EE 791 Lecture 8

Measures of Dynamic Properties (cont'd) March 15, 2018

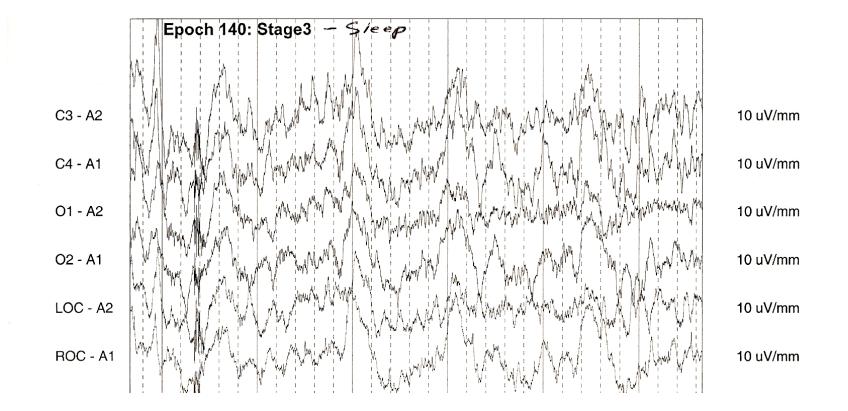
Awake

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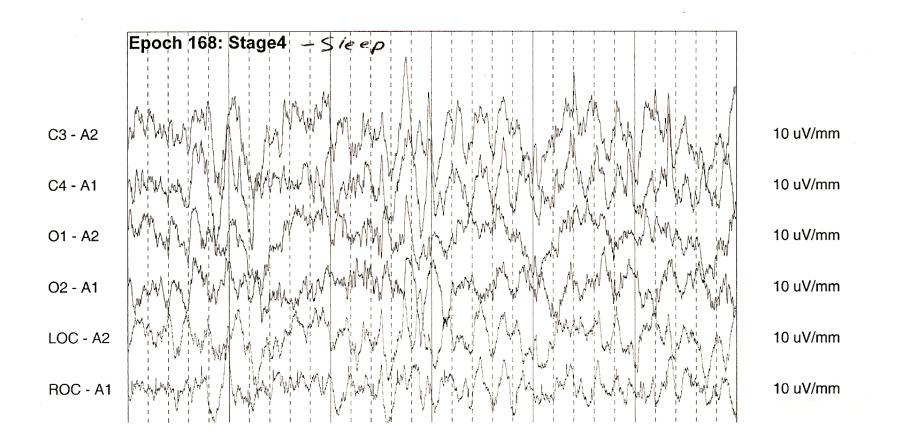
Stage 1

	Epoch 382: Stage1 → <i>Sieep</i>	
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C4 - A1	and many many hyperson and the second of the	10 uV/mm
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O2 - A1	mala all and many many male and many many many many many many many many	10 uV/mm
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Stage 3



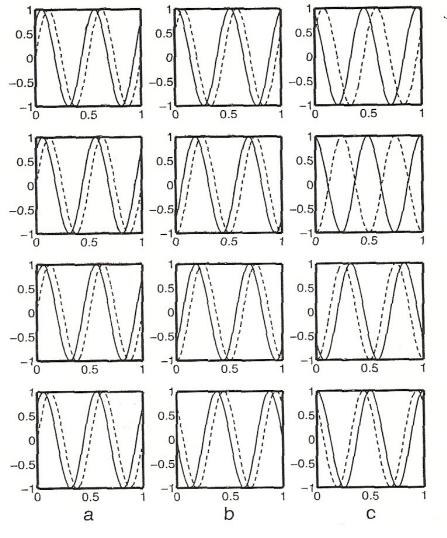
Stage 4



Coherence

- Spatial analysis of EEG
- Defined as a linear correlation coefficient that estimates primarily the amount of phase synchronization between any two data channels
- Obtain an estimate
- Similar to squared correlation coefficient which estimates the proportion of variance in one channel that can explained by a linear transformation of another channel

