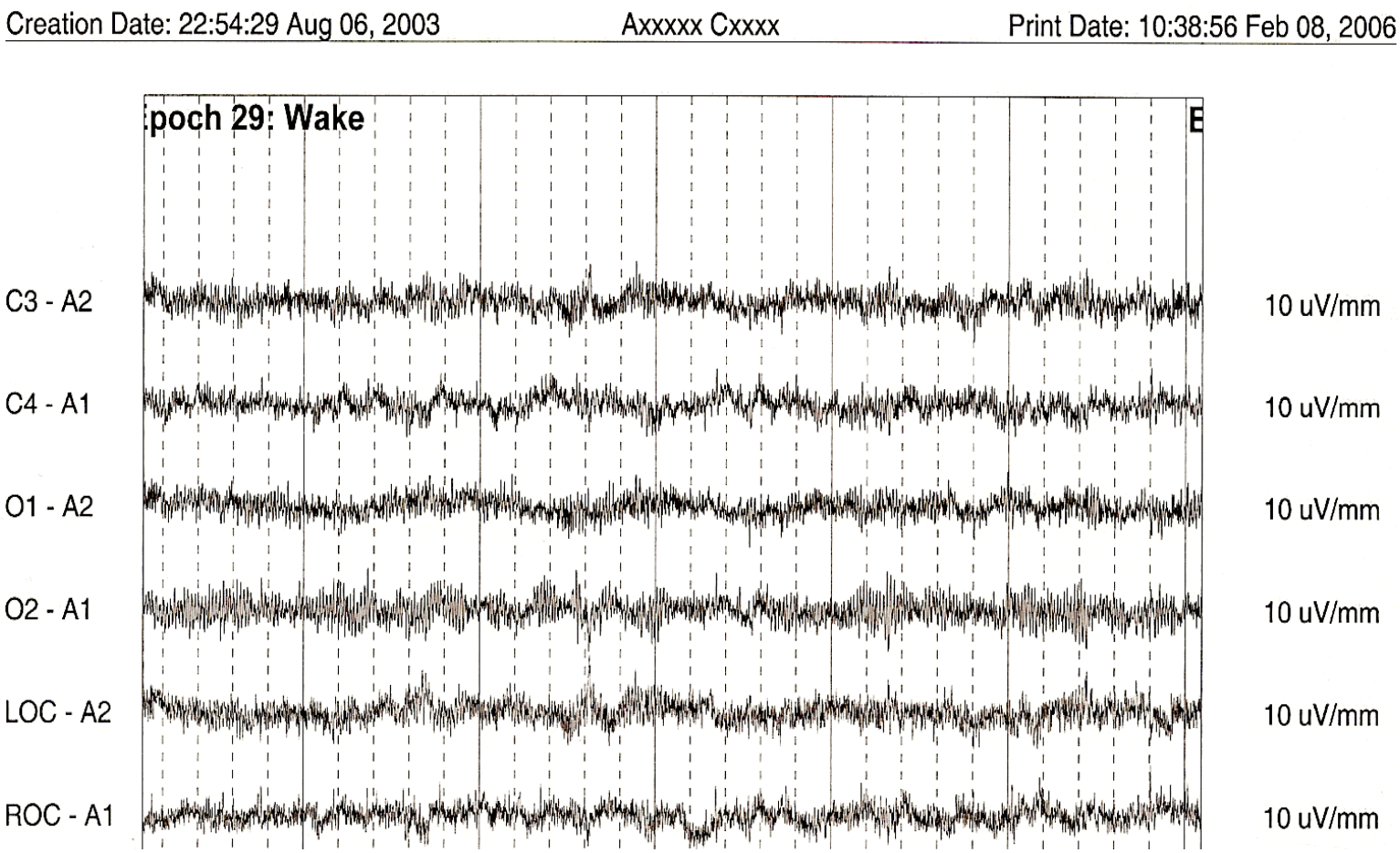
EE 791 Lecture 8

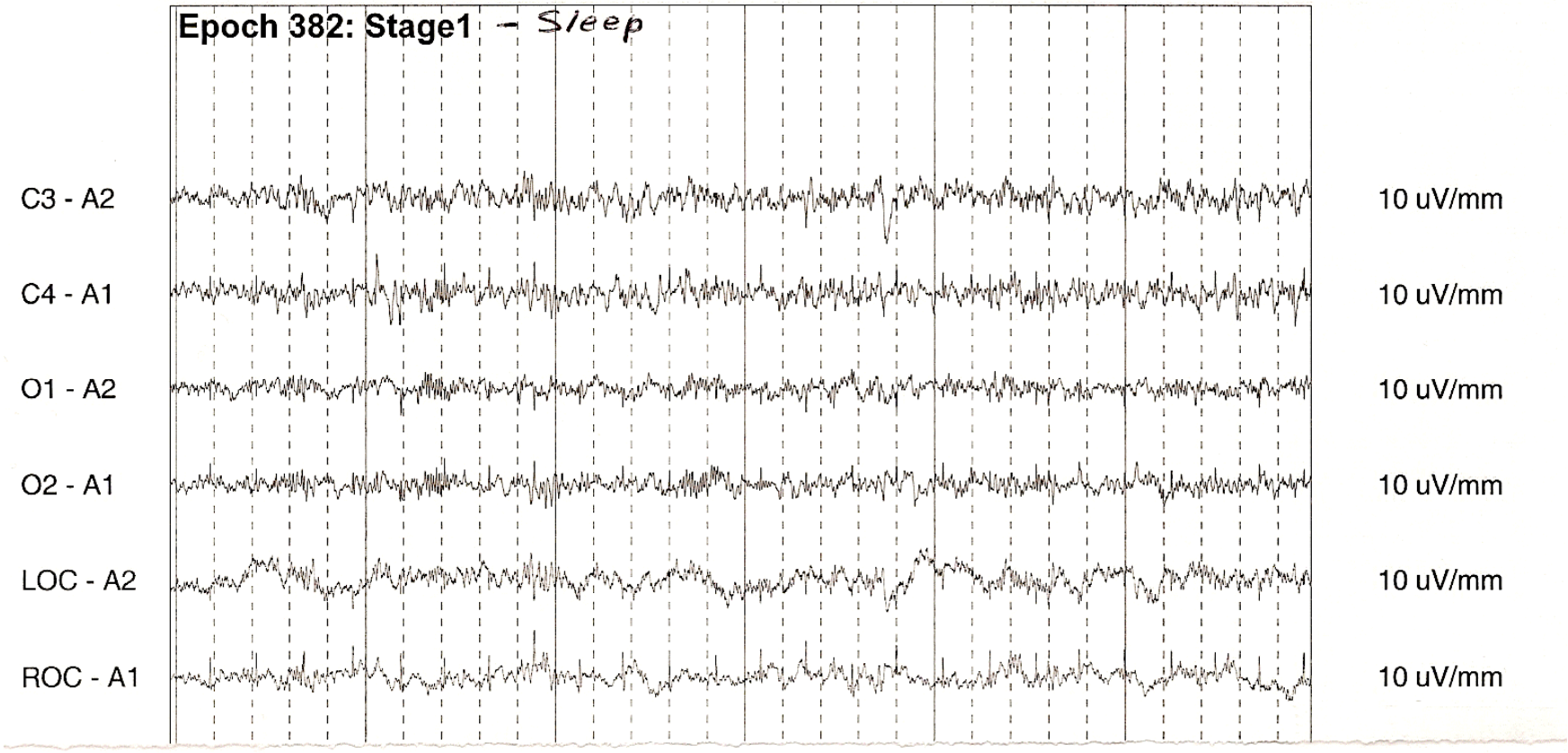
Measures of Dynamic Properties (cont'd)

