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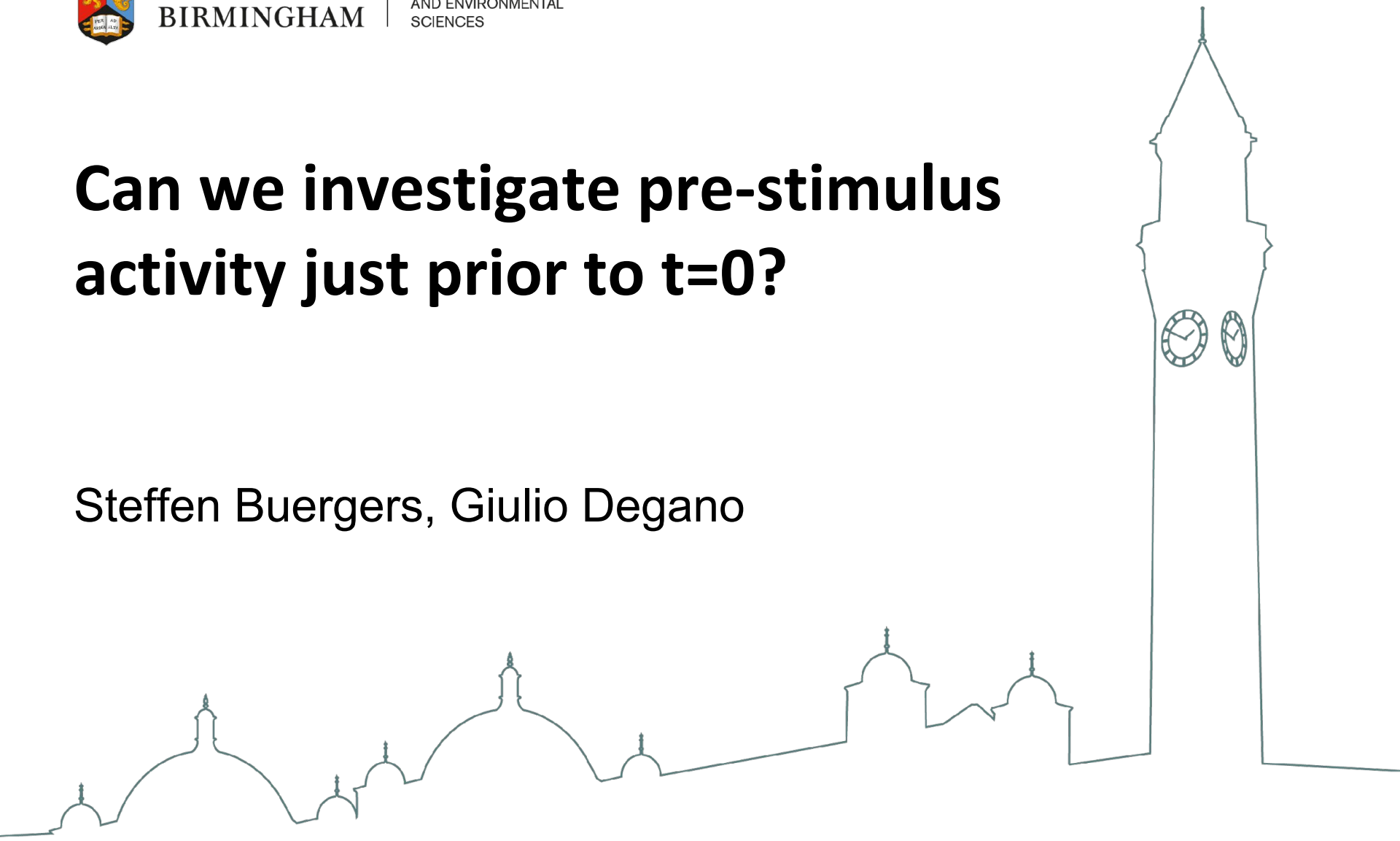
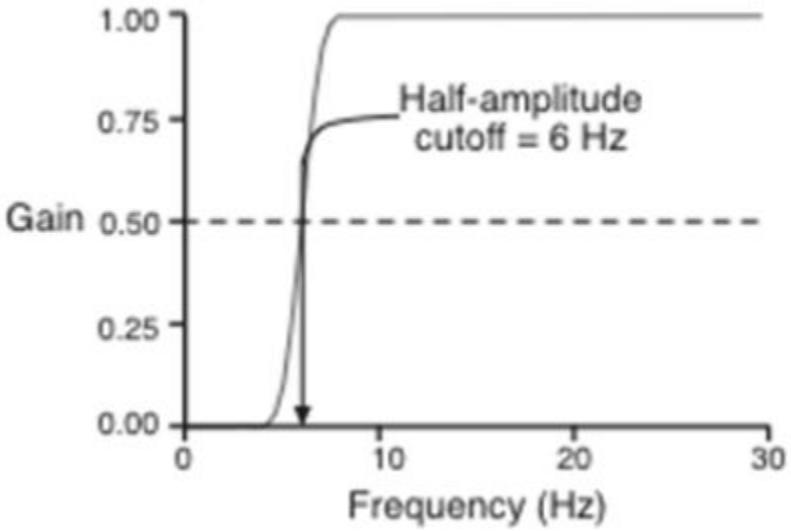
Can we investigate pre-stimulus activity just prior to t=0?