Phase Relations



Calculation of Coherence

Cross Spectrum

$$C_{uv}(f_n) = A_{uv}e^{j\phi_{uv}} = \frac{2}{K}\sum_{k=1}^{K}F_{uk}(f_n)F_{vk}^*(f_n)$$

n = 1,2,.....N/2-1

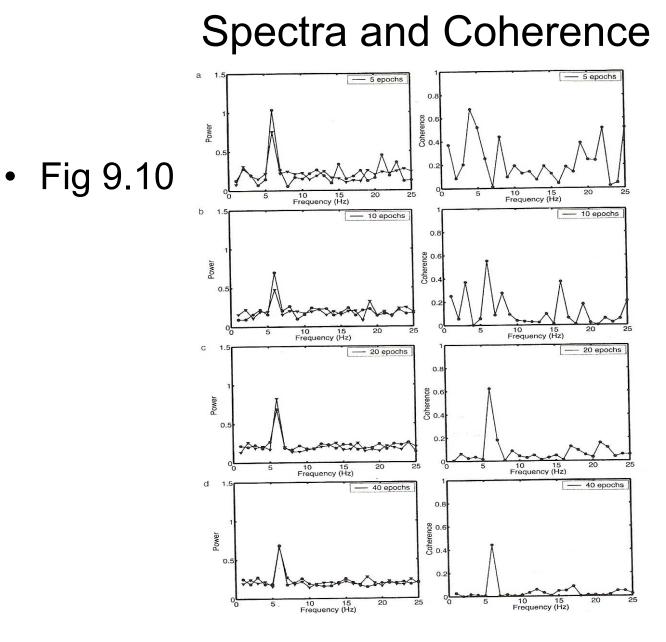
Where the estimate is made over K signal epochs and the F's are Fourier coefficients. Factor 2 because only considering positive f (similar to covariance)

Calculation of Coherence (cont'd)

Coherence between two channels

$$\Upsilon_{uv}^{2}(f_{n}) = \frac{|C_{uv}(f_{n})|^{2}}{P_{u}(f_{n})P_{v}(f_{n})} \qquad n = 0, 1, 2, \dots (N-1)/2$$

Sensitive to relative phase between two channels. If phase difference is constant coherence = 1, if purely random = 0

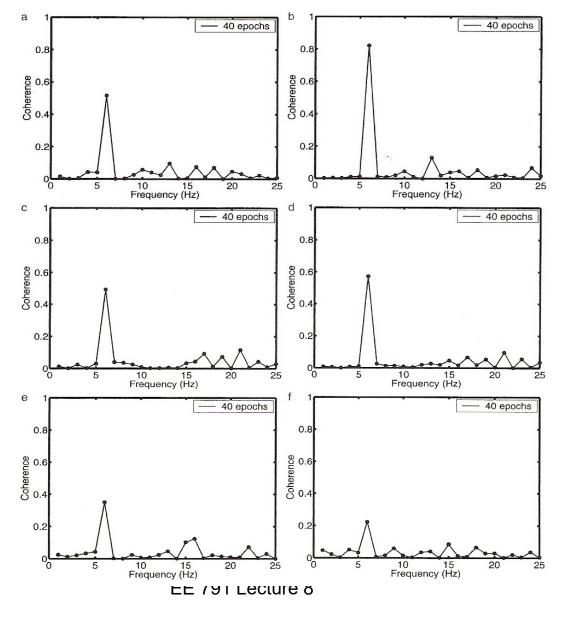


Implications of Coherence

- A coherence value does not imply a linear relationship between two dynamic processes just the fraction of the phase coherence between the data sets (i.e. a model)
- Relationship between two EEG channels could be deterministic but nonlinear, resulting in a coefficient <1
- Consider both relative phase and amplitude with larger EEG Fourier coefficients giving more reliable estimates of coherence.

Effects of Phase-only Coherence

• Fig 9.11



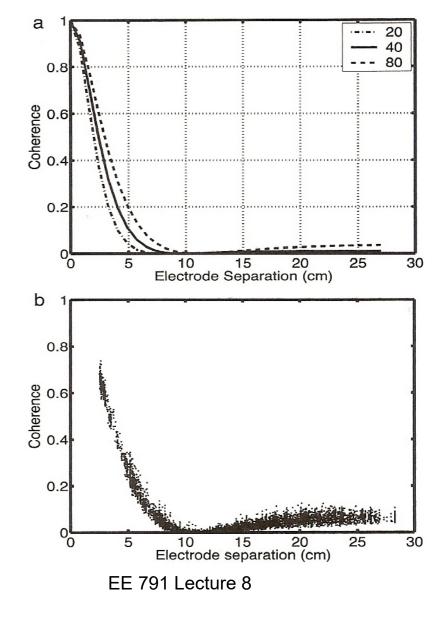
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Effects of Spatial Filtering by Volume Conduction

