Guided source separation for phase-amplitude coupling using generalized eigendecomposition (GEDCFC) in a sample of contact-collision athletes.

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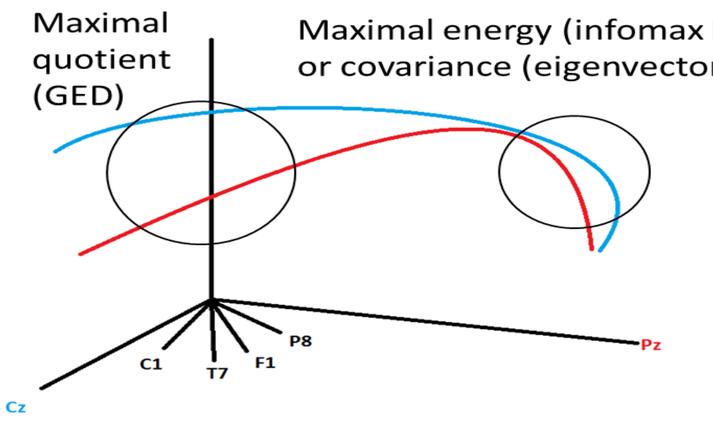
Synopsis

GEDCFC is a useful technique for hypothesis-driven source-separation and investigating CFC. Head injuries can disrupt CFC that depends on precise timing of cell assemblies and intact cortico-cortical connectivity.

Rationale

- Neurocognitive functions are implemented by complex neurophysiology, including cross-frequency coupling (CFC).
- Brain injury can disrupt neurocognitive performance.
- Brain injury may also disrupt CFC.
- Spurious CFC can result from non-sinusoidal signals and harmonics.
- The GEDCFC approach can improve SNR and mitigate spurious CFC.

Methods

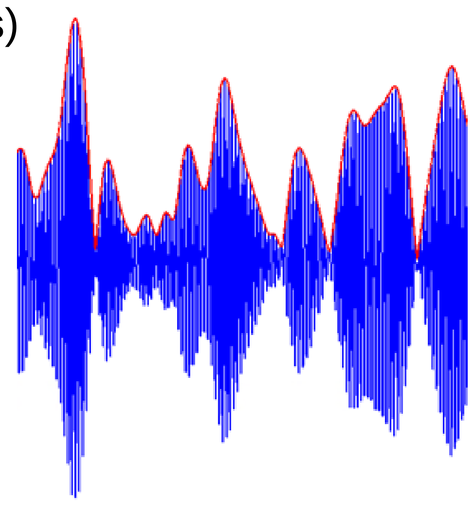


GED is the quotient of signal (S) and reference (R) covariance matrices:
$Rw = wS\Lambda$

Components are not generally orthogonal

Not PCA!

- 10 Healthy Athletes (AHC; Mean age = 20.8, SD = 1.5)
- 19 Injured Athletes (INJ; Mean age = 21.8, SD = 1.5)
  Mean number of concussions = 1.37 (SD = 1.8, range 1-7)
- Recruited from intramural college sports
- 57-channel montage, average offline reference
- Flanker test, only error trials examined
- Morlet wavelets for TF power calculation
- Theta source separation (0ms to 600ms)
  1. theta covariance (S) / broadband covariance (R)
  2. semi-automated selection of theta component
  3. Identification of theta troughs
- Trough source separation
  1. trough covariance (S) / broadband covariance (R)
  2. automated selection of trough component (>8Hz)
- Phase-Amplitude Coupling (PAC)
  Phase-synchrony between theta and high-frequency envelope(s)
- Statistics
  95% CI of group contrast
  False-Discovery Rate (FDR) correction



