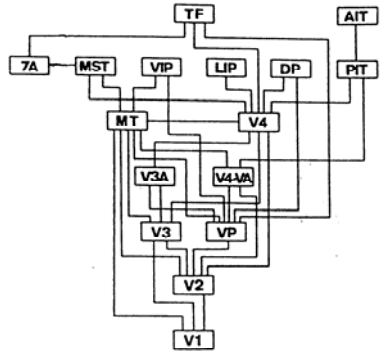
In Search of the Brain's Independent Components

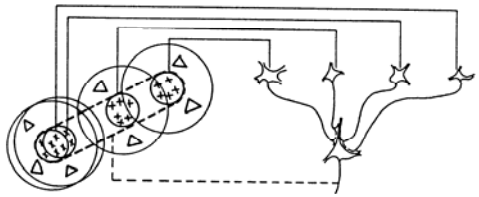
Terrence Sejnowski

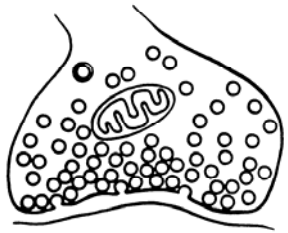
HHMI
Salk Institute
University of California, San Diego

Levels of Investigation

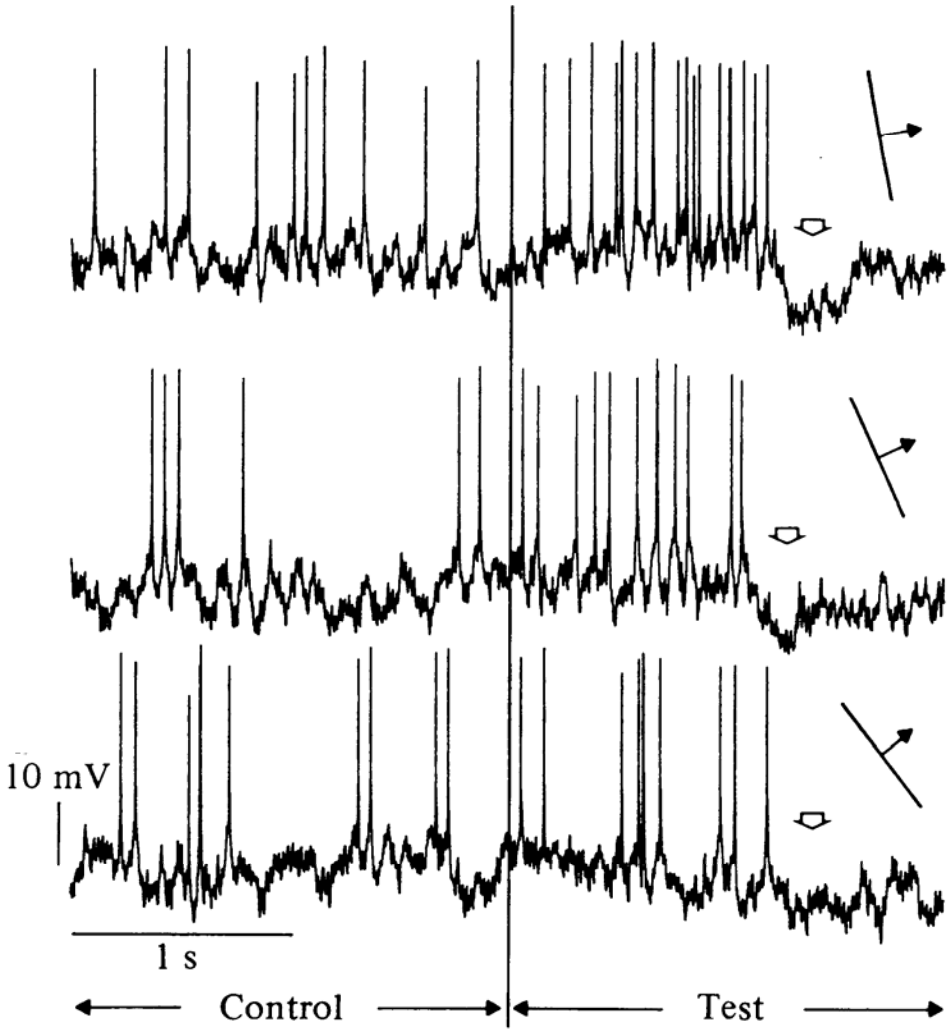
1 m	CNS
10 cm	Systems
1 cm	Maps
1 mm	Networks
100 μm	Neurons
1 μm	Synapses
1 Å	Molecules





