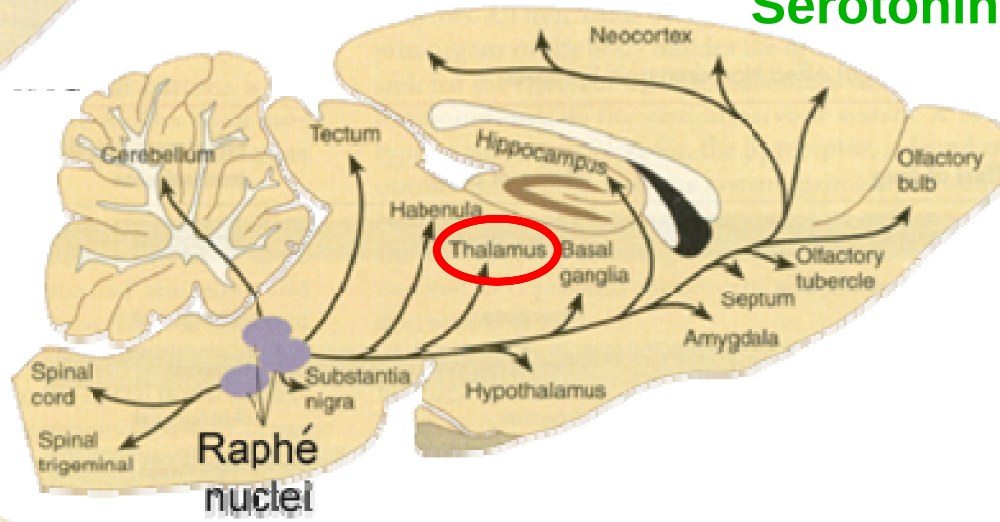


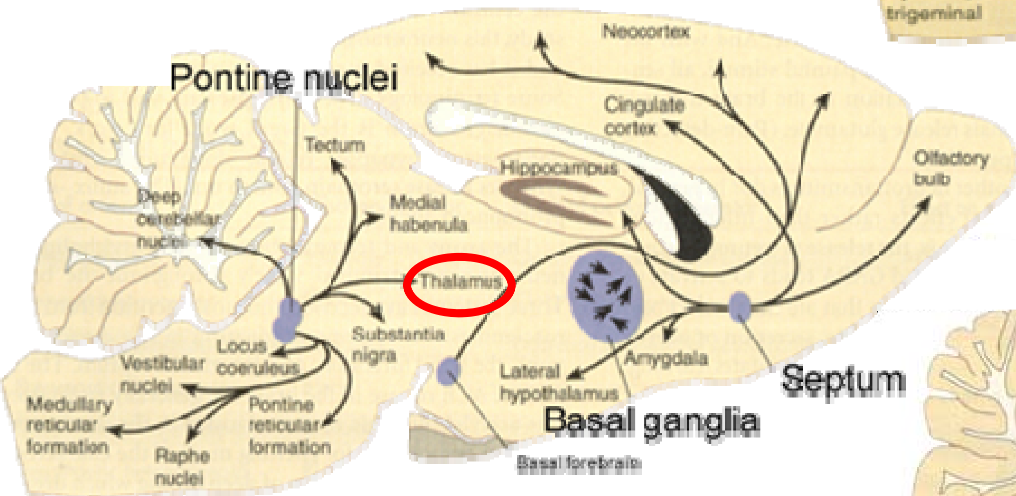
What causes dynamic spectral changes?