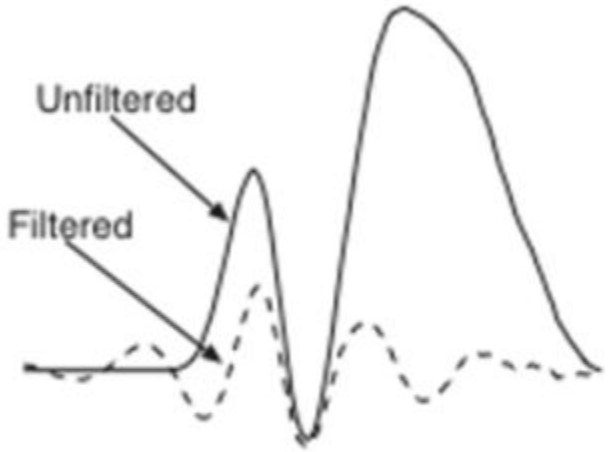
Steffen Buergers, Giulio Degano



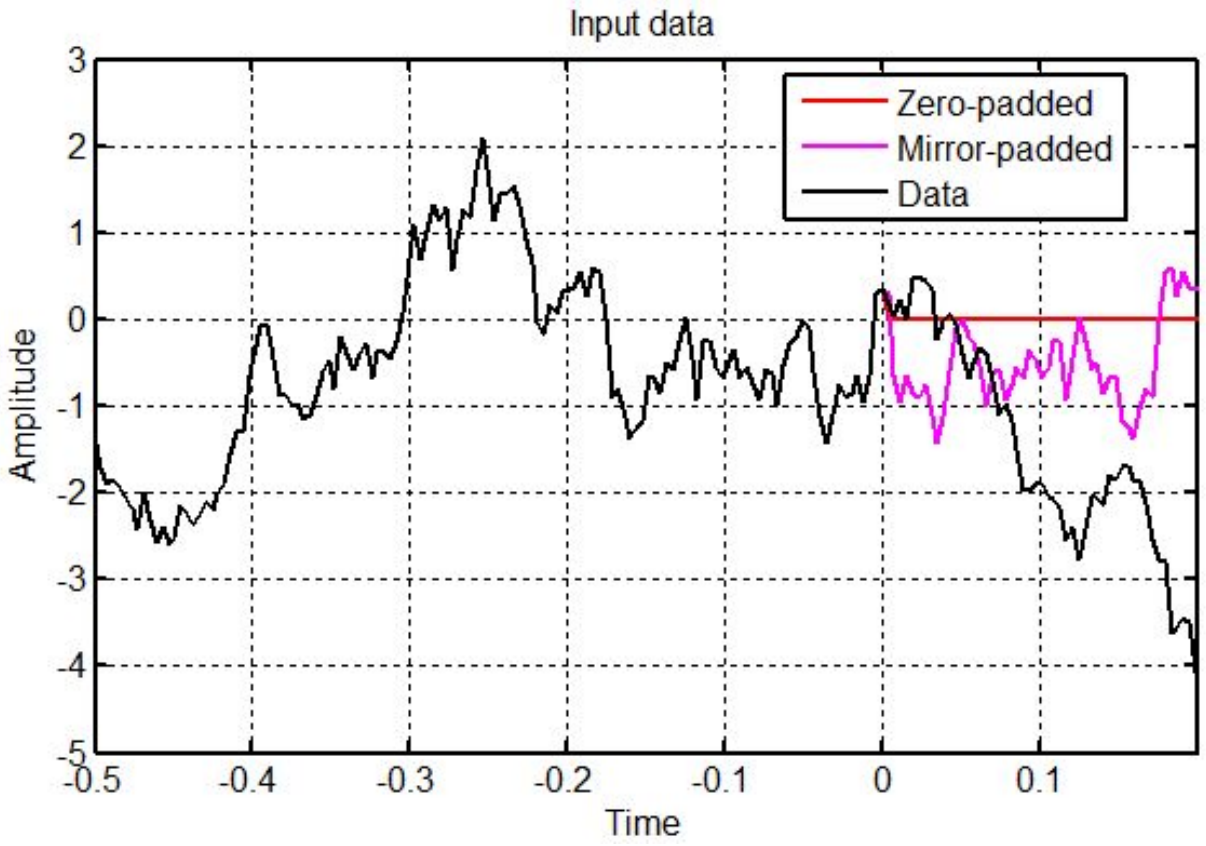
The problem of post-stim artifacts

Information bleeds into pre-stimulus period when analysing oscillatory activity!





Avoiding post-stimulus artifacts



Frequency sliding

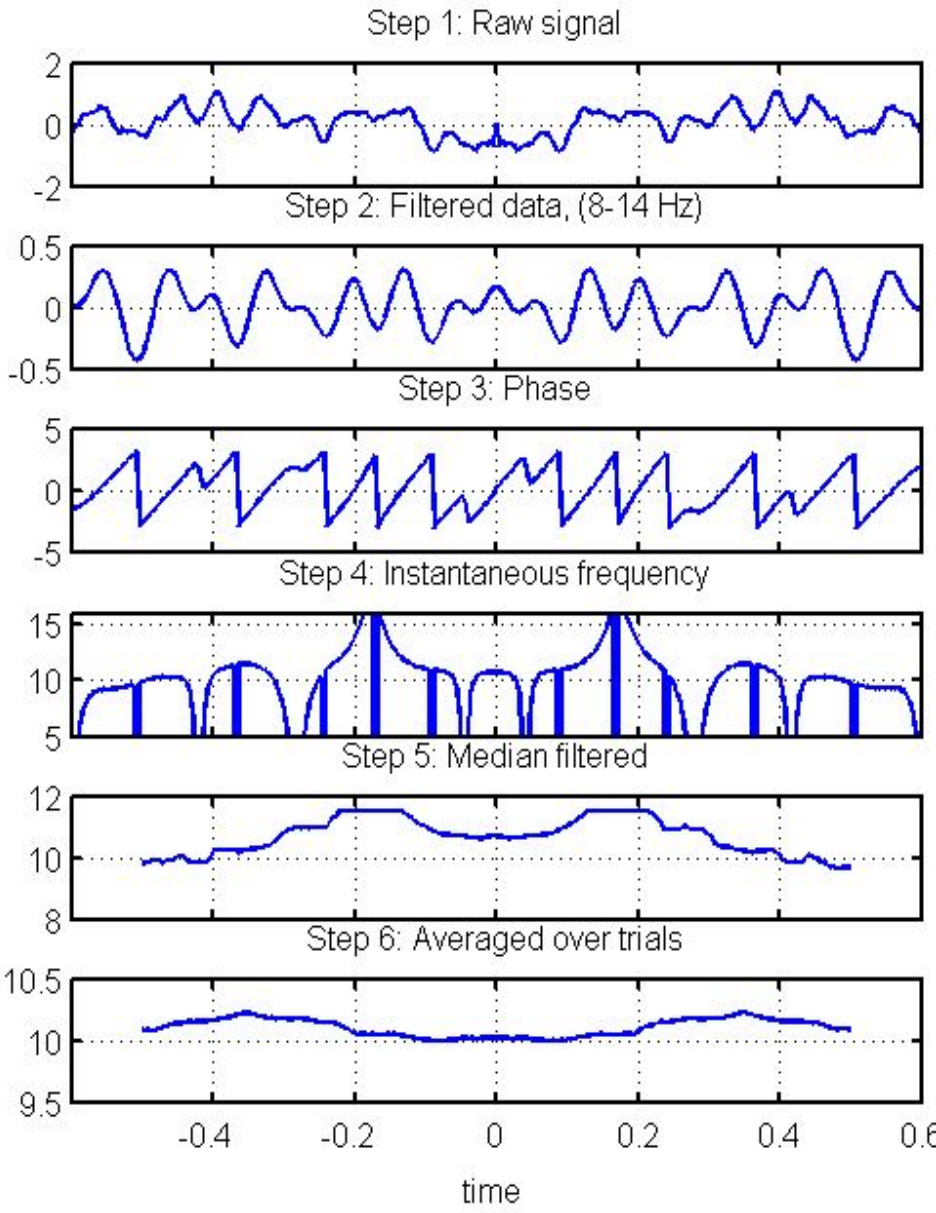
Hilbert transform (or fft or wavelet)

Take temporal **derivative of phase** angle time series

Apply 10 **median filters** with different orders

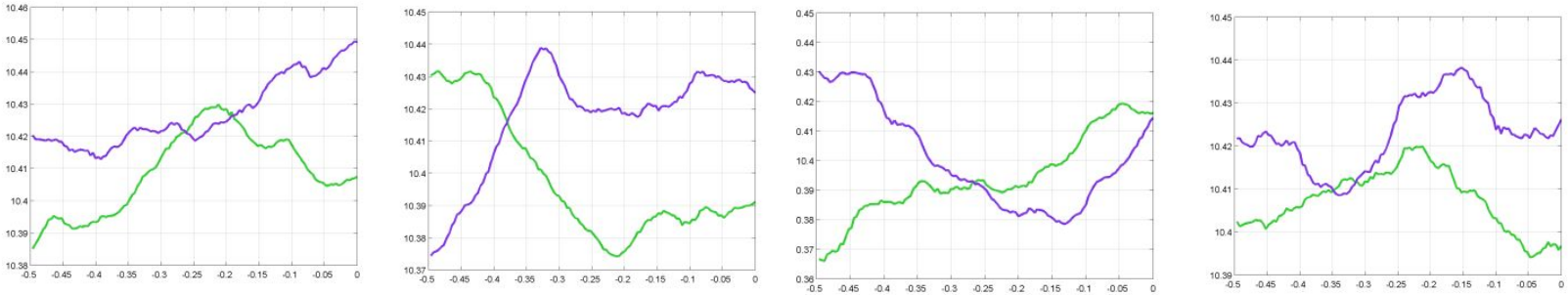
Take the **median** of the median filter values