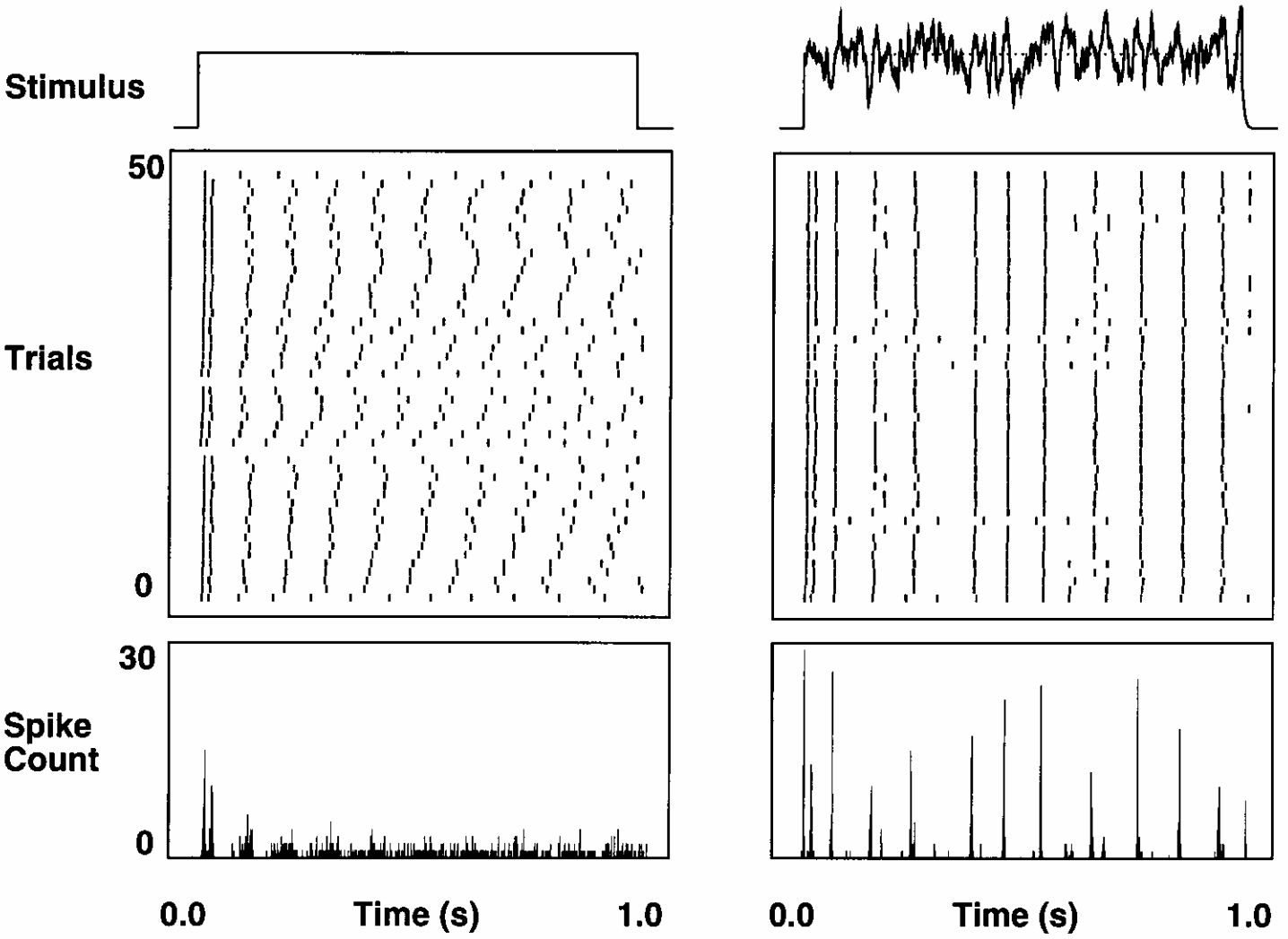


Intracellular Recordings in Visual Cortex



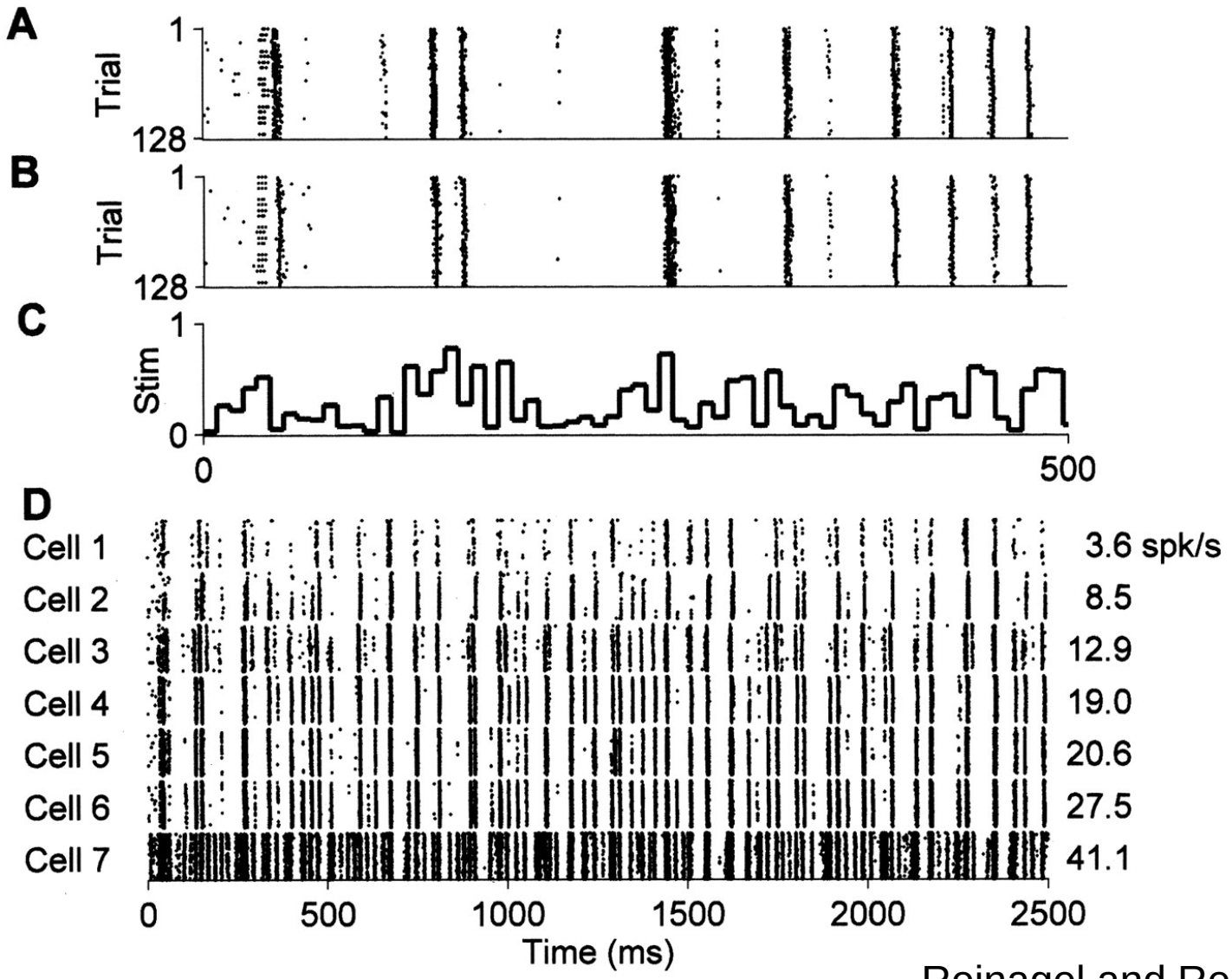
Kevan Martin

Reliability of Spike Timing



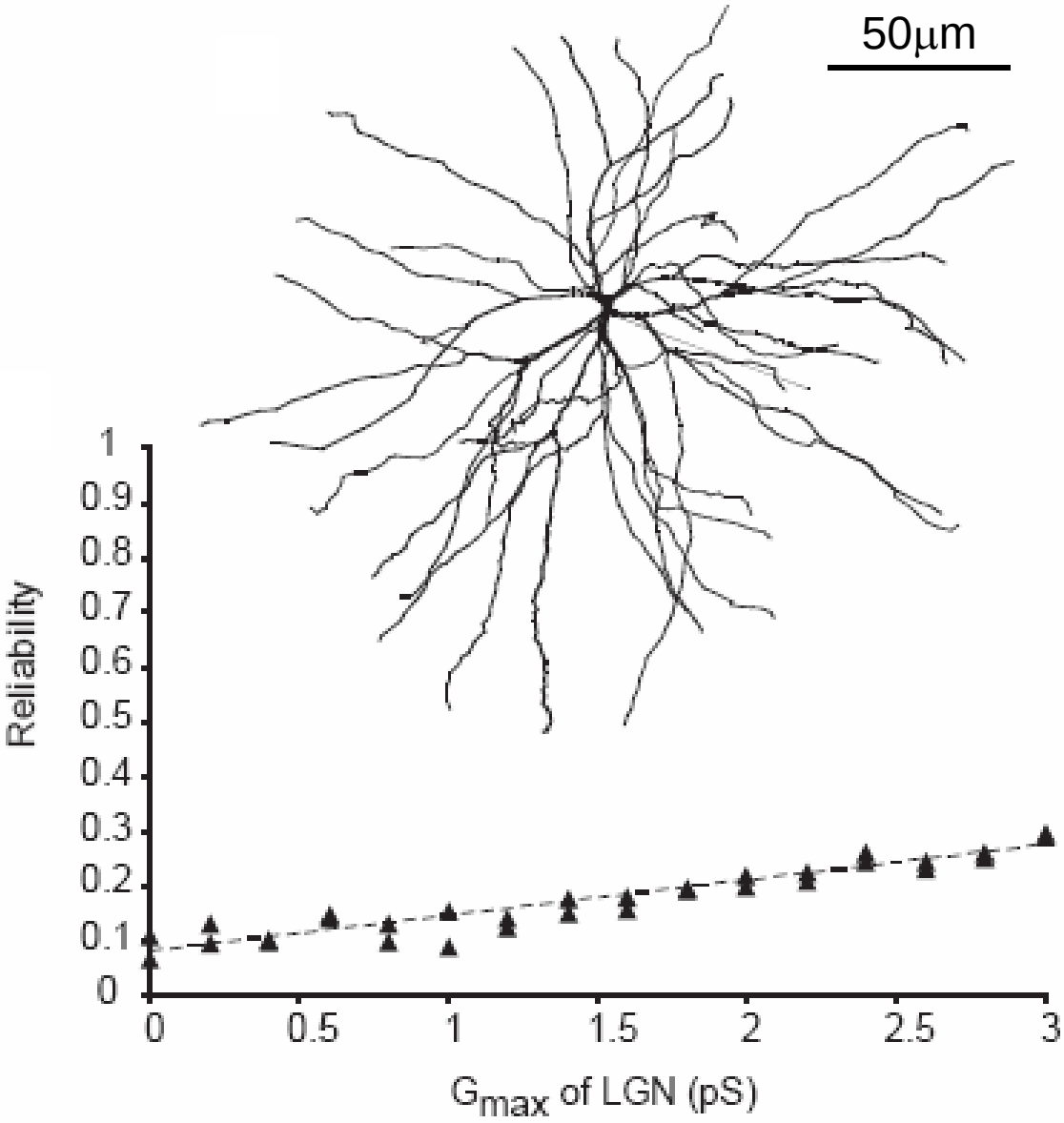
Mainen and Sejnowski, 1995

Spike Time Synchrony in the Cat Thalamus

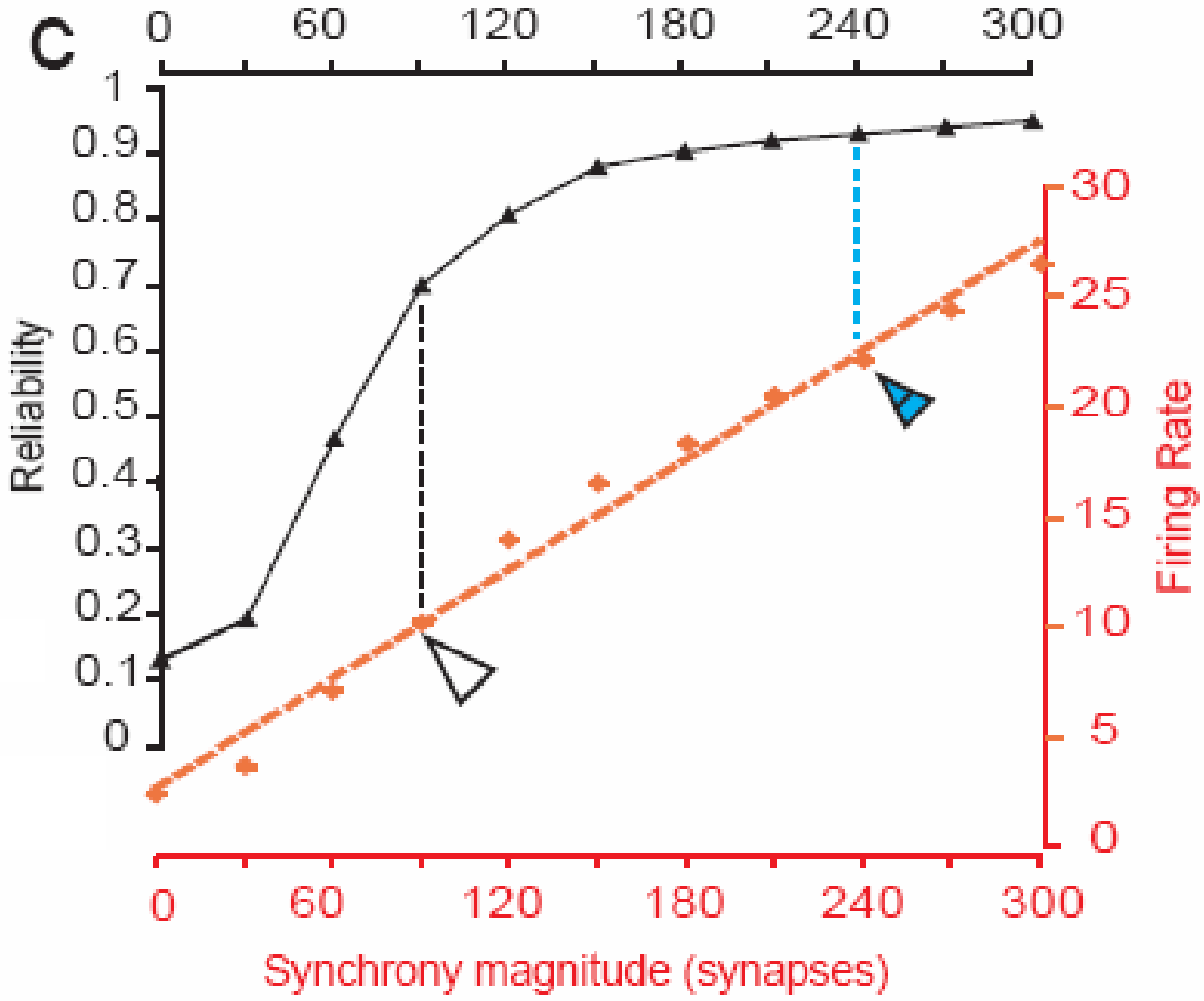


Reinagel and Reid, 2000

Cortical Layer 4 Spiny Stellate Cell

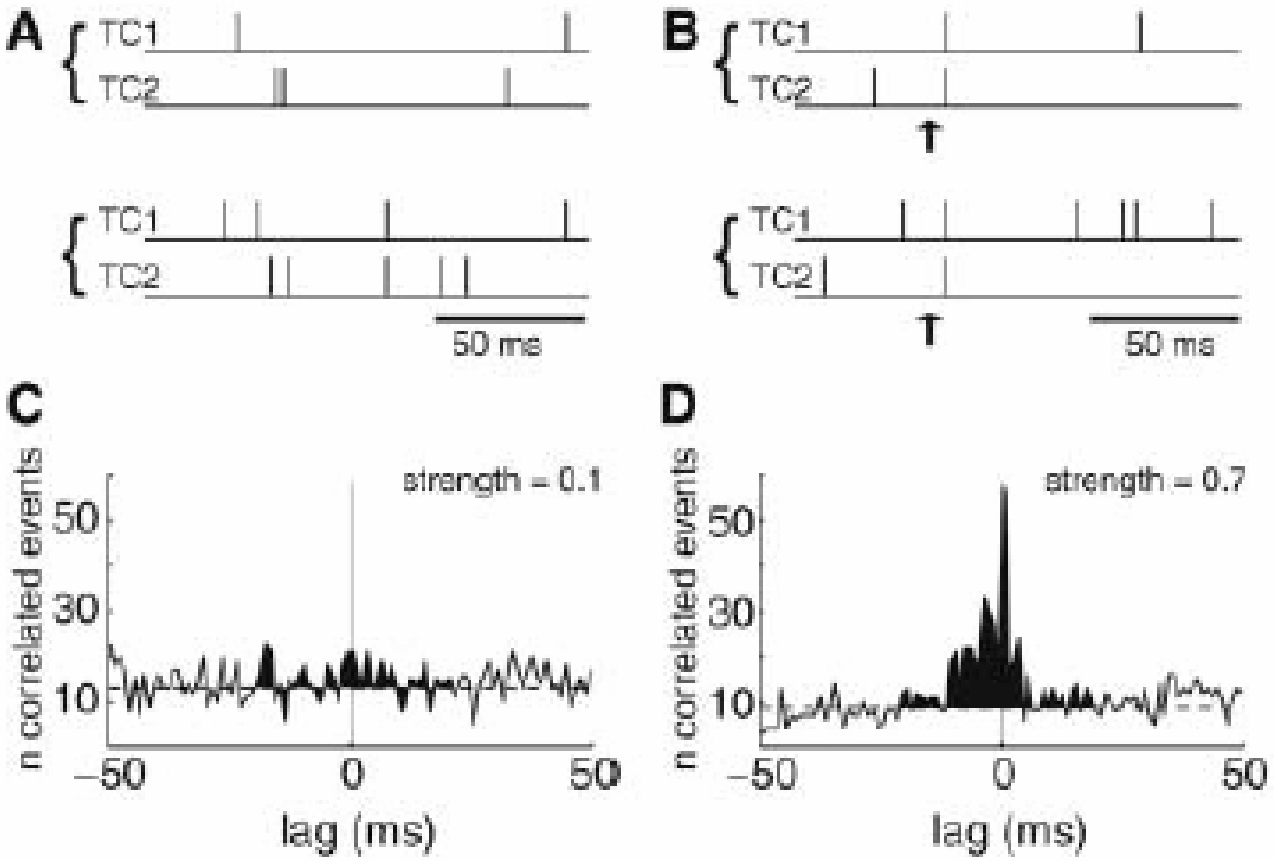


Supralinear Reliability by Synchrony



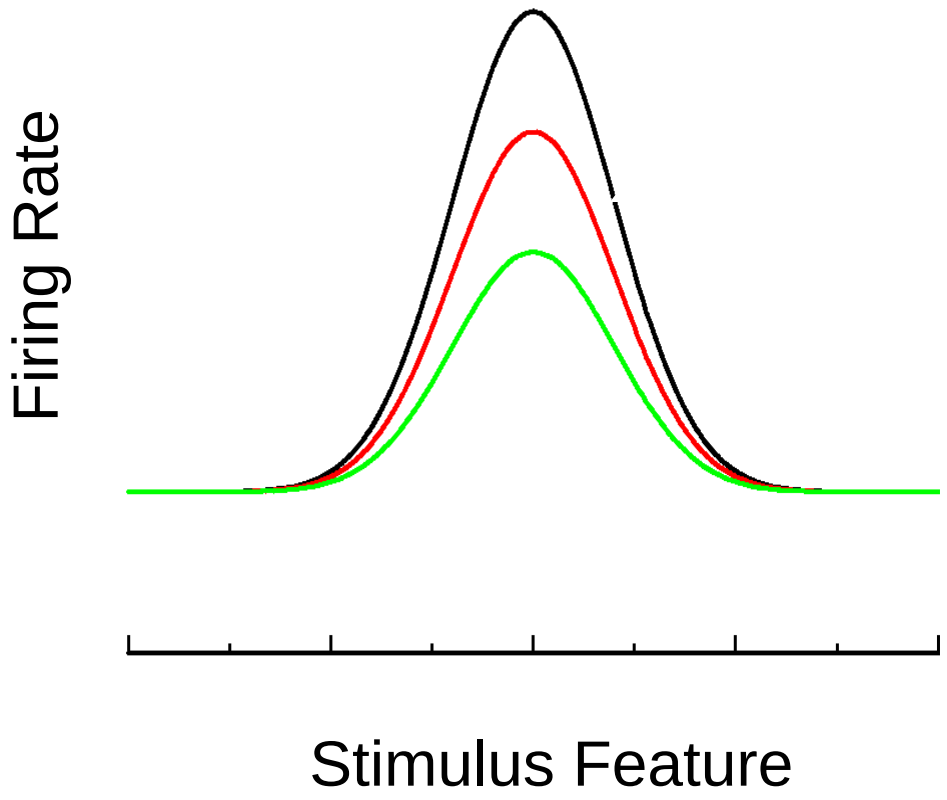
Wang, Fellous and Spencer, 2006

