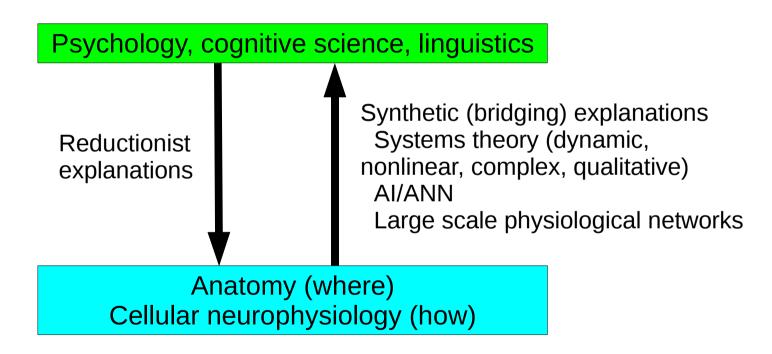
Spatiotemporal network dynamics from human brainwave data

Richard E. Greenblatt PhD Source Signal Imaging, Inc. www.sourcesignal.com reg@sourcesignal.com **Background and motivation** Network identification methods Instantaneousness Phase Synchrony Phase Locking Value (PLV) Normed Aggregate synchrony matrix Composite synchrony profile (CSP) Deterministic clustering algorithm Results

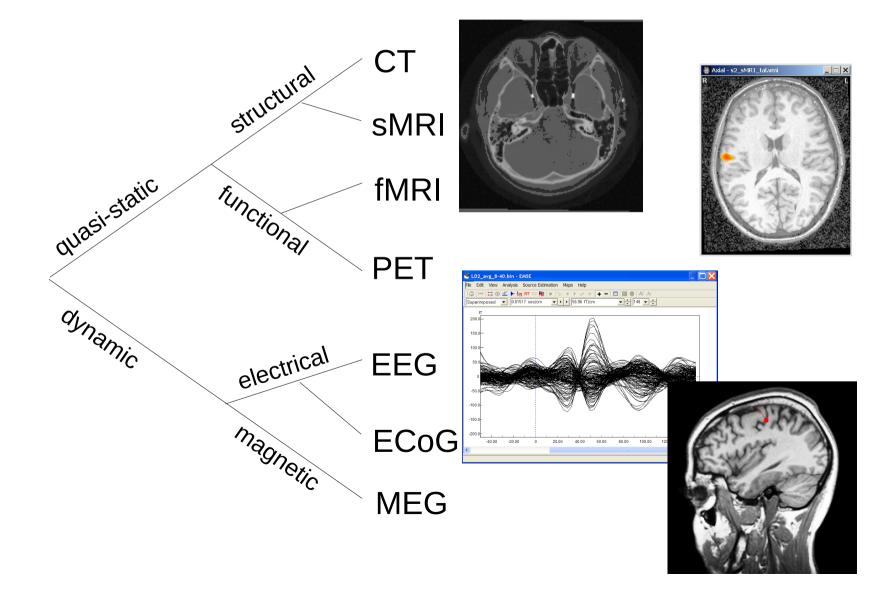
- Seizure
- Word recognition

Summary and future directions

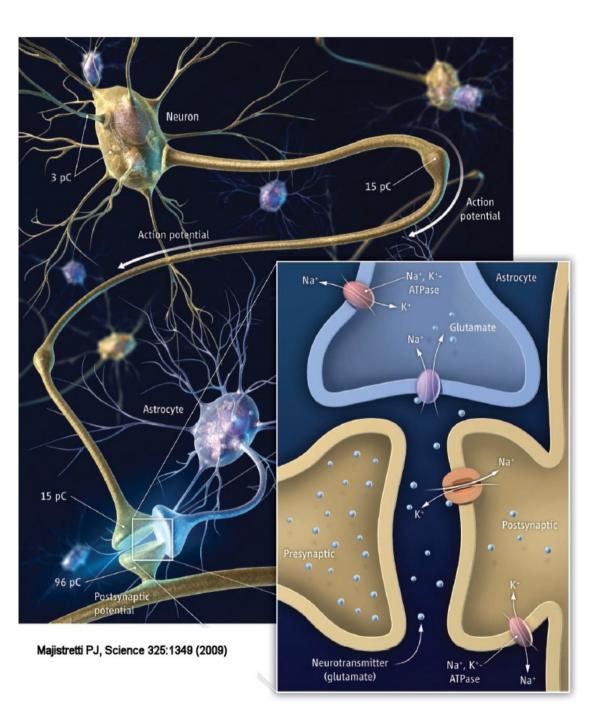
Background and Motivation Explanatory levels in neuroscience: Ways of talking about brains and behavior



