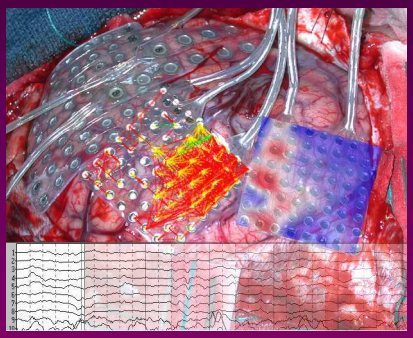
Patterns of EEG Coherence Across the Brain Surface



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Epilepsy in America

- 2.3 million epileptic patients in USA
  (180,000 new cases each year)
  2/3 can be managed medically
- 1 million medically intractable patients
  75% have severe, multifocal epilepsy
  250,000 potential surgical candidates

(There are only 1,500 epilepsy surgeries/year)
(>90% remain inadequately treated)

The Epilepsy Surgery Work-up

After several days of non-invasive monitoring…

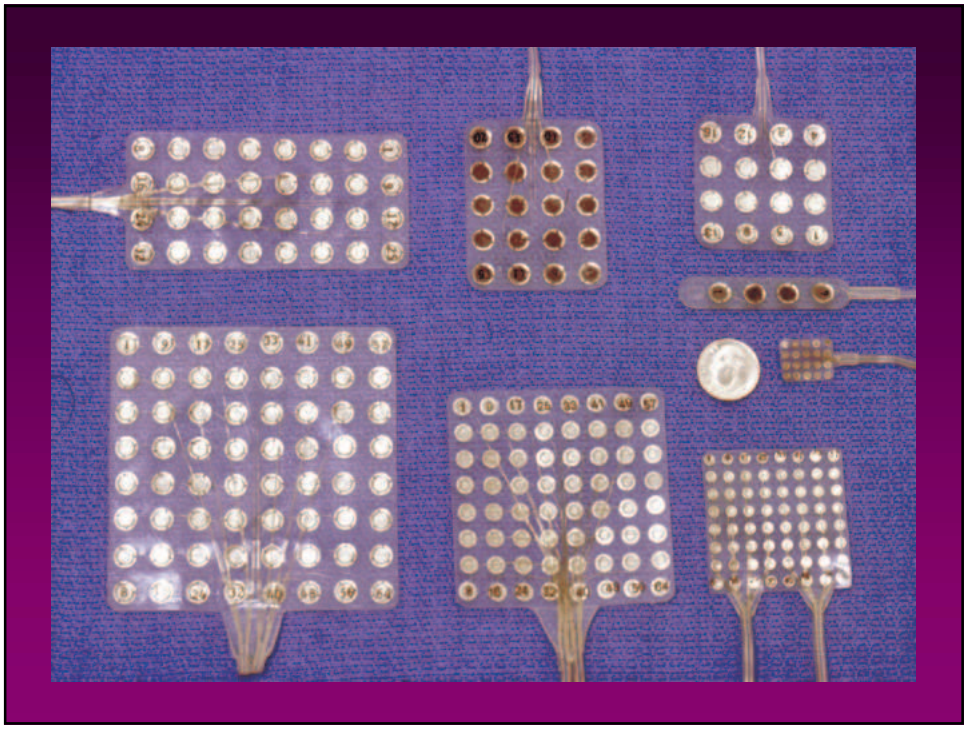
- Implantation of 50-200 electrodes
- Recording 3-14 days/nights of EEG (@ 400 Hz/ch)
- Catching > 5 stereotyped seizures
- Analysis and identification/resection of the epileptogenic zone

Epileptic Brain Regions

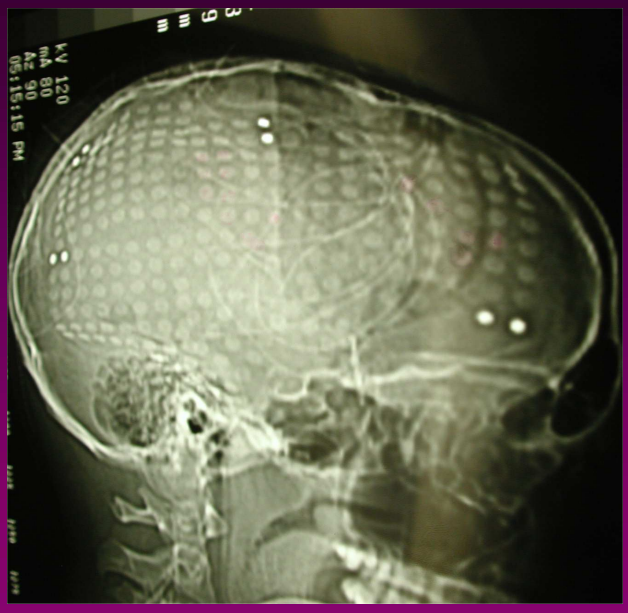
- ***Epileptogenic Lesion:*** The structural pathology that directly causes the seizures (CT/MRI, tissue pathology).
- ***Ictal Onset Zone:*** The area of cortex that initiates seizures (EEG).
- ***Epileptogenic Zone:*** The total area that must be removed to abolish seizures (?).

Luders, 1993

Can we predict where seizures will arise?