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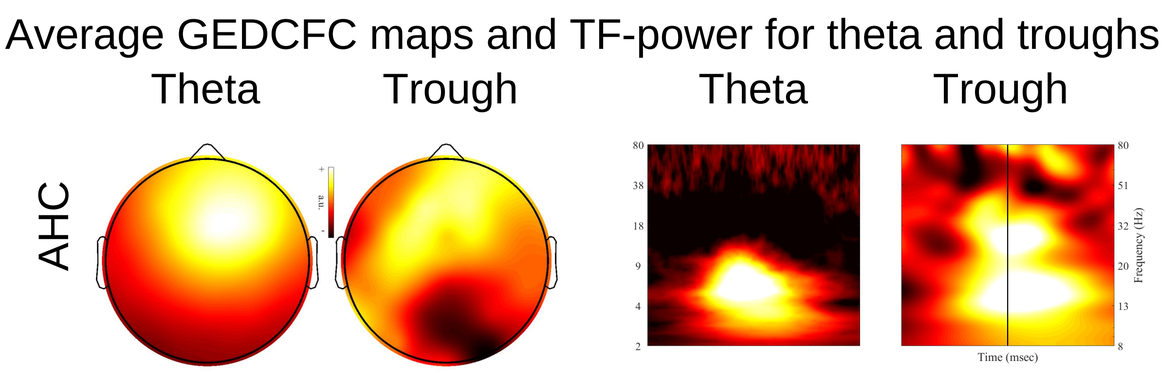
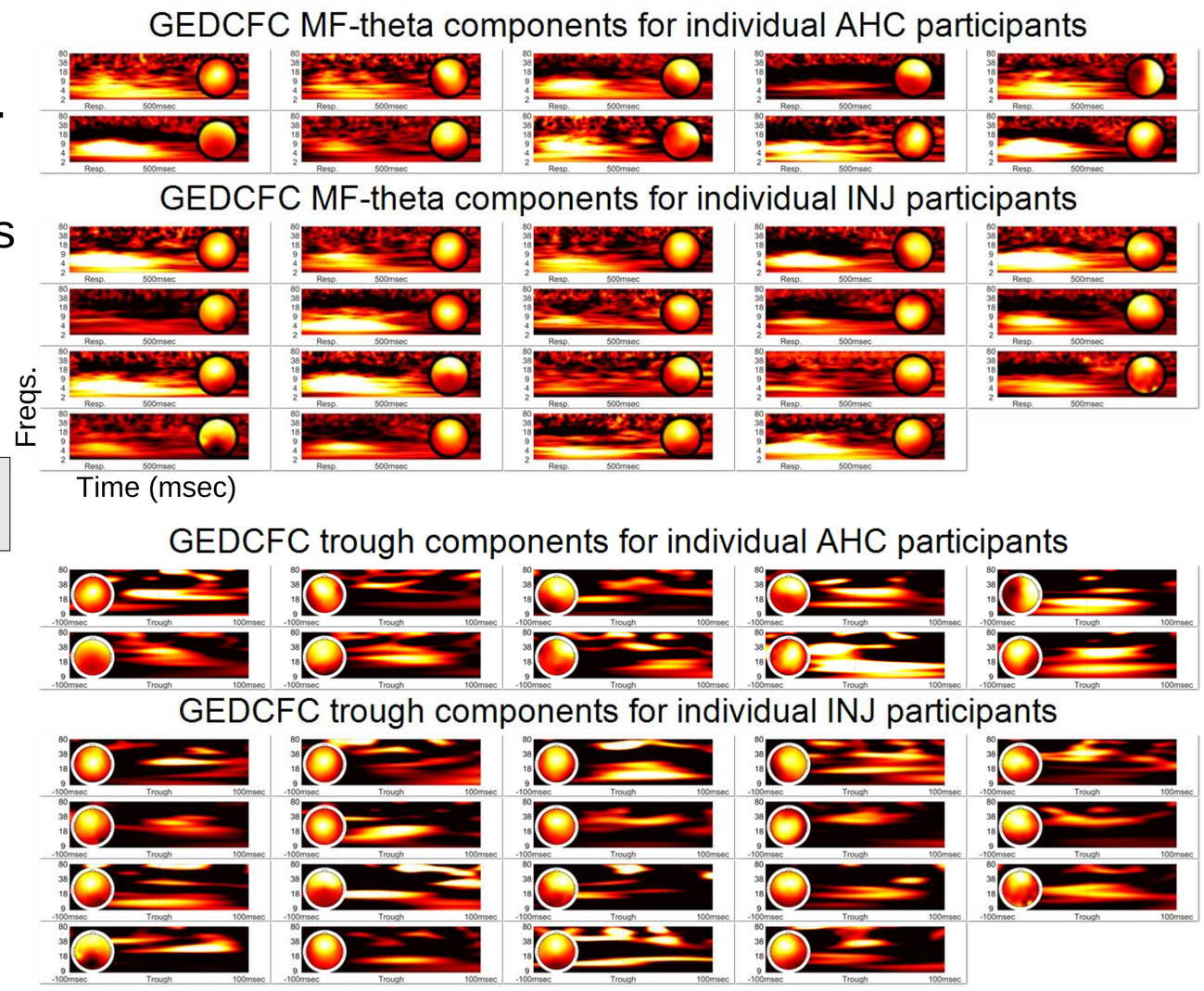
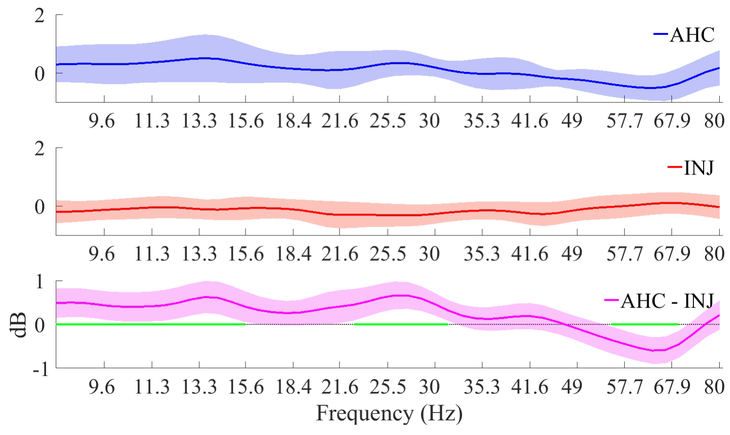
Results