Correlation Strength in Barrel Cortex



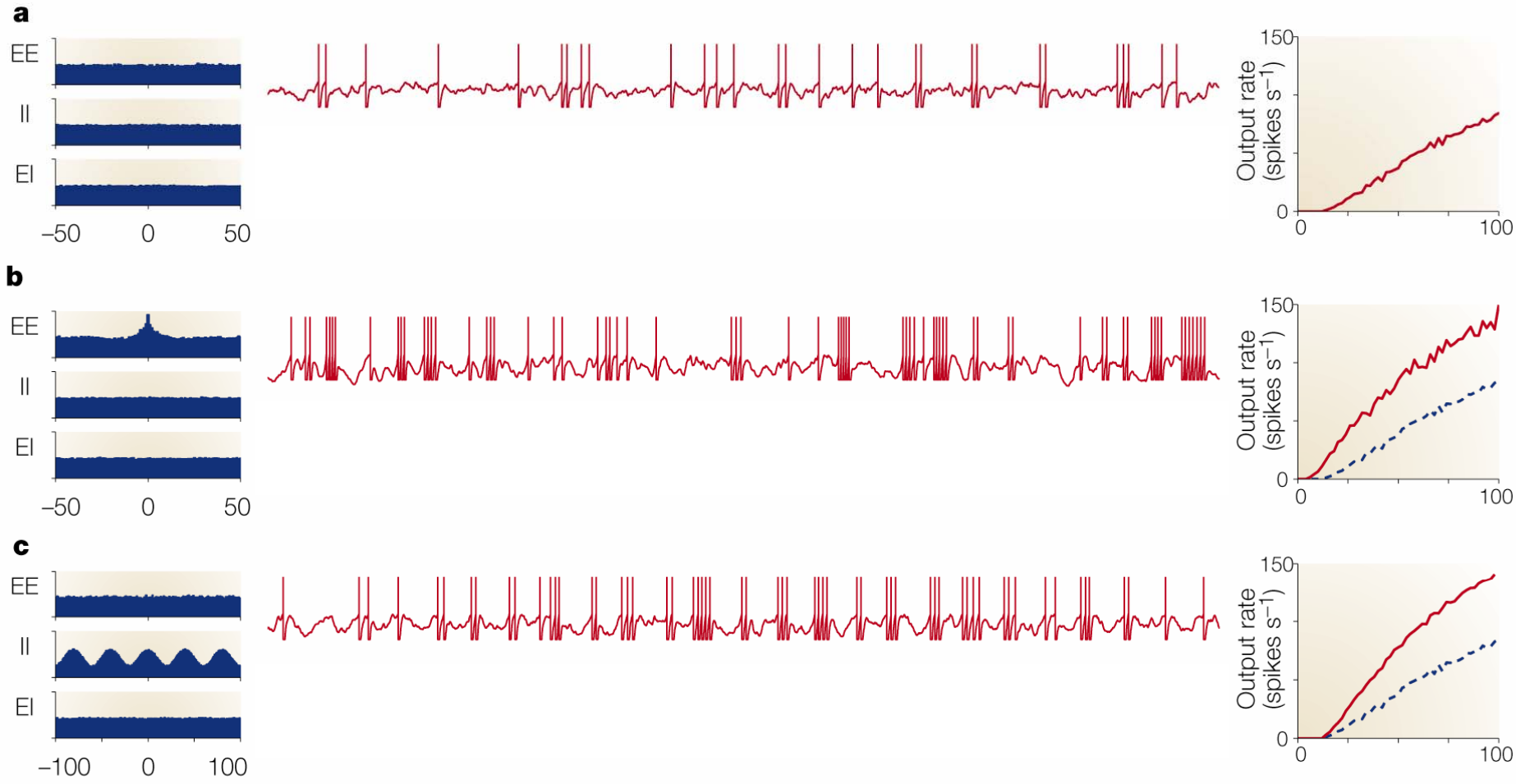
Bruno and Sakmann, 2006

Attentional Gain Modulation



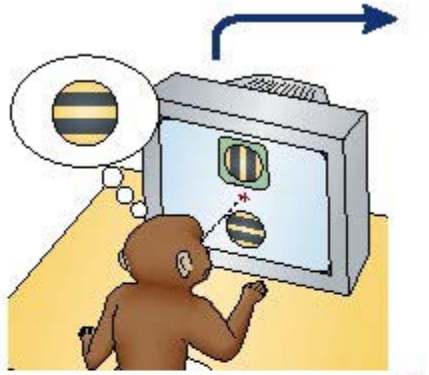
Firing Rate = Feature x Gain

Impact of Correlated Spike Trains

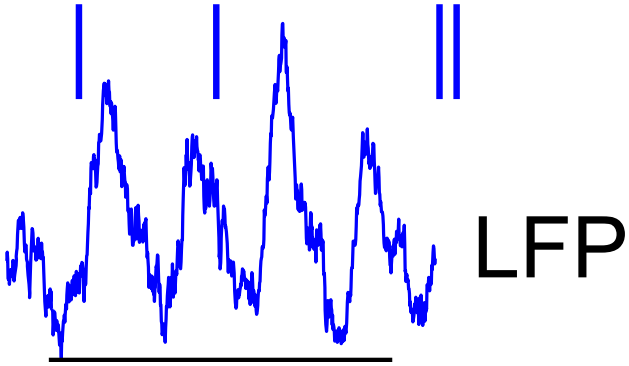


Salinas and Sejnowski, 2001

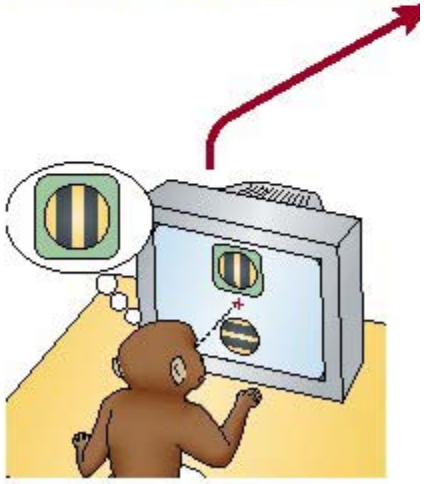
Attention Increases Spike-time Coherence of Gamma Oscillations



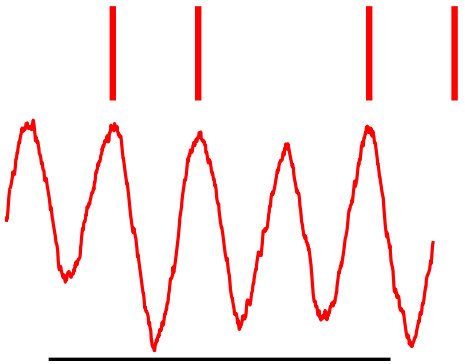
"Not attended"



LFP



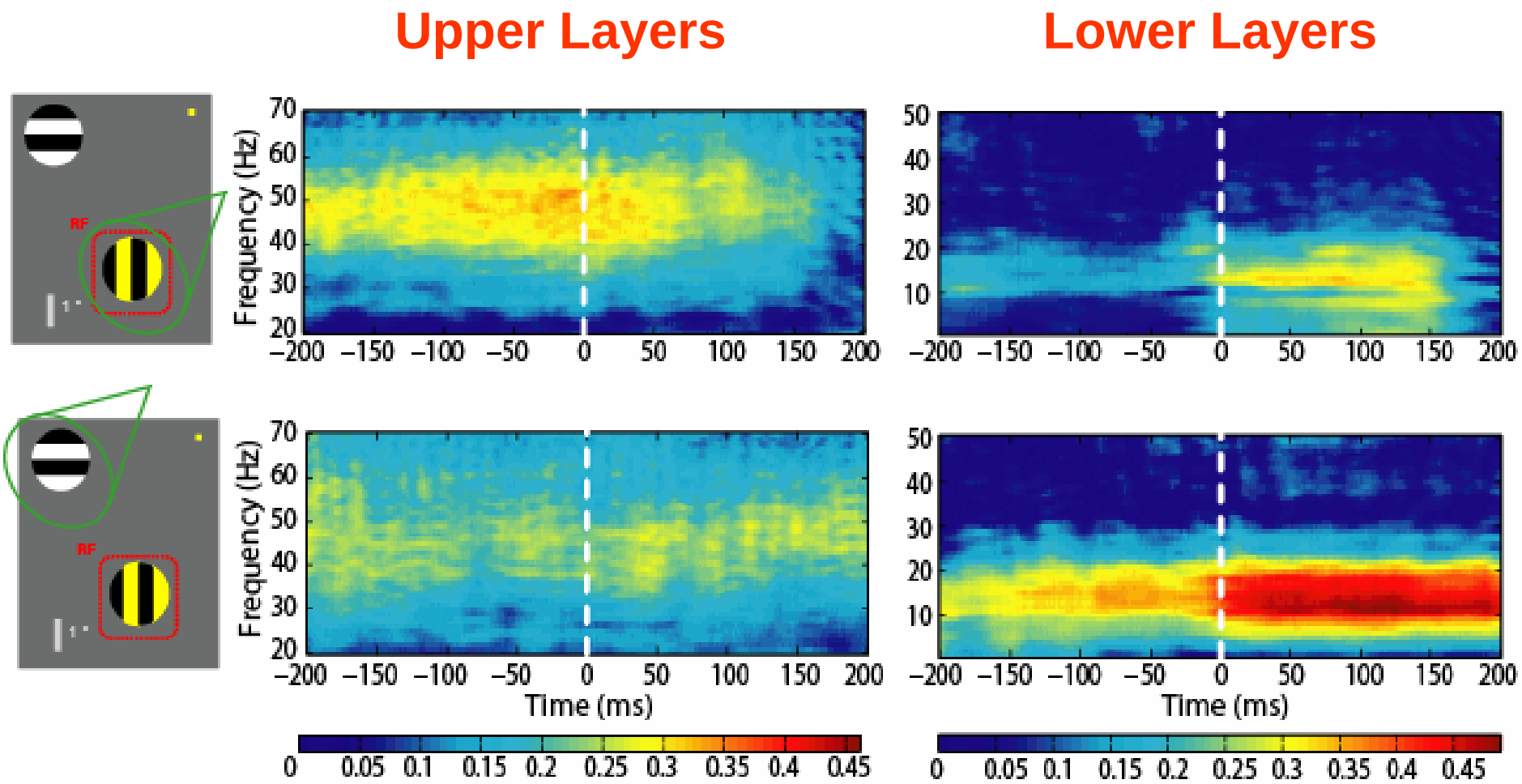
"Attended"