Average over trials

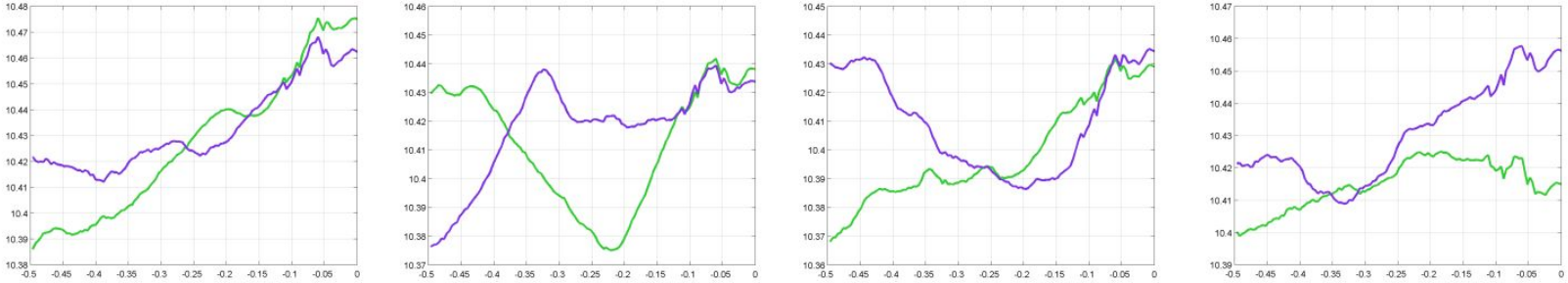


Frequency sliding (pink noise simulations, N=20, n=125)

Continued



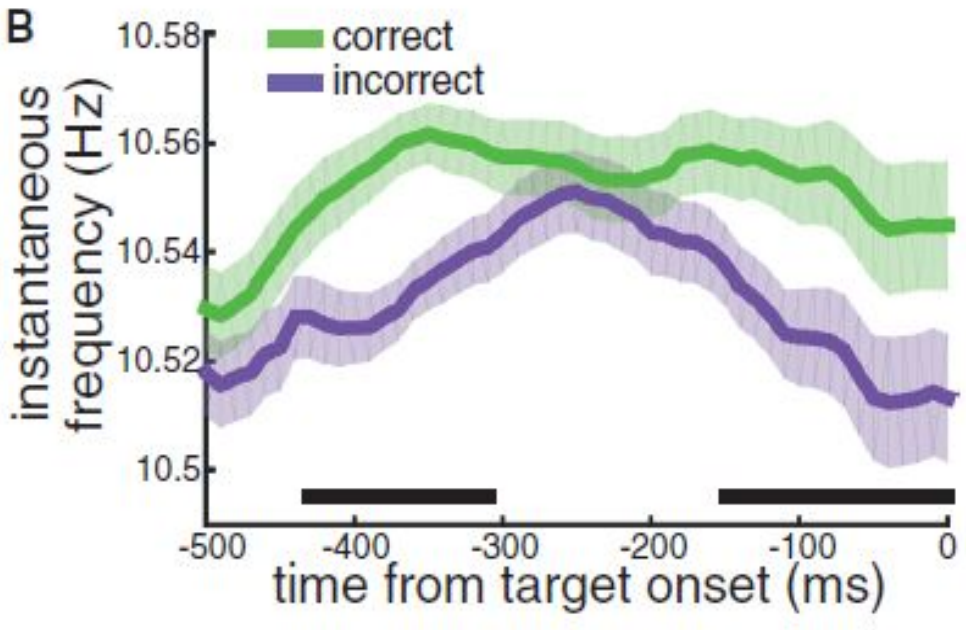
Mirrored



Frequency

Time (-0.5 to 0s)