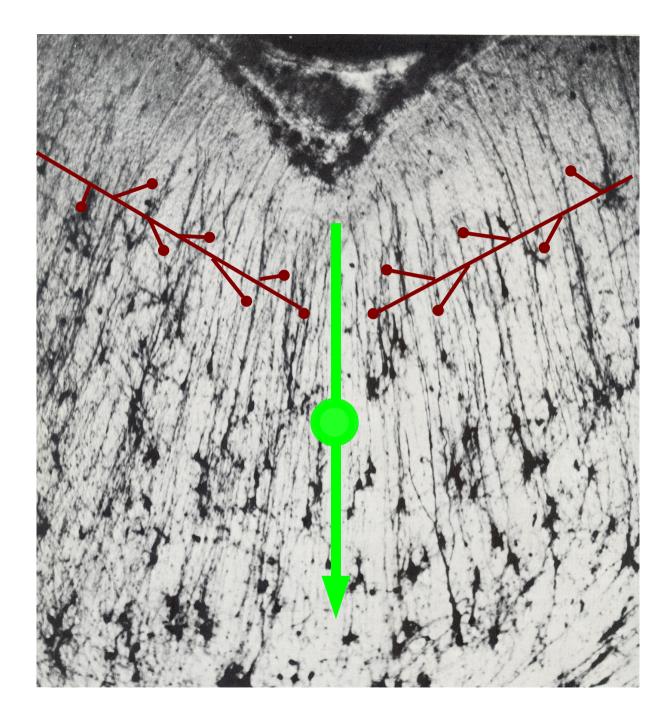
Where does the human data come from? Brain Imaging Modalities



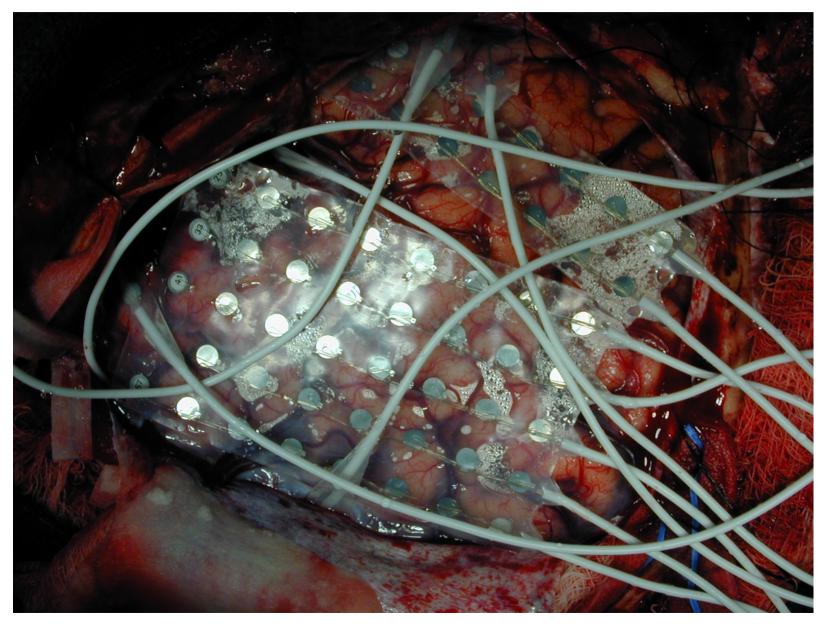
Brain Imaging -Cellular Physiology



From neuron to field potentials

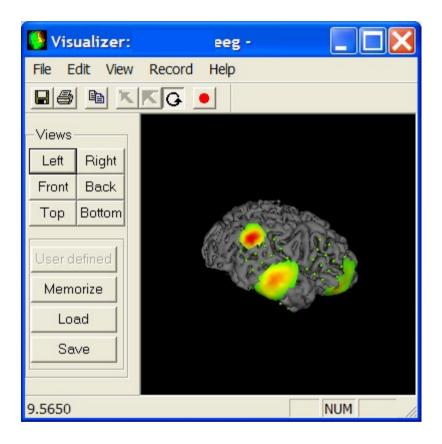


Electrocorticography - ECoG



R. Emerson MD, Columbia P&S

Clinical Seizure – Video ECoG



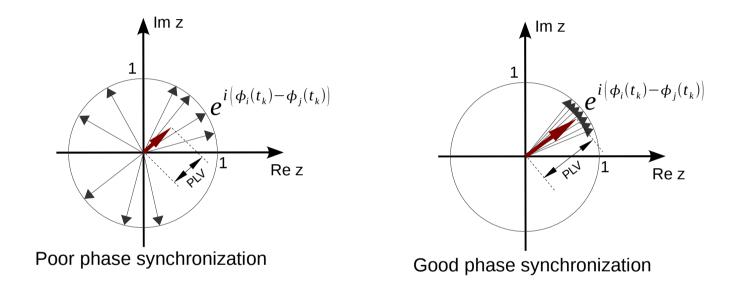
Background and motivation

Network identification methods Instantaneousness Phase Synchrony Phase Locking Value (PLV) Normed Aggregate synchrony matrix Composite synchrony profile (CSP) Deterministic clustering algorithm Results

- Seizure
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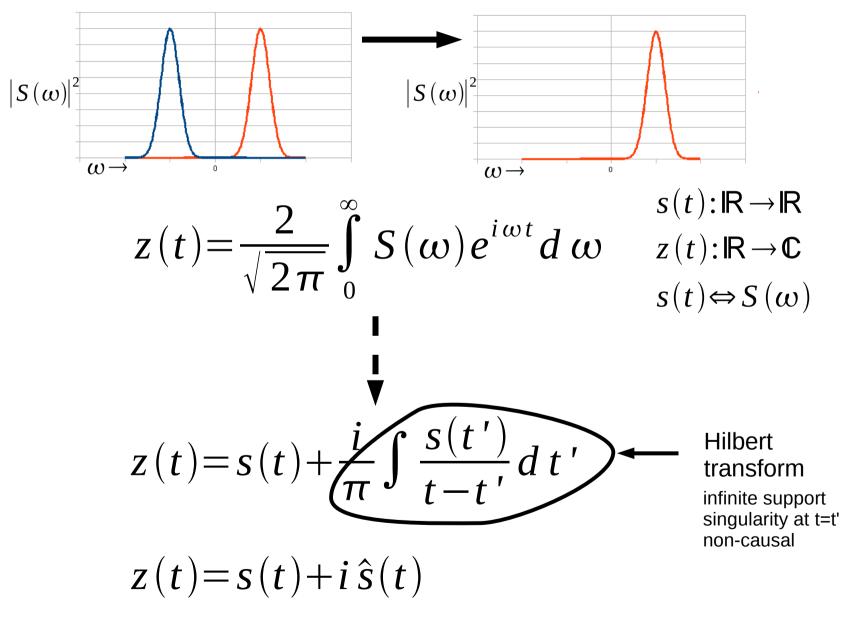
Summary and future directions