100 ms

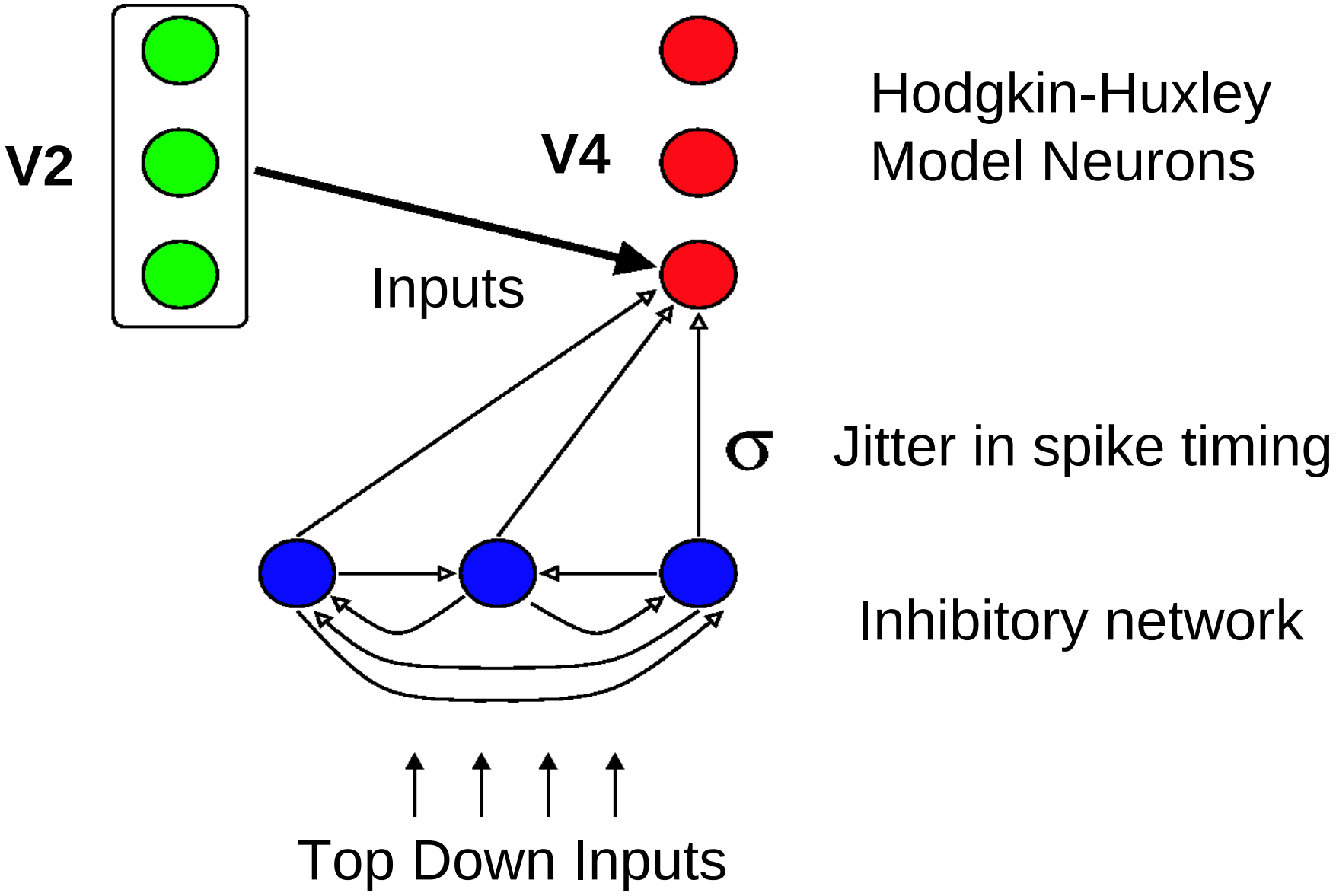
Fries, Reynolds, Rori and Desimone, 2001