Average GEDCFC maps and TF-power for theta and troughs

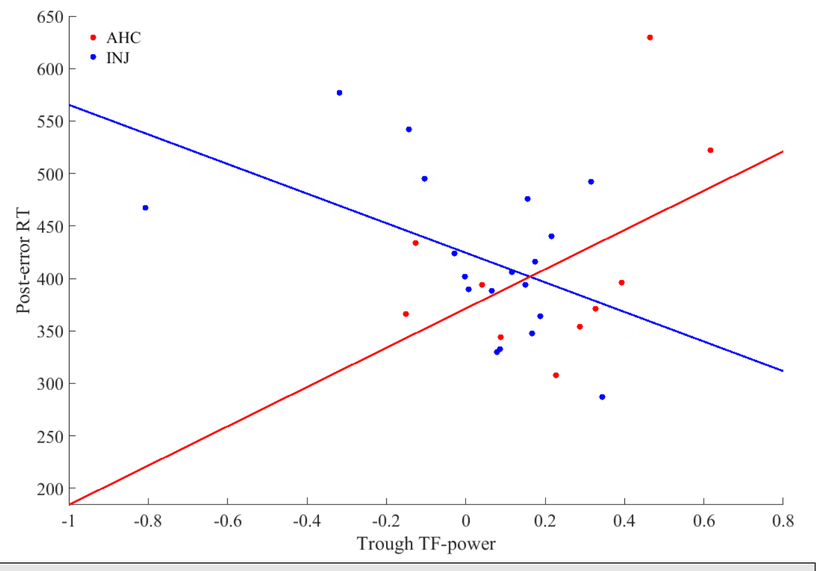






Group differences in CFC across frequency bands. Theta-beta PAC correlated with concussion $r(29)=-.44$, $p=.02$. CFC for other frequencies was unrelated to concussion history or post-error RT.

Trend for CFC * Group interaction on post-error RT ($R^2=.23$, $F(2,28)=2.6$, $p=.07$). Theta-beta CFC predicted post-error slowing for AHC participants, and post-error speeding for INJ participants.



Conclusion

Head injury may disrupt a theta-beta stopping network. Different researchers have emphasized the importance of beta and theta for cognitive control. This work suggests that MF-theta may coordinate local beta activity at lateral PFC regions, theta-beta CFC is sensitive to head injury, and disrupted theta-beta CFC can disrupt post-error slowing.