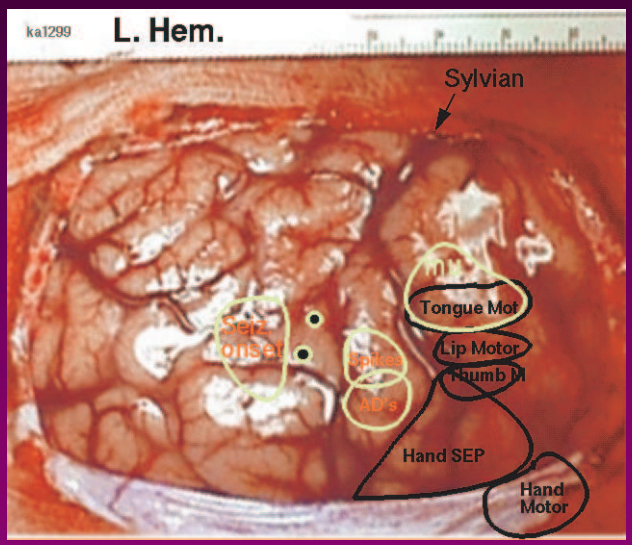


Subdural Grids



Signal-Acquisition System

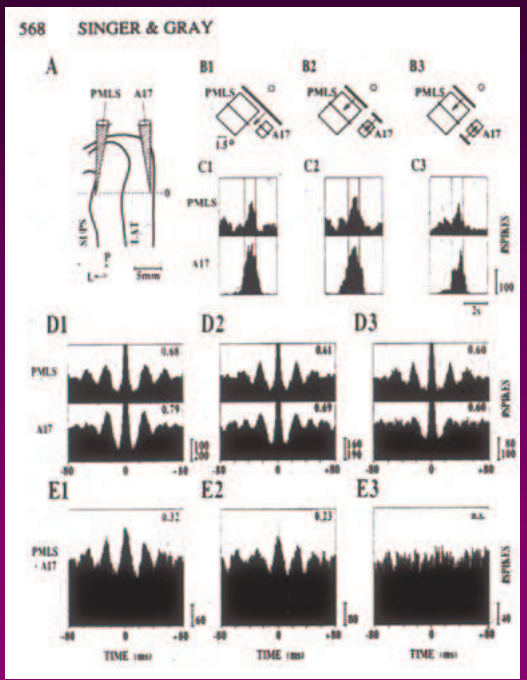
Functional Mapping



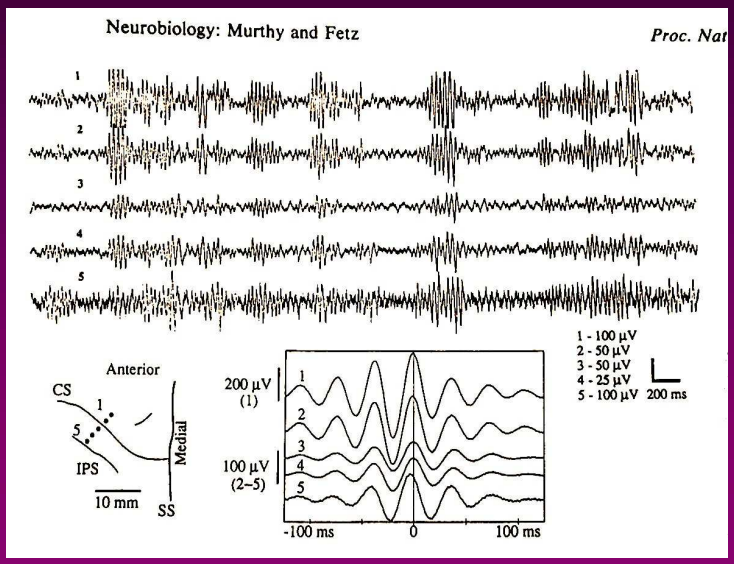
Types of Signals from Cortex

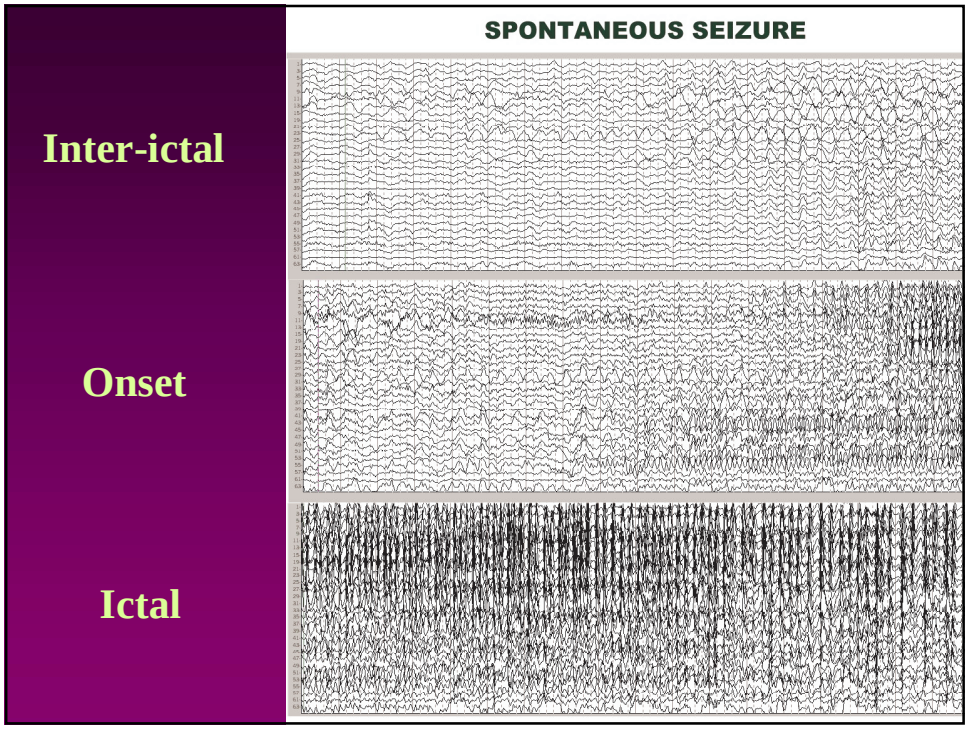
- Spikes from individual neurons
- Normal rhythms accompanying behavior
- Abnormal rhythms indicating pathology

Temporal Binding Hypothesis

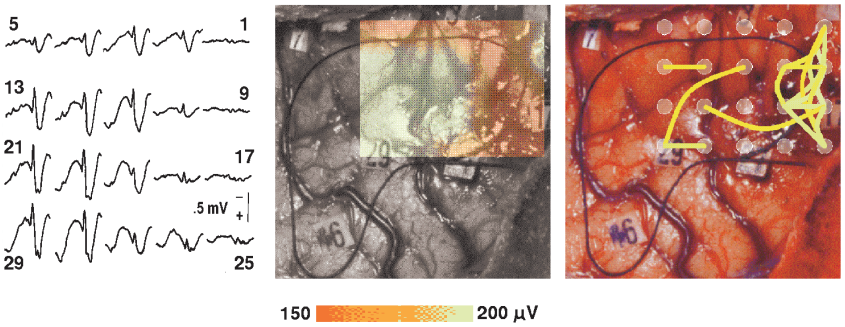


Oscillations Accompany Behavior



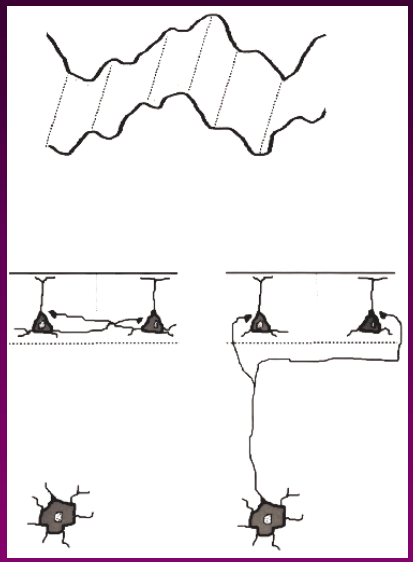


Time and Frequency Domains



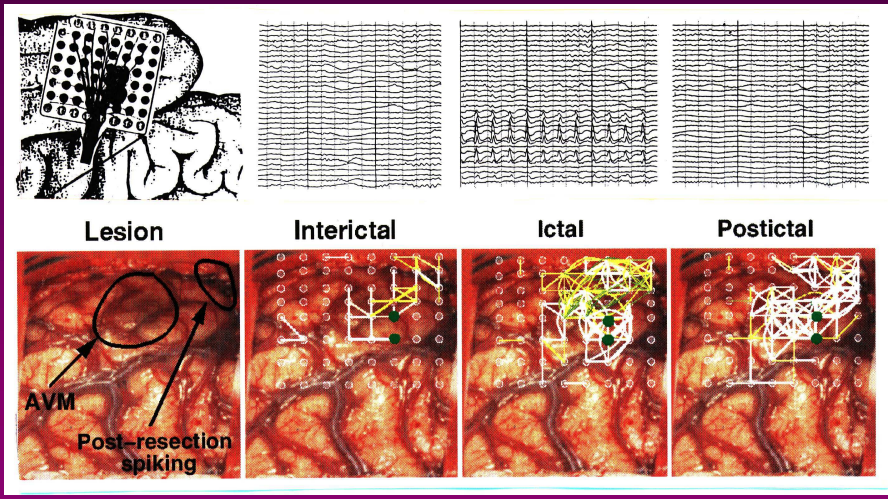
Lateral Coherence:

Coherence (0.0-1.0)
Phase (0-180 deg)

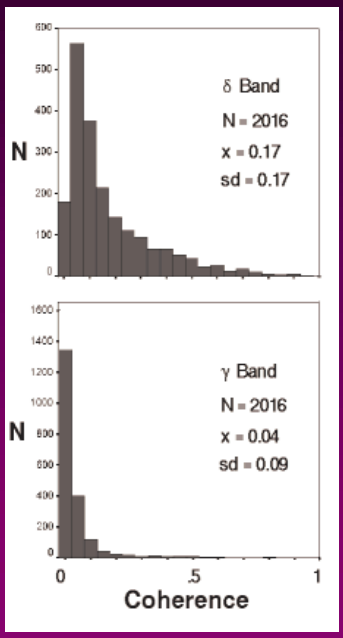


intracortical resonance
subcortical driving

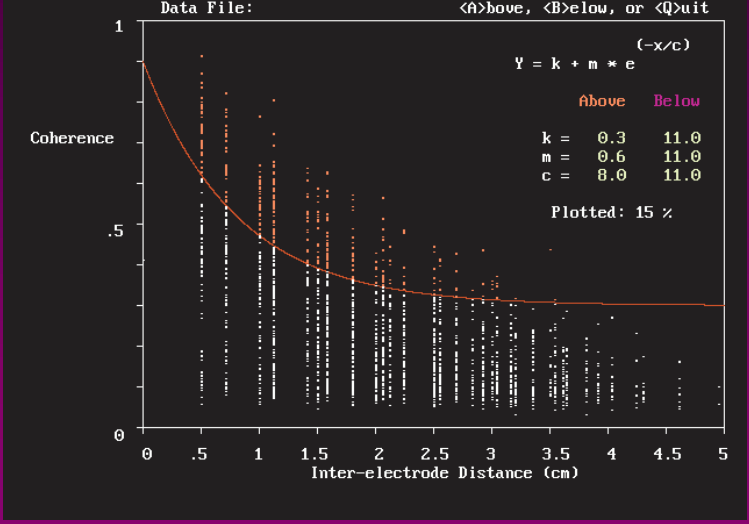
An Epileptic System?