Attentional Modulation of Spike-Field Coherence



Buffalo and Desimone, 2004

Network Model of Attention

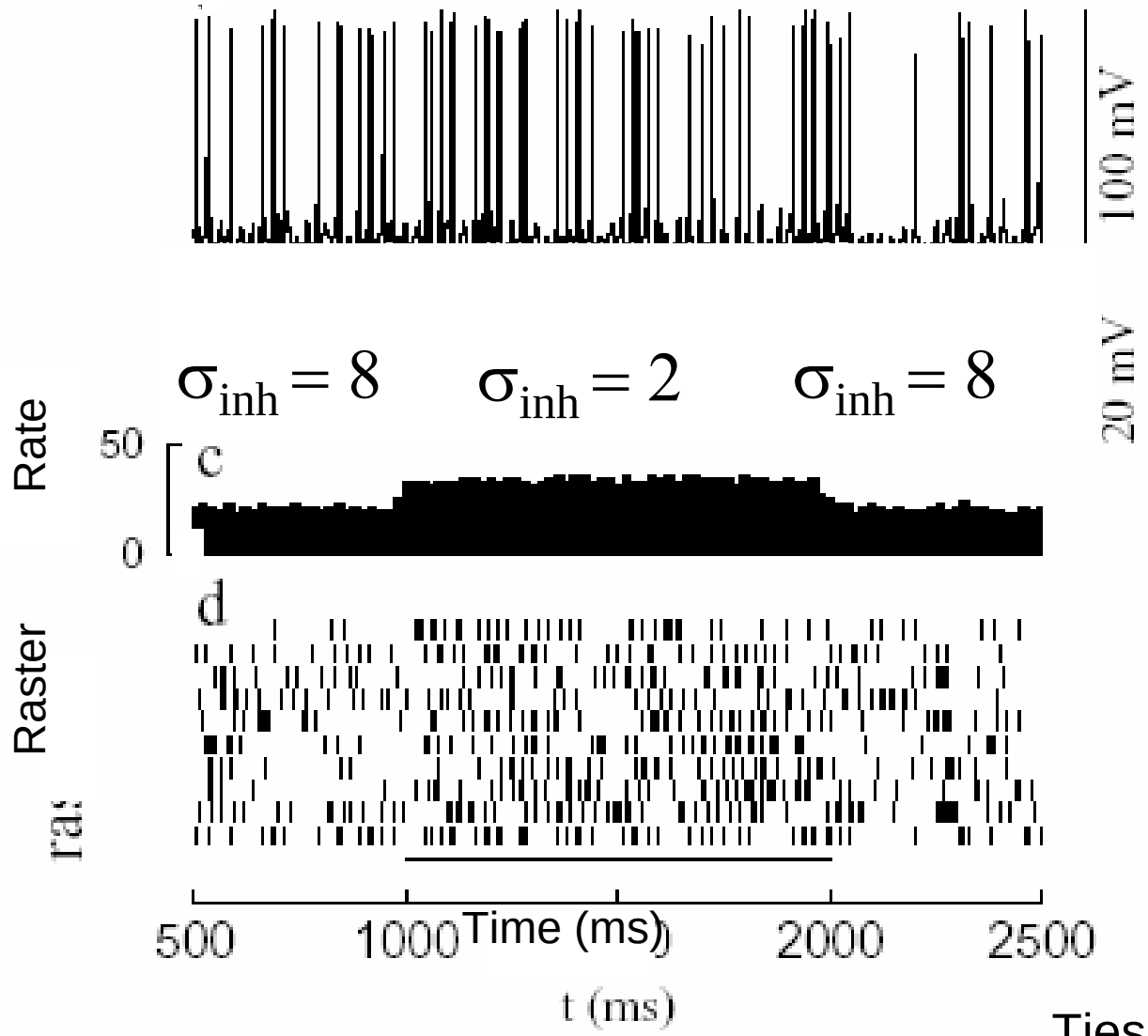


Hodgkin-Huxley
Model Neurons

Jitter in spike timing

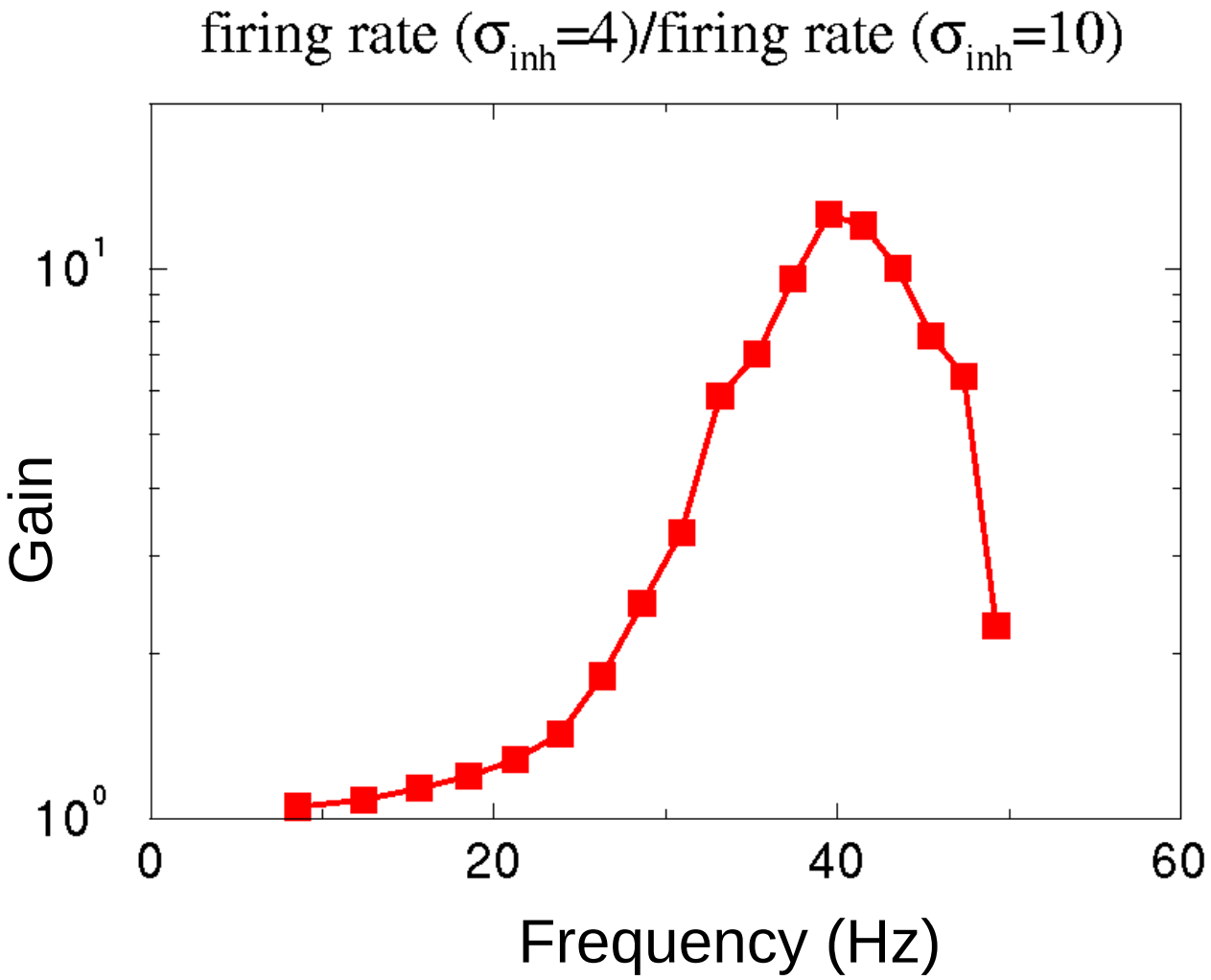
Inhibitory network

Inhibitory Synchrony Modulates Firing Rates of Pyramidal Neurons



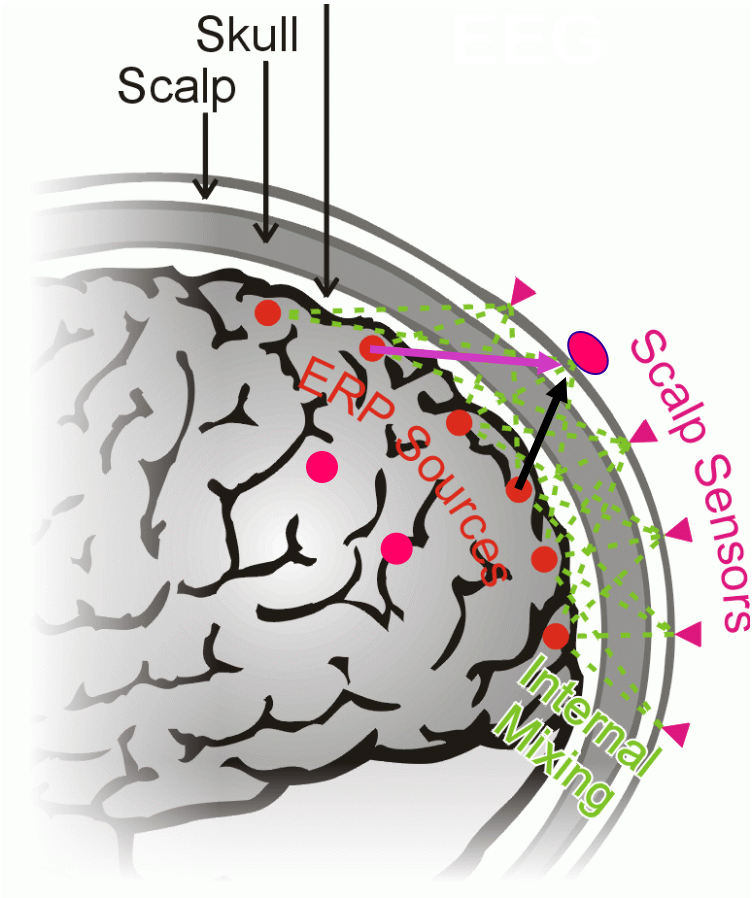
Tiesinga et al., 2004

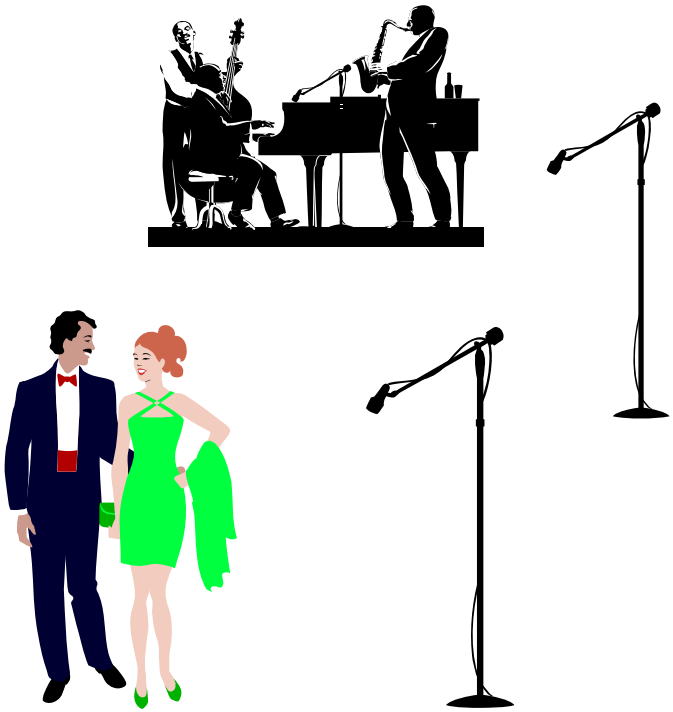
Optimal Gain at Gamma Frequencies