Phase Synchrony



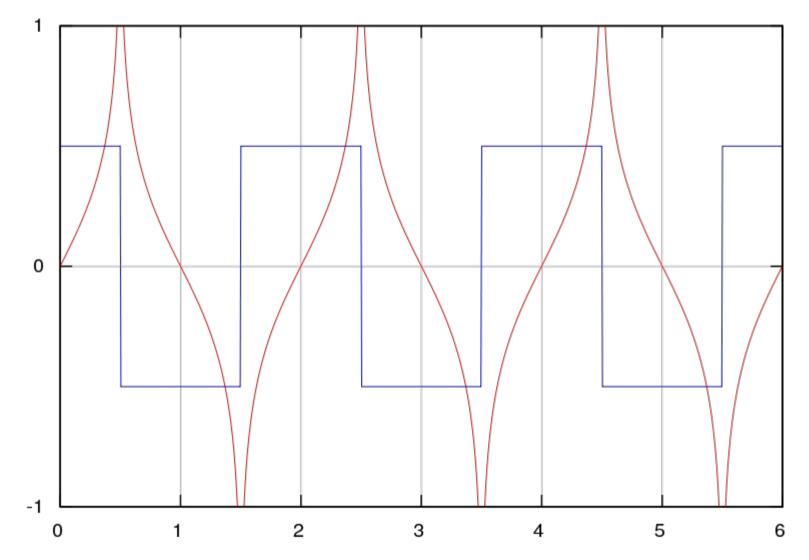
Note: Phase synchrony is independent of signal amplitude