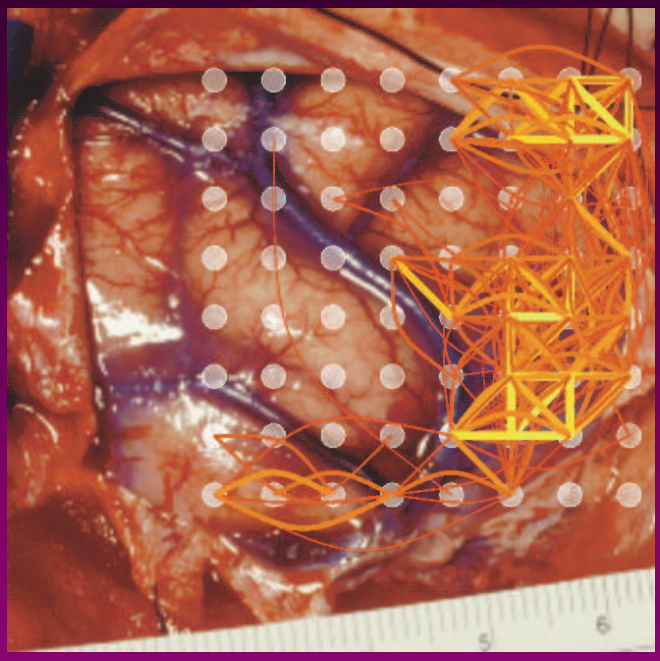
Distributions of Coherence



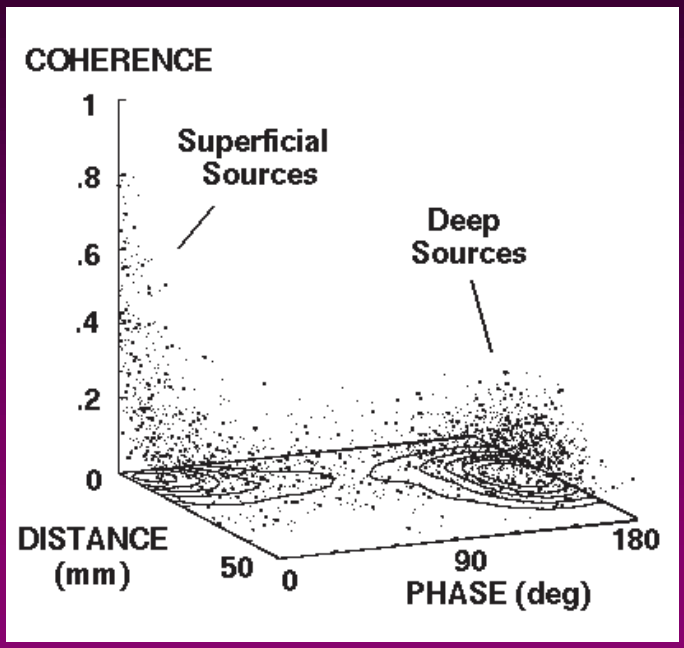
Coherence and Distance



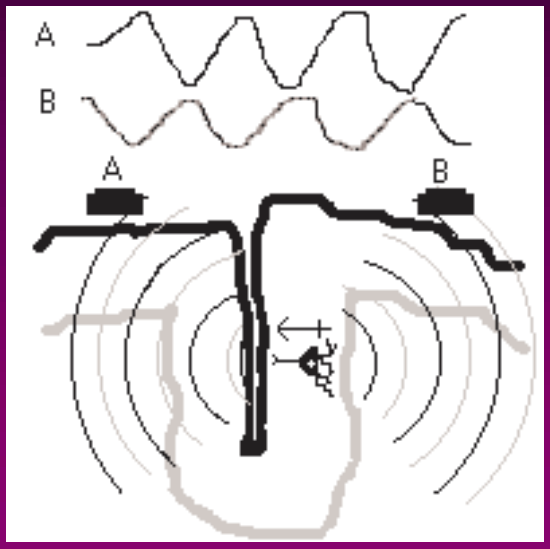
Frontal vs. Parietal Lobe Coherence



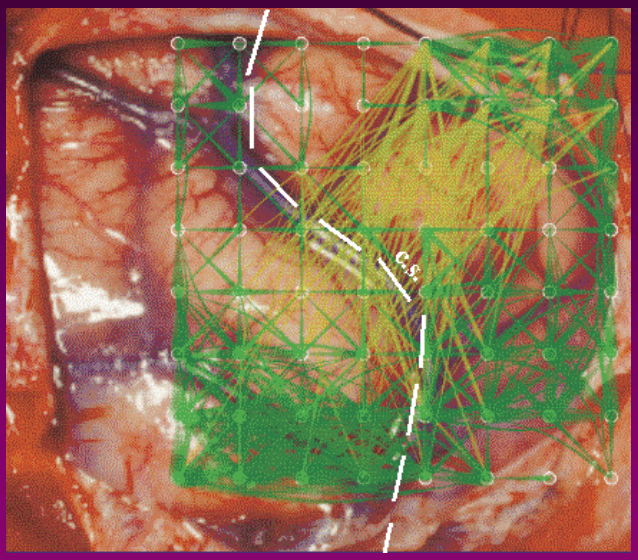
Distance and Phase



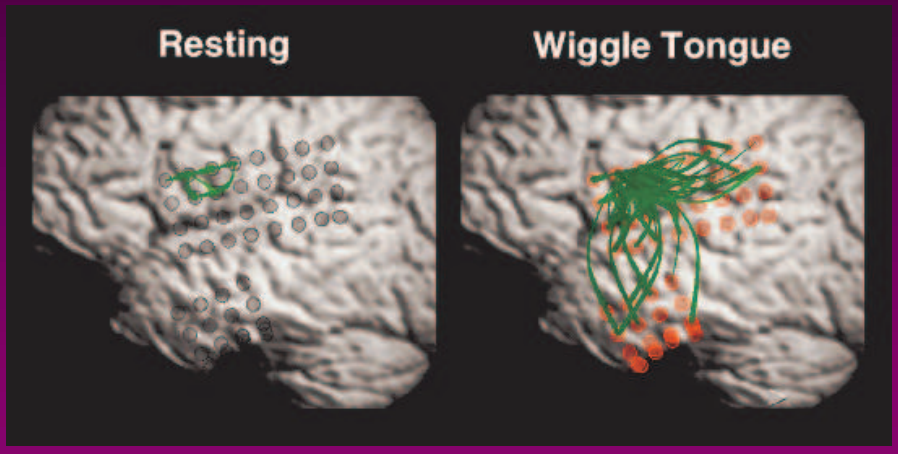
Deep Sources



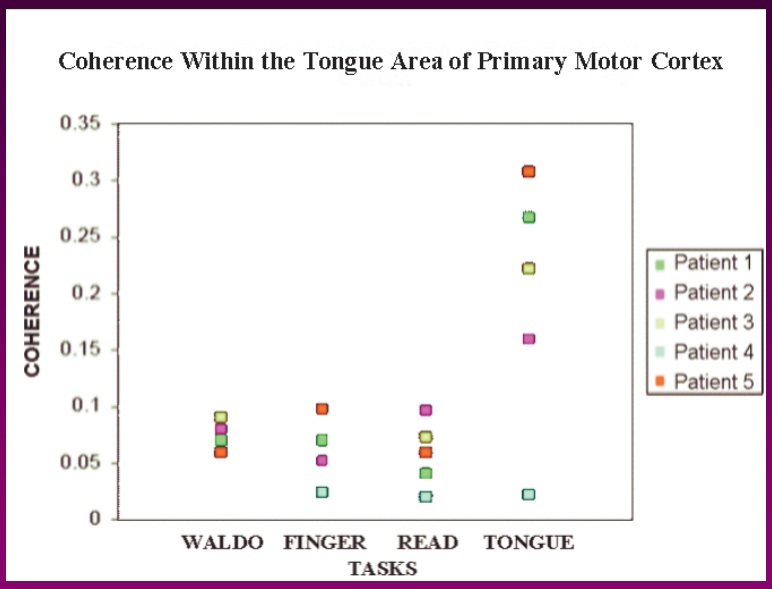
Phase and the Central Sulcus

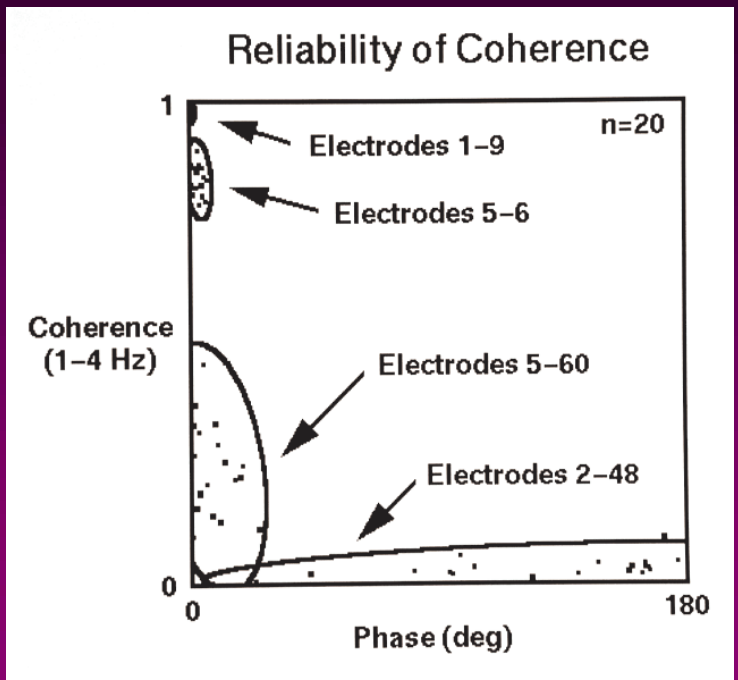