March 15, 2018

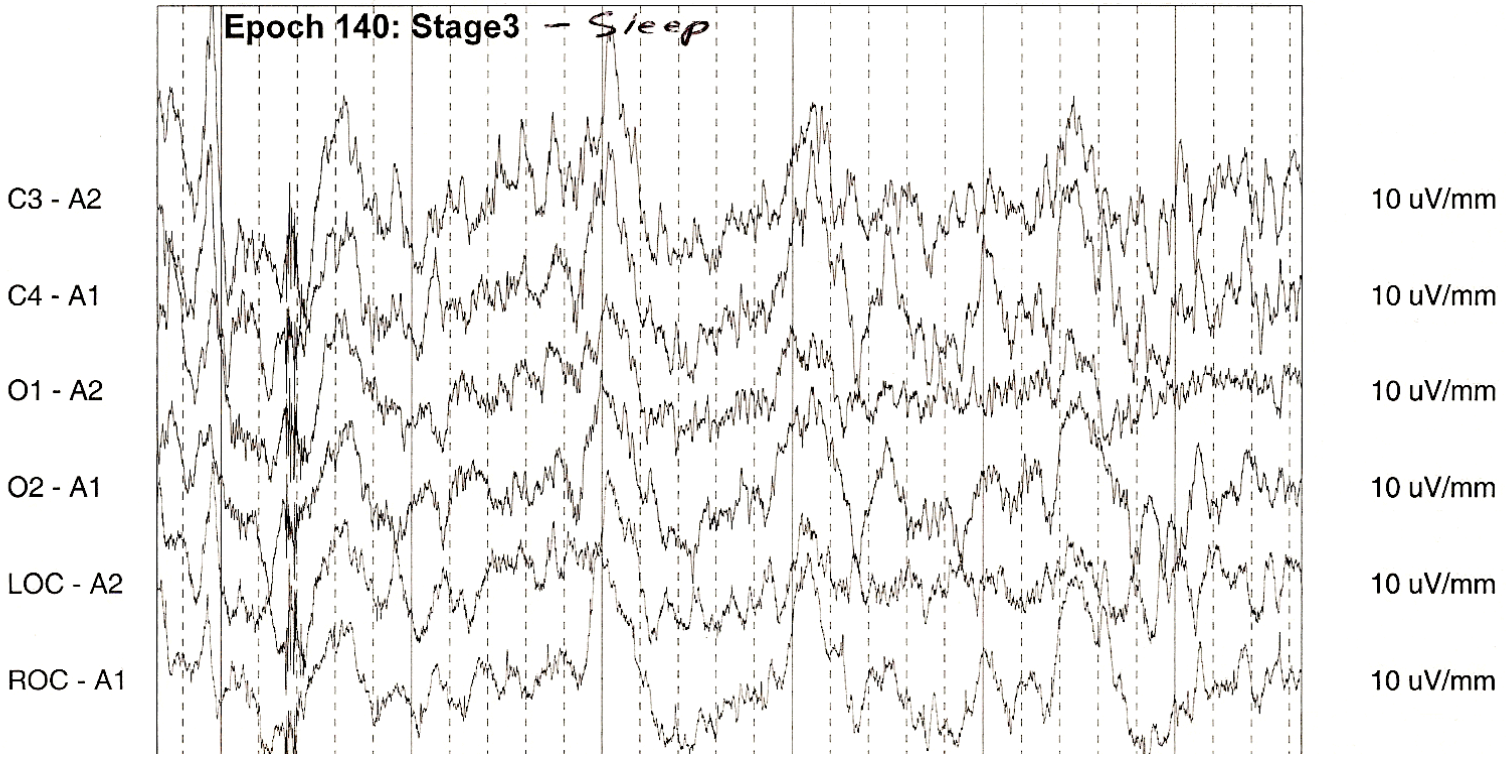
Awake


Creation Date: 22:54:29 Aug 06, 2003
Axxxxx Cxxxx
Print Date: 10:38:56 Feb 08, 2006
poch 29: Wake
C3 - A2
C4 - A1
O1 - A2
O2 - A1
LOC - A2
ROC - A1
10 uV/mm
10 uV/mm
10 uV/mm
10 uV/mm
10 uV/mm
10 uV/mm