Hilbert Transform



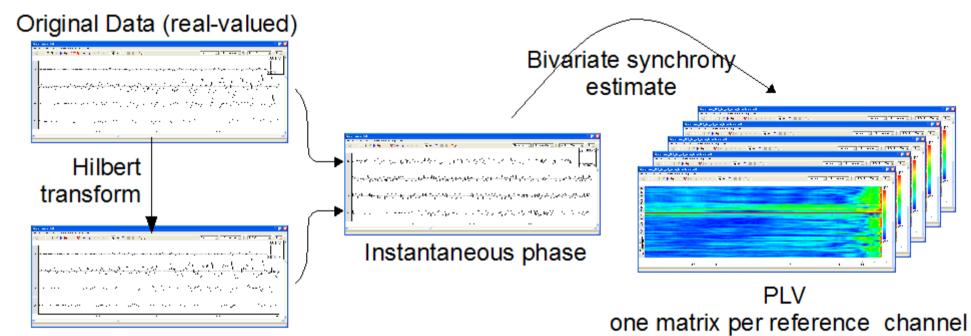
Cohen L, Time-Frequency Analysis, 1995

Hilbert transform – square wave

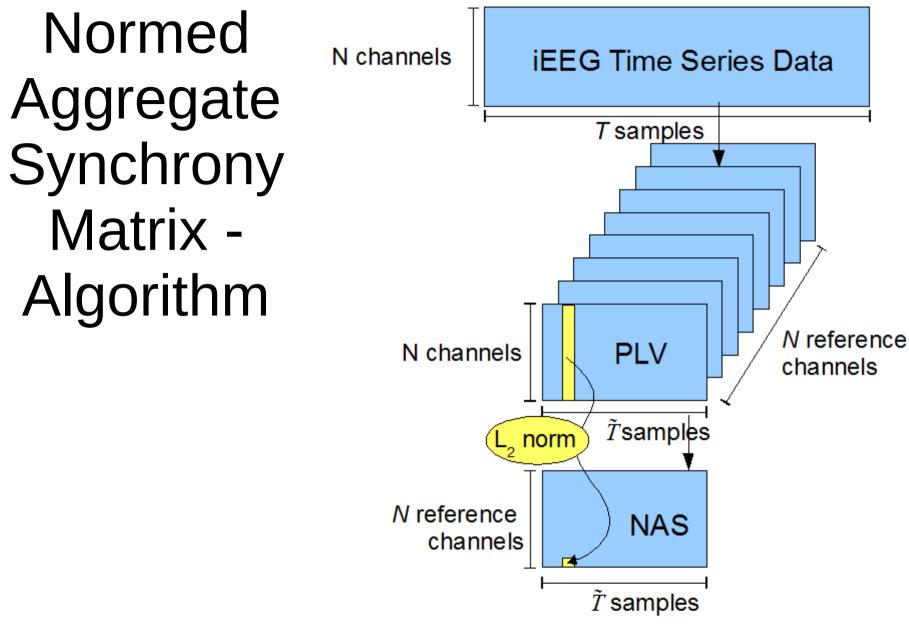


http://en.wikipedia.org/wiki/Hilbert_transform

Phase Locking Value - PLV

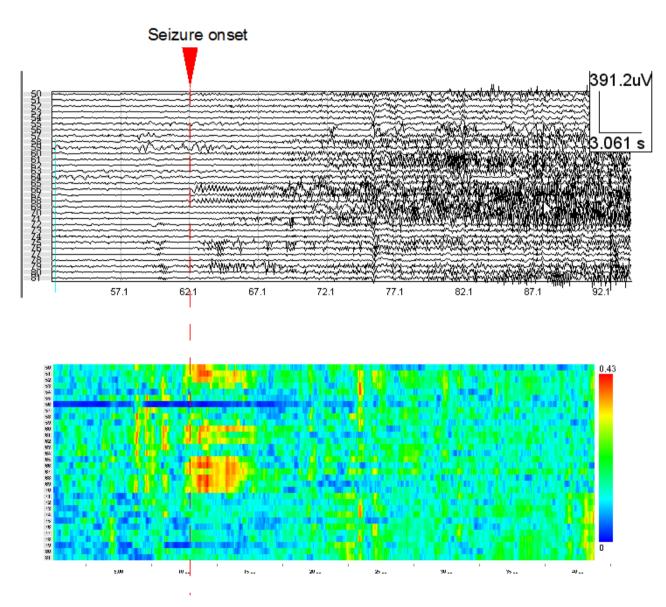


imaginary-valued

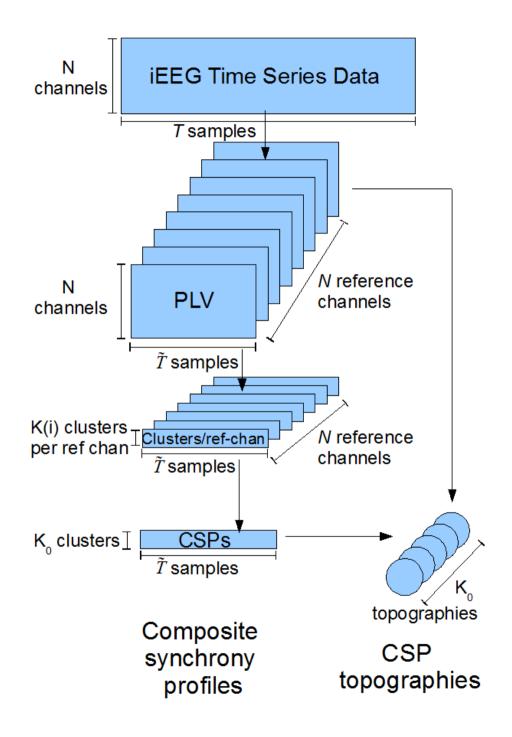


Normed aggregate synchrony matrix

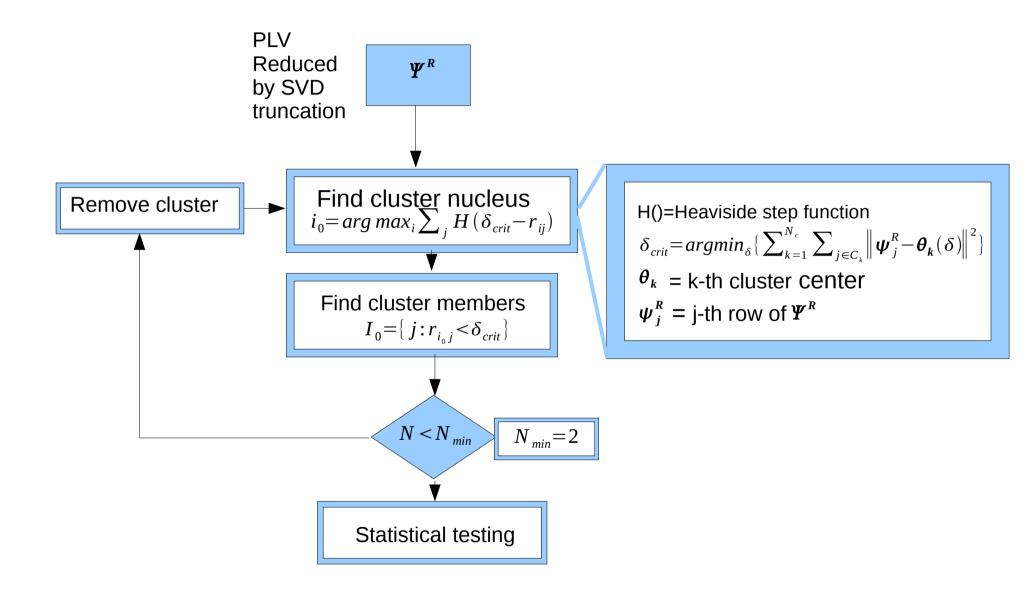
Normed Aggregate Synchrony Matrix – Seizure Data



Composite Synchrony (CSP) Algorithm



Deterministic clustering algorithm



Background and motivation Network identification methods Instantaneousness Phase Synchrony Phase Locking Value (PLV) Normed Aggregate synchrony matrix Composite synchrony profile (CSP) Deterministic clustering algorithm