Norepinephrine



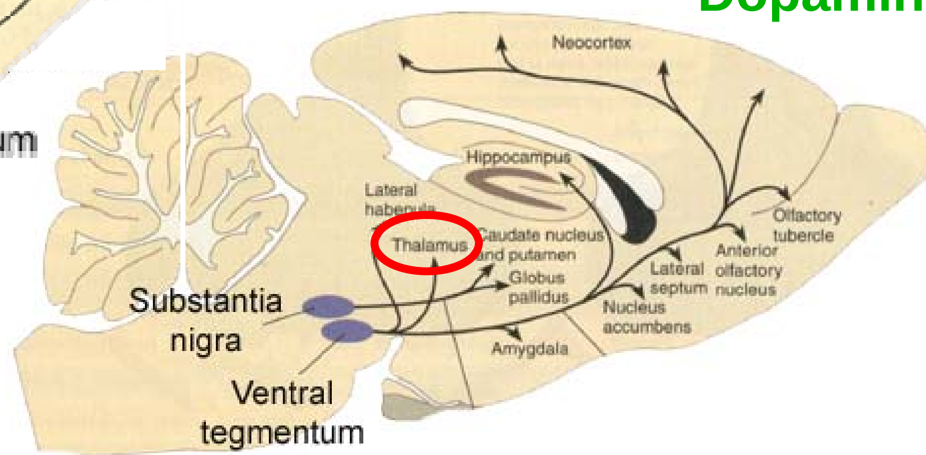
Serotonin



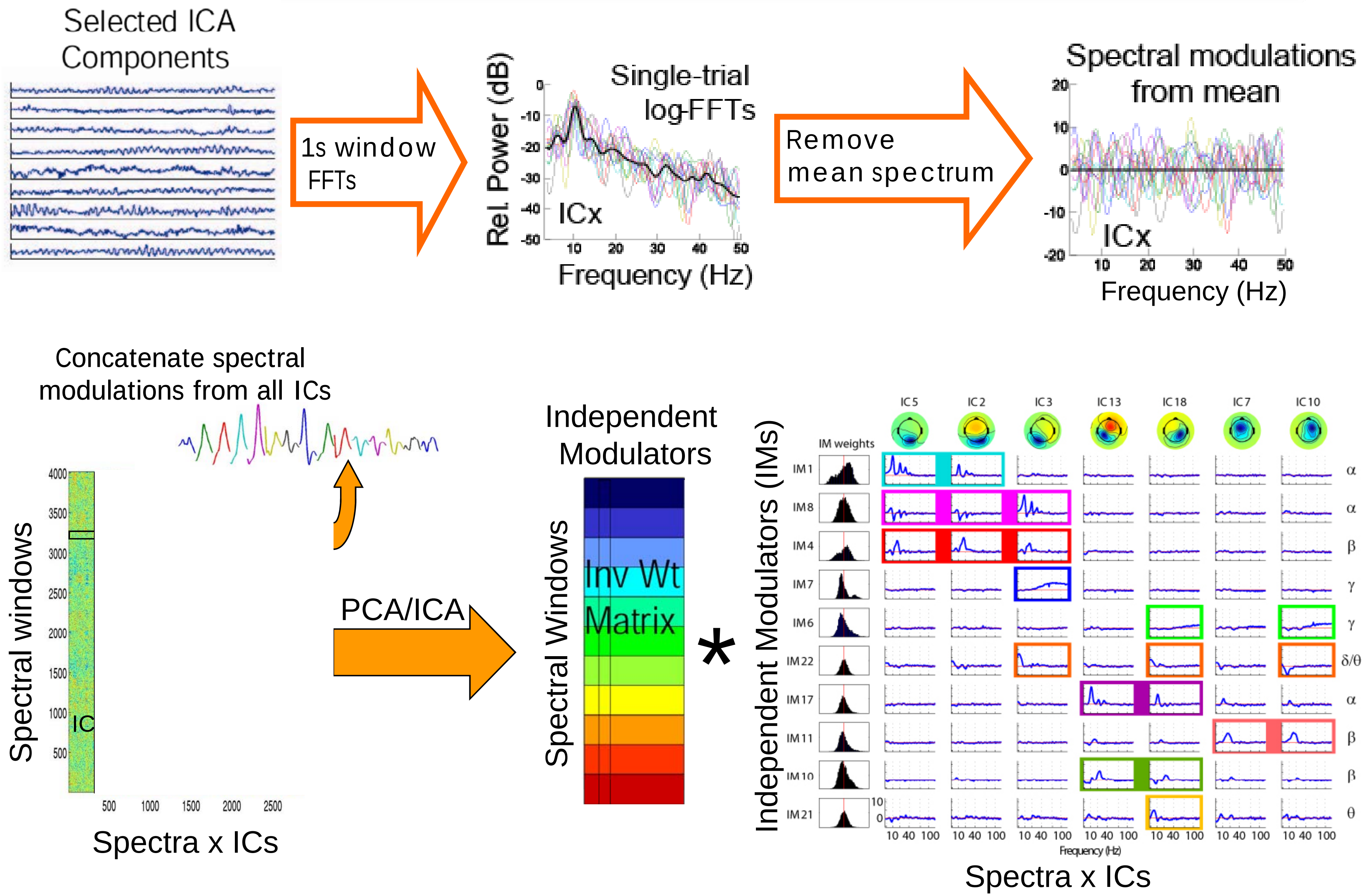


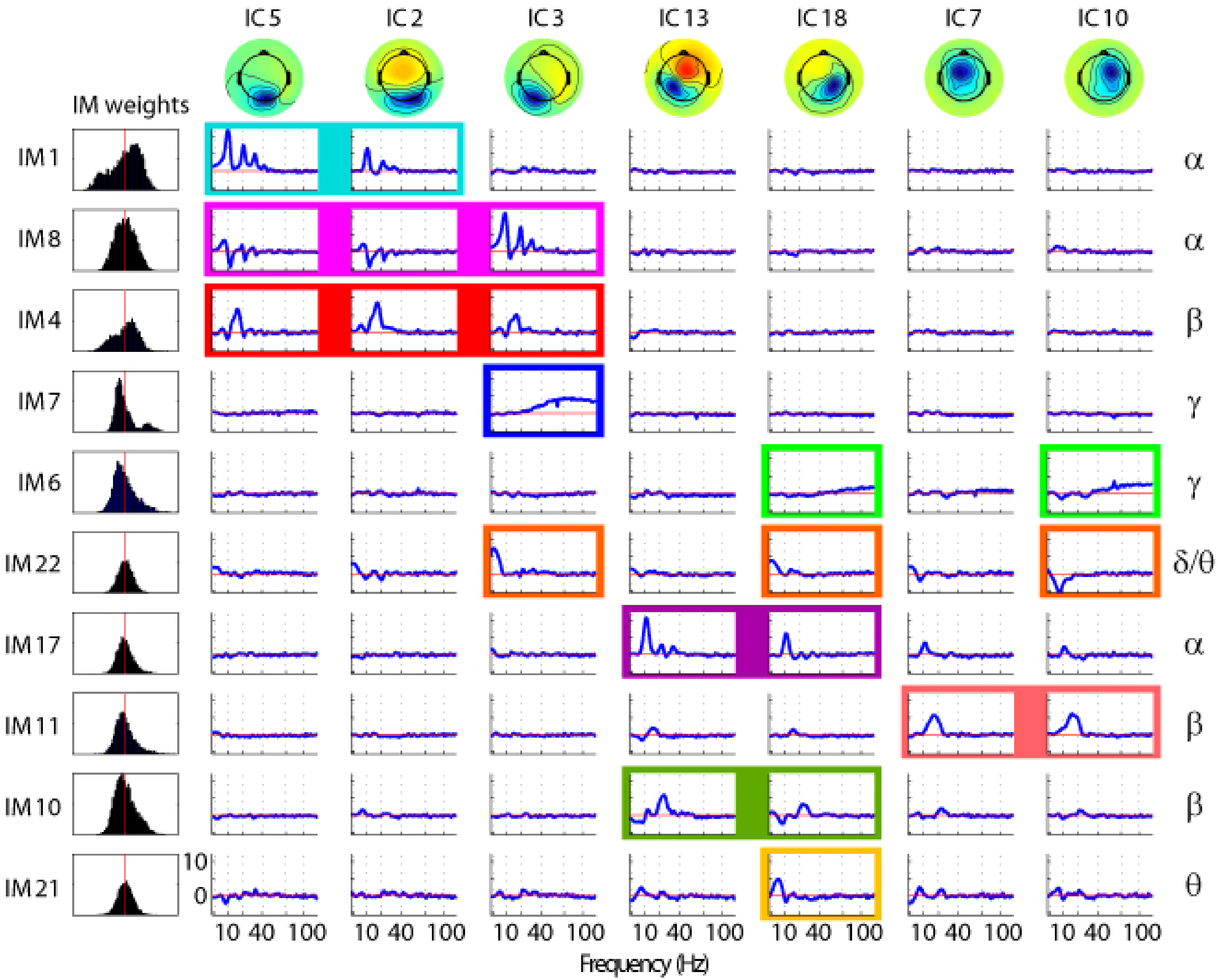
Acetylcholine

Dopamine



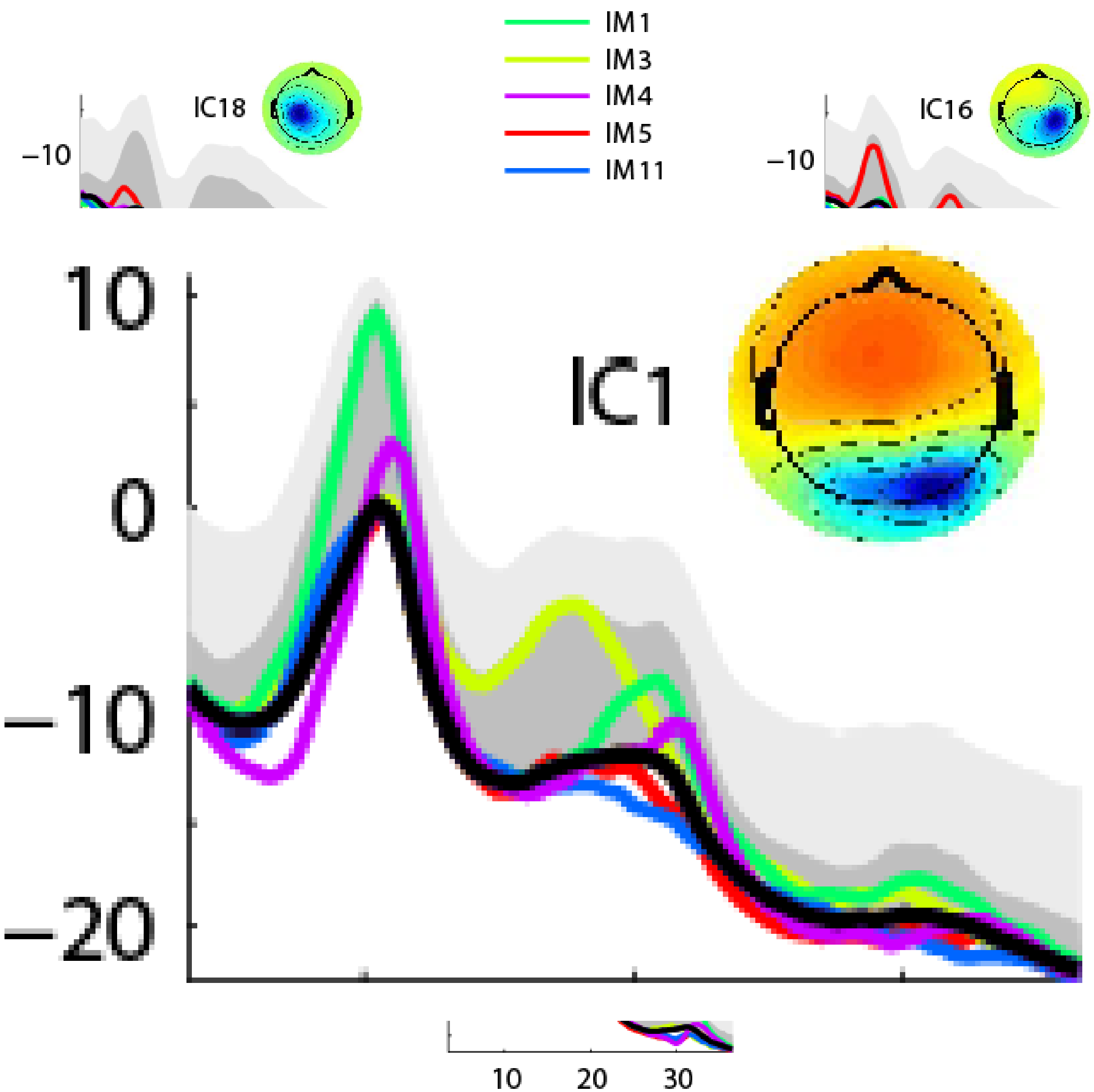
Log-spectral decomposition



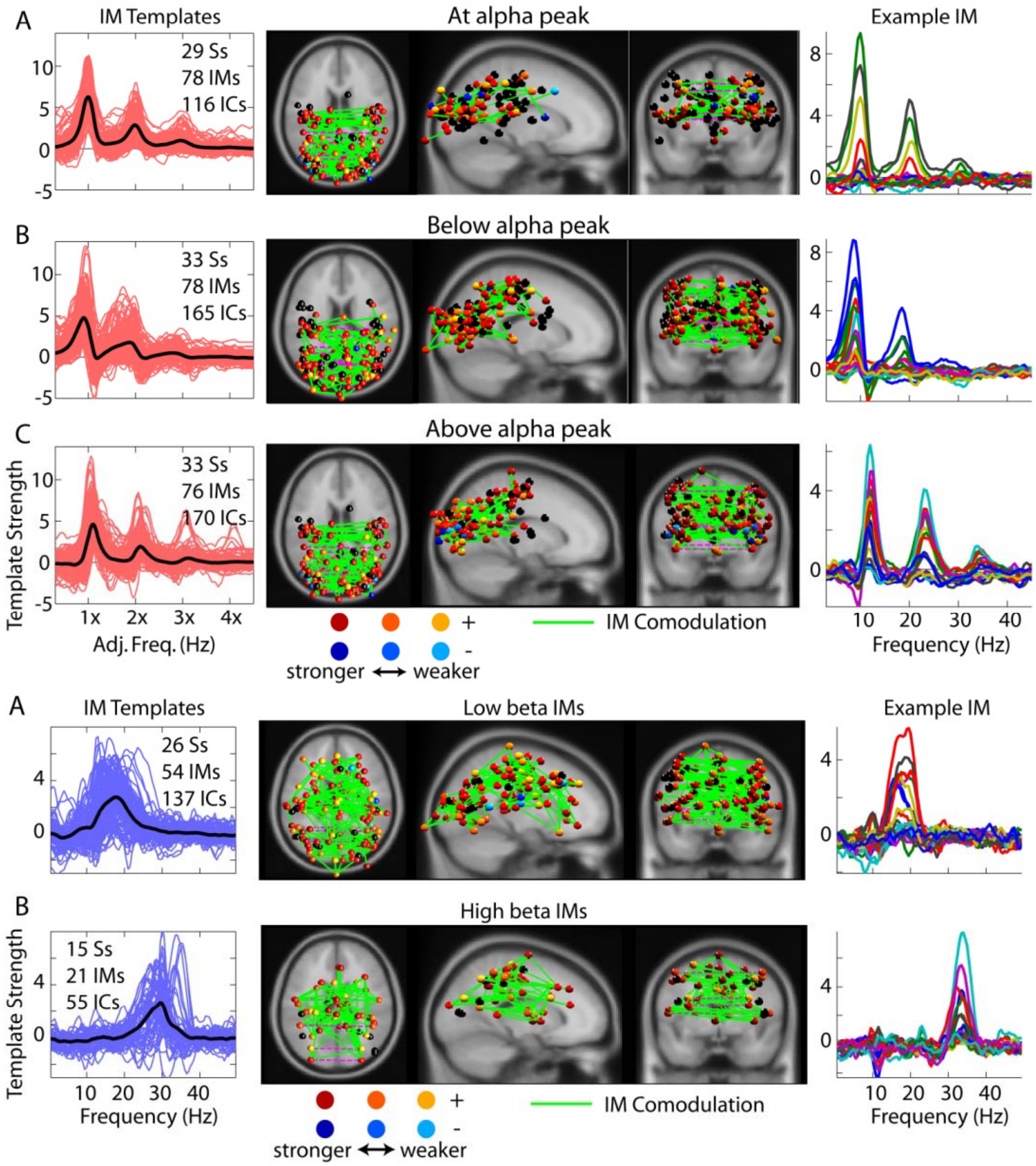


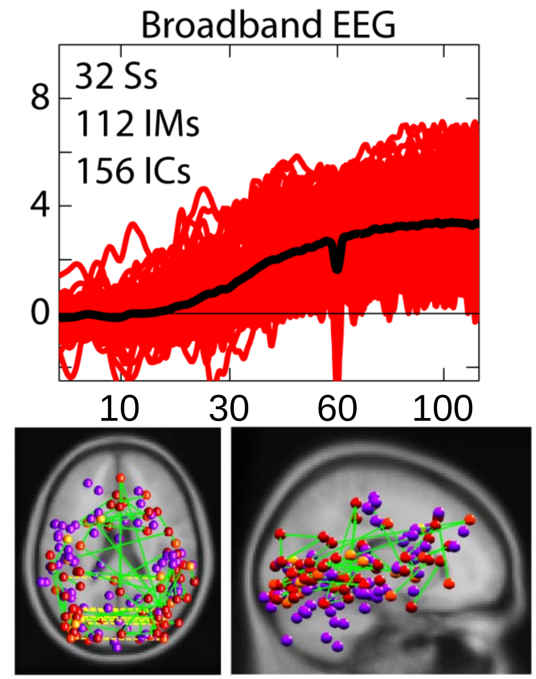
IC5
IC2
IC3
IC13
IC18
IC7
IC10
IM weights
IM1
IM8
IM4
IM7
IM6
IM22
IM17
IM11
IM10
IM21
α
α
β
γ
γ
δ/θ
α
β
β
θ
10
0
10 40 100
Frequency (Hz)