SYNCHRONY REGULATES FLOW OF INFORMATION

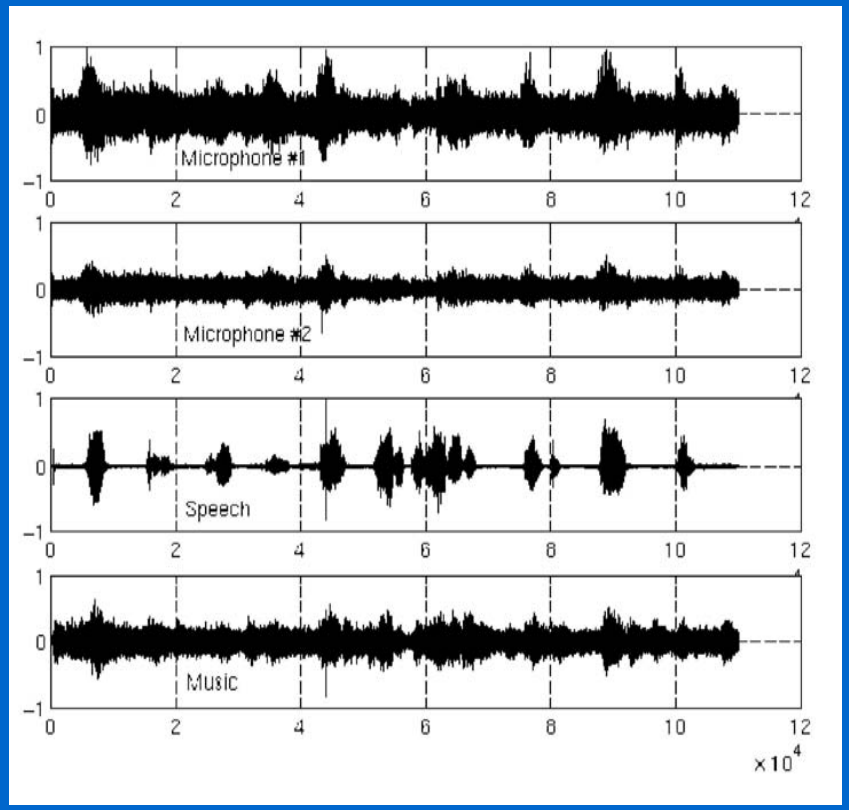
EEG Source Mixing Problem





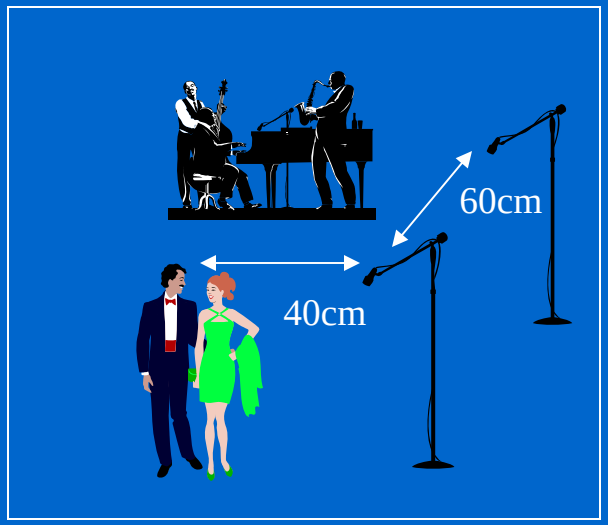
Blind Source Separation

Separation of Music & Speech

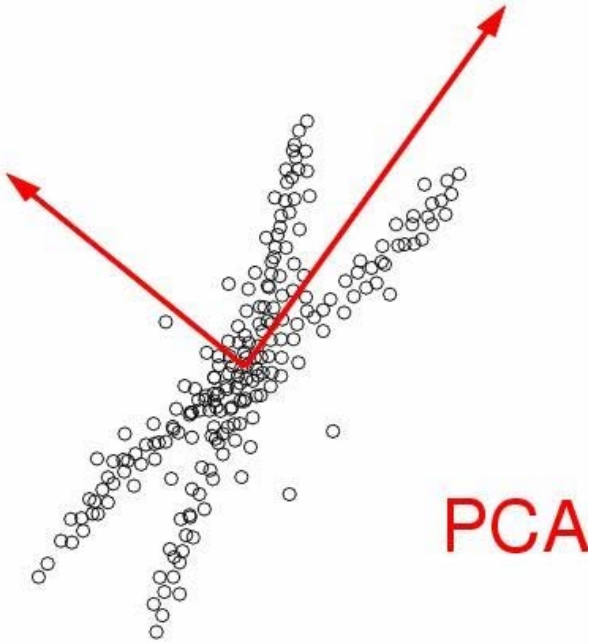


Experiment-Setup:

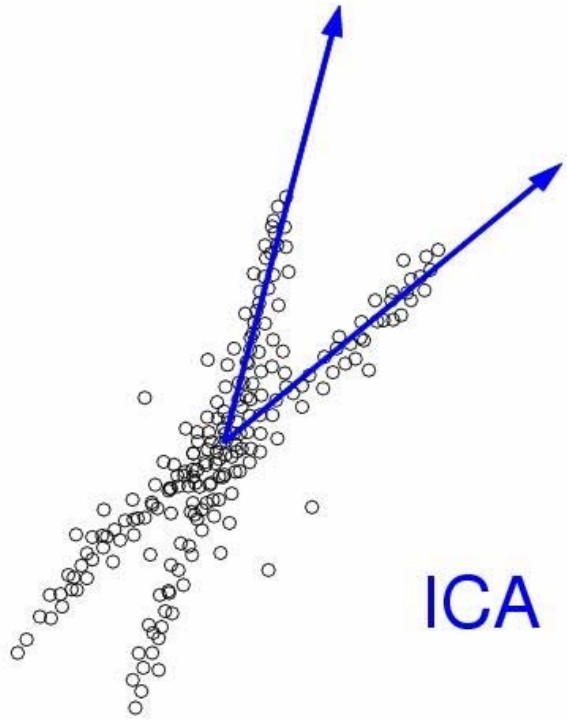
- *office room (5m x 4m)*
- *two distant talking mics*
- *16kHz sampling rate*



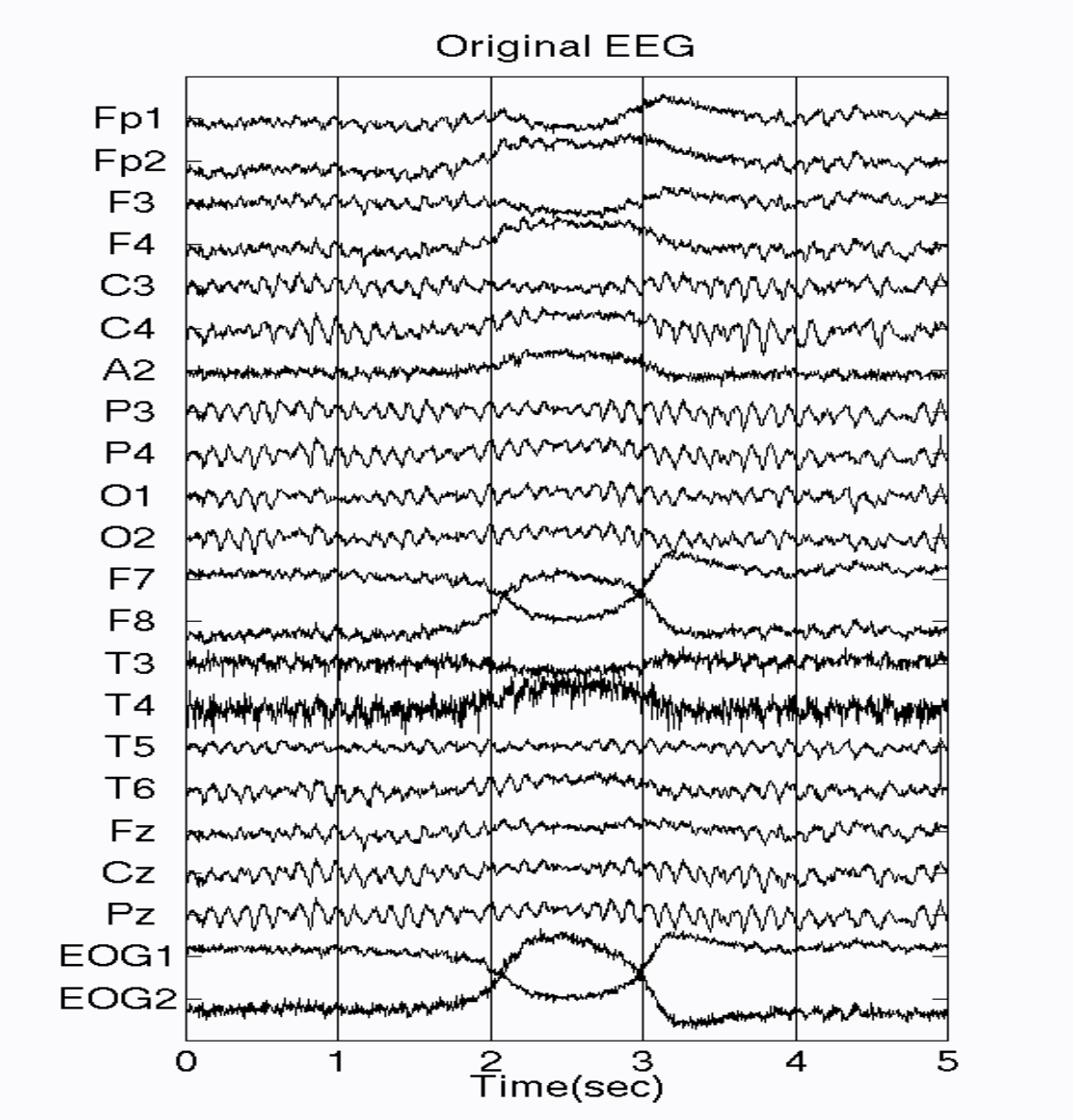
PCA finds the directions of maximum variance