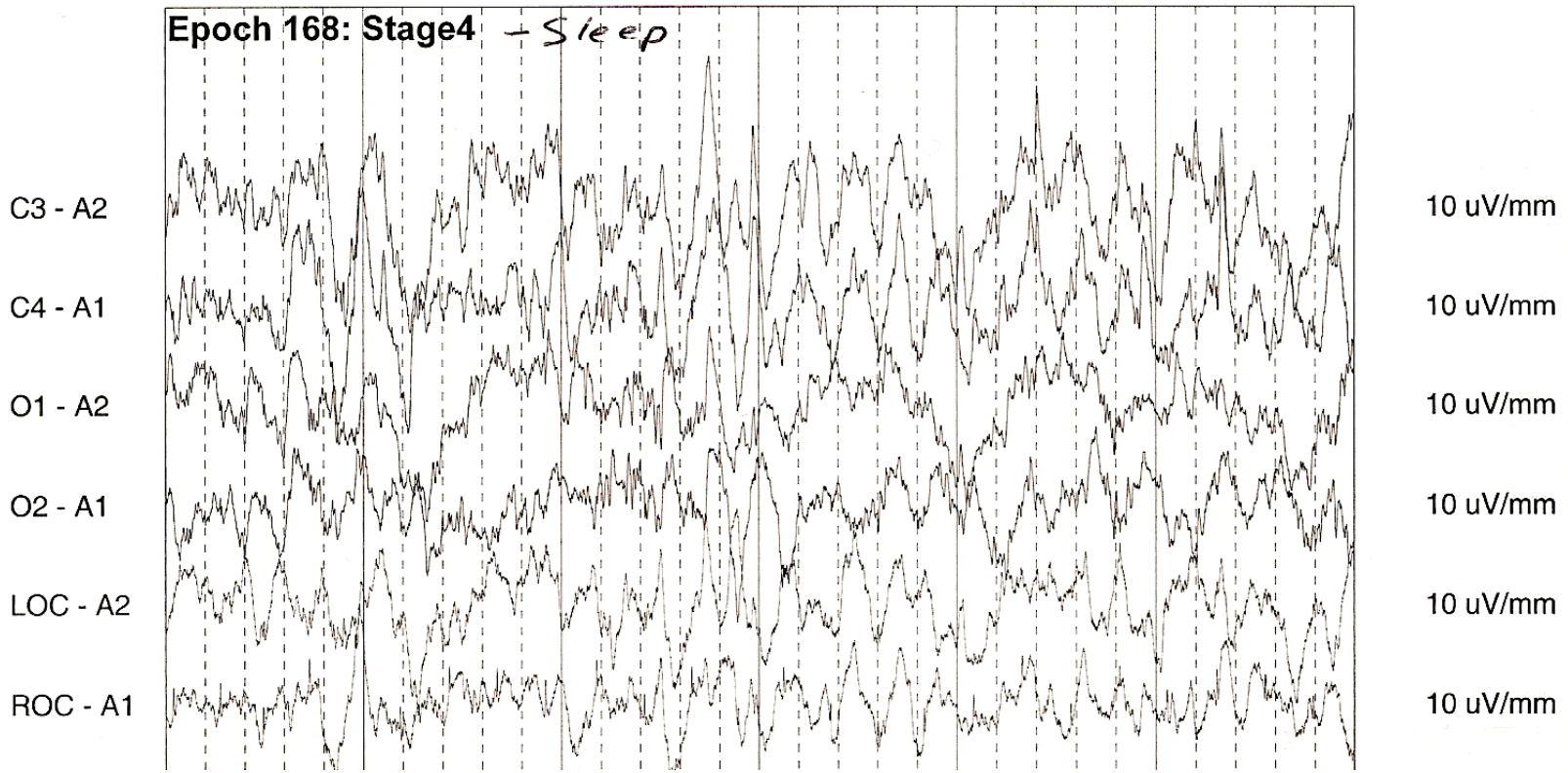
Stage 1


Epoch 382: Stage1 – Sleep
C3 - A2
C4 - A1
O1 - A2
O2 - A1
LOC - A2
ROC - A1
10 uV/mm
10 uV/mm
10 uV/mm
10 uV/mm
10 uV/mm
10 uV/mm

Stage 3


Epoch 140: Stage3 – Sleep
C3 - A2
C4 - A1
O1 - A2
O2 - A1
LOC - A2
ROC - A1
10 uV/mm
10 uV/mm
10 uV/mm
10 uV/mm
10 uV/mm
10 uV/mm

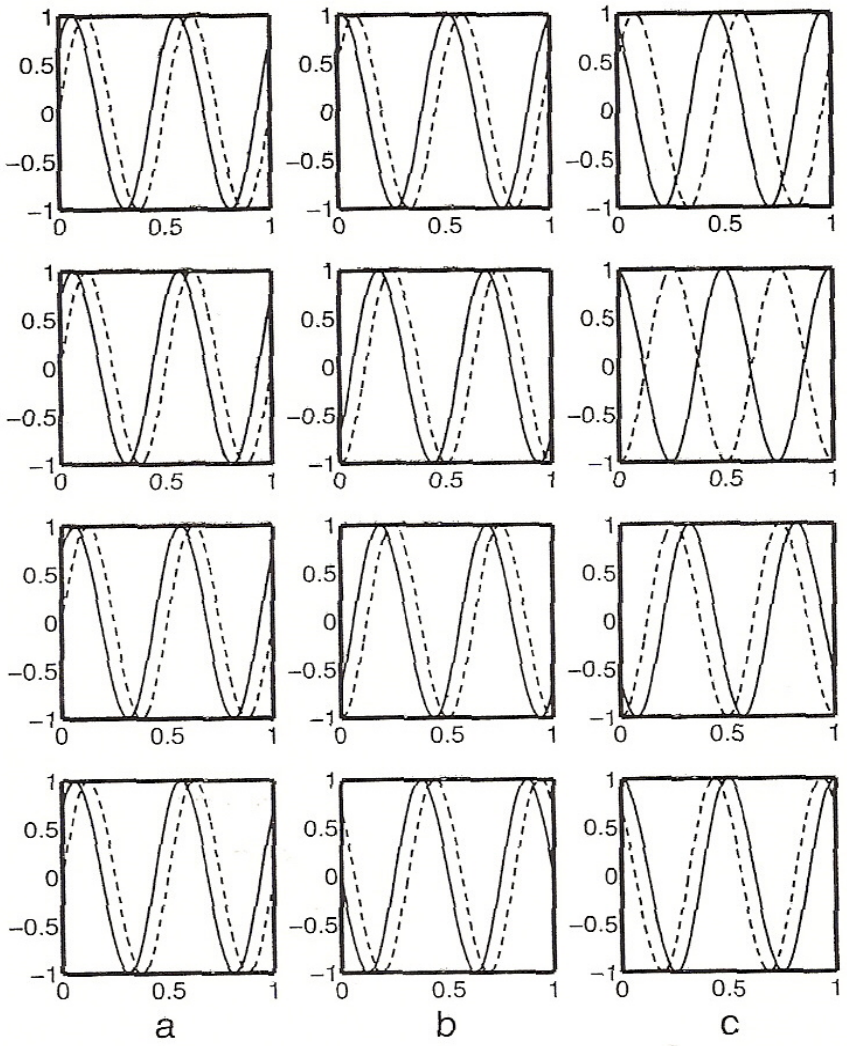
Stage 4


Epoch 168: Stage4 - Sleep
C3 - A2
C4 - A1
O1 - A2
O2 - A1
LOC - A2
ROC - A1
10 uV/mm
10 uV/mm
10 uV/mm
10 uV/mm
10 uV/mm
10 uV/mm