Example IM templates + mean power spectrum



Clusters of spectral modulators (33 Ss)





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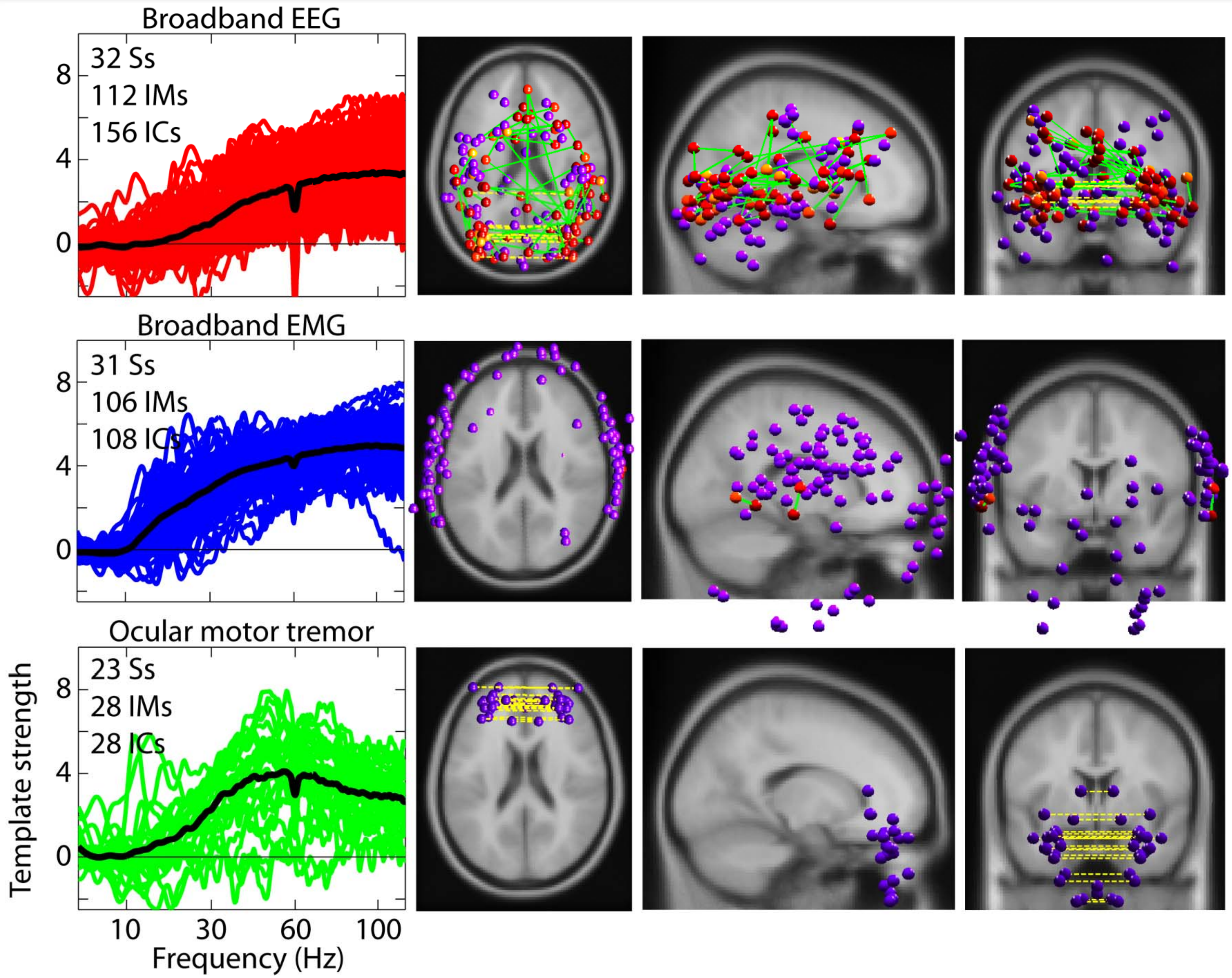
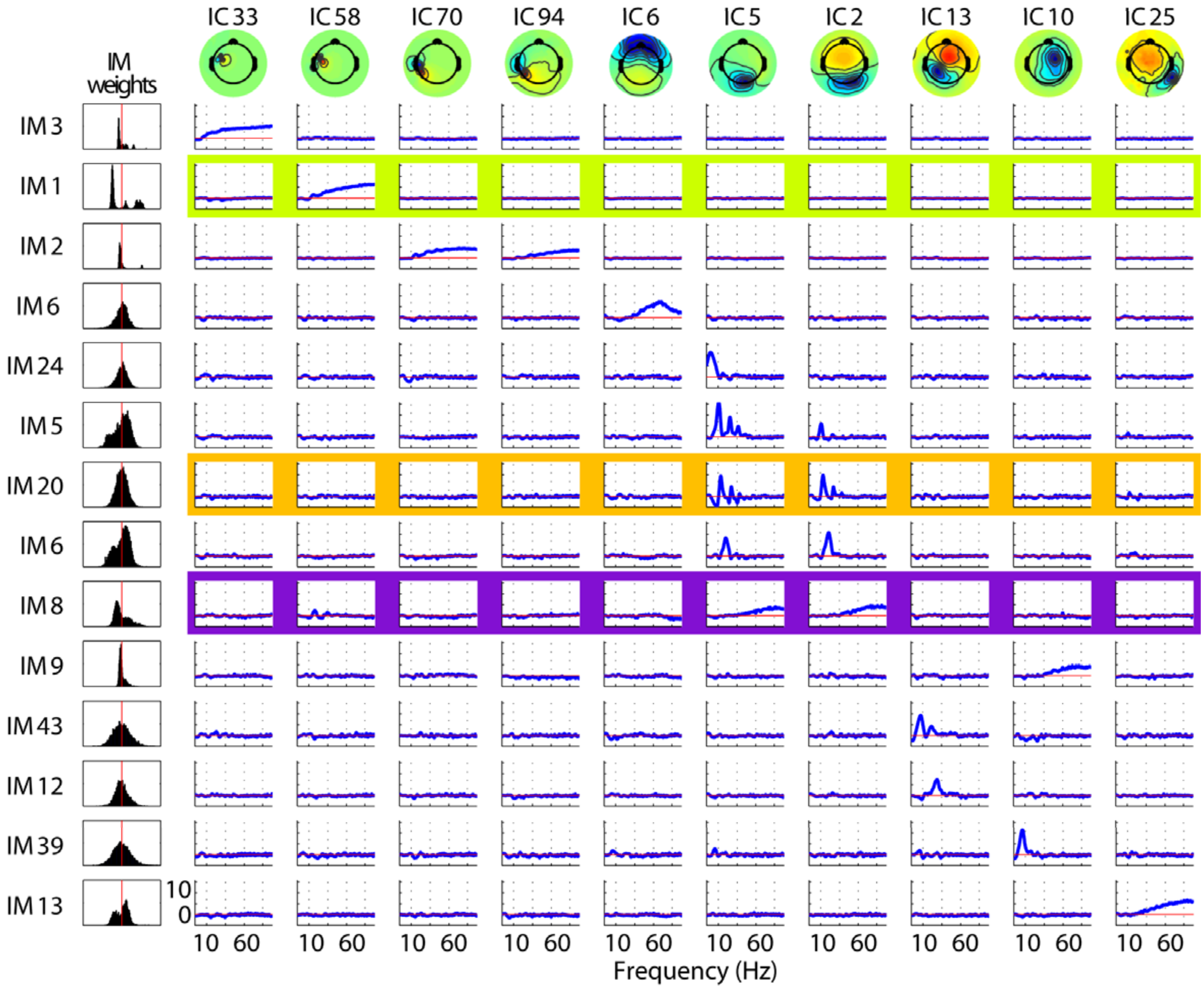
Broadband gamma modulator clusters