Task-related Beta Activity

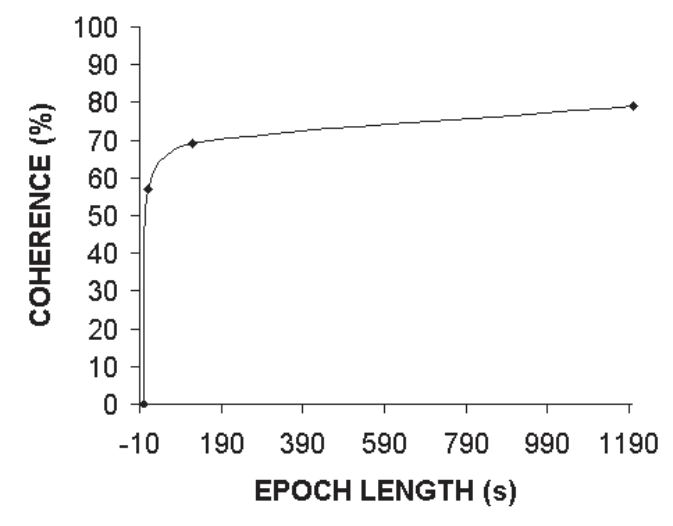


Task-specific Beta Band Coherence



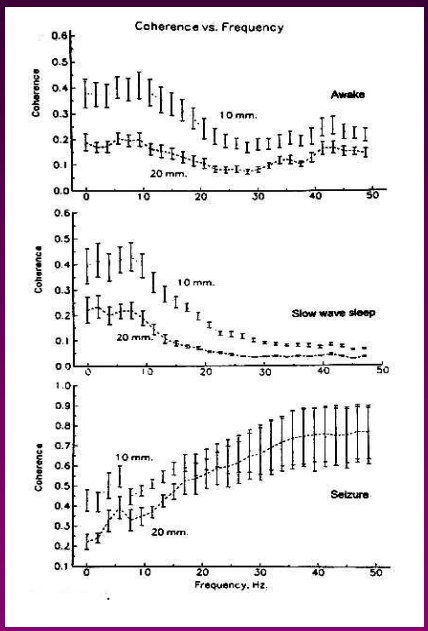


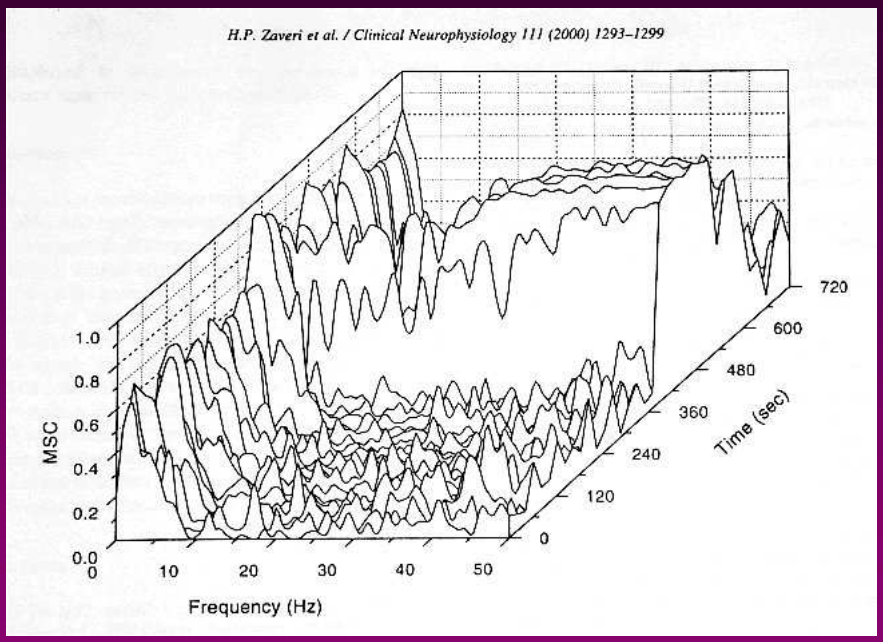
Sample Size and Reliability



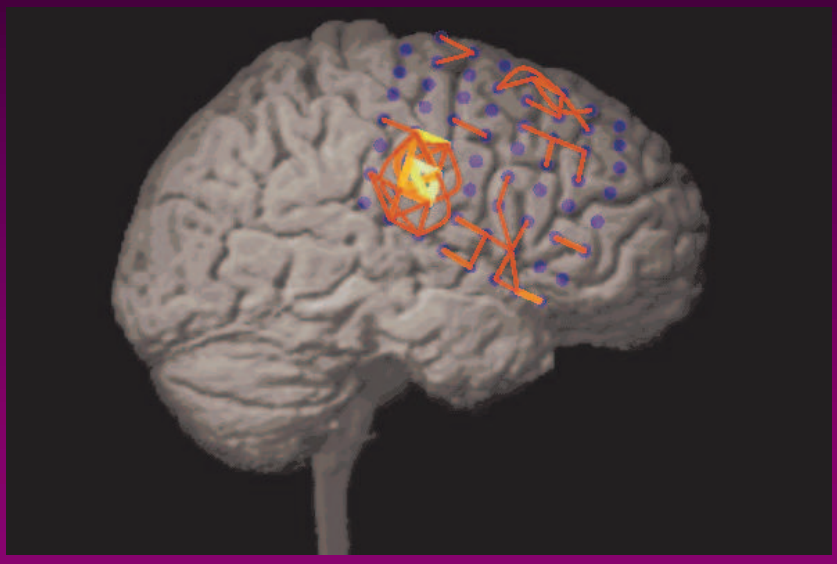
Coherence and Seizures

- Gotman, 1987
- Duckrow & Spencer, 1992
- Zaveri *et al.* 1993, 2000
- Franaszczuk *et al.* 1994
- Bullock *et al.* 1995
- Bartolomei, 1999, 2000
- Le Van Quyen *et al.* 1998, 2000