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)

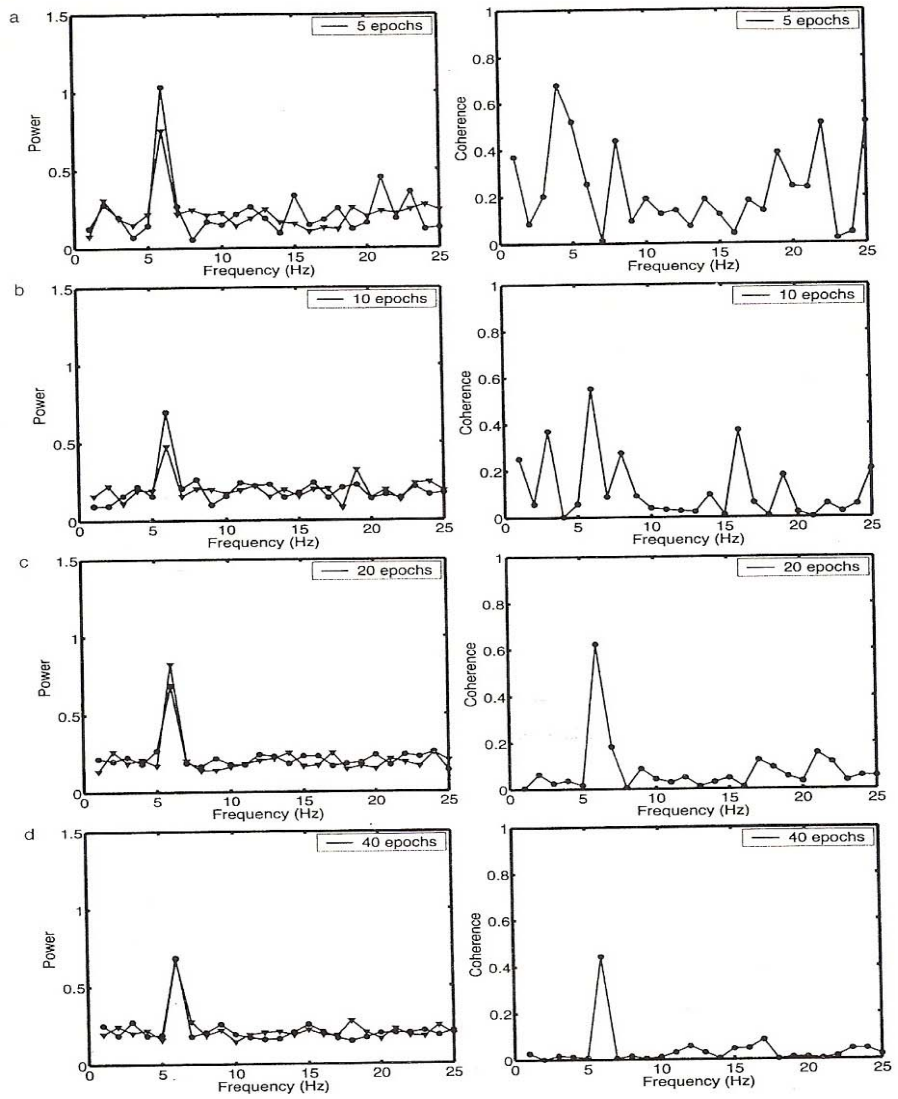
- Coherence between two channels

$$\Upsilon_{uv}^2(f_n) = \frac{|C_{uv}(f_n)|^2}{P_u(f_n)P_v(f_n)} \qquad \text{n = 0,1,2,……(N-1)/2}$$