Muscle is not co-modulated with brain



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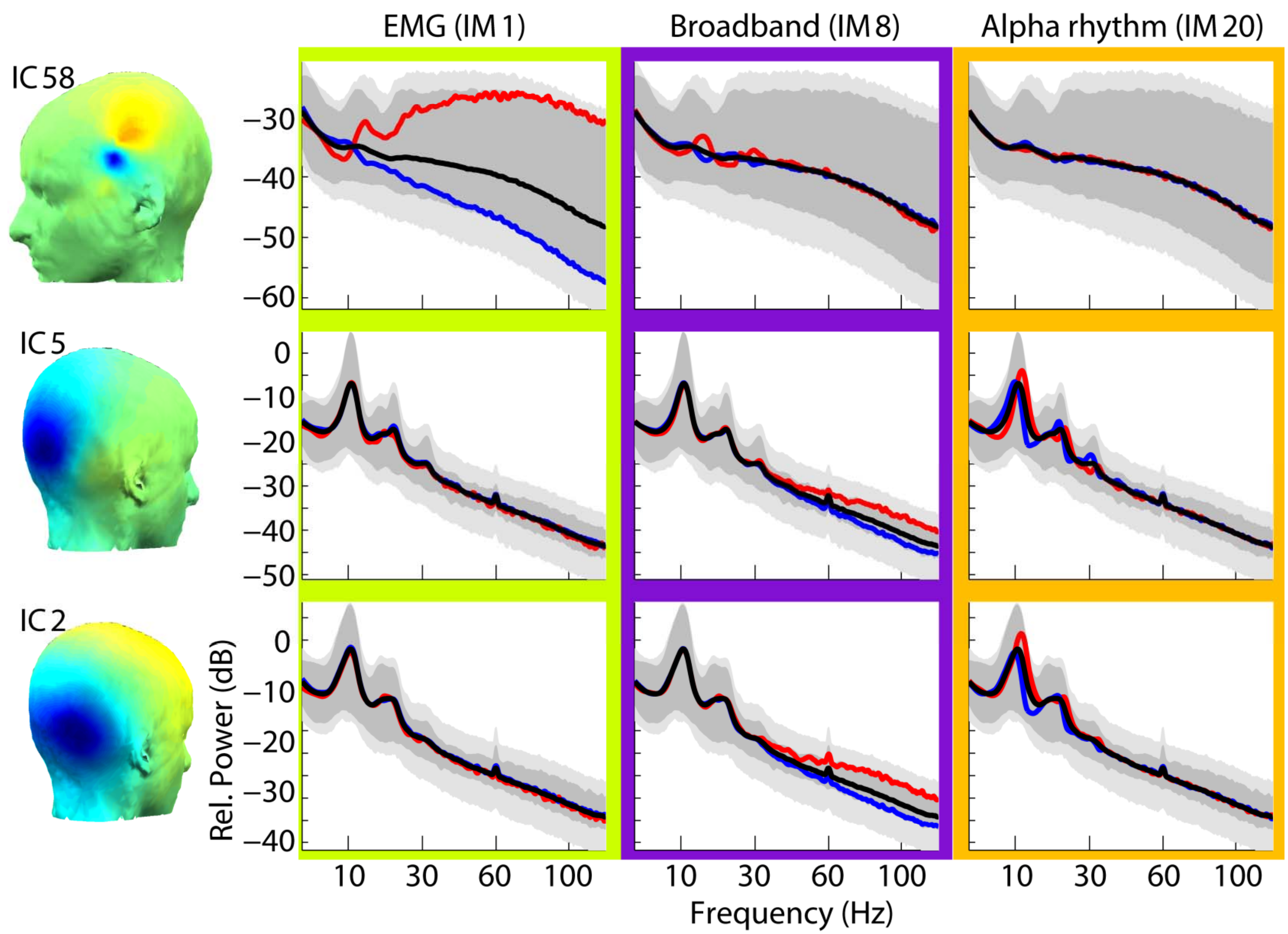
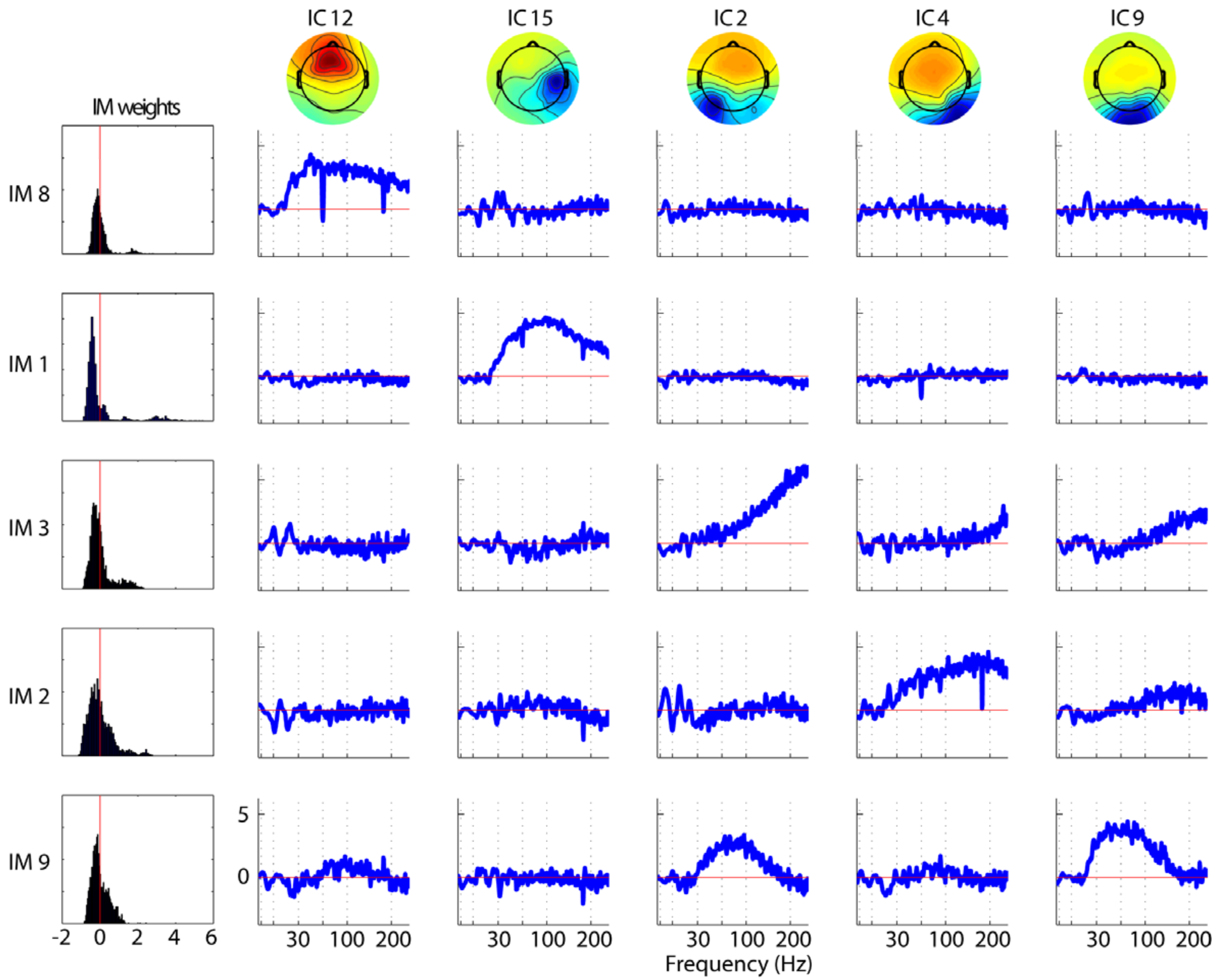
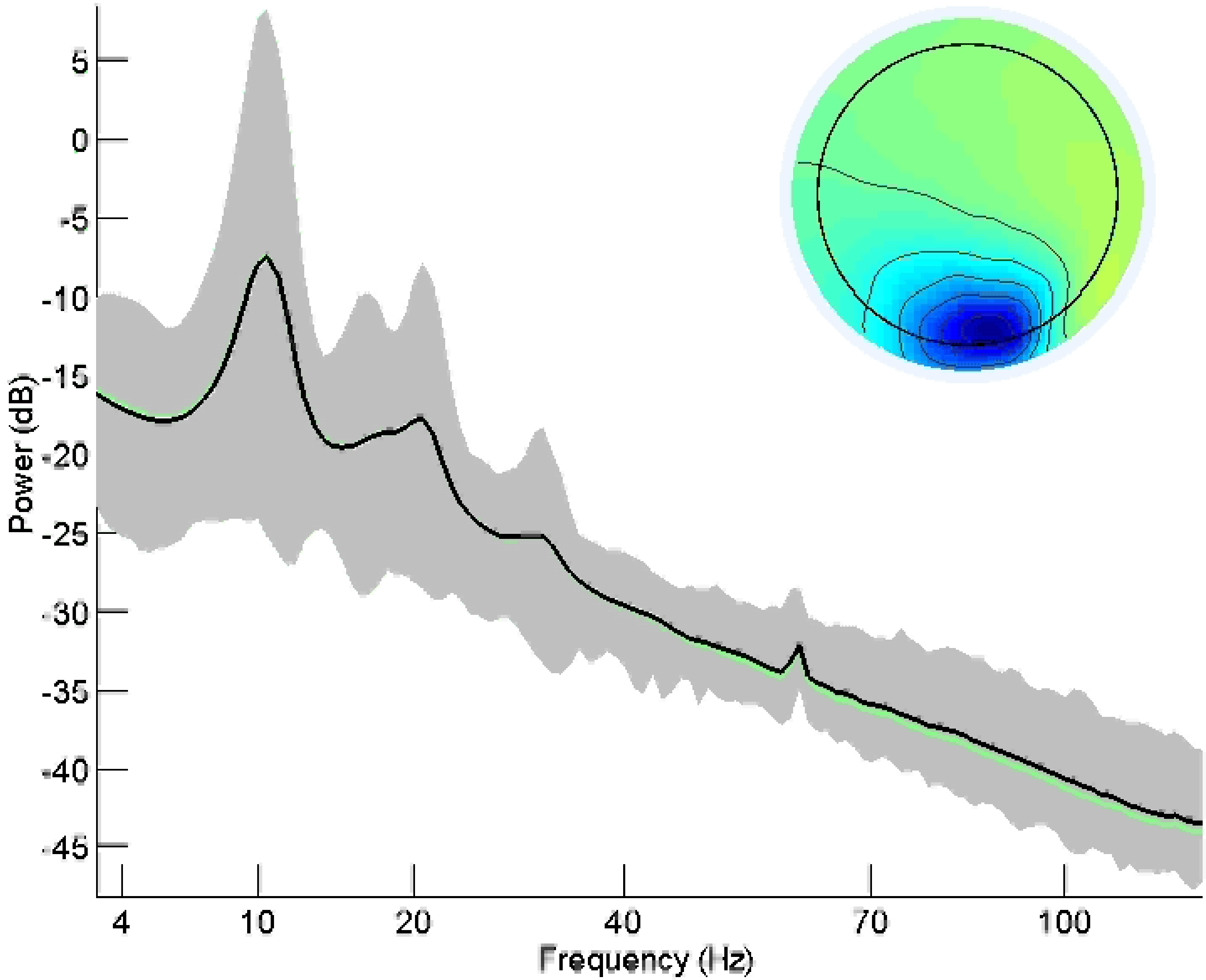