Frequency sliding

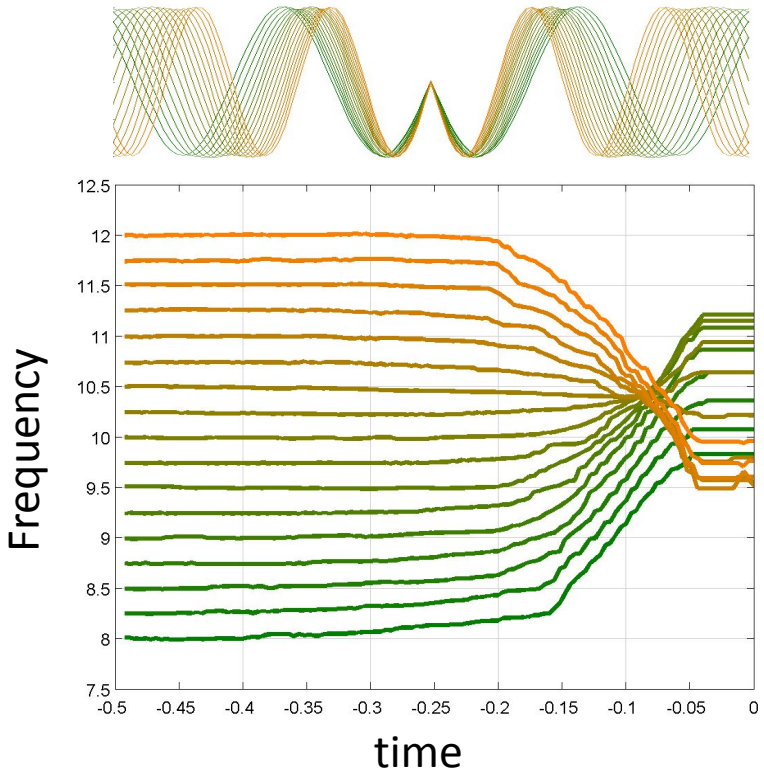


Significant difference at roughly 0.03 Hz

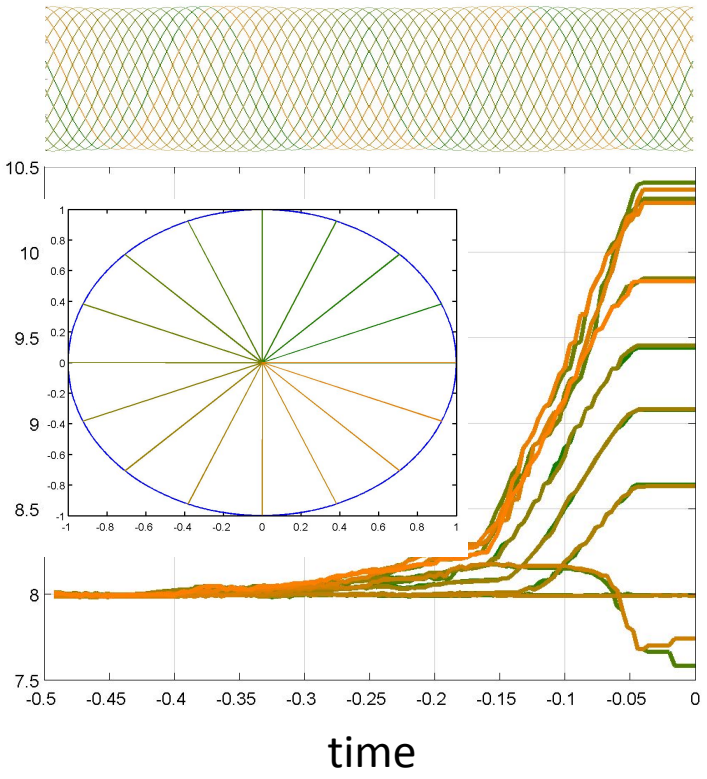
Samaha et al., 2015

Frequency sliding: Mirror padding

Different frequencies

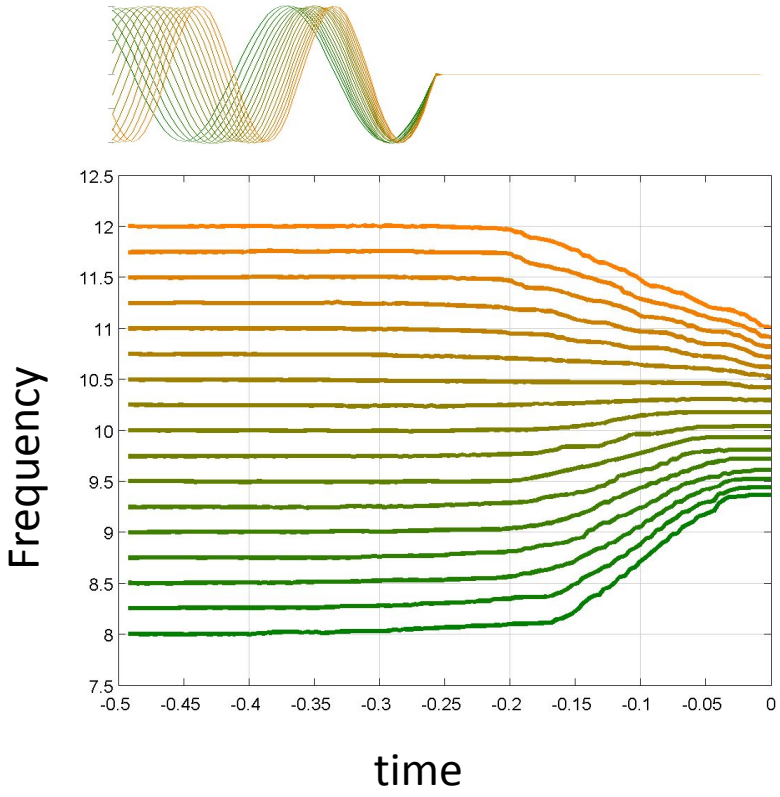


Different phase angles

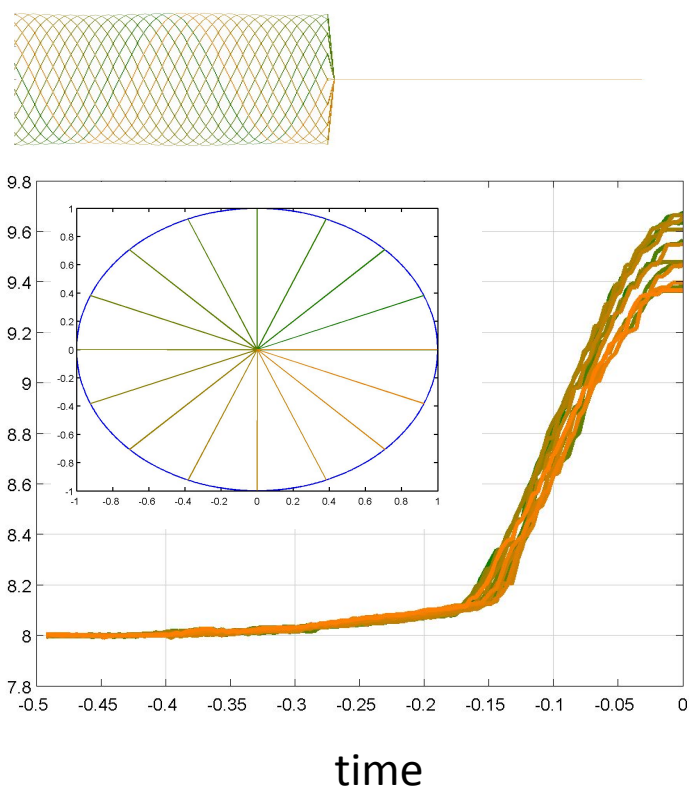


Frequency sliding: Zero padding

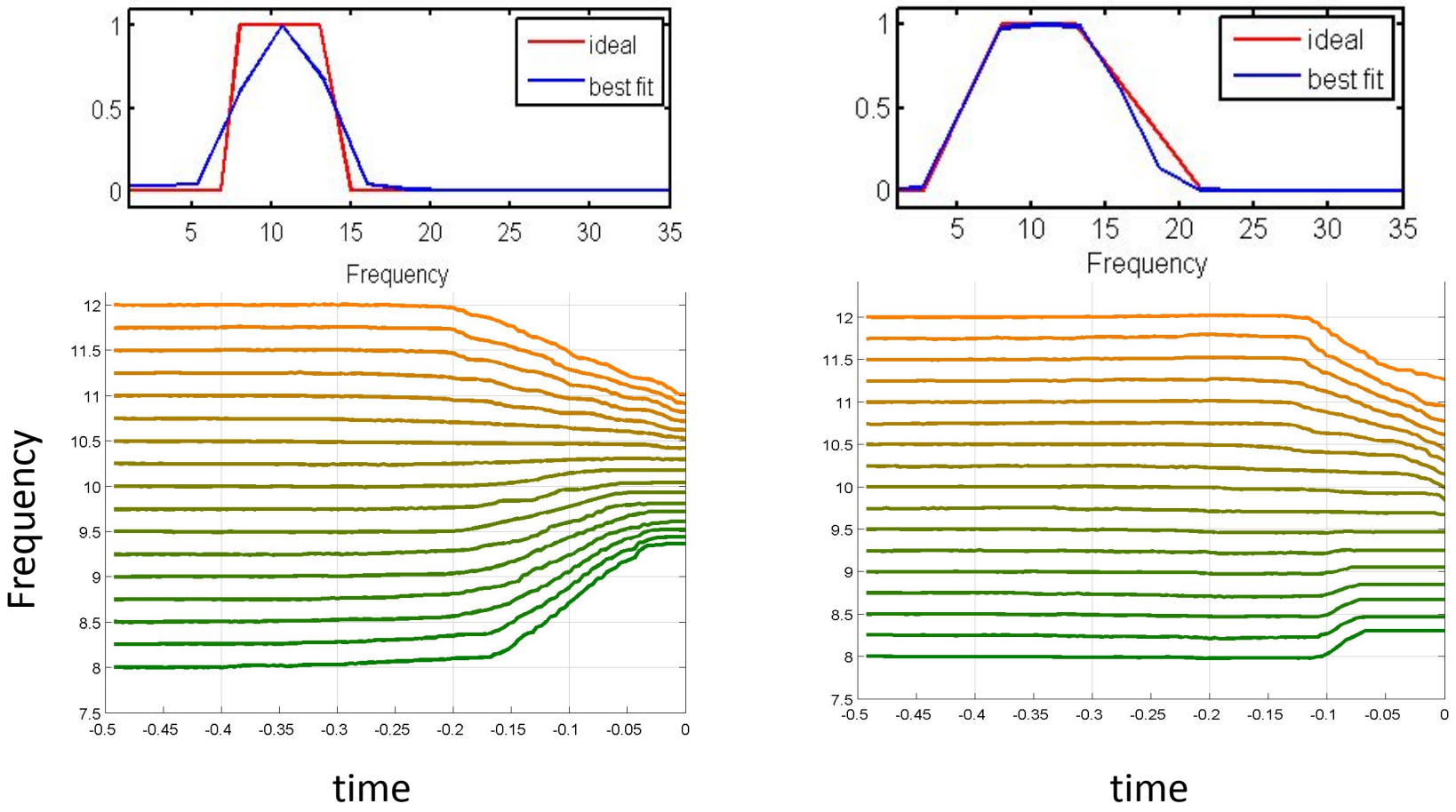
Different frequencies



Different phase angles



Frequency sliding: Zero padding



Simulation summary:

Mirror-padding distorts data more than zero-padding

In both cases it is hard to interpret a difference between conditions, especially for small sample sizes