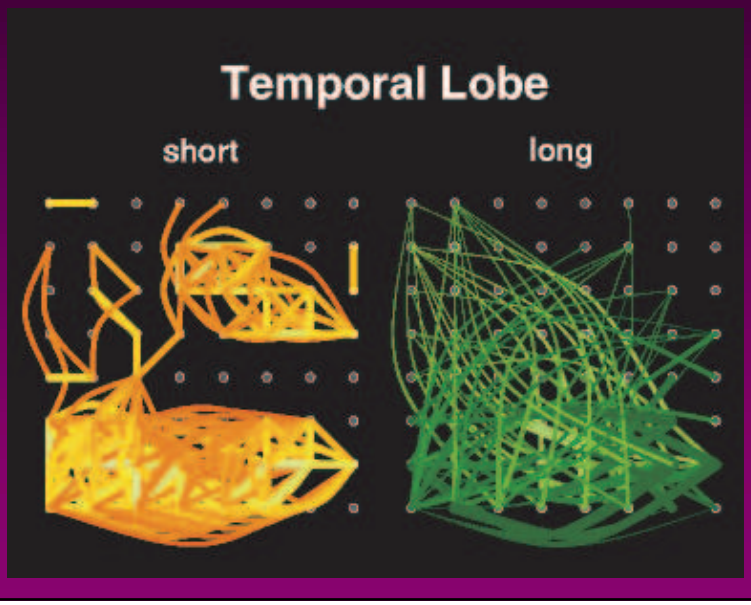




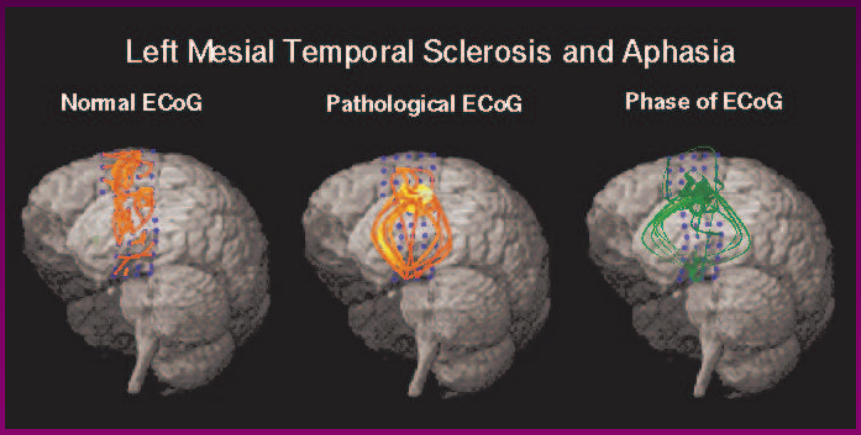
Epilepsy Partialis Continua



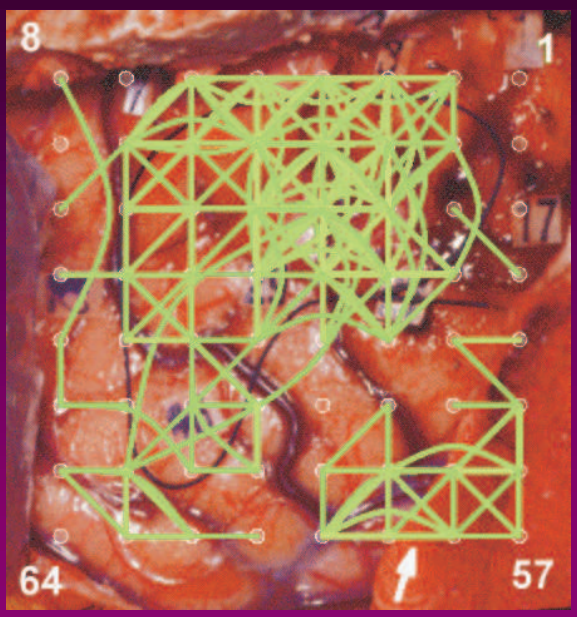
Temporal Lobe Coherence



Relating Symptoms with Pathology

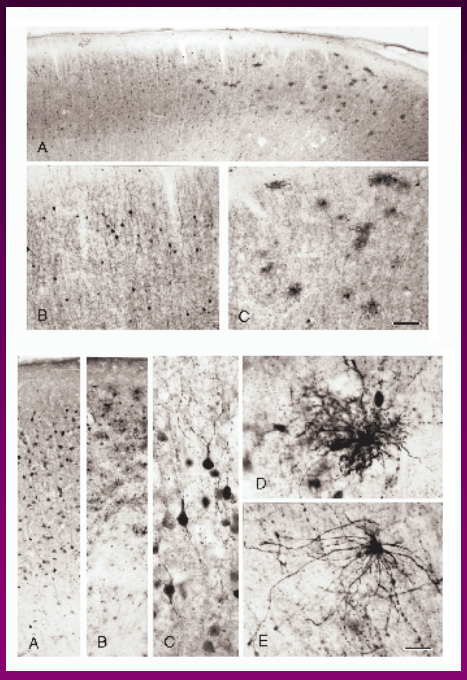


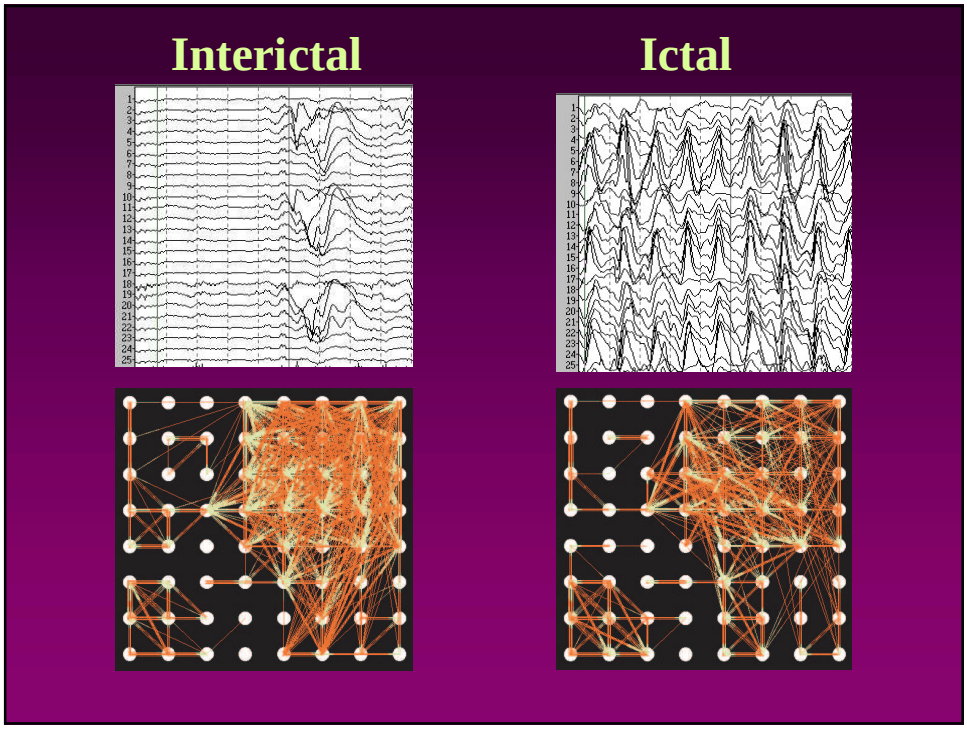
Interictal Coherence



Pathologic Changes

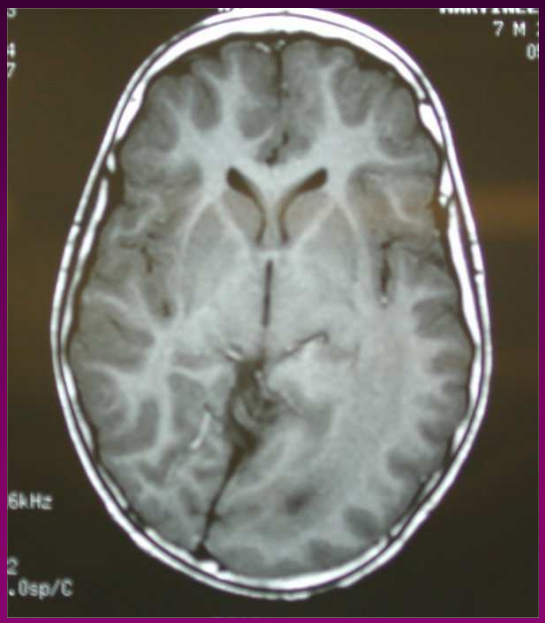
- Parvalbumin immunoreactivity
- Calbindin immunoreactivity





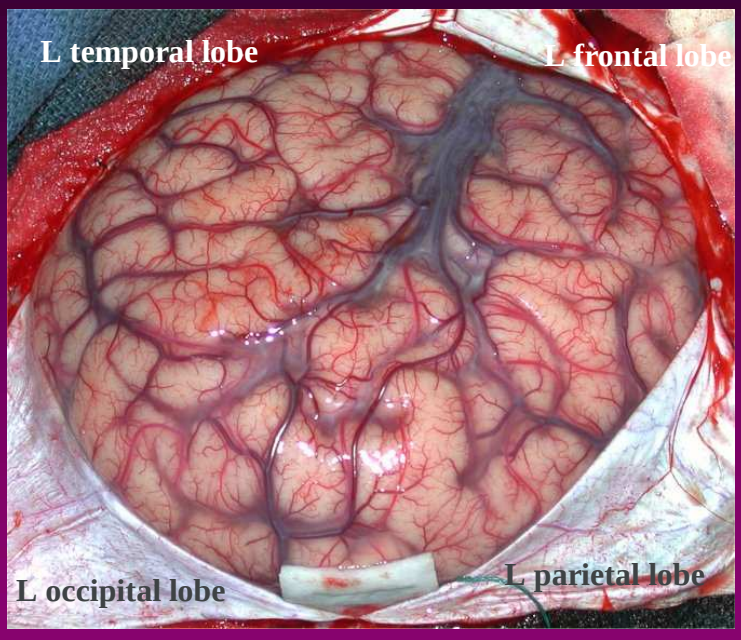
Hemimegencephaly

- 8 year old male
- parietal/occipital cortex
- Developmental delay
- Daily seizures

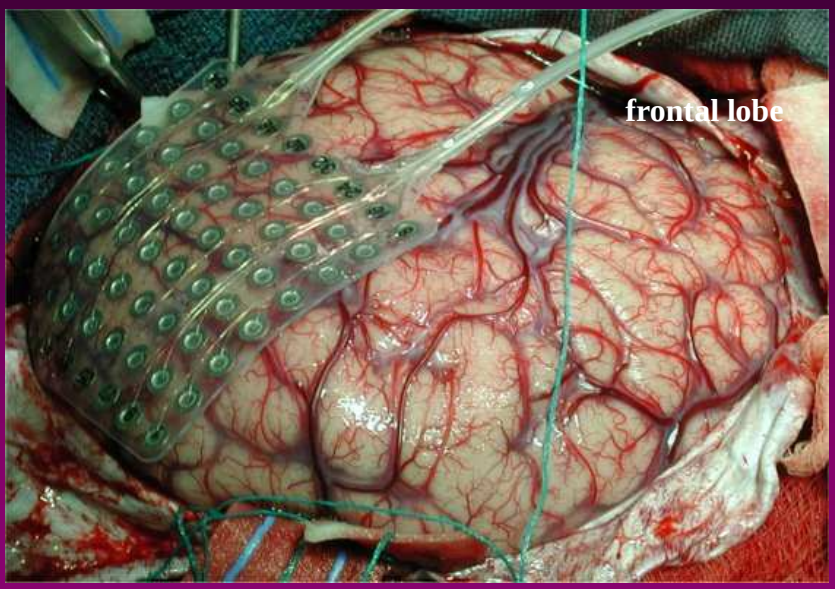


Post-op:

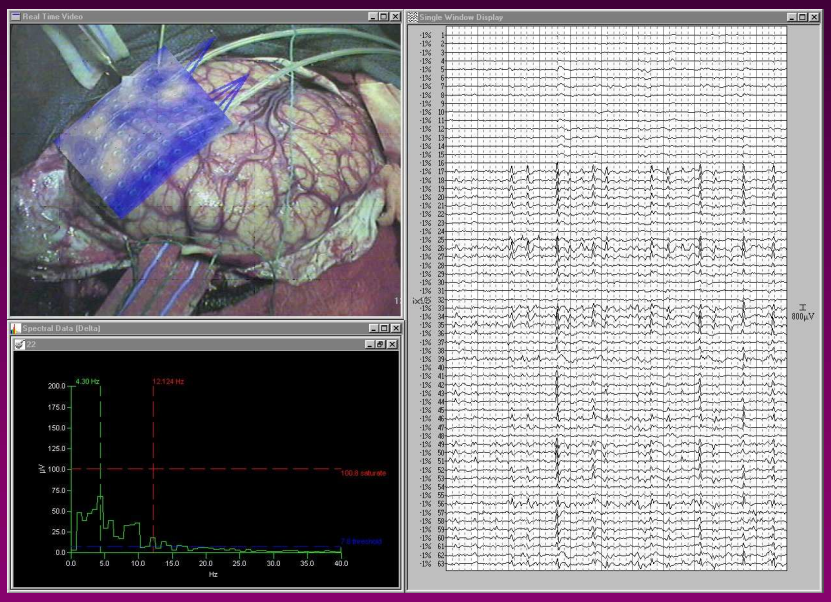
- 3 sz immediately
- 0 sz at 6 months
- Ambulatory – running
- Increased vocabulary