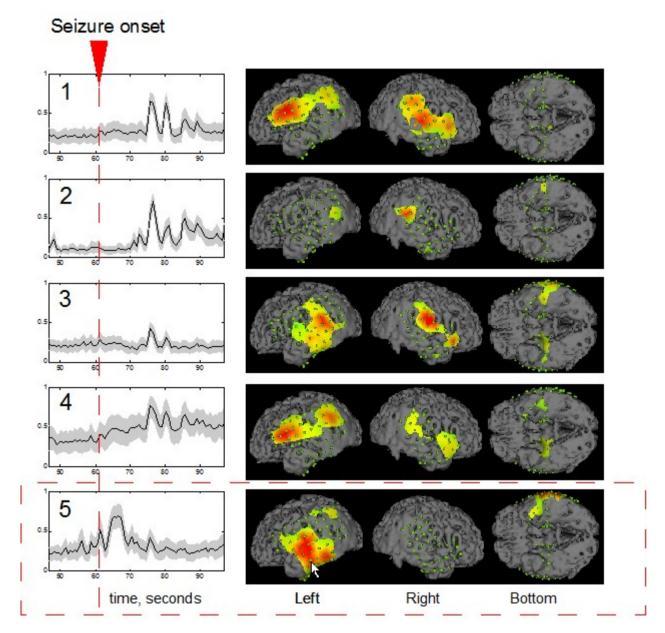
Results

Seizure

Word recognition

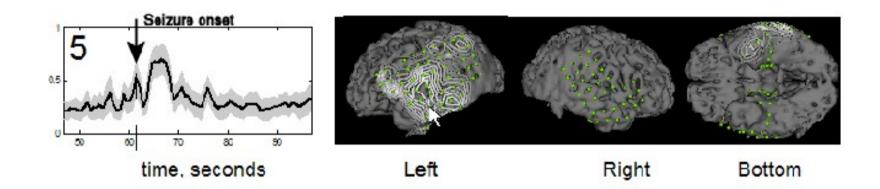
Summary and future directions

PLV/CSP – Seizure Data



Ossadtchi et al., J Clin Neurophysiol (submitted)

PLV/CSP – Seizure Data



Background and motivation Network identification methods Instantaneousness Phase Synchrony Phase Locking Value (PLV) Normed Aggregate synchrony matrix Composite synchrony profile (CSP) Deterministic clustering algorithm

Results

Seizure

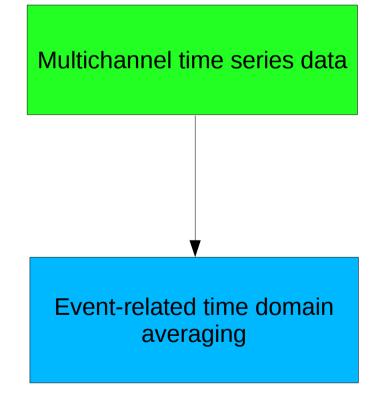
Word recognition

Summary and future directions

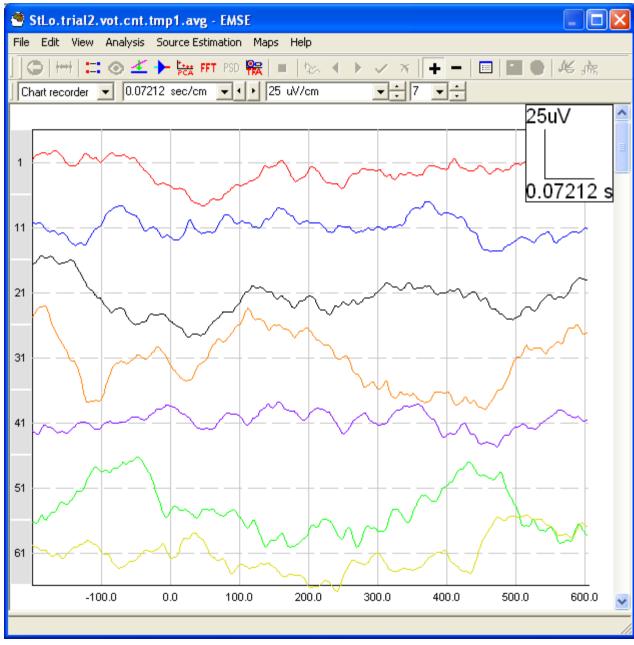
Event-related ECoG - Data

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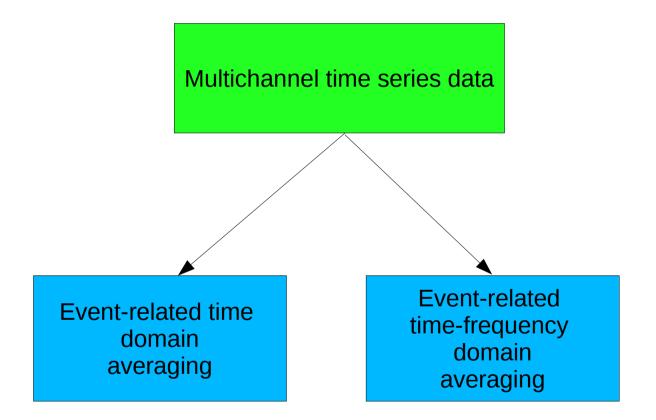
Event-related data analysis: Averaging