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

Spectra and Coherence

- Fig 9.10

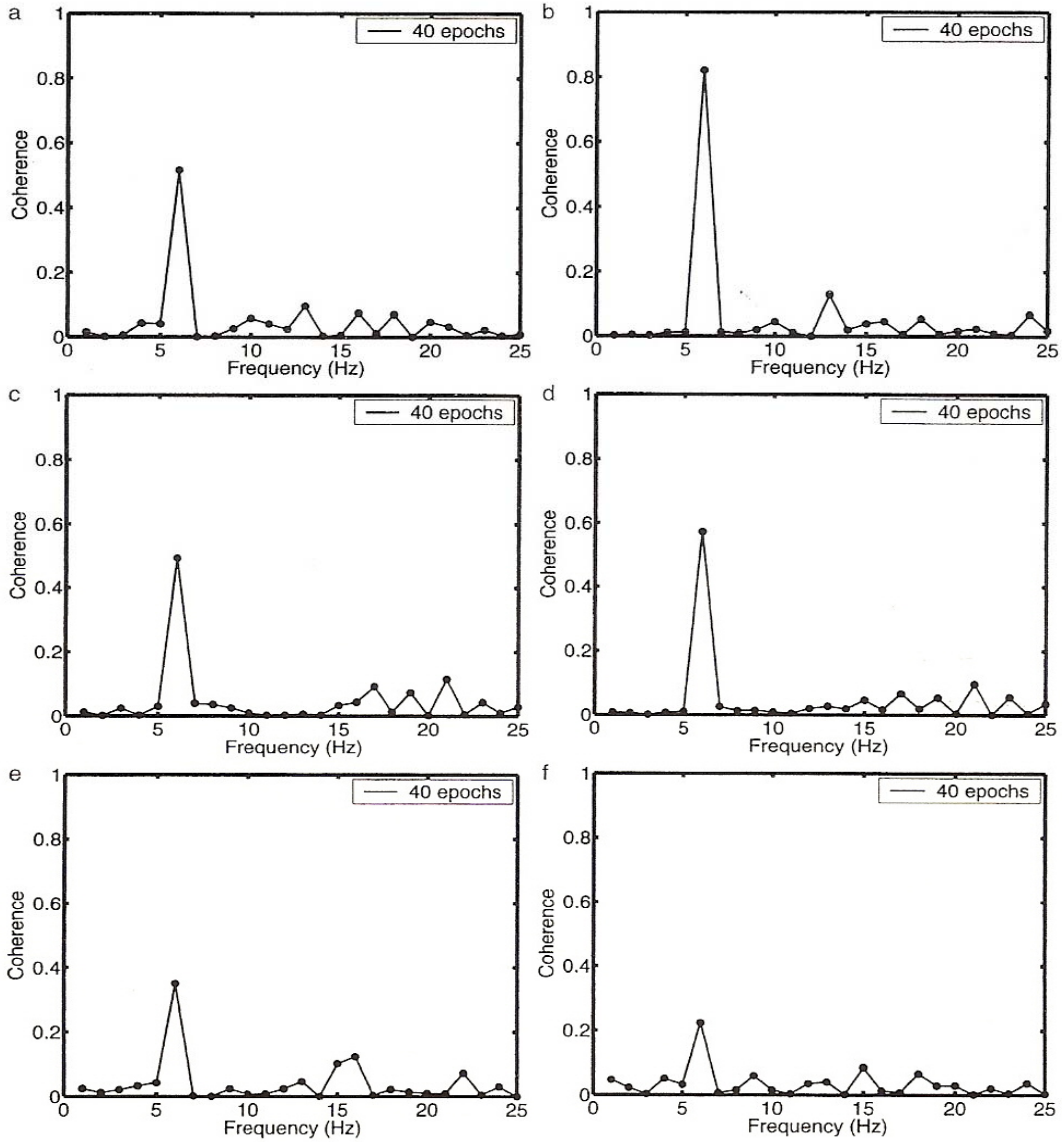


Implications of Coherence

- 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

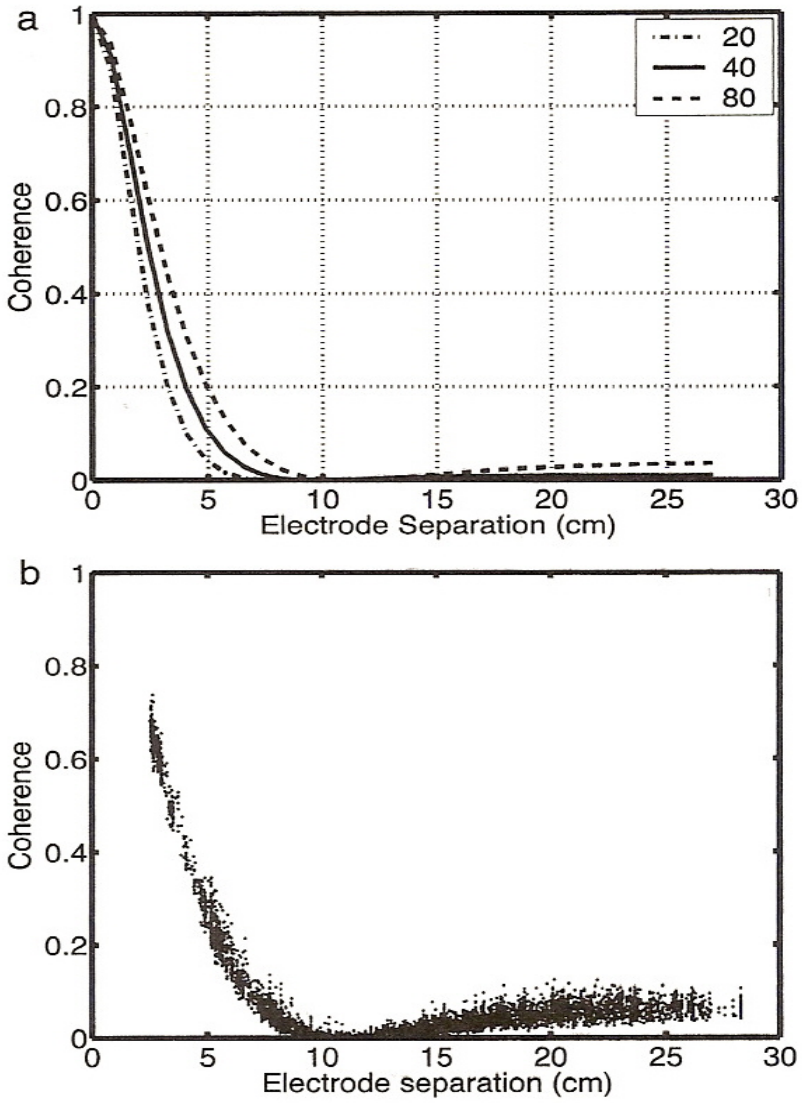