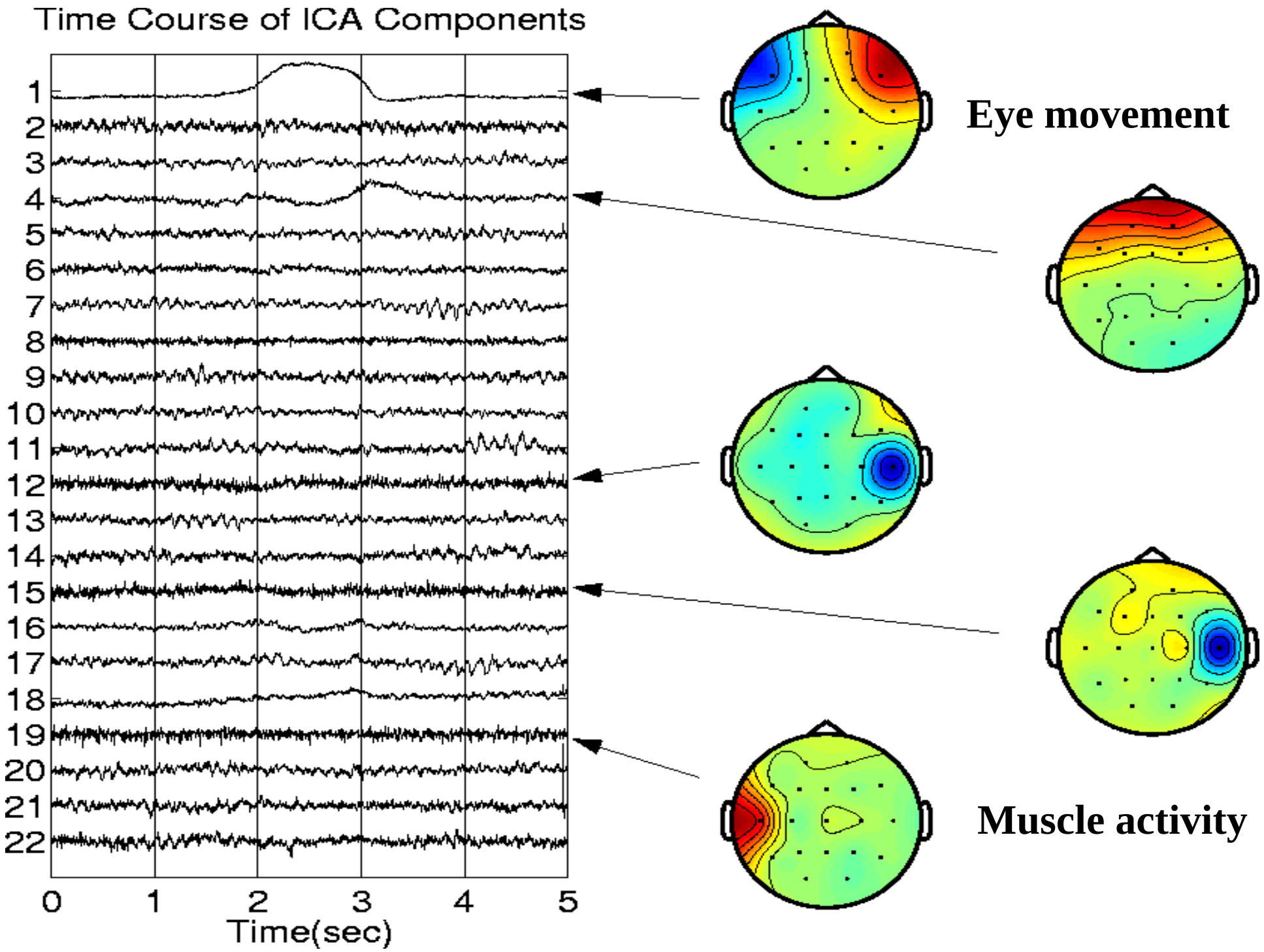


ICA finds the directions of maximum independence

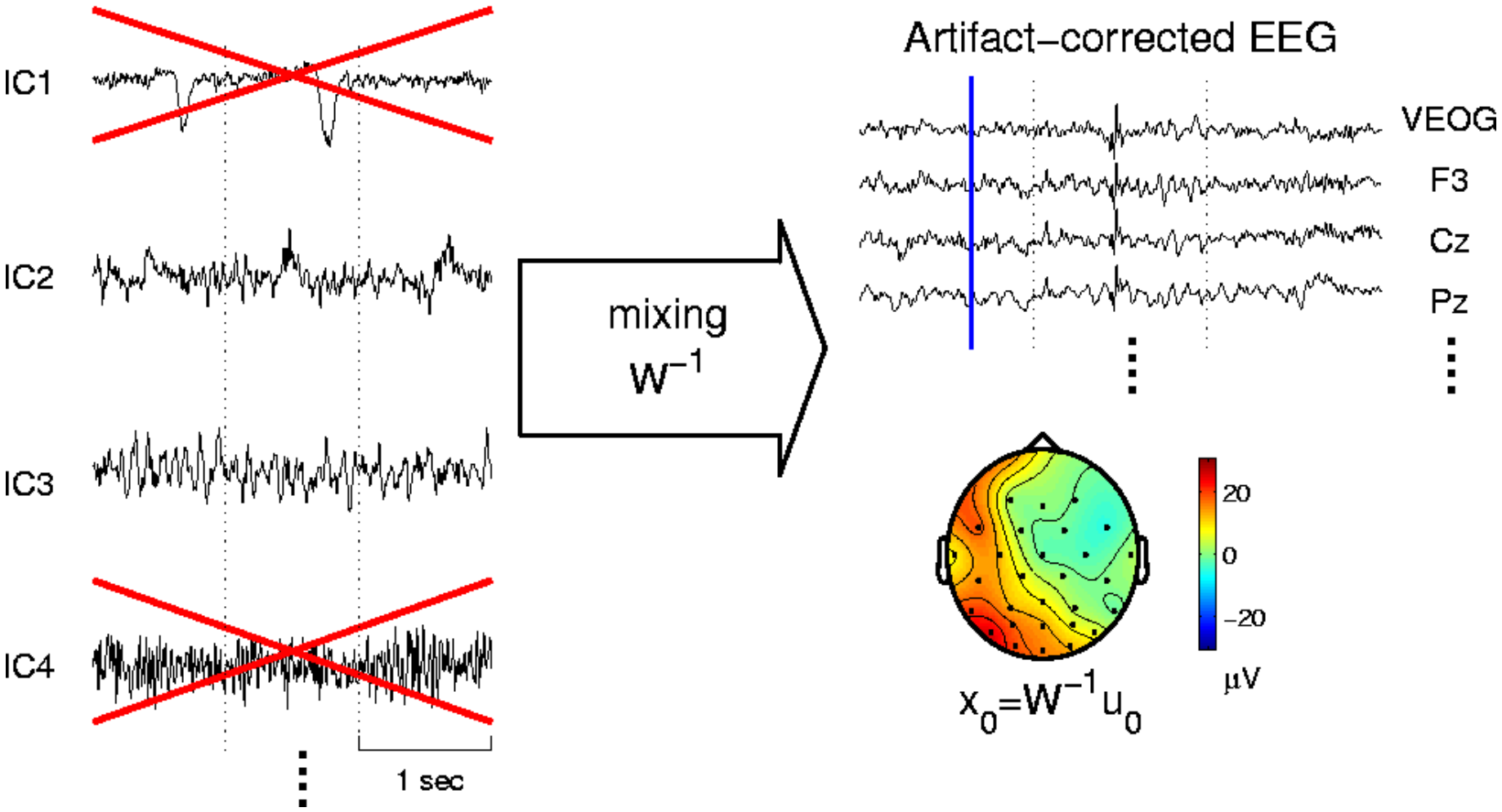


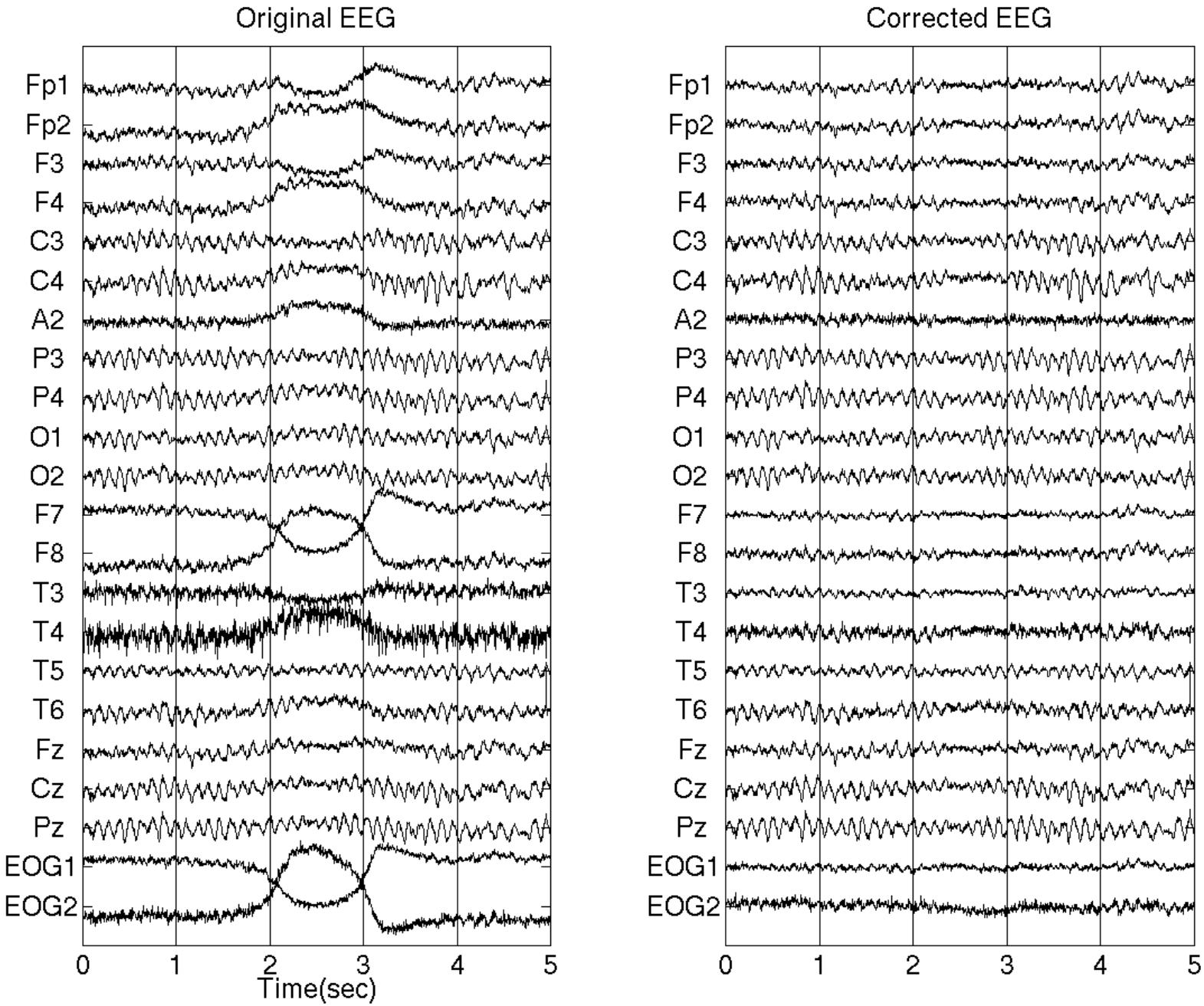
ICA Applied to EEG Data

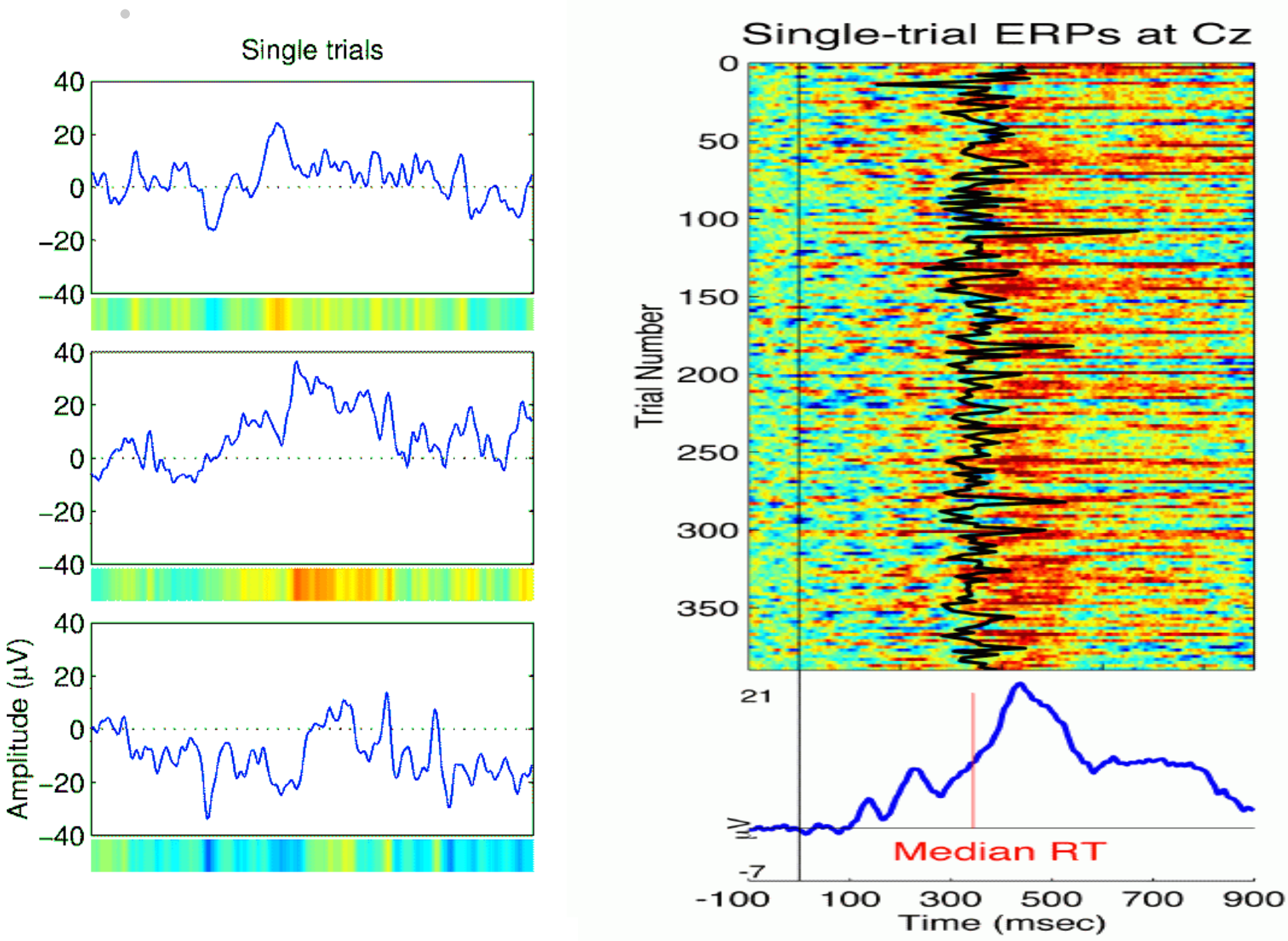


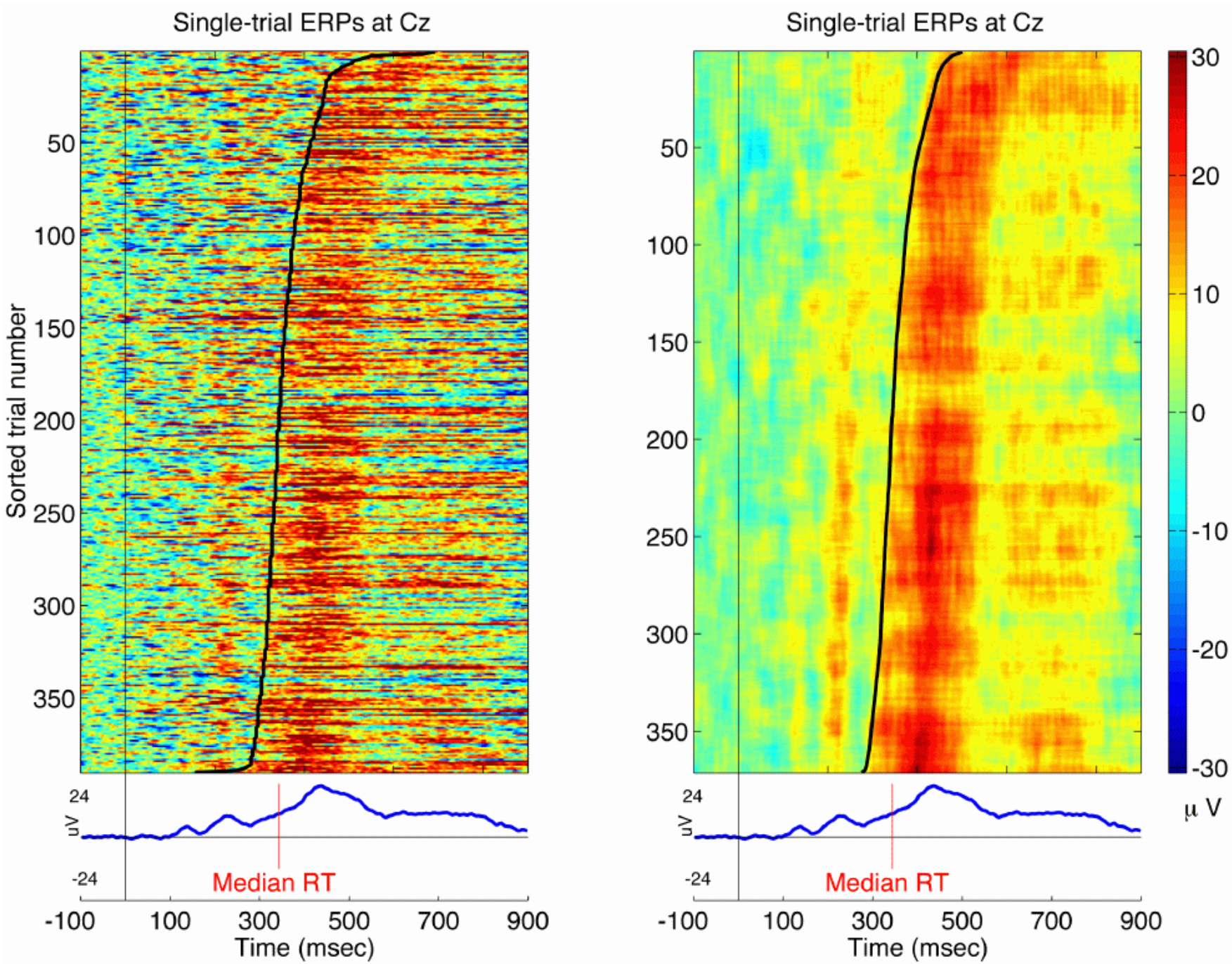

Time Course of ICA Components
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
0
1
2
3
4
5
Time(sec)
Eye movement
Muscle activity