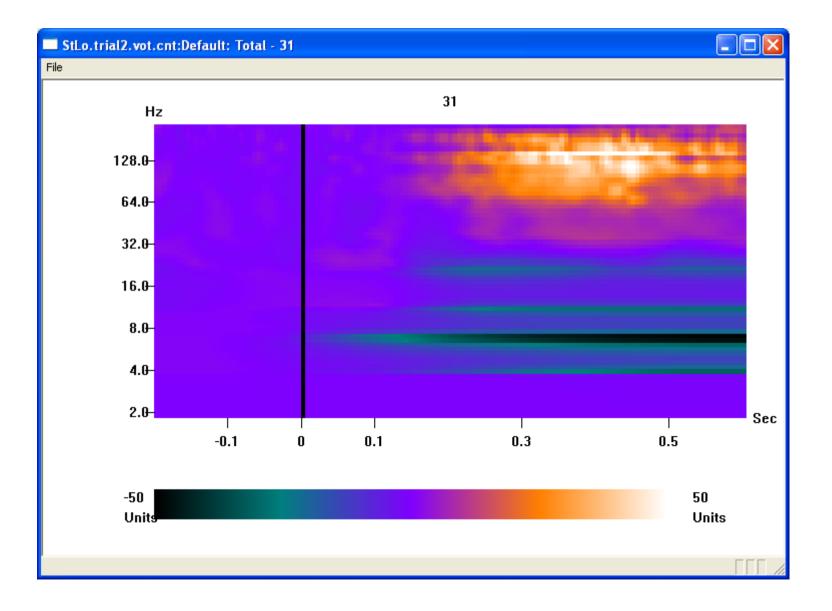
Event-related ECoG - Averaging



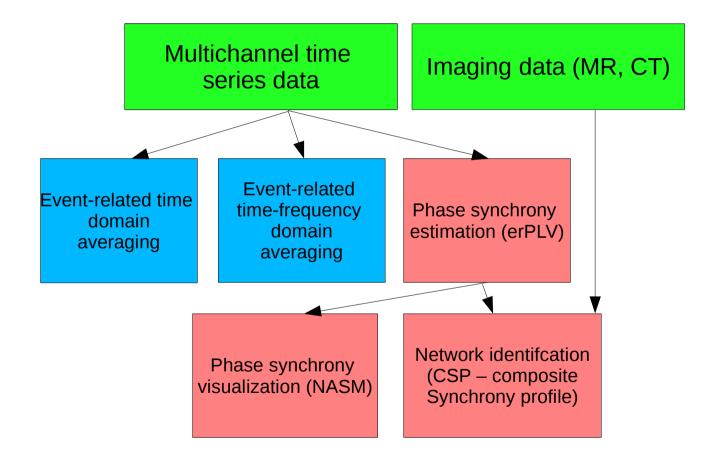
Event-related data analysis: Time-frequency Averaging



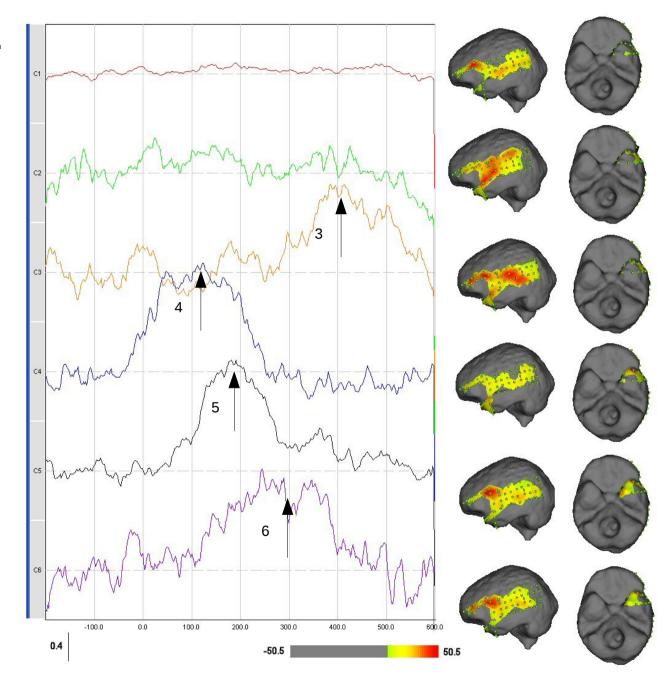
Event-related ECoG - Time-Frequency



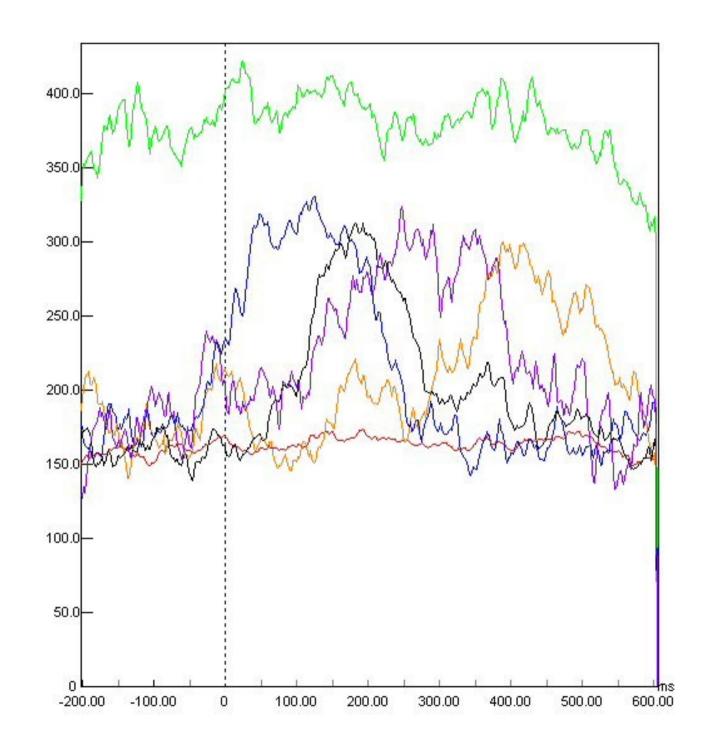
Event-related data analysis: network identification