Effects of Spatial Filtering by Volume Conduction

- 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

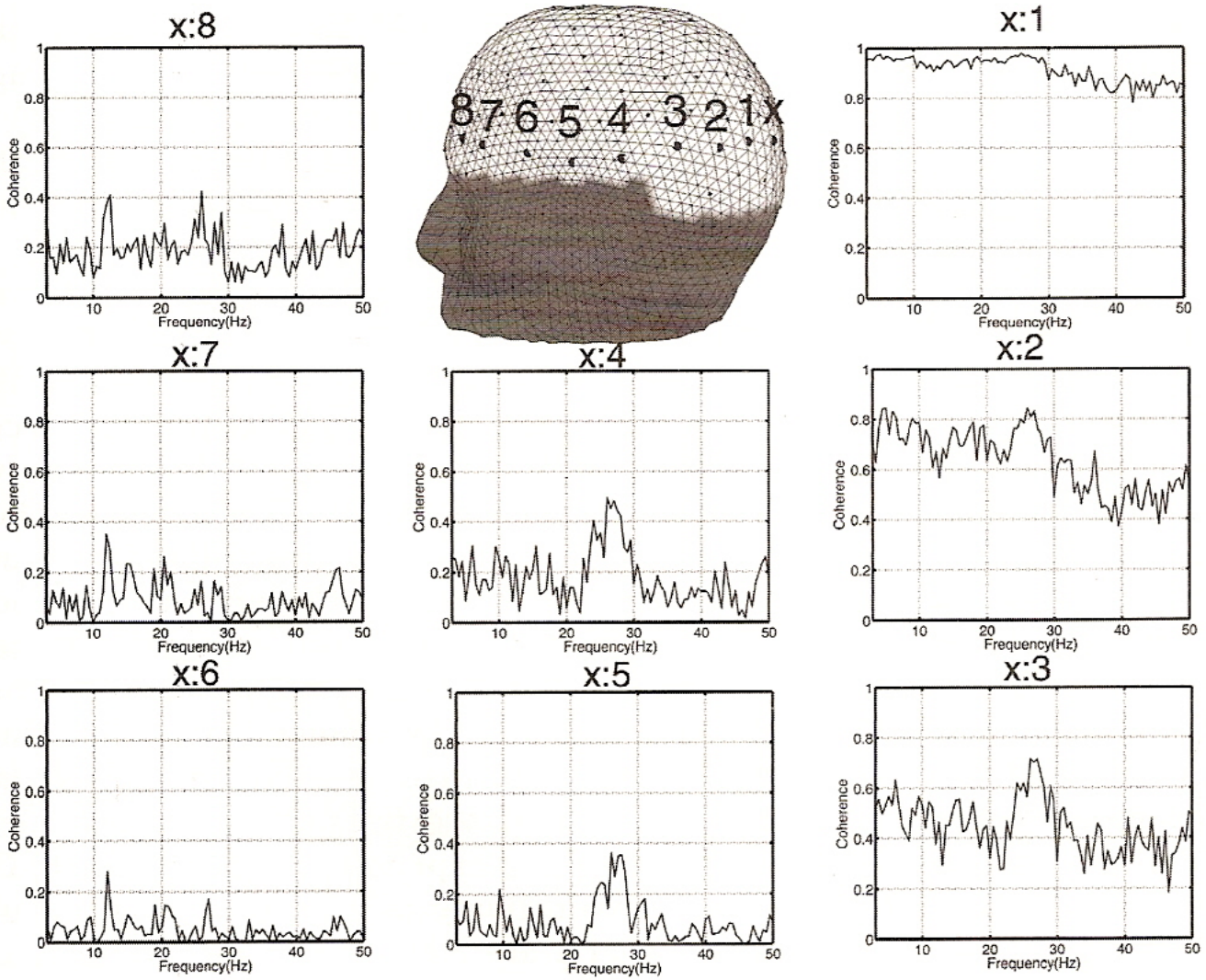
Effect of Volume Conduction (simulated)

- Fig 9.12



Effect of Volume Conduction (real)