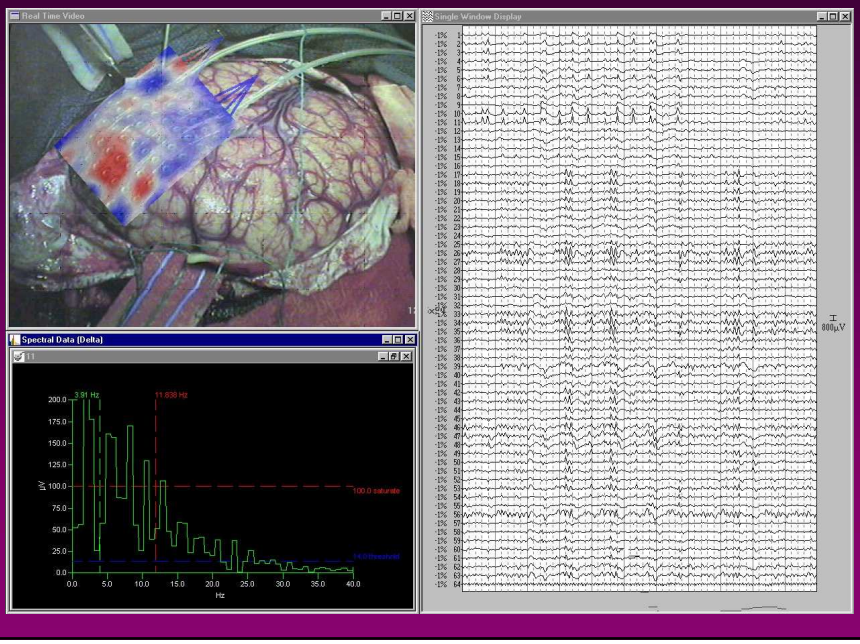
Left Occipital Grid



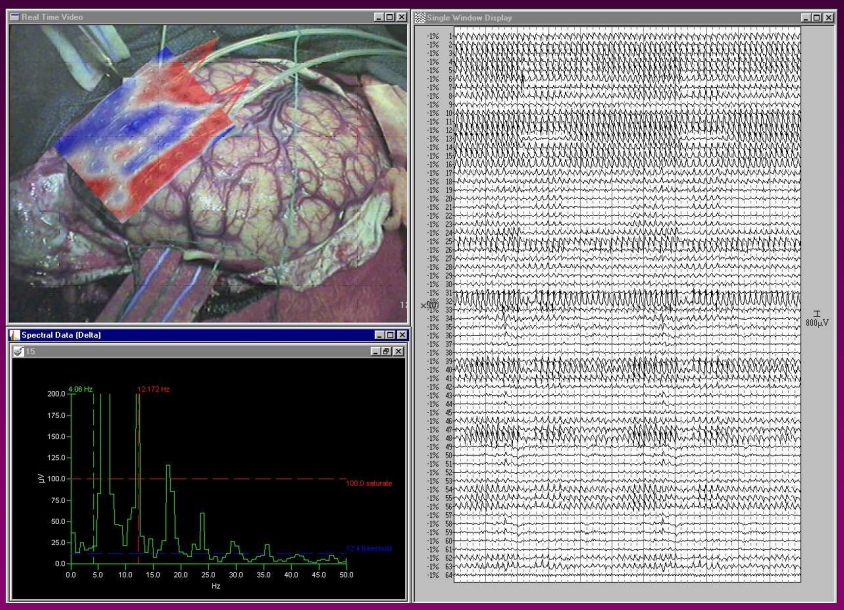
Interictal Power



Seizure Onset

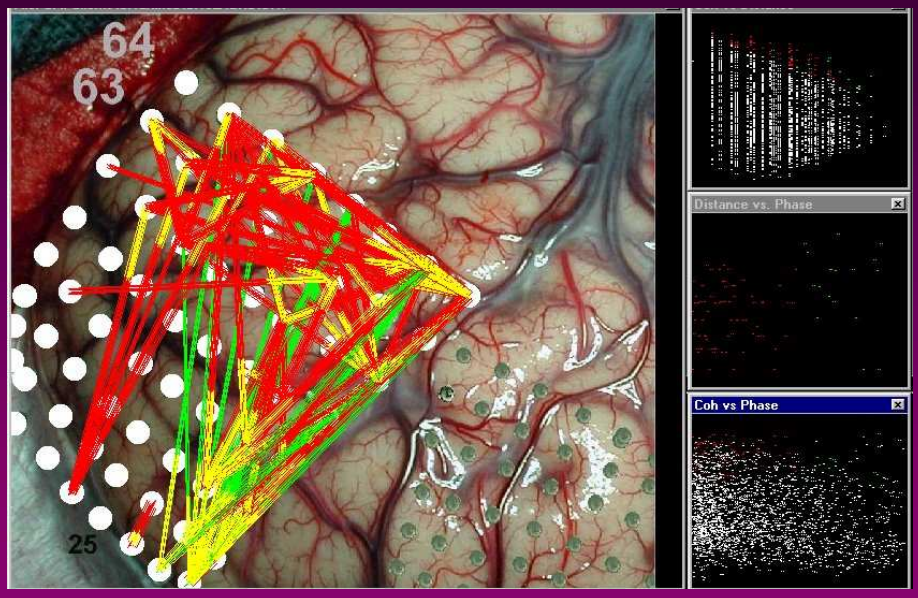


Ictal Power

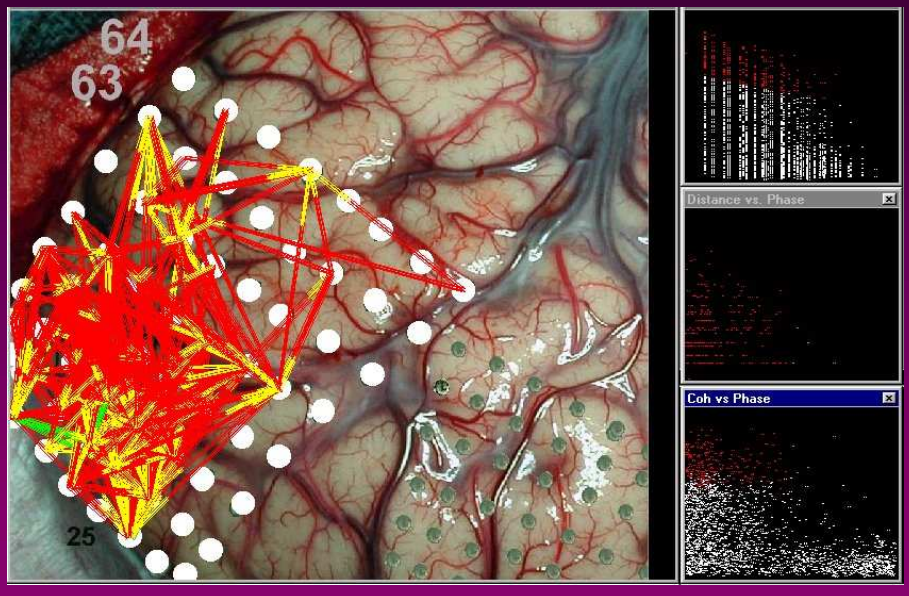


Resection and Topectomy

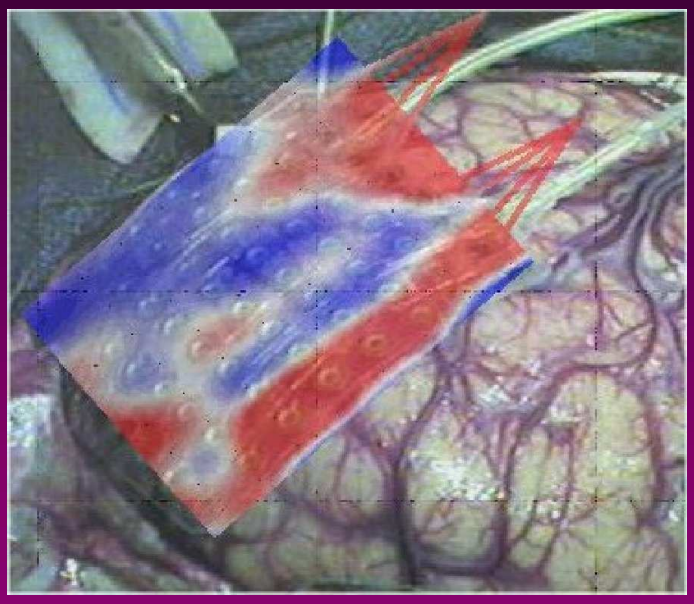
Ictal Coherence



Interictal Coherence



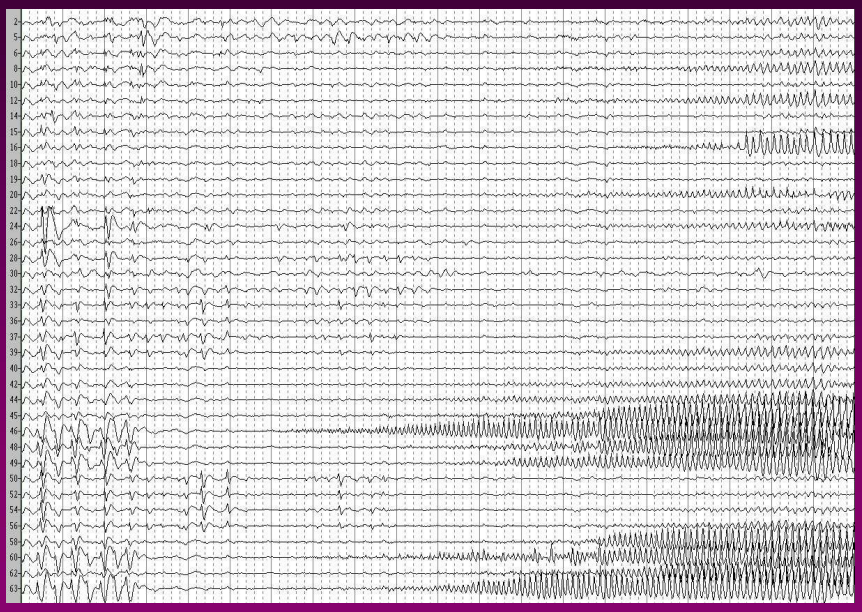
Ictal Power



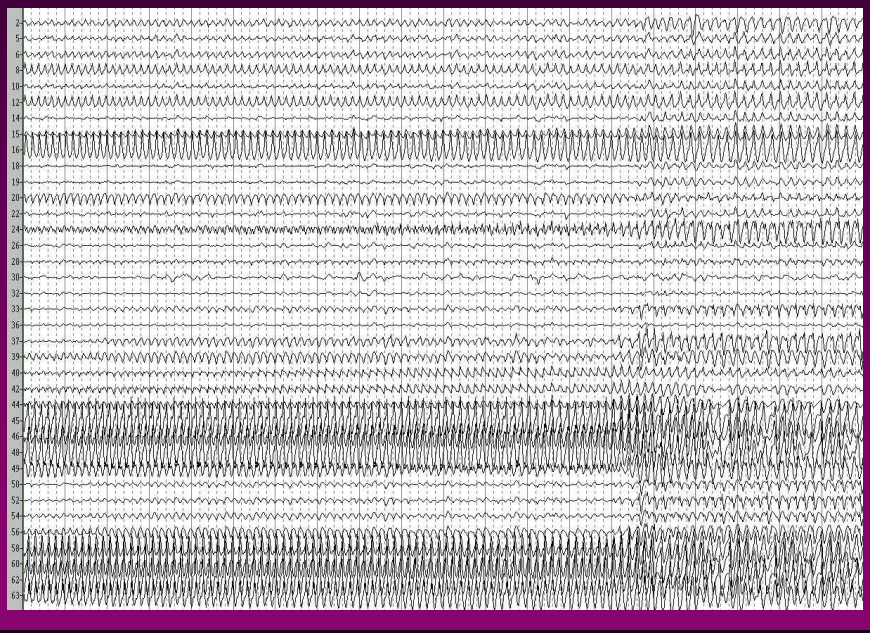
Tuberous Sclerosis

- 7 year-old female
- Severe mental retardation
- Left hemiparesis
- 8 generalized t-c seizures/day
- +20-40 sub-clinical