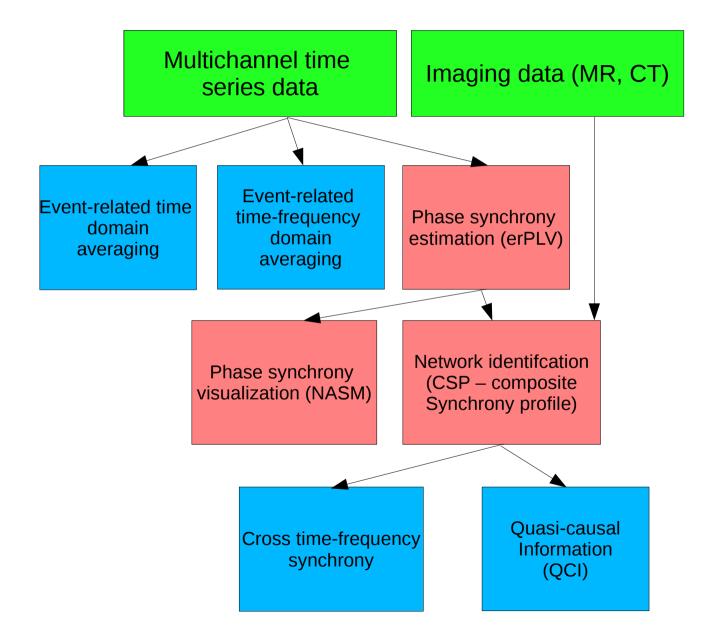
PLV/CSP **Event**related ECoG word recognition task



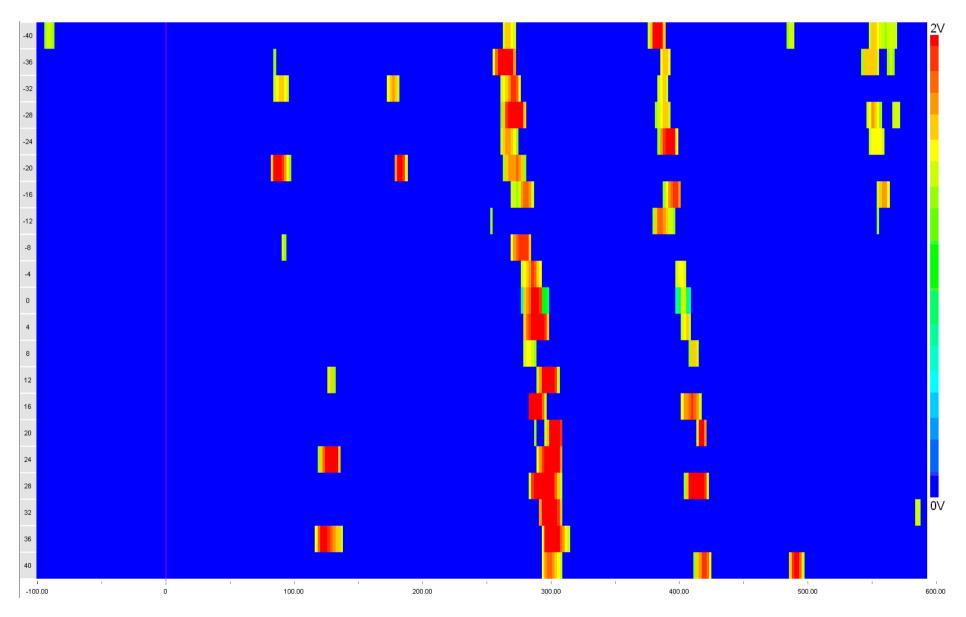
PLV/CSP Eventrelated ECoG word recognition task



Event-related data analysis: network characterization



QCI – Theta/High Gamma



Background and motivation Network identification methods Instantaneousness Phase Synchrony Phase Locking Value (PLV) Normed Aggregate synchrony matrix Composite synchrony profile (CSP) Deterministic clustering algorithm Results Seizure

Word recognition

Summary and future directions

Conclusions

We describe procedures for identifying brain networks from electrophysiological data

Normed aggregate synchrony

Composite synchrony profile

When applied to seizure data, we find clinically reasonable seizure networks, including temporal/limbic and parietal/frontal

When applied to event-related data, we find evidence for a newly observed phenomenon, the network cascade