- Fig 9.13

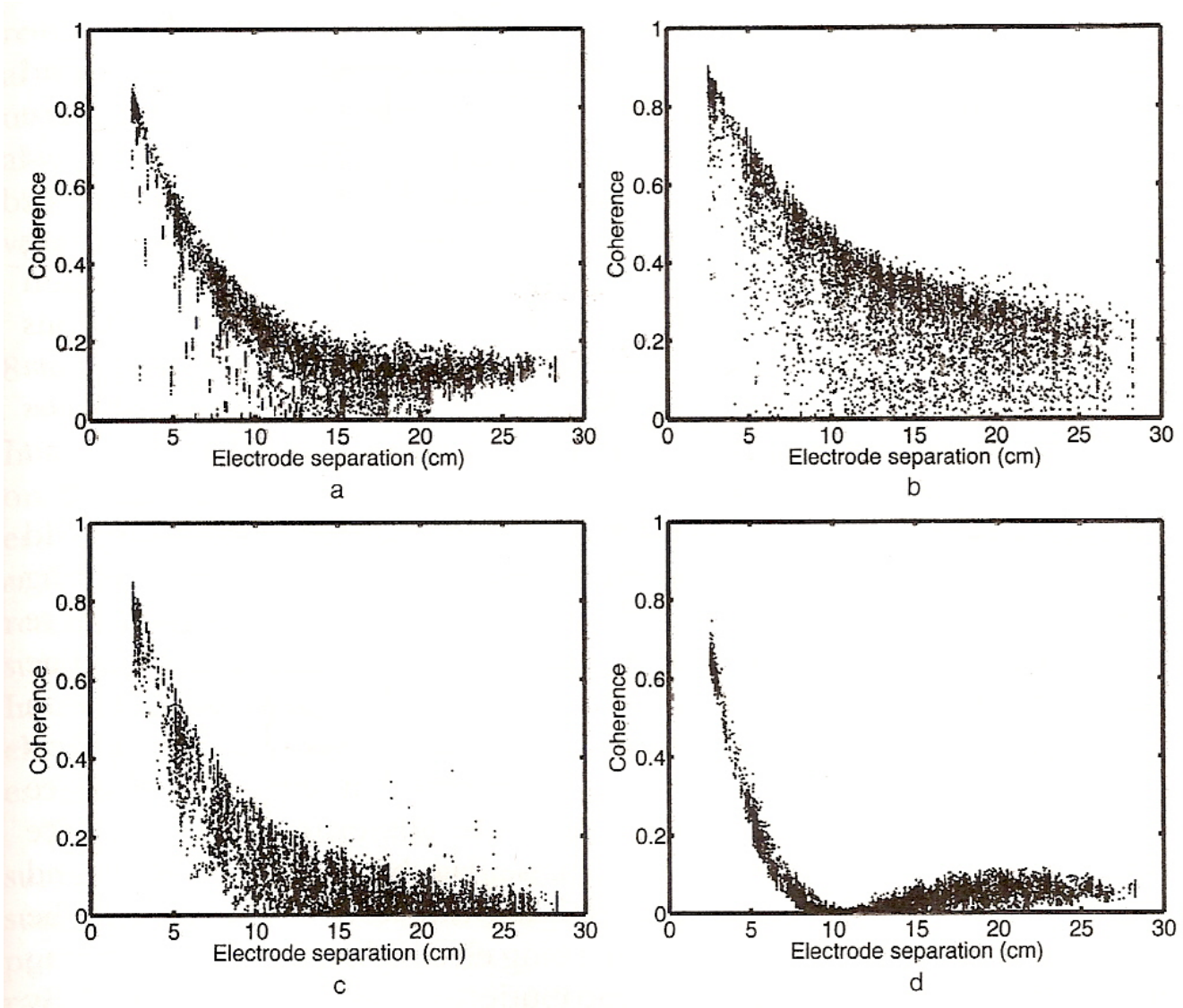


Effects of Reference System

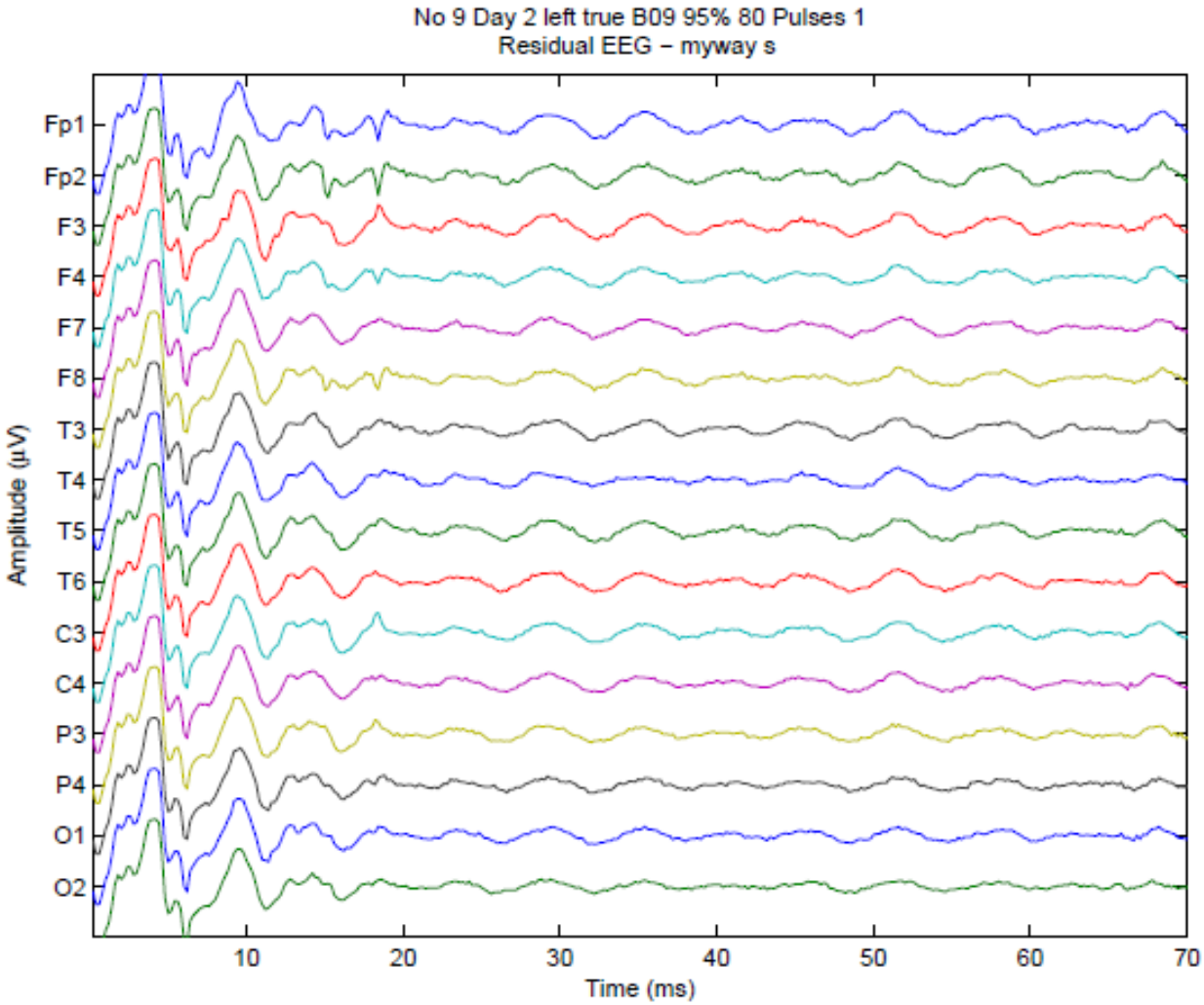
- Simulations using 3600 dipole sources and 111 electrodes with a 4-sphere head model
- Results show using vertex as reference results in lower coherence than a single mastoid
- Linked ear is better but best results for averaged reference (similar to reference free theoretical calculations)