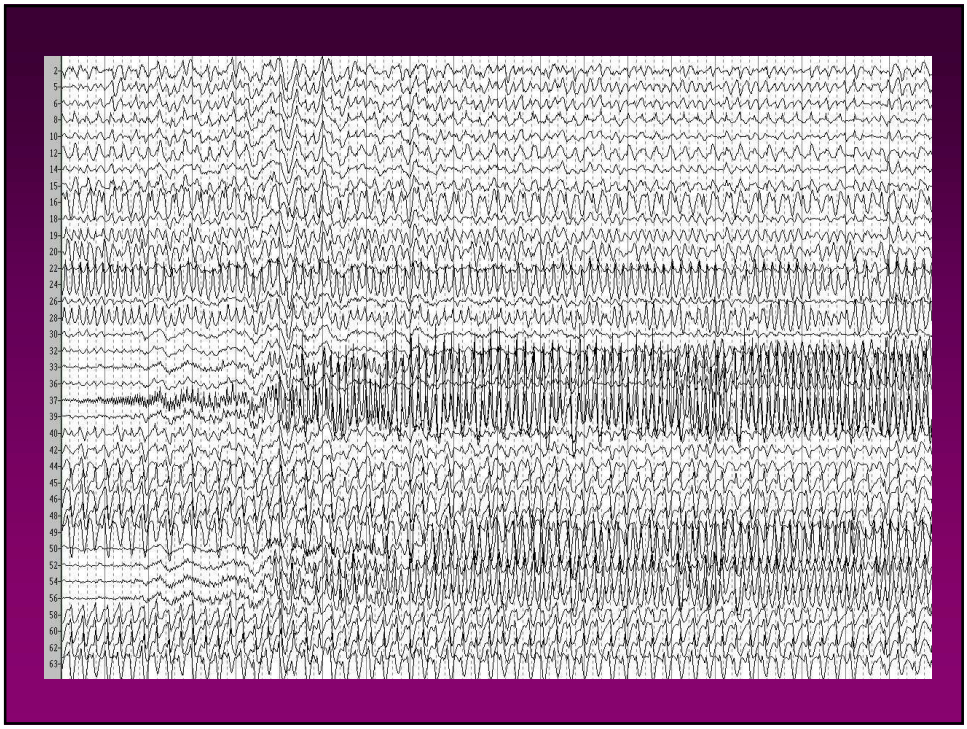
Seizure Onset

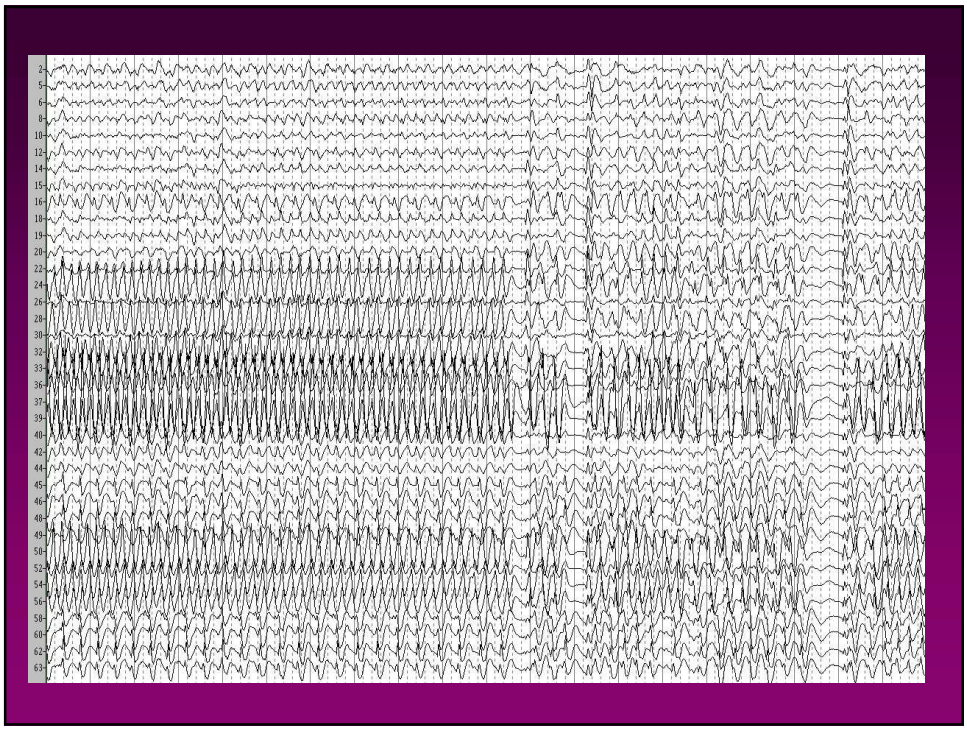


Seizure Spread



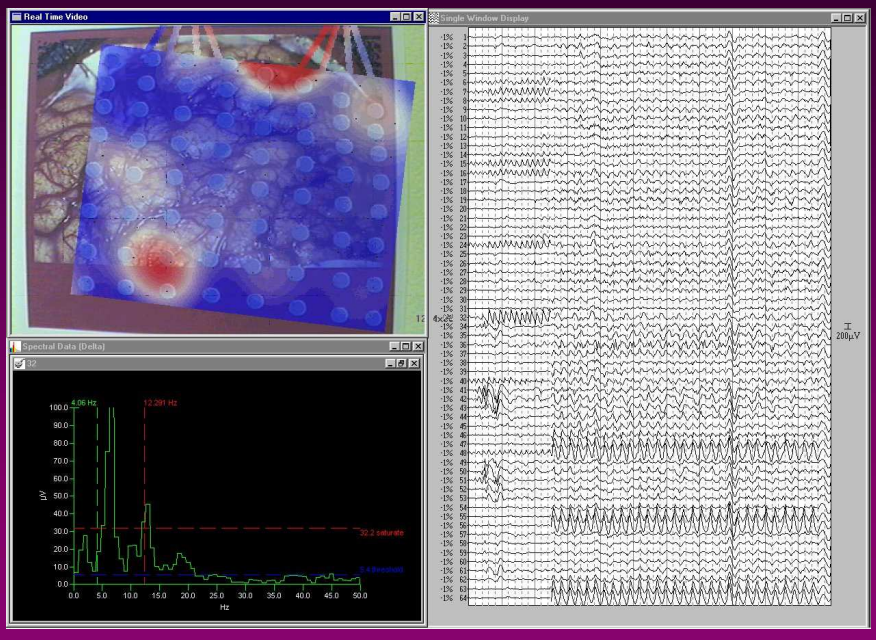
Neurophysiologic Signals Recorded Directly from Human Cortex



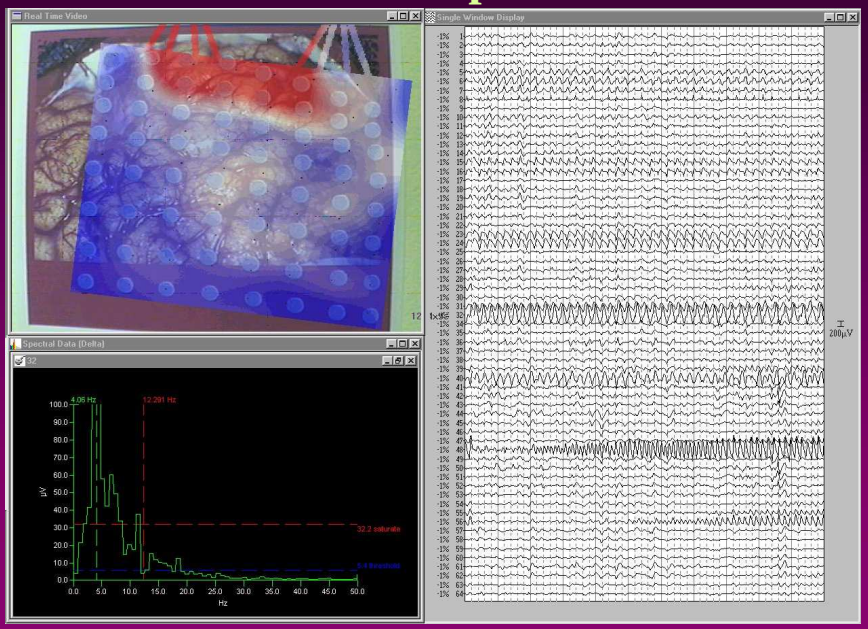


Seizure End

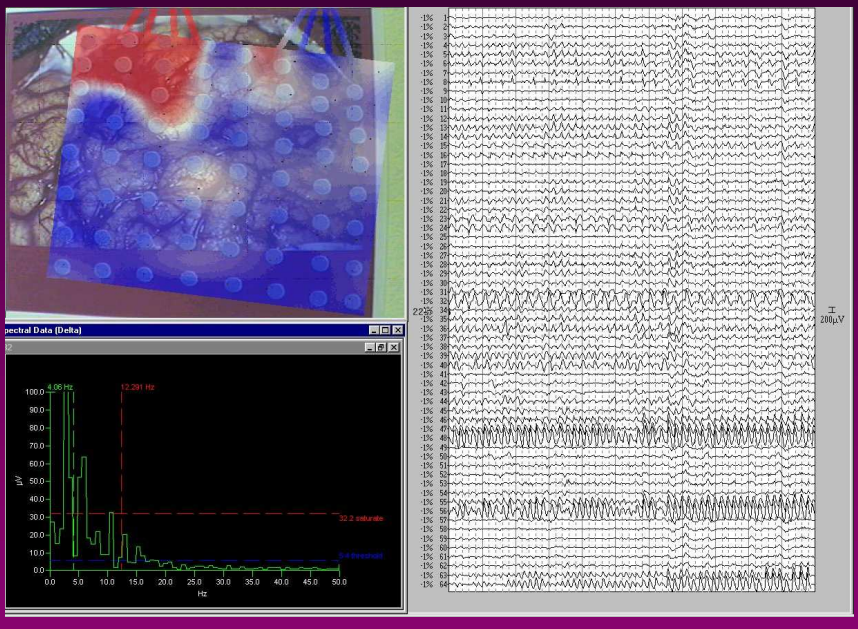
Seizure Onset



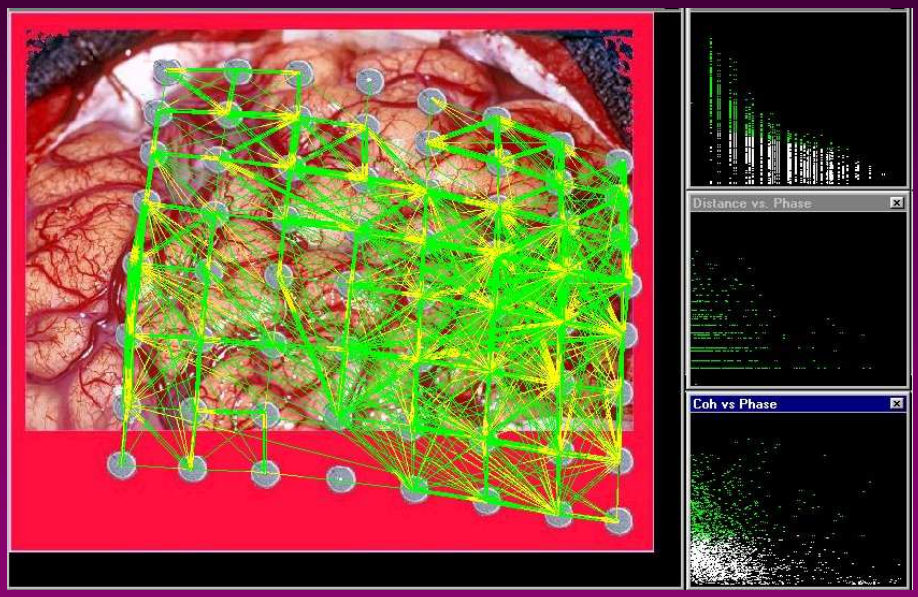
Seizure Spread