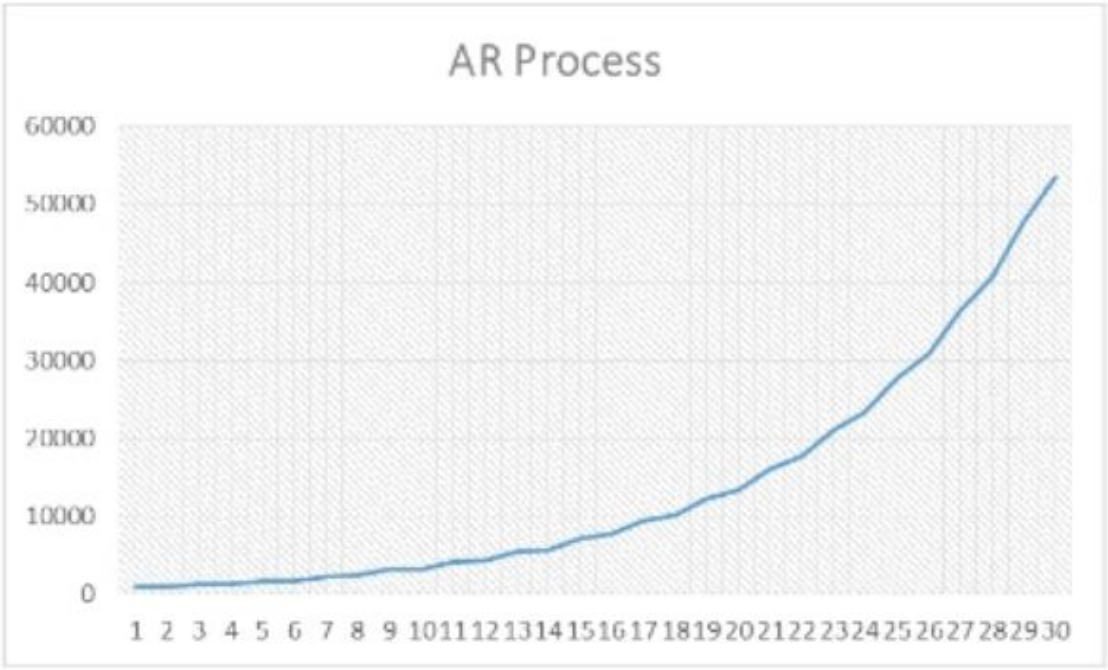
So should we ignore pre-stimulus activity?

Maybe we can forecast the signal

EEG is very noisy, and we want to predict data on single trials

Even a poor prediction should be better than zero-padding (if unbiased)

Autoregressive moving average modeling (ARMA)



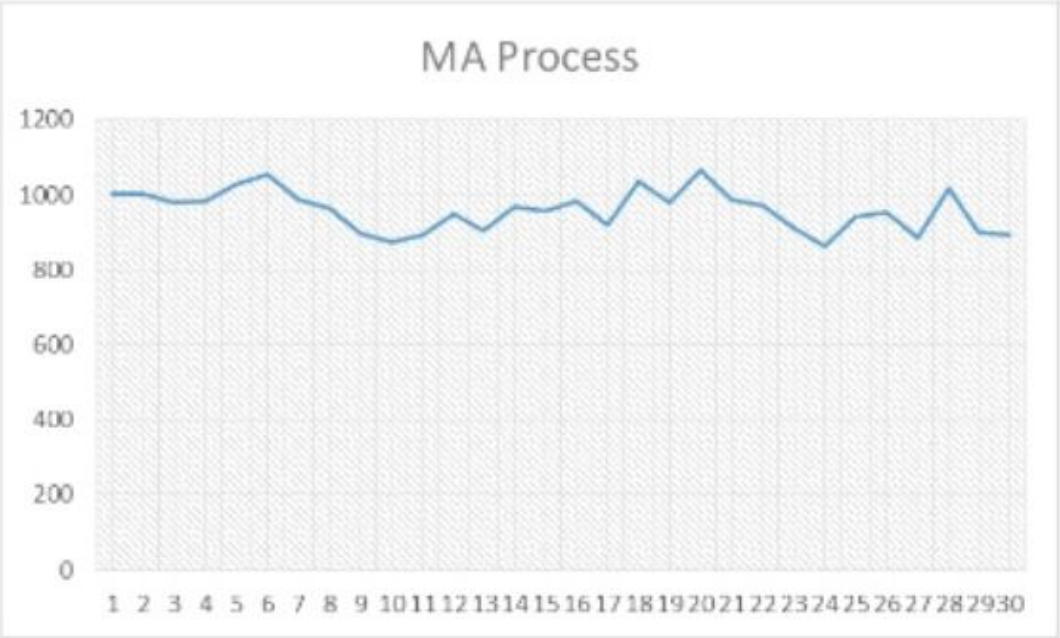
AR(1) $y_t = a1 * y_{t-1}$

AR(2) $y_t = a1 * y_{t-1} + a2 * y_{t-2}$

AR(3) $y_t = a1 * y_{t-1} + a2 * y_{t-2} + a3 * y_{t-2}$

From https://www.slideshare.net/21_venkat/arima-26196965

Autoregressive moving average modeling (ARMA)



MA(1) $\varepsilon_t = b1 * \varepsilon_{t-1}$

MA(2) $\varepsilon_t = b1 * \varepsilon_{t-1} + b2 * \varepsilon_{t-2}$

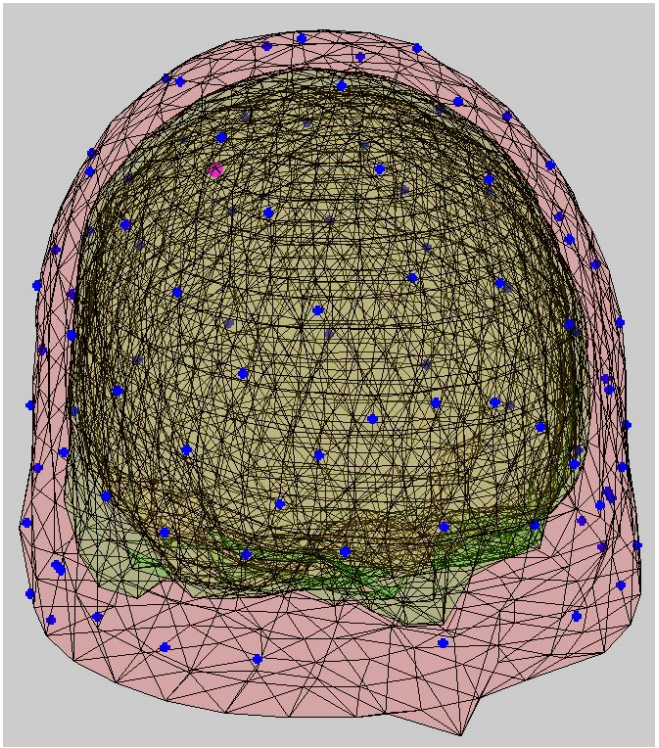
MA(3) $\varepsilon_t = b1 * \varepsilon_{t-1} + b2 * \varepsilon_{t-2} + b3 * \varepsilon_{t-3}$