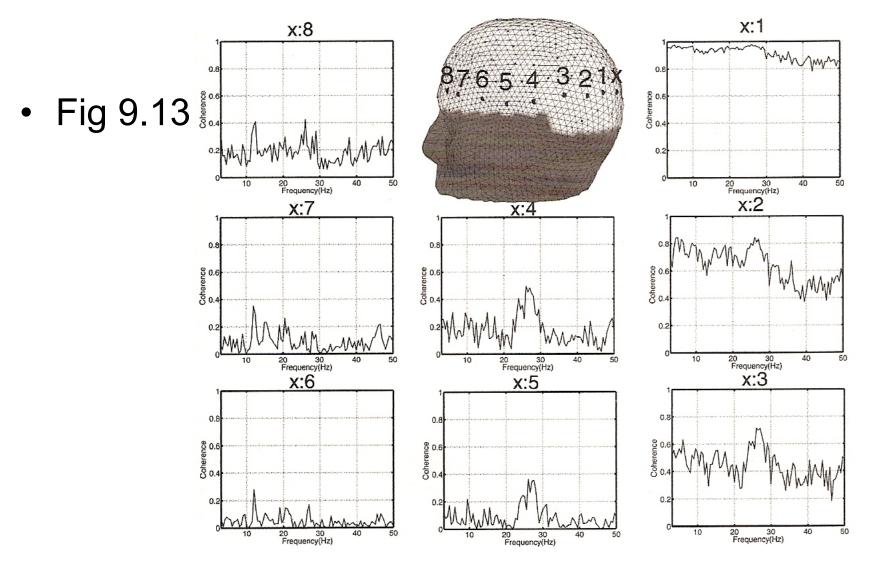
- Objective of coherence estimates is to estimate statistical properties of source processes.
- Need a model to relate these properties to statistical properties of scalp potentials.
- Effects of volume conduction on EEG coherence are independent of temporal frequency.
- Perceived coherence effect due to angular distance between electrodes relative to source

Effect of Volume Conduction (simulated)

• Fig 9.12



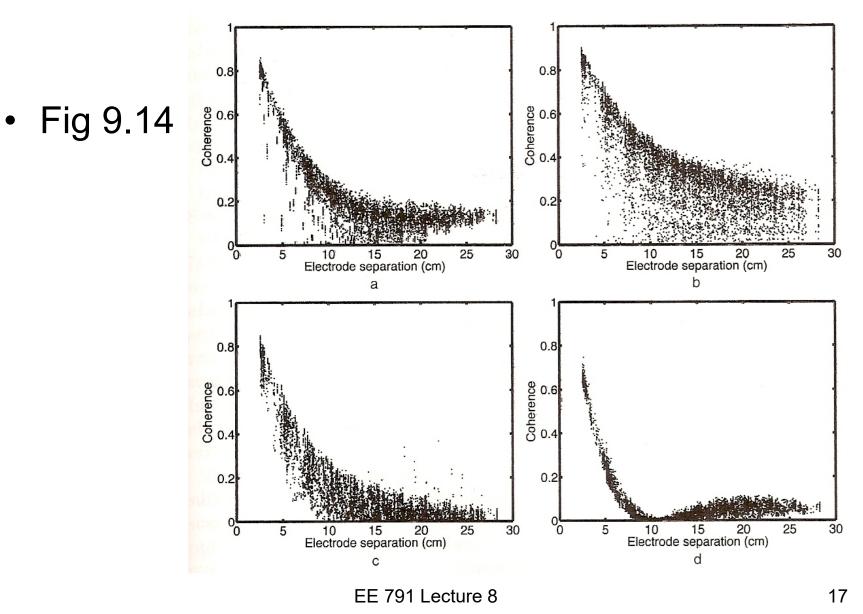
Effect of Volume Conduction (real)