Effects of Reference

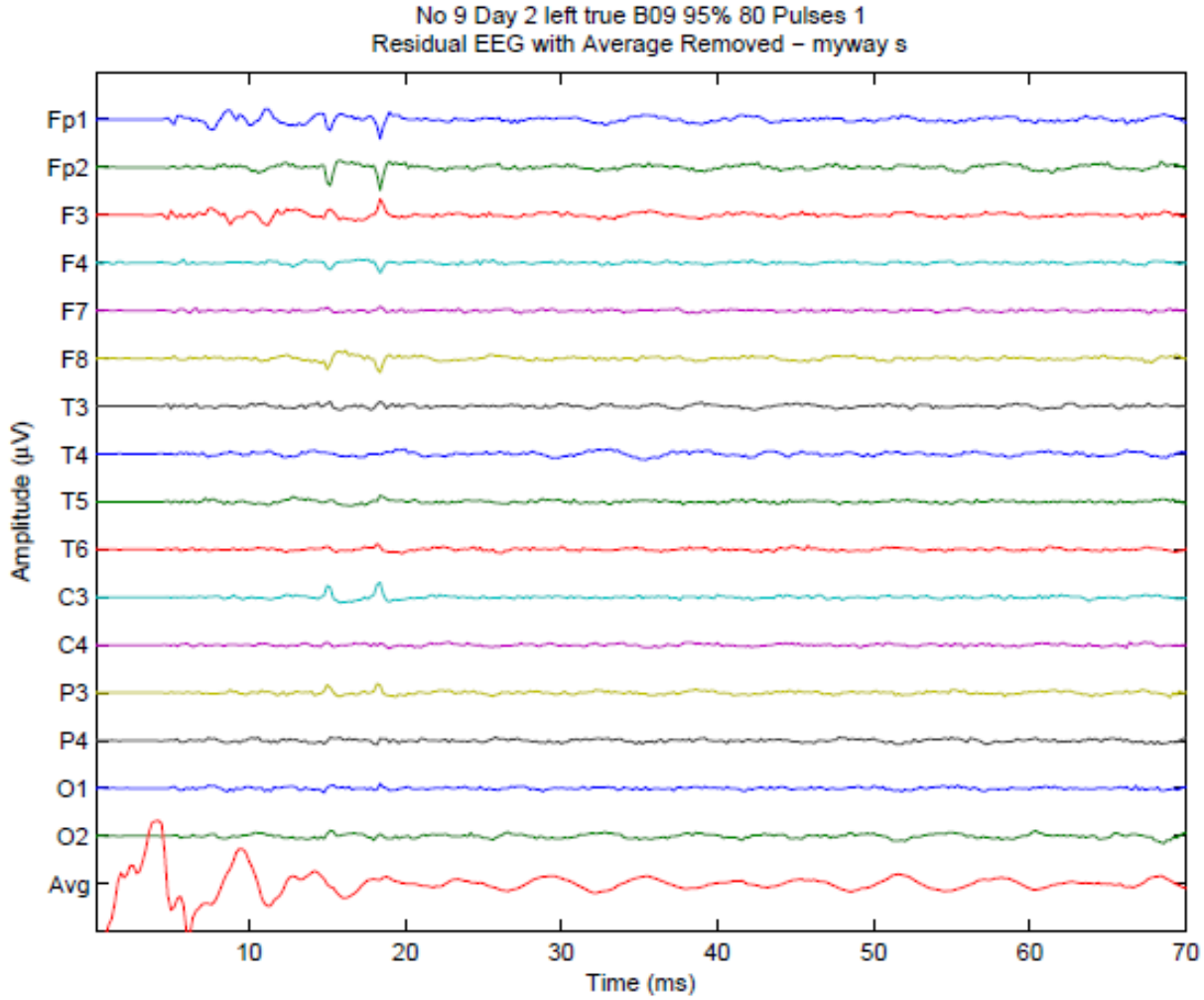
- Fig 9.14



Evoked Potential Data

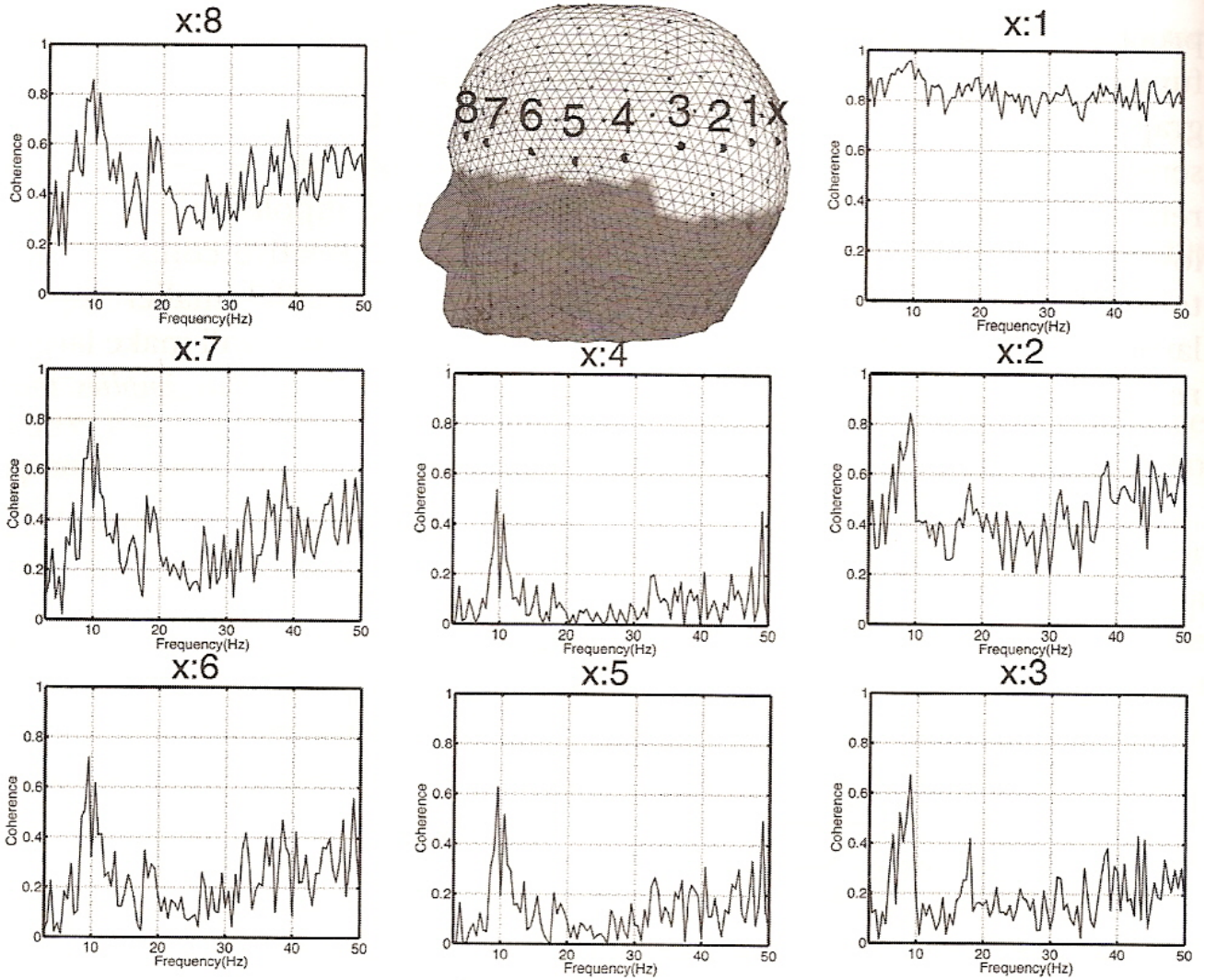


Evoked Potential Avg. Reference



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