Gamma power up to 250 Hz



Sorted broadband IM weights



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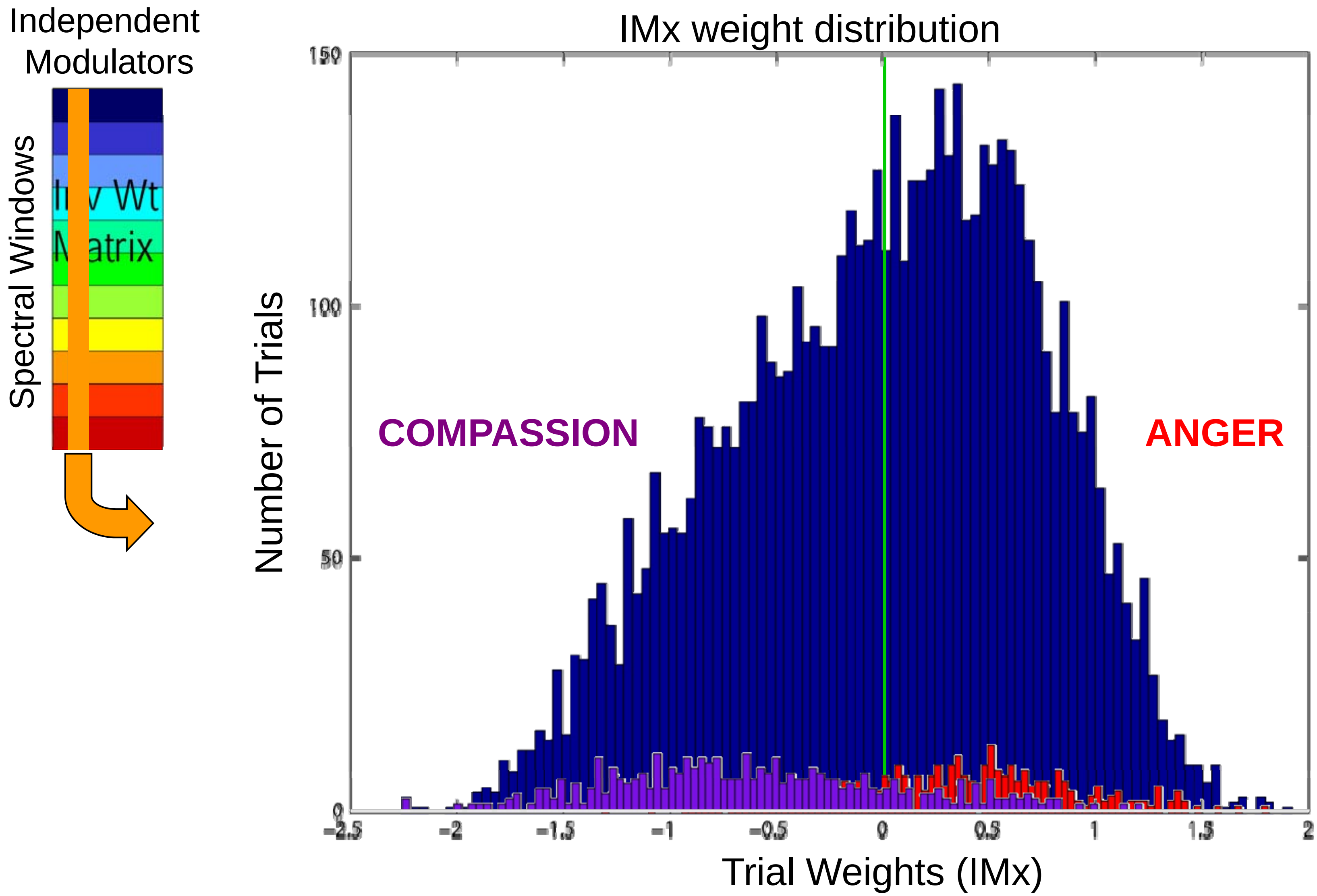
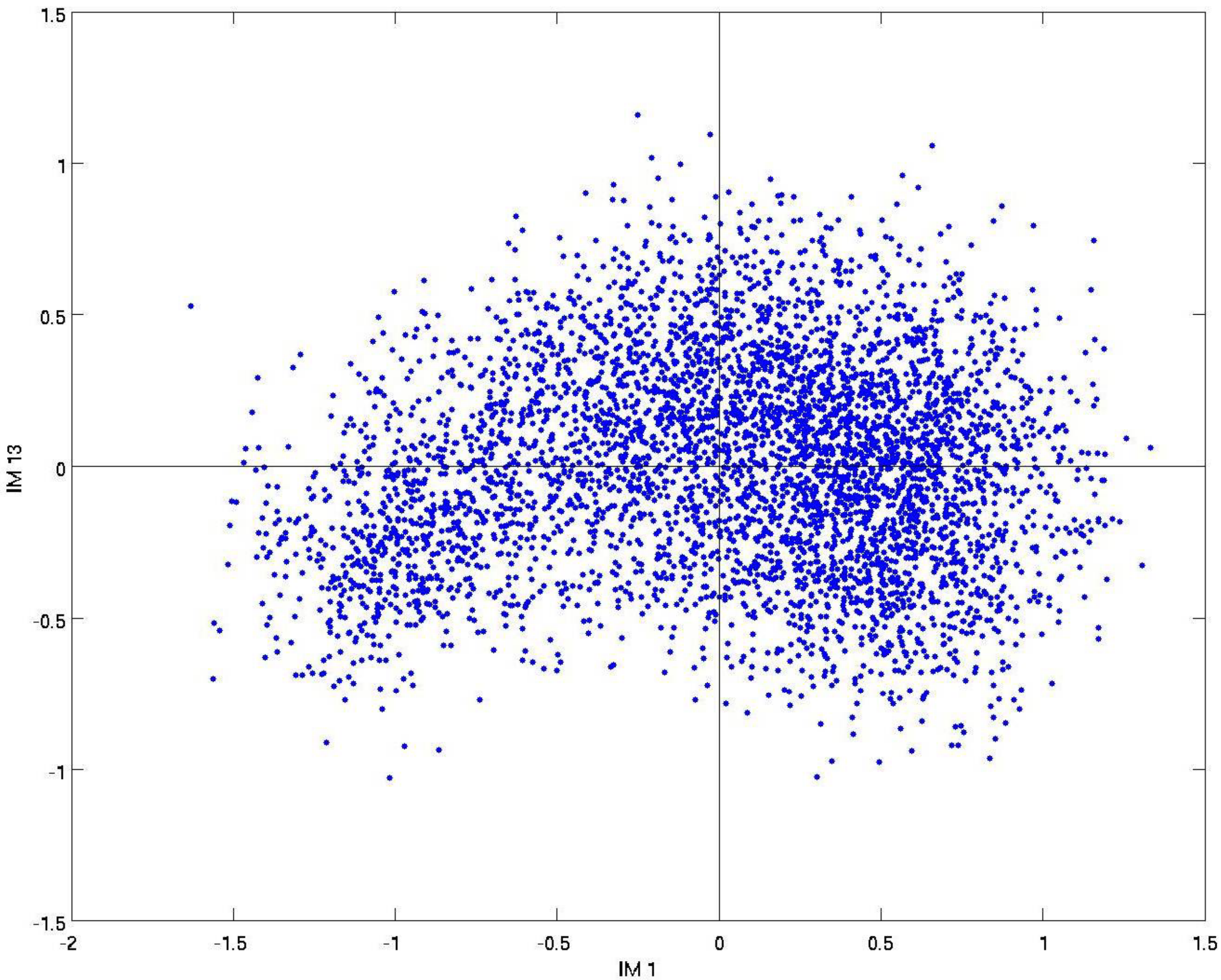
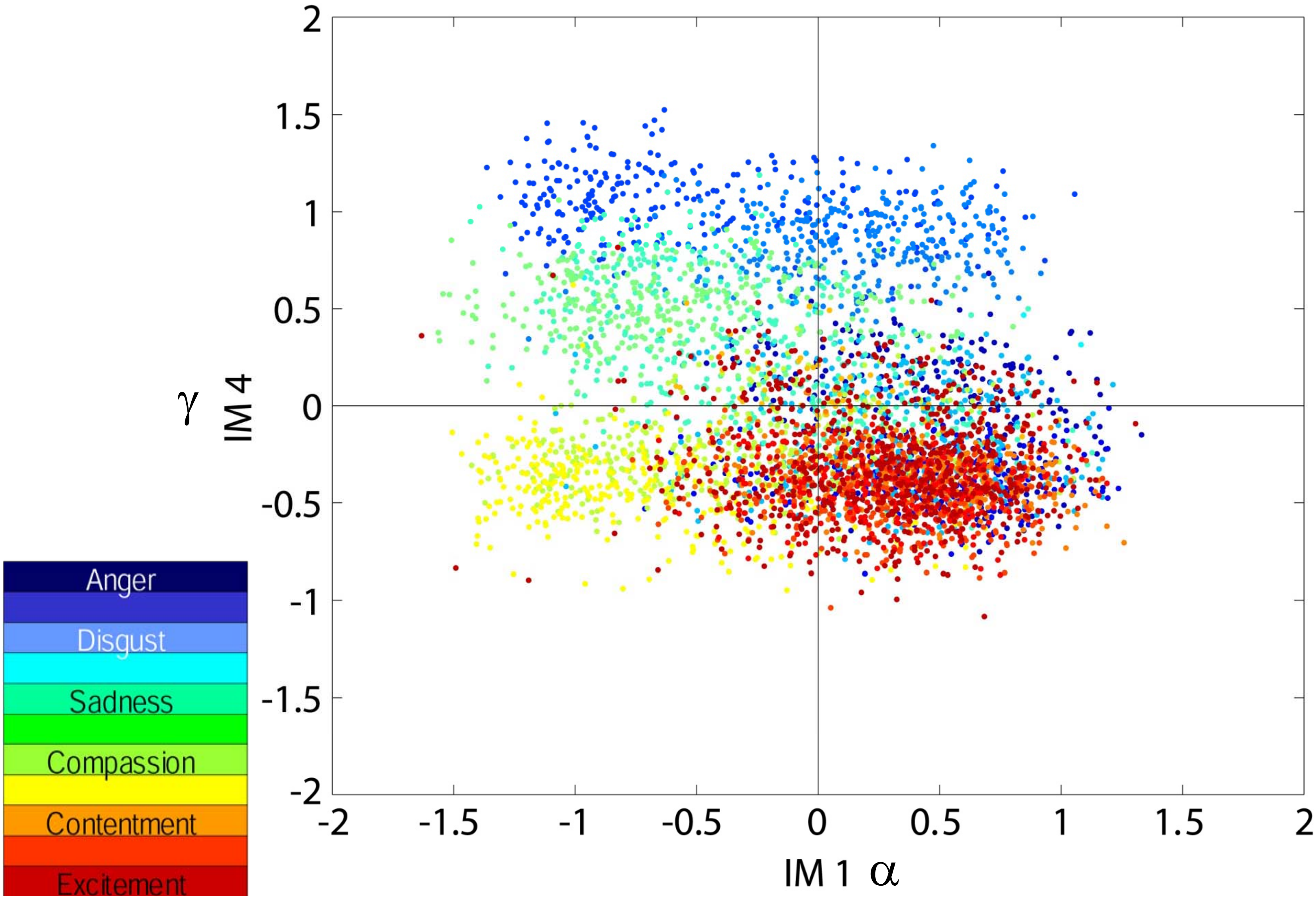
IM distribution shifts with emotional state changes