From https://www.slideshare.net/21_venkat/arima-26196965

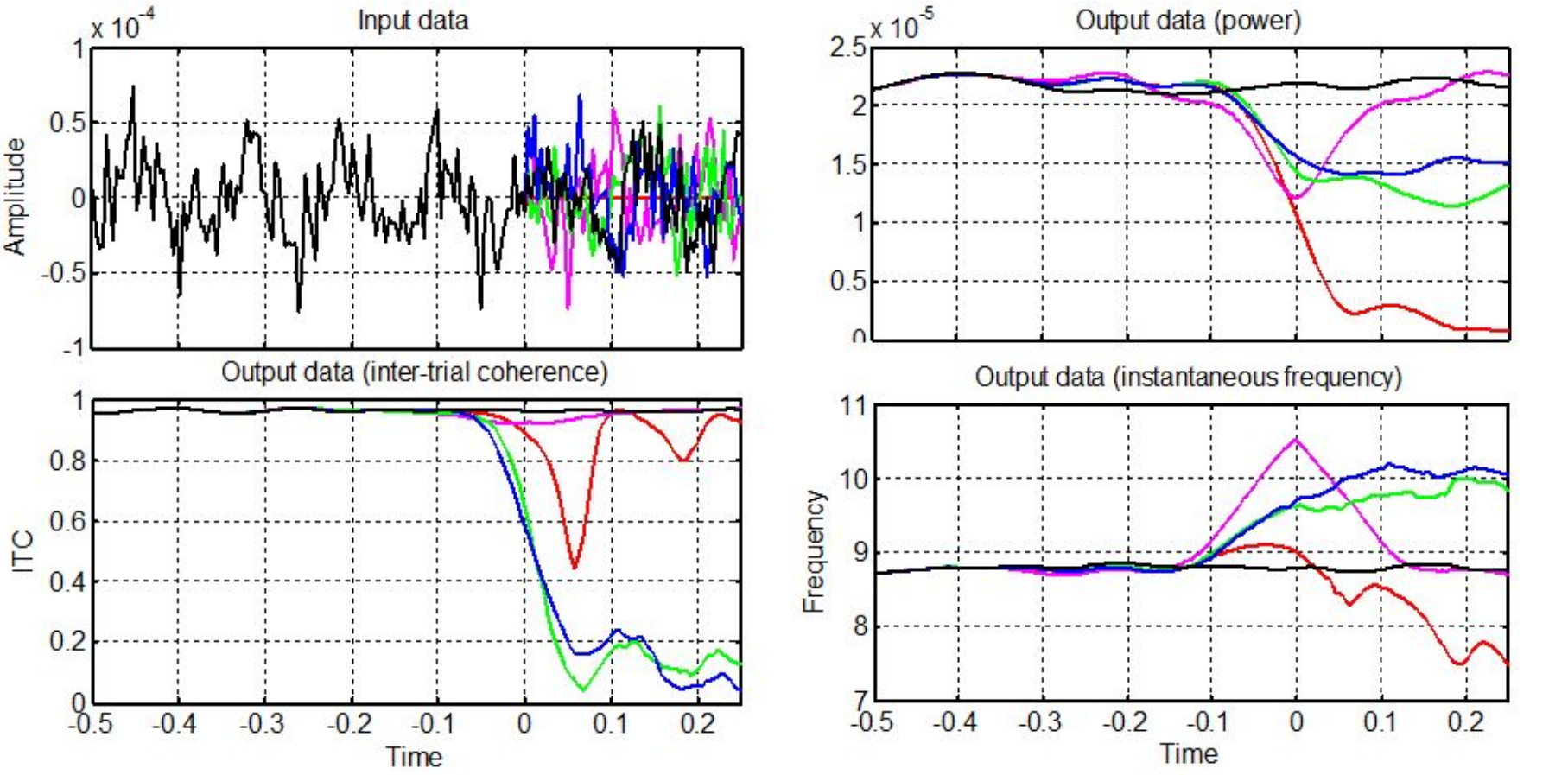
Simulations with ft_dipolefitting

Simulate sine wave at frequency F with phase P and certain SNR using BEM volume conduction model.

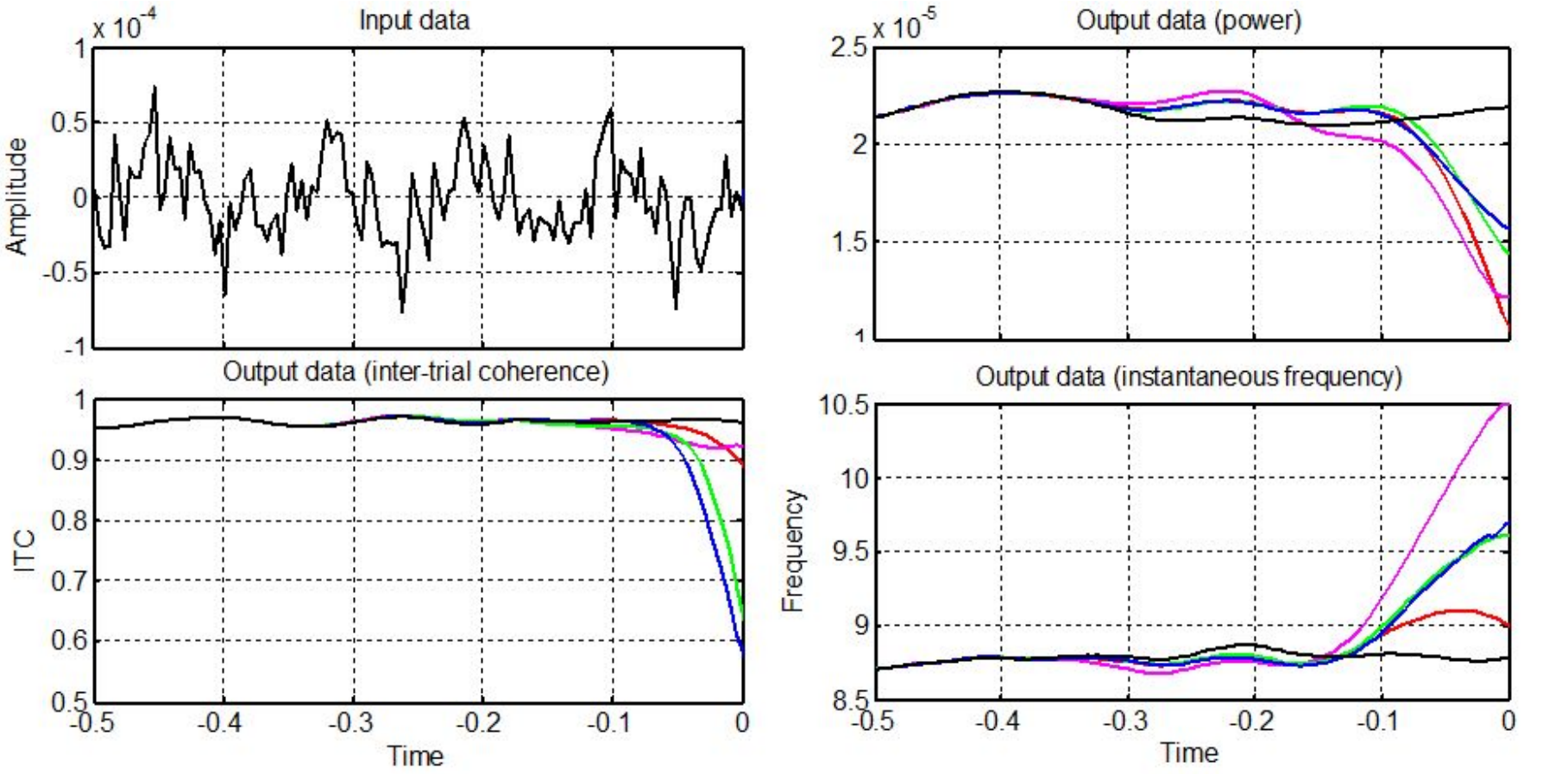
AR order = 7
ARMA: na = 25, nc = 10
(modeling by Giulio Degano)