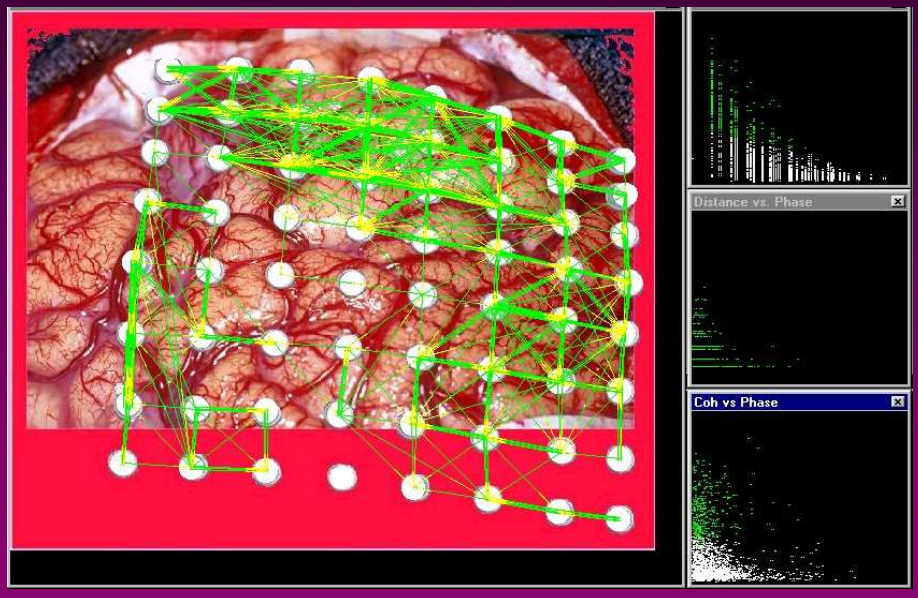
Seizure End



Ictal Coherence



Interictal Coherence



Preliminary Conclusions

1. During the ictal period coherence increases within each cortical component of the epileptic system.

2. Coherence can be used to identify the borders of epileptic areas.

4. It appears that under some circumstances the epileptogenic zone can be identified from analysis of interictal recordings.