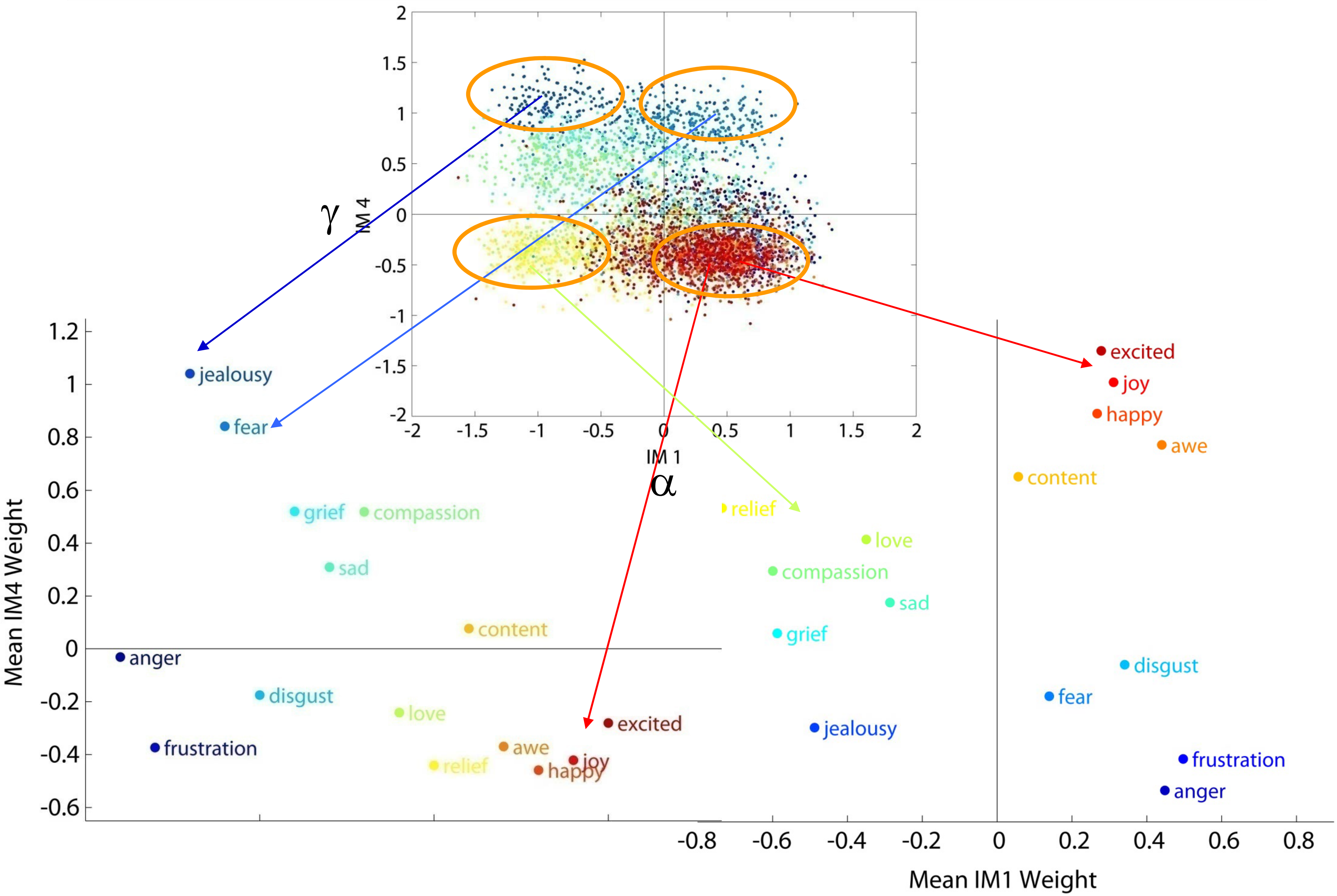
IM weights for different emotions



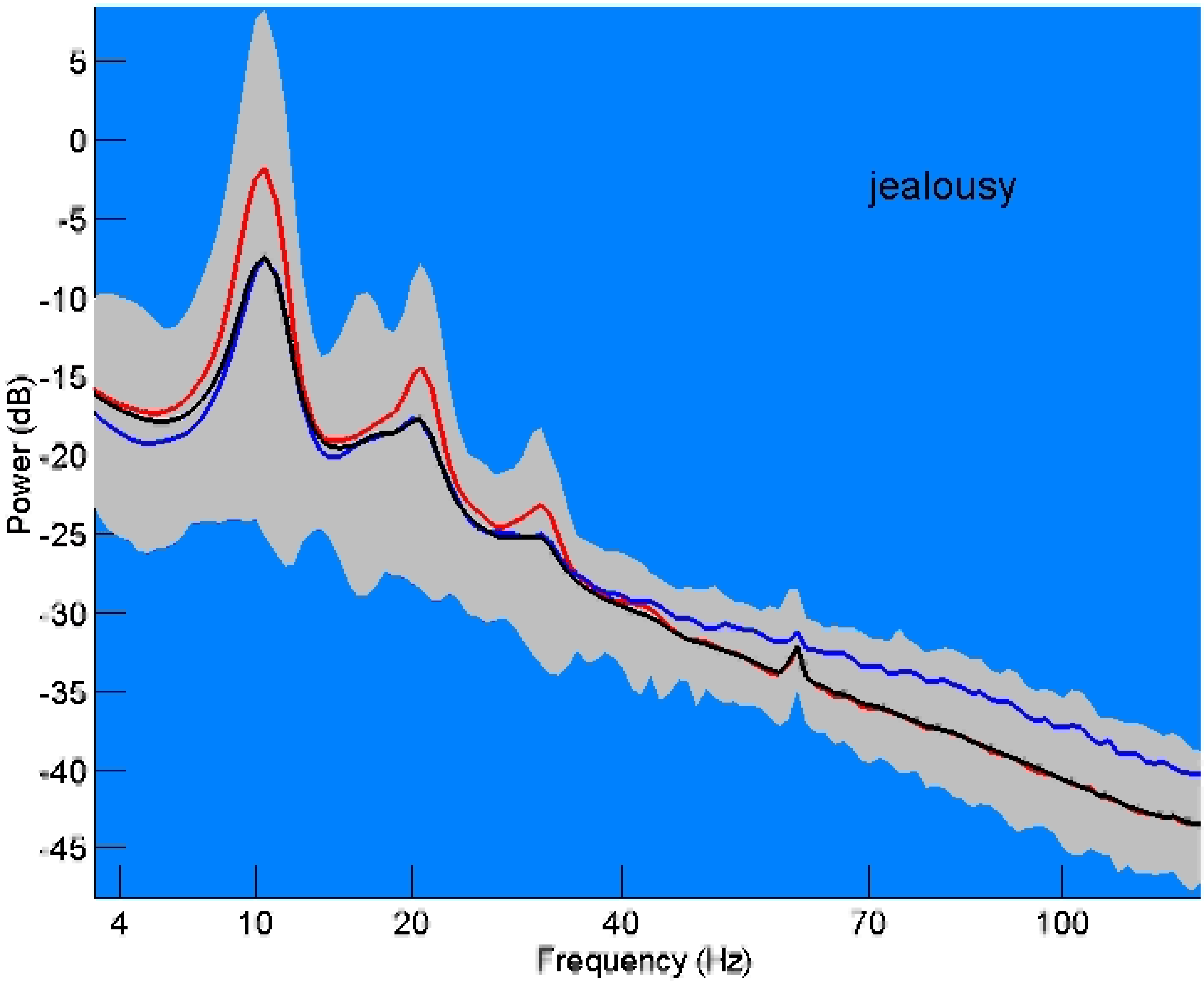
IM weights for different emotions



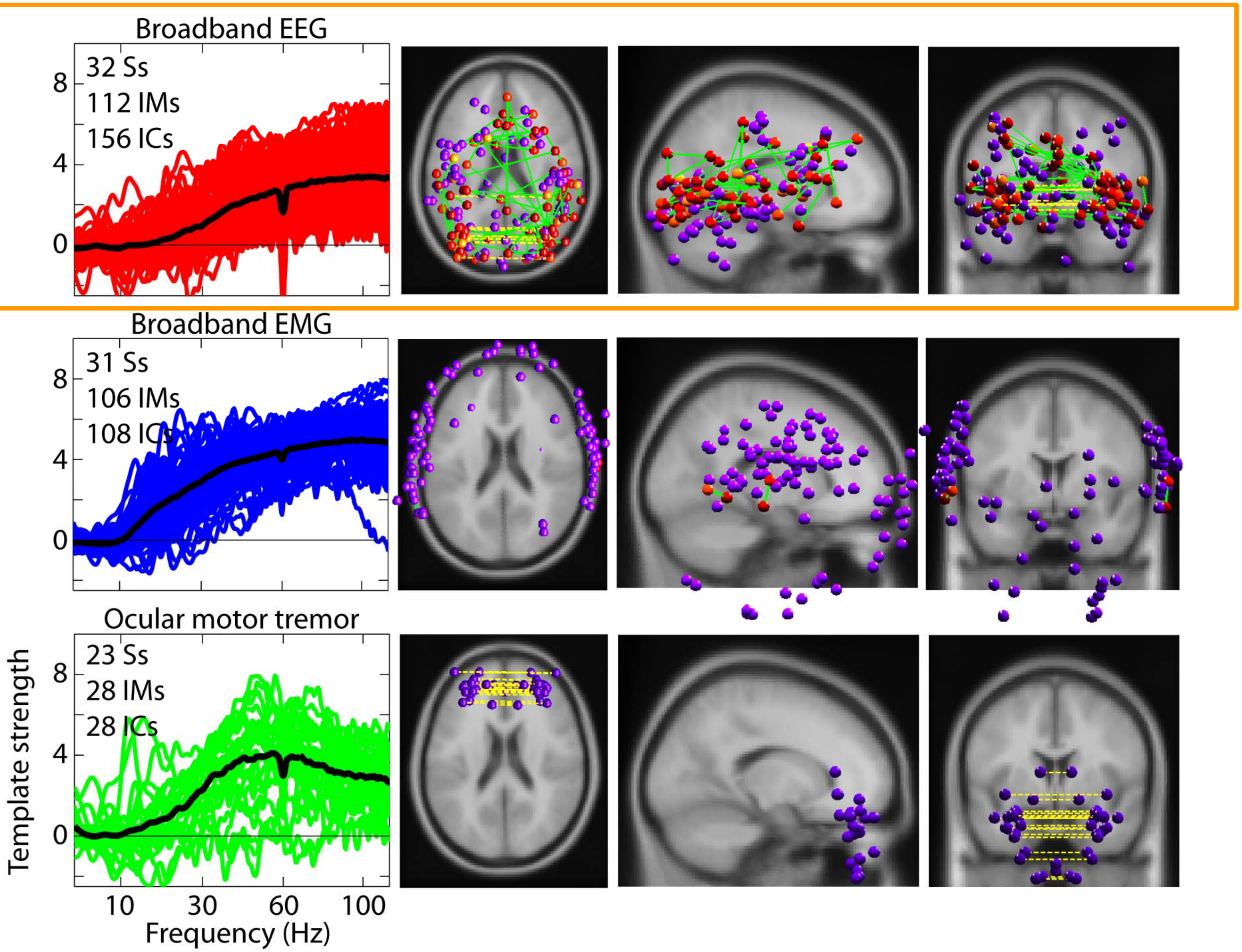
Momentary and mean IM weights



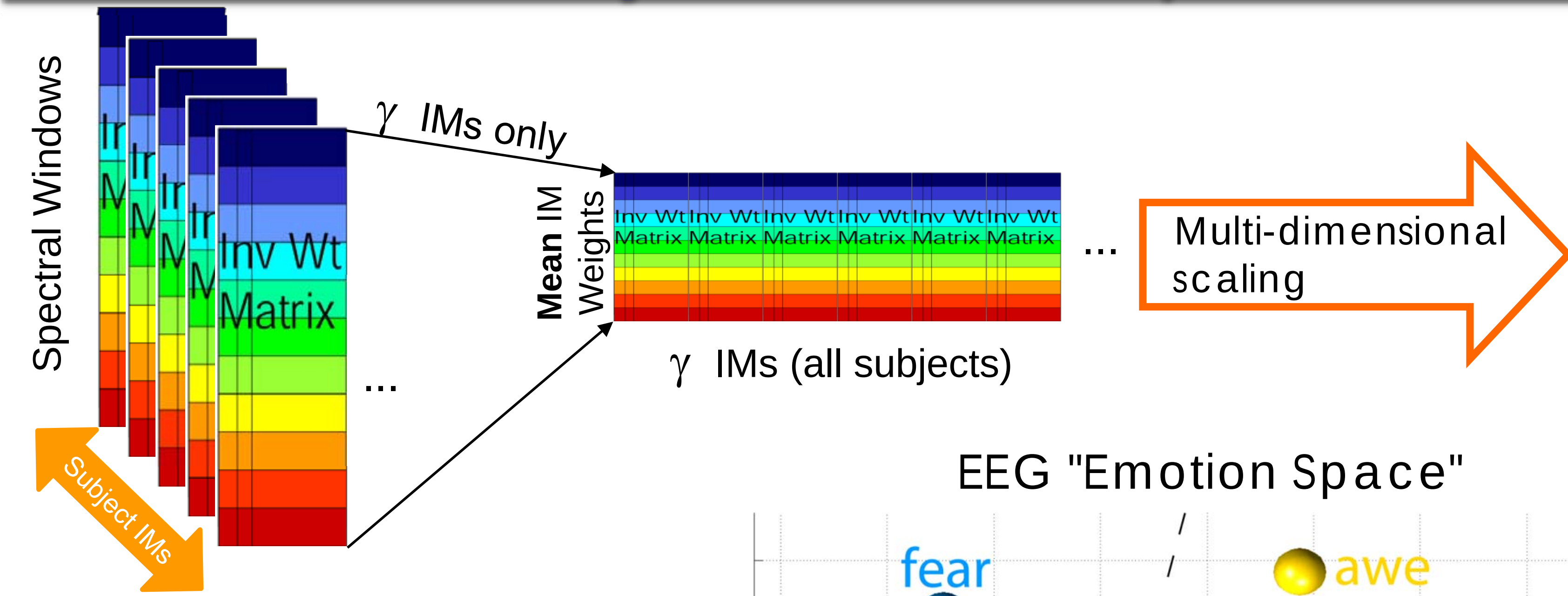
IM weights during emotional imagery

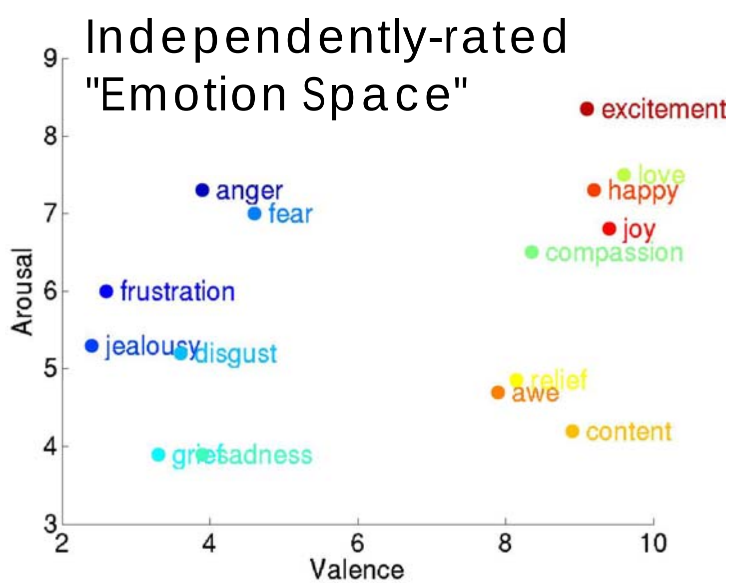


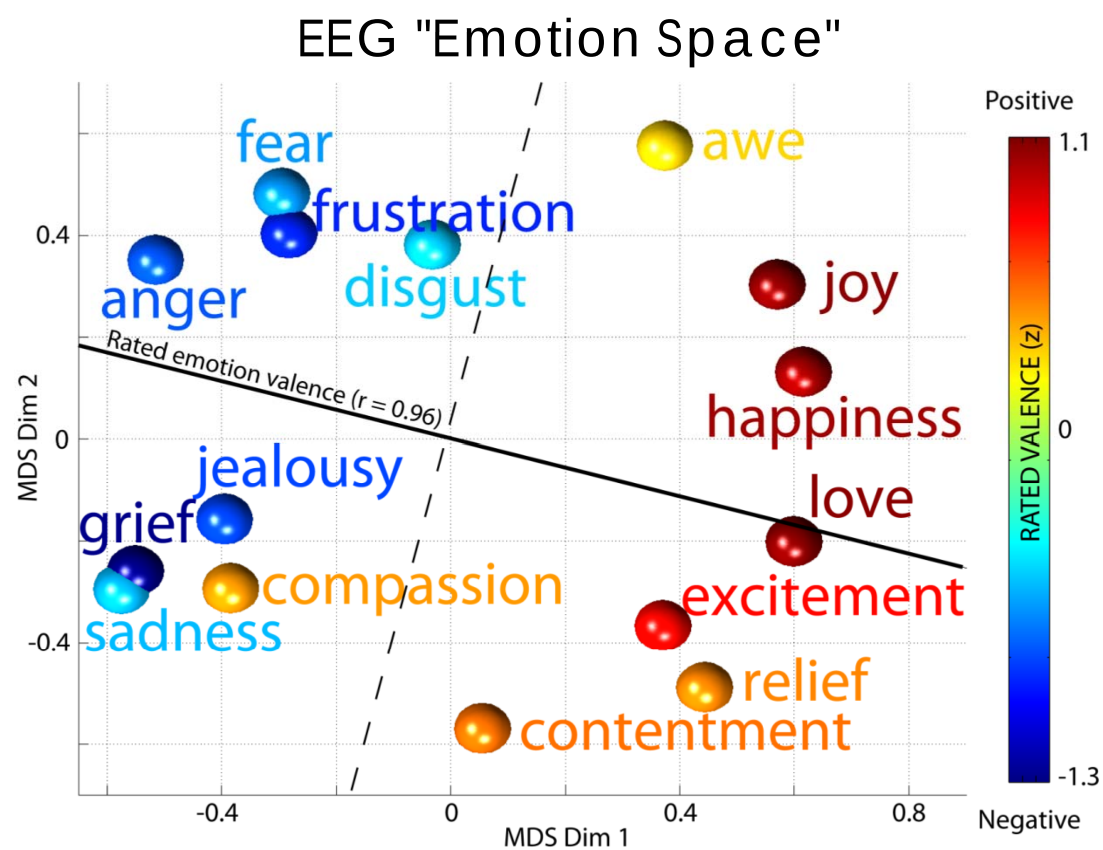
Broadband gamma modulator clusters



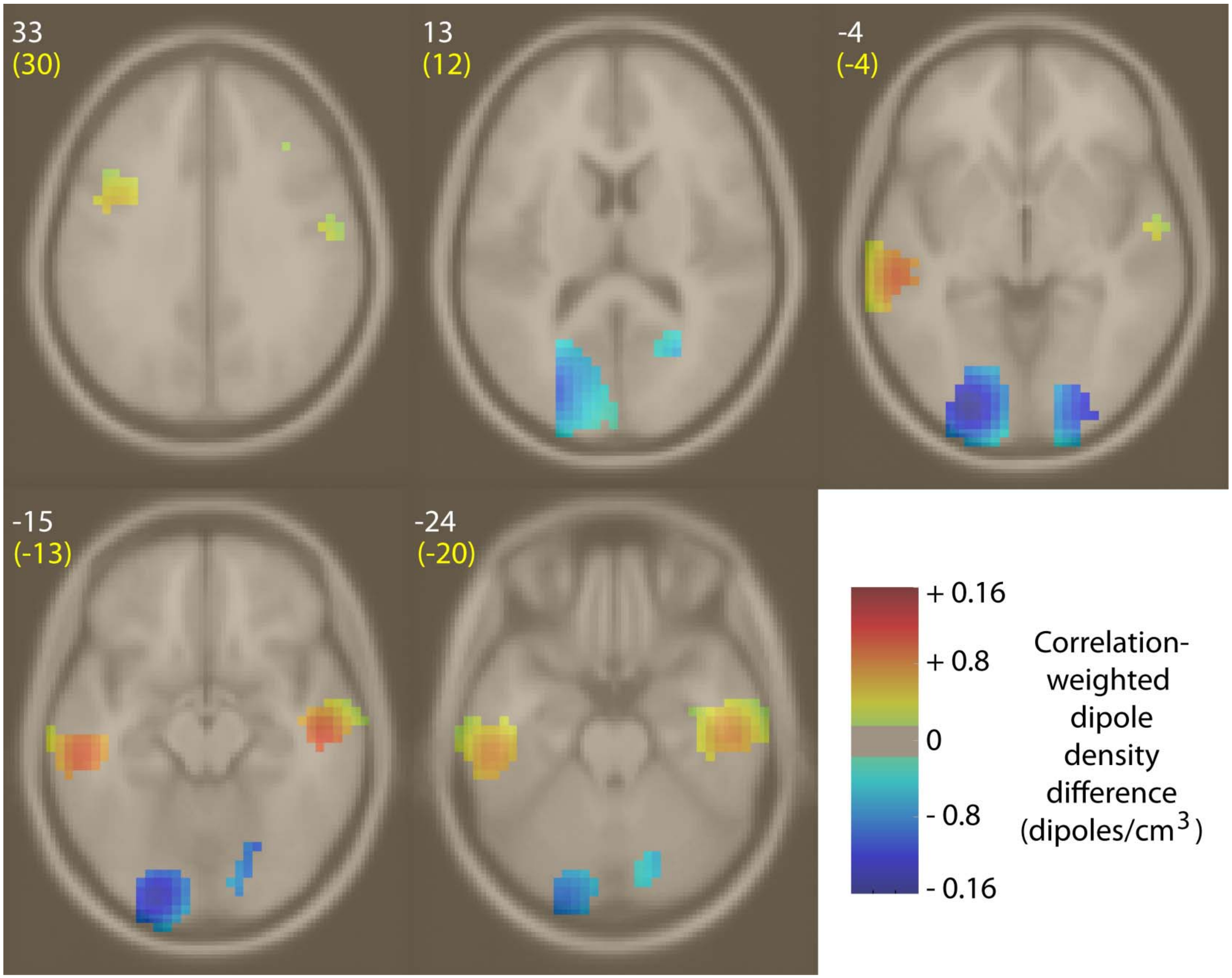
Inter-subject emotion space







Valence-correlation-weighted dipole density of γ IMs



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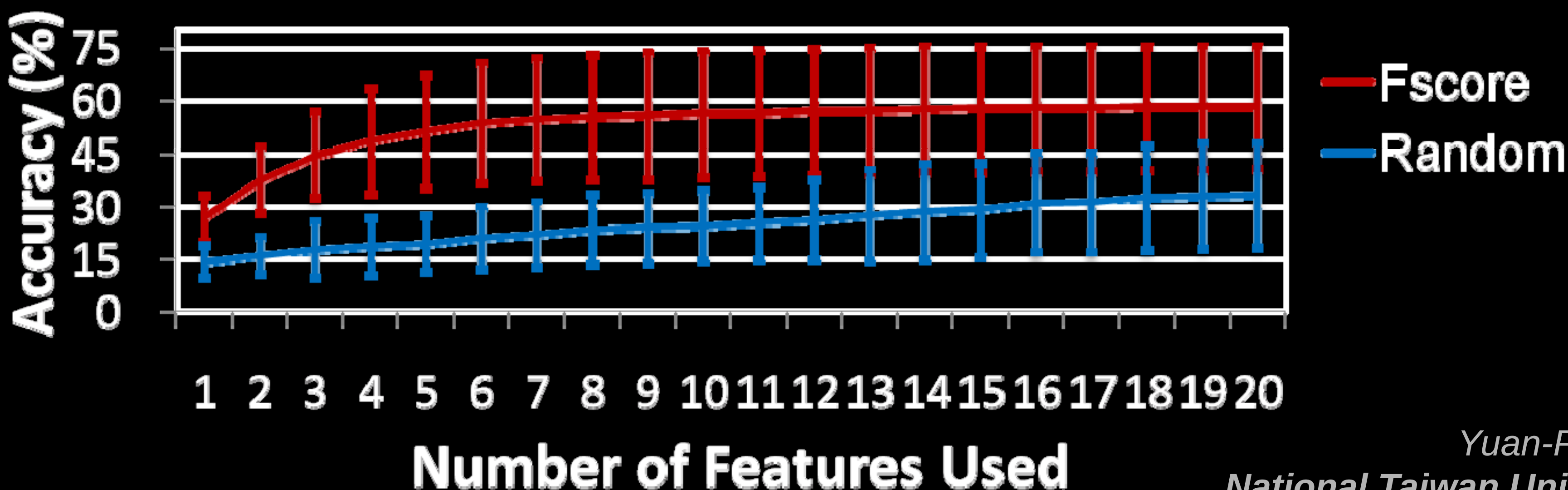