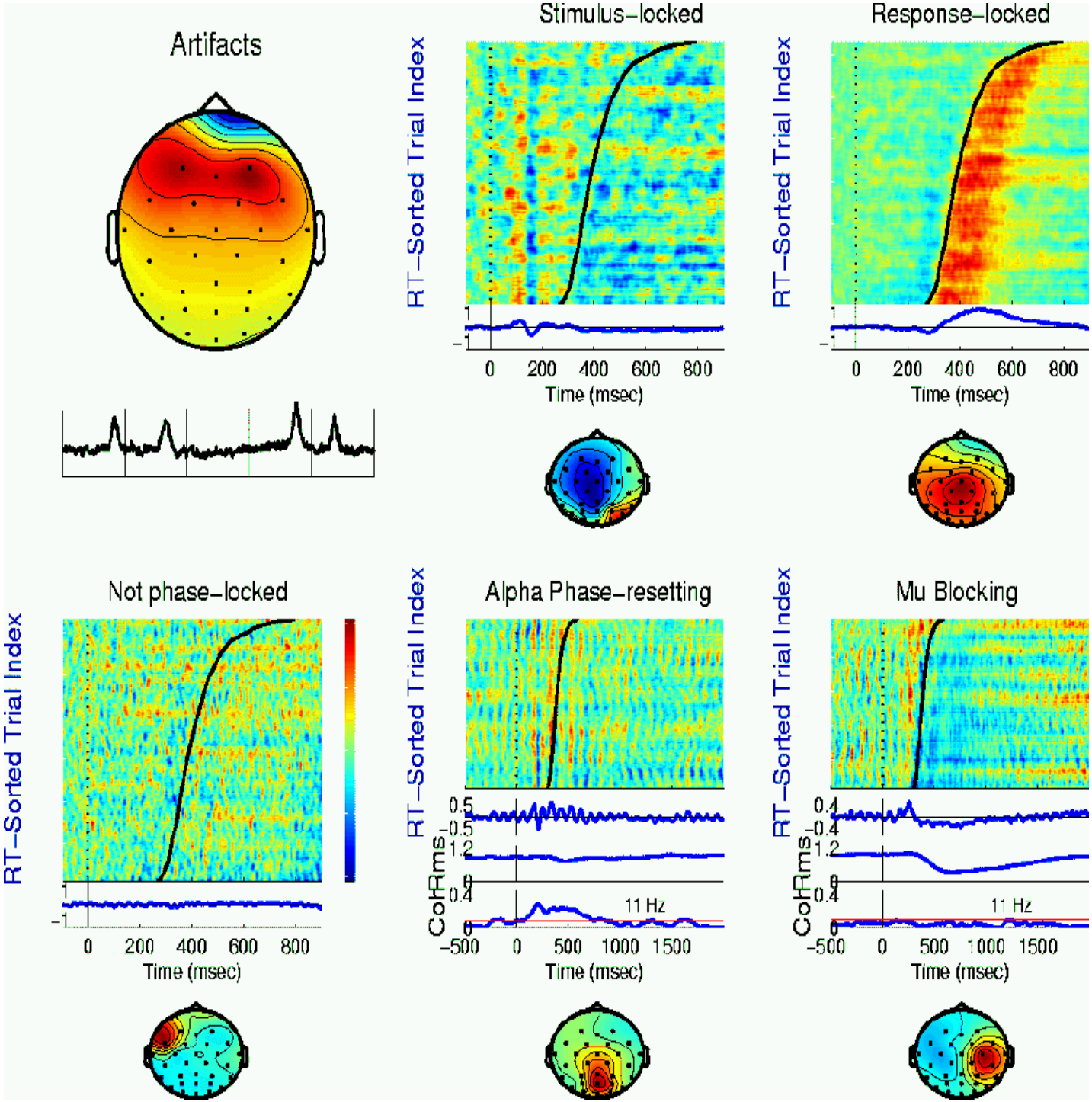
EEG Artifact Rejection



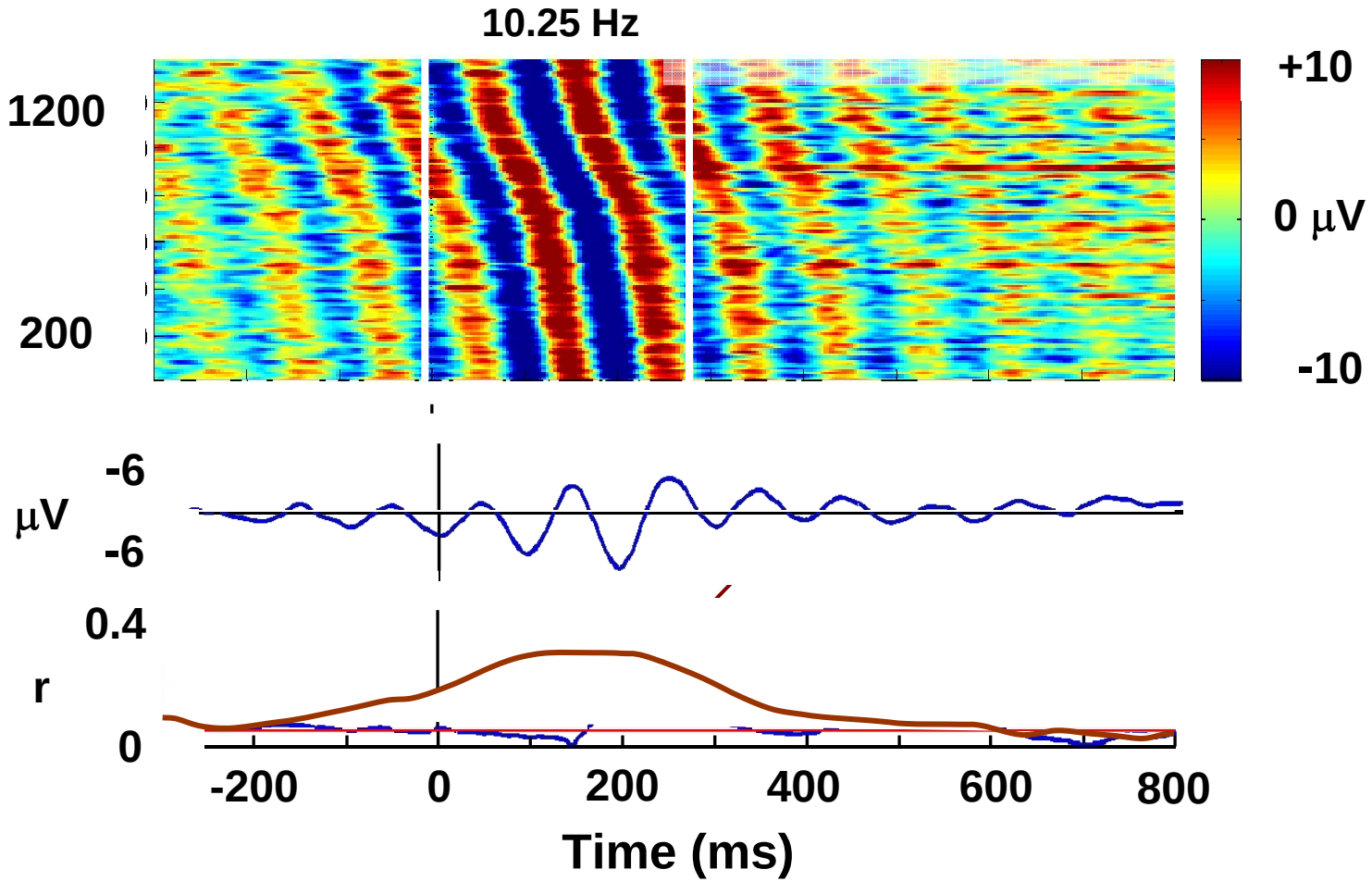

Original EEG
Corrected EEG
Fp1
Fp2
F3
F4
C3
C4
A2
P3
P4
O1
O2
F7
F8
T3
T4
T5
T6
Fz
Cz
Pz
EOG1
EOG2
0
1
2
3
4
5
Time(sec)


Single trials
40
20
0
−20
−40
Amplitude (μV)
Single-trial ERPs at Cz
Trial Number
0
50
100
150
200
250
300
350
21
μV
-7
Median RT
-100
100
300
500
700
900
Time (msec)

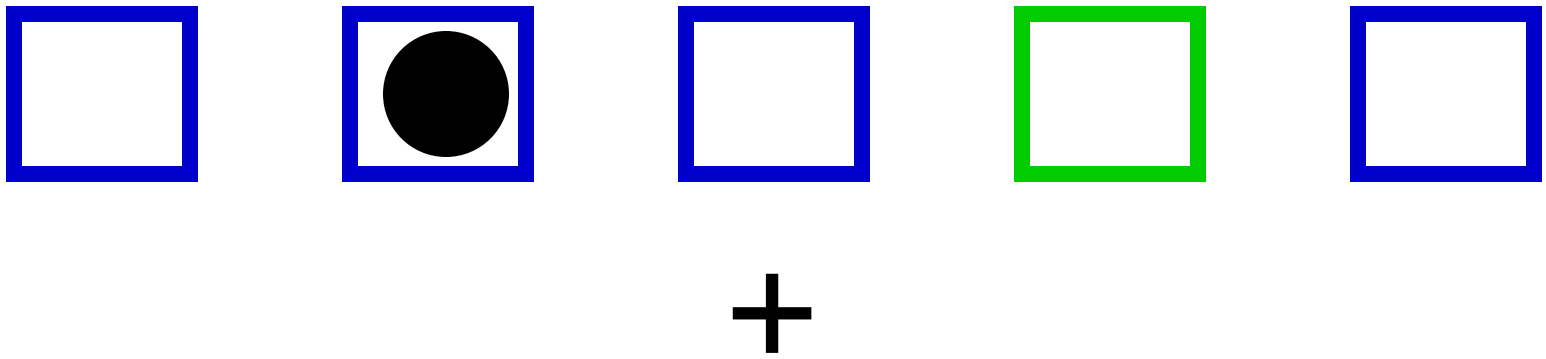

Single-trial ERPs at Cz
Sorted trial number
50
100
150
200
250
300
350
24
uV
-24
Median RT
-100
100
300
500
700
900
Time (msec)
Single-trial ERPs at Cz
30
20
10
0
-10
-20
-30
μ V


Artifacts
Stimulus−locked
Response−locked
RT−Sorted Trial Index
0 200 400 600 800
Time (msec)
Not phase−locked
Alpha Phase−resetting
Mu Blocking
ColRms
11 Hz
−500 0 500 1000 1500

Alpha Phase Reseting



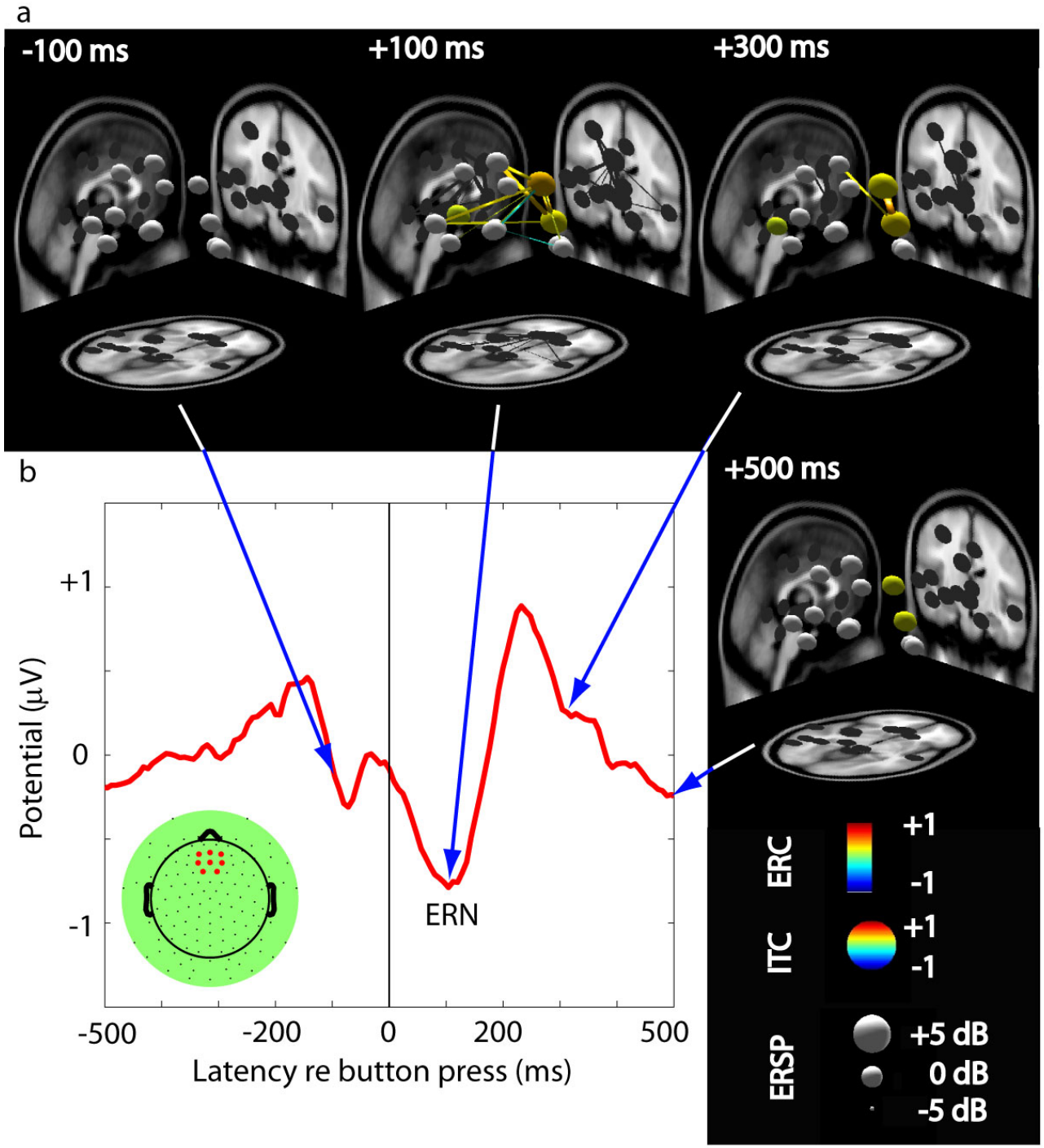
Experiment



Task: Fixate **cross** while covertly attending to **green box**. Press button when **circle** is flashed in green box.

Session: 30 76-s task blocks, including 120 **targets** and 480 nontargets in each of the 5 locations.

Subject: 28 normal control, 14 autistic and 8 cerebellar lesion subjects.


a
-100 ms
+100 ms
+300 ms
+500 ms
b
+1
0
-1
Potential (μV)
ERN
-500
-200
0
200
500
Latency re button press (ms)
ERC
+1
-1
ITC
+1
-1
ERSP
+5 dB
0 dB
-5 dB

Emilio Salinas
Jean-Marc Fellous
Paul Tiesinga
Don Spencer
Ping Wang
Tzyy-Ping Jung
Scott Makeig