Future directions

Basic Research

Verify and characterize network cascade Clinical Research

Networks and seizure onset

Software technology

Verification and validation

Extension

Usability

Collaborators/Acknowledgements

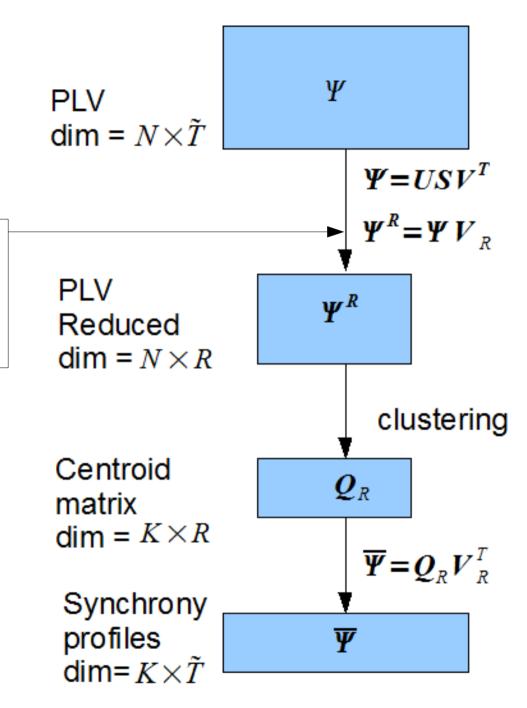
- St. Petersburg State University
- Alexei Ossadtchi University of Chicago
- Leo Towle Michael Kohrmann University of Tokyo Kyosuke Kamada

- Source Signal Imaging
 - Mark E. Pflieger
 - Li Gao
 - **David Nichols**
 - Jandro Kirkish
 - Don Lawson
 - **Demetrios Voreades**
 - Janet Henrickson

Support - NIH – NINDS, Source Signal Imaging

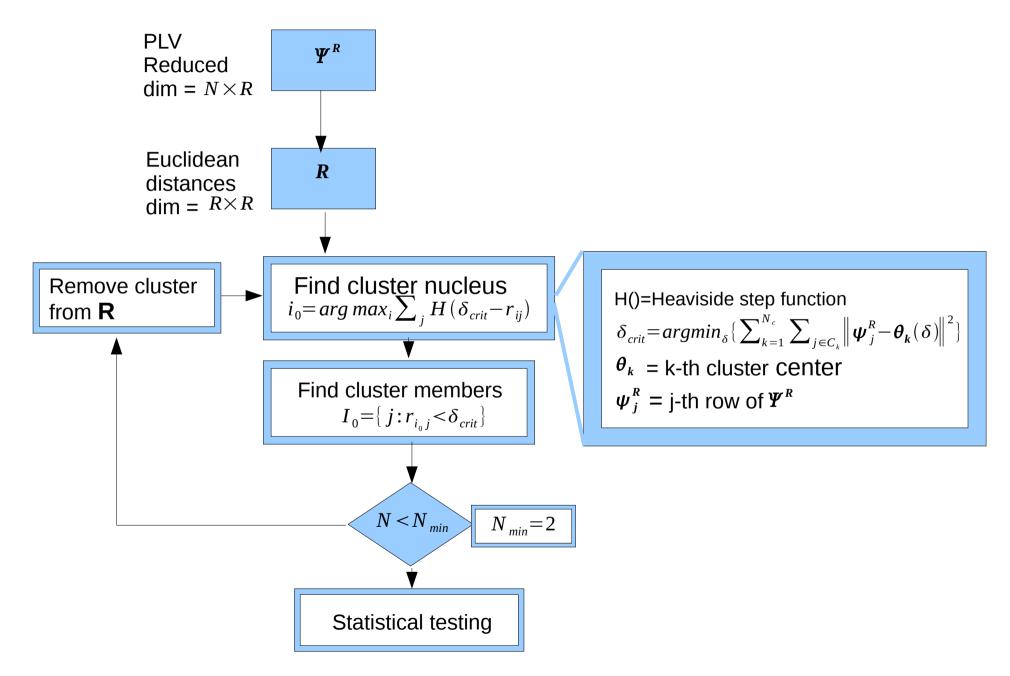
Thank you for your attention

Subspace clustering

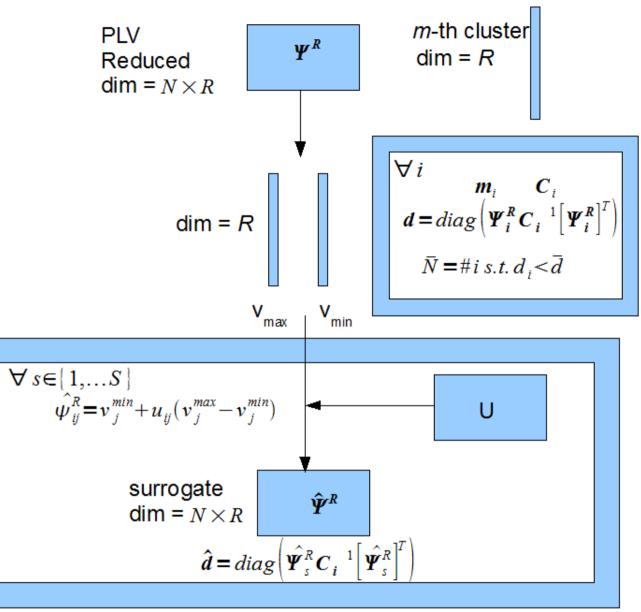


Subspace dimension R is determined by comparing the singular value spectrum S with the spectrum of a random matrix with the same Frobenius norm as Ψ

Deterministic clustering algorithm



Cluster significance testing



$$p = \frac{1}{S} \sum_{s=1}^{S} I(\bar{N}_{s} > \bar{N})$$