Emotion classification procedure

1) ANOVA across columns of W^{-1} (IMs)
2) Sort IMs by ANOVA F-score
3) Select IMs with highest F-scores for classification (bet. 3-17)
4) Remove 10% of each emotion period as 'test' data
5) Classify each non-overlapping 1-sec of 'test' data with SVM
6) Calculate % correct classification across all 1-sec 'test' epochs
7) Separate classification IMs into theta, alpha, beta, gamma categories



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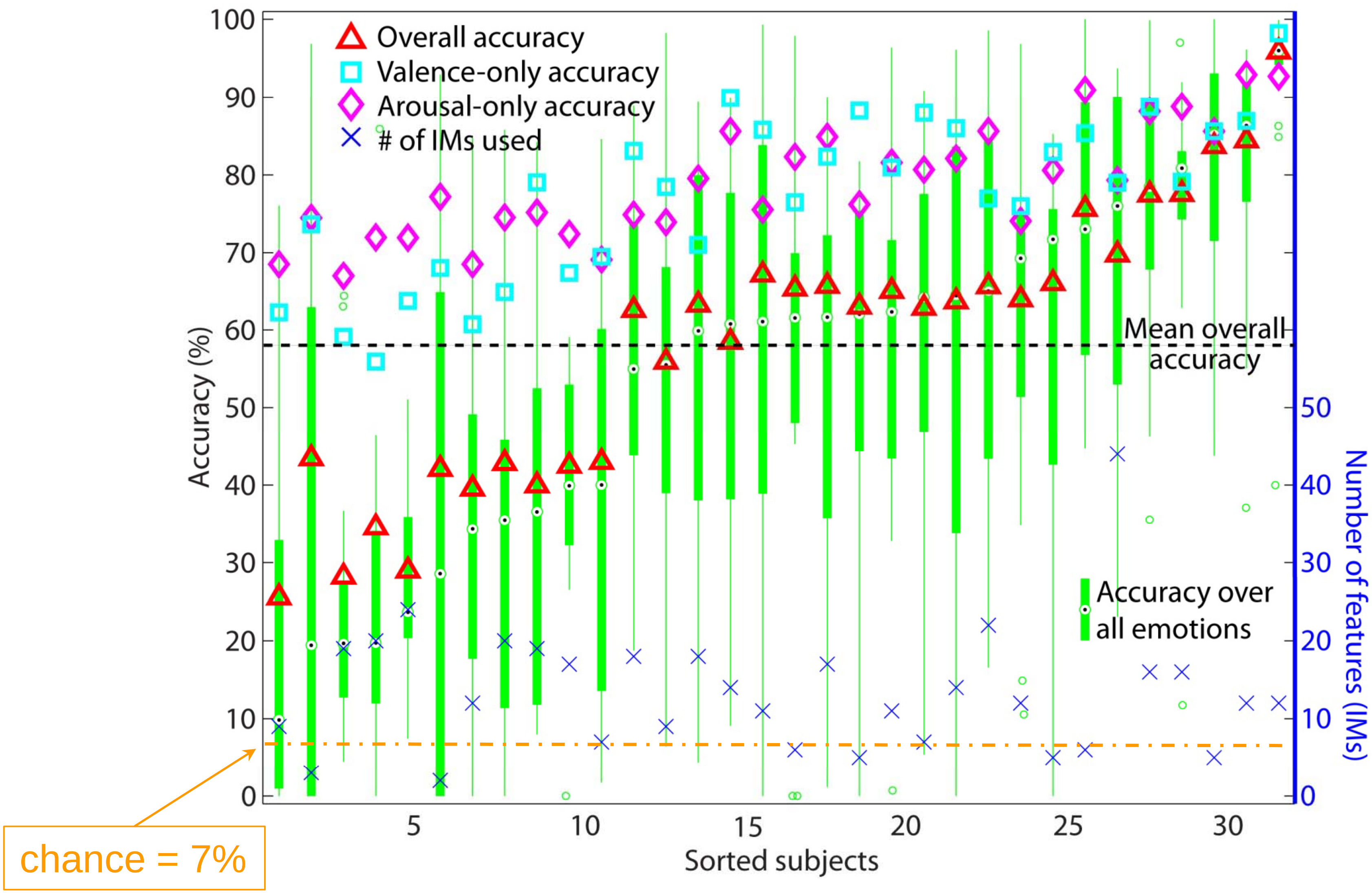
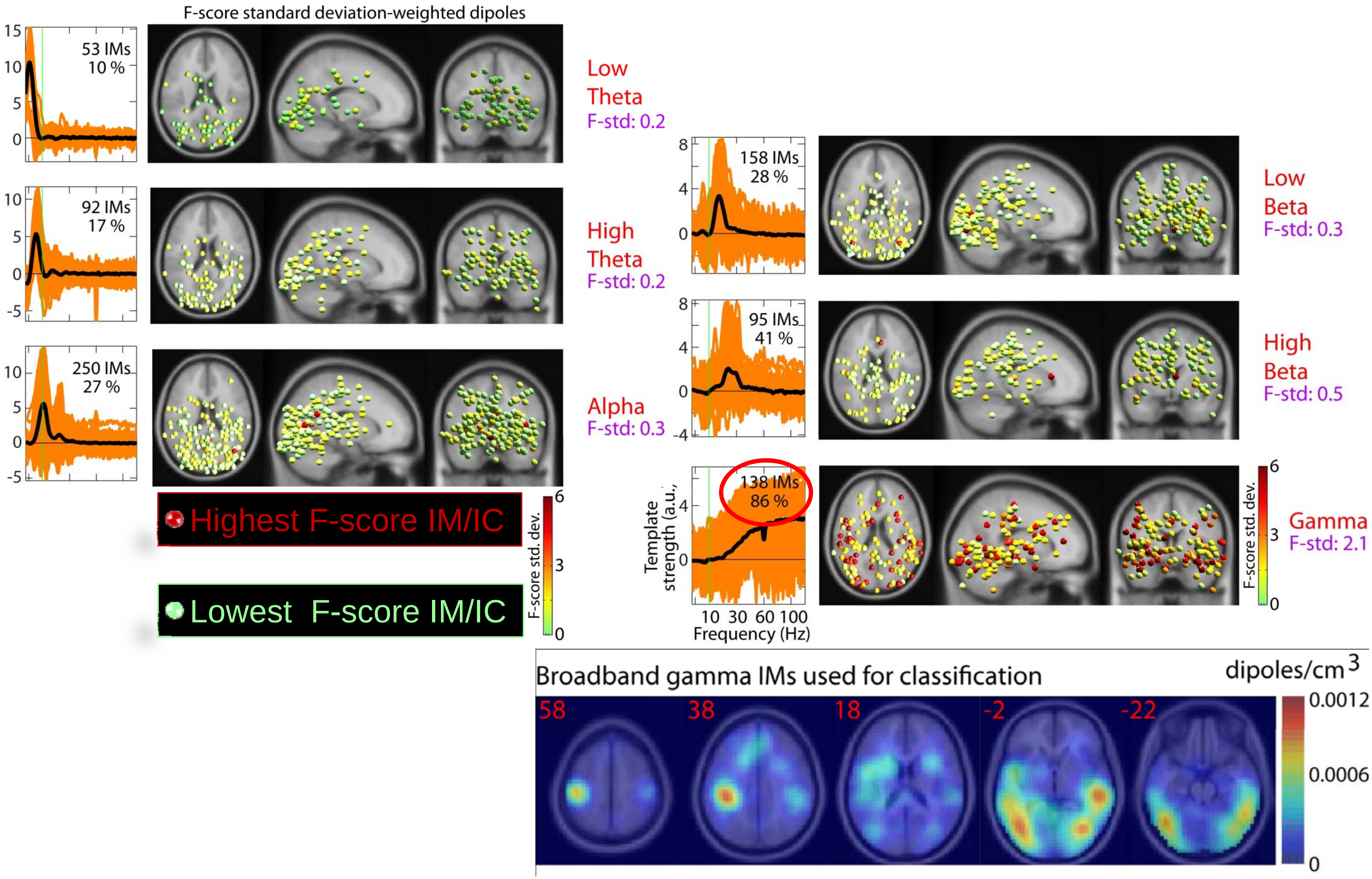
National Taiwan University

Classification accuracy (1-sec, non-overlapping epochs)



Brain sources with emotion-related IMs



Summary

- ☑ ICA isolates independent brain activity from scalp EEG
  - ➢ separates high frequency brain from scalp muscle
- ☑ IC power is affected by independent modulator processes
  - ➢ possibly neuromodulatory influences
- ☑ High frequency IM strength is related to emotional valence
- ☑ IM strengths can differentiate between subjective states
  - ➢ high freq. IMs are more likely to differentiate between emotions

Thank you to

Jerry Swartz,

Scott Makeig,

and

thank you

for your attention