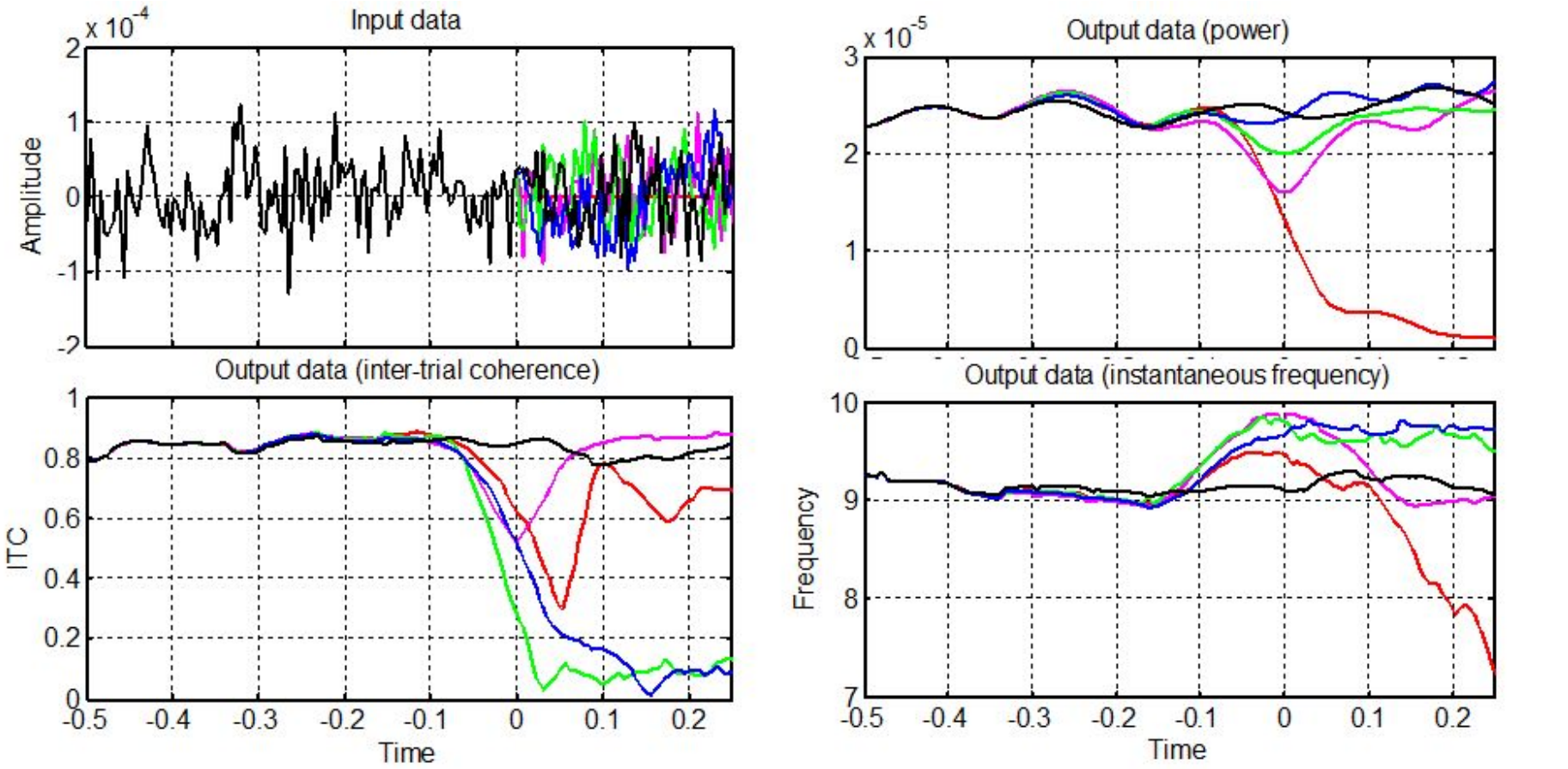
F=8.67Hz, P=0, SNR=1



F=8.67Hz, P=0, SNR=1



F=8.67Hz, P=0, SNR=1/2



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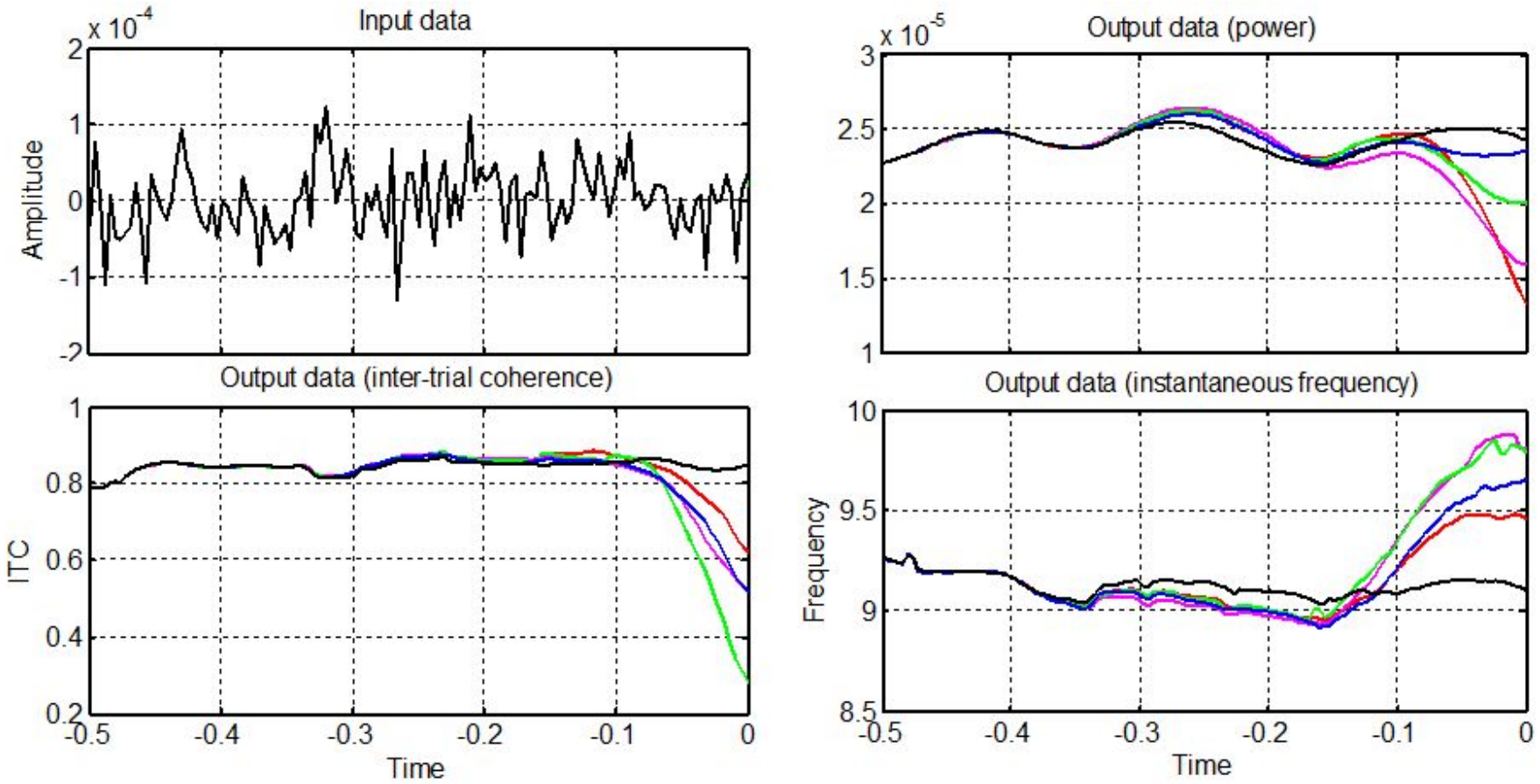
F=8.67Hz, P=0, SNR=1/2