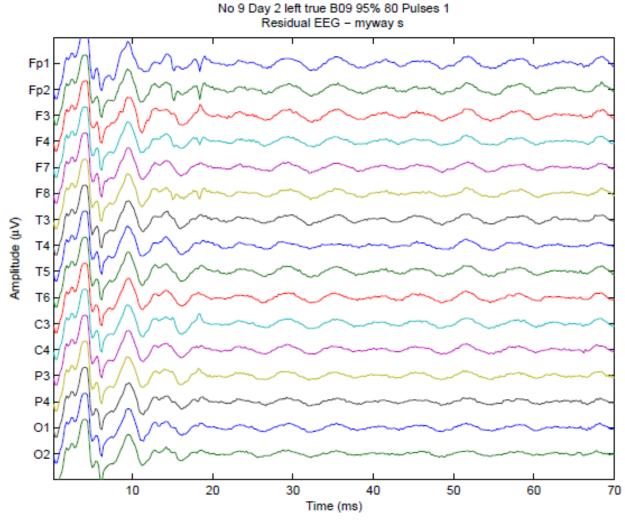
Effects of Reference System

- Simulations using 3600 dipole sources and 111 electrodes with a 4-sphere head model
- Results show using vertex as reference results in lower coherence than a single mastoid
- Linked ear is better but best results for averaged reference (similar to reference free theoretical calculations)

Effects of Reference



Evoked Potential Data

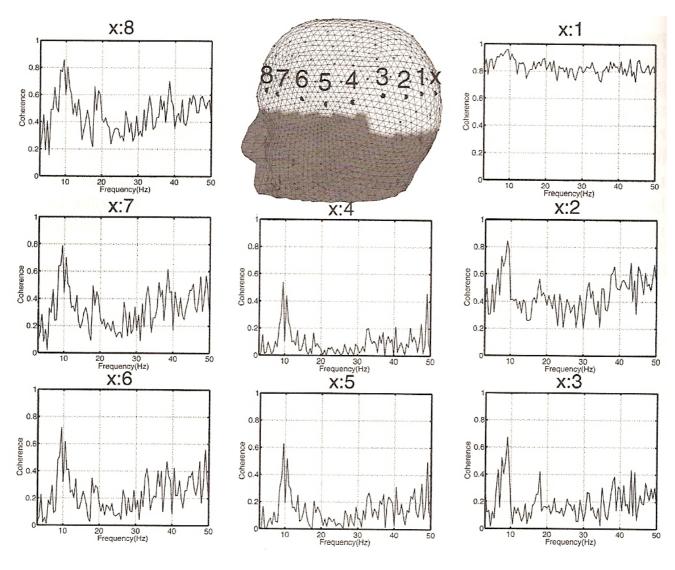


Evoked Potential Avg. Reference

No 9 Day 2 left true B09 95% 80 Pulses 1 Residual EEG with Average Removed - myway s Fp1 Fp2 F3 F4 F7 F8 Т3 Amplitude (µV) Τ4 Τ5 Т6 C3 C4 P3 P4 01 02 Avg 10 20 30 40 50 60 70 Time (ms)

Standard Coherence Calculations

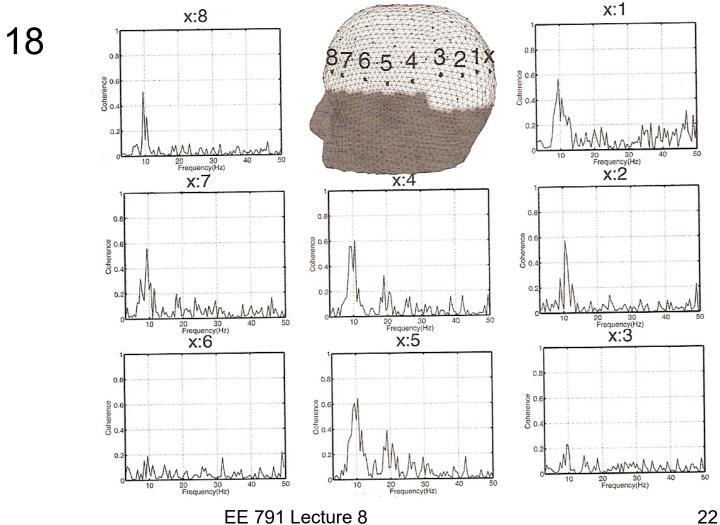
• Fig 9.17



Laplacian Reference

- Previous real results were calculated using an average reference
- Earlier Laplacians with the 10-20 system could be estimated as the average potential between an electrode and its 4 surrounding electrodes
- Later versions, such as that used for the 111 electrode arrays shown in the figures use spline functions to estimate continuous functions of the Laplacian

Coherence Calculations using Spline Laplacian



• Fig 9.18