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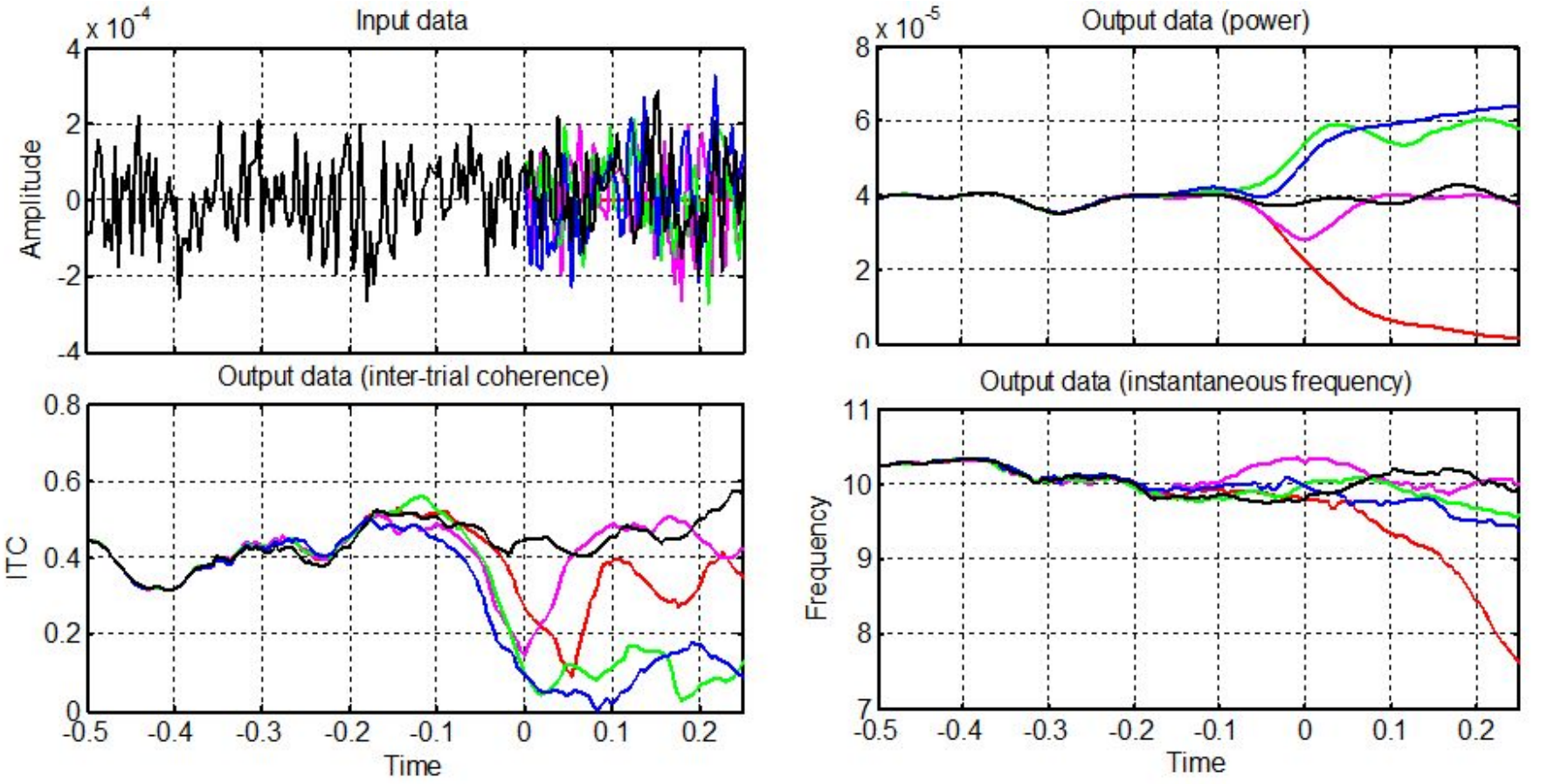
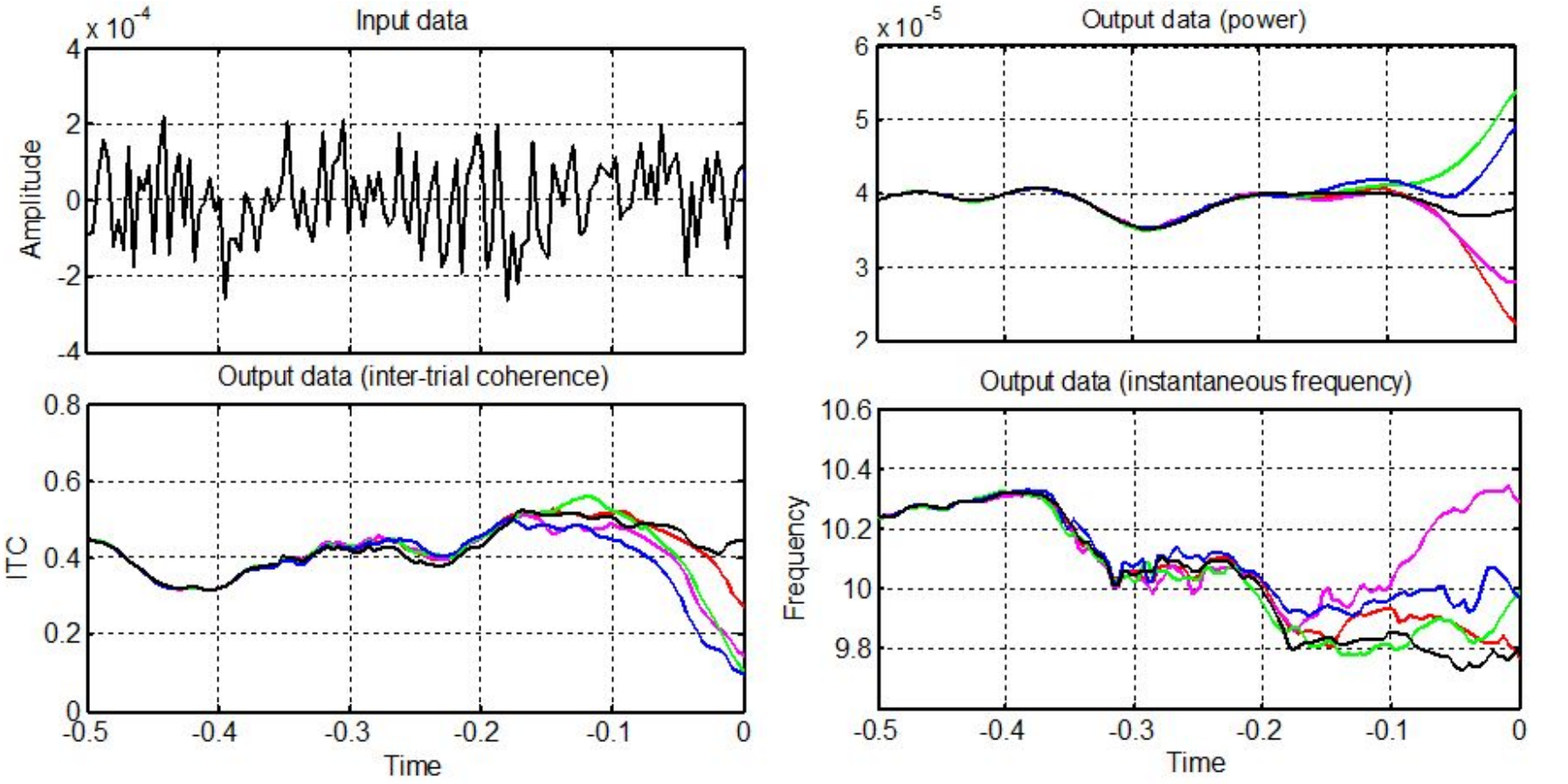
F=8.67Hz, P=0, SNR=1/5



F=8.67Hz, P=0, SNR=1/5



Simulation summary:

For the given simulation and model specifications we observe significant distortions, similar to zero- or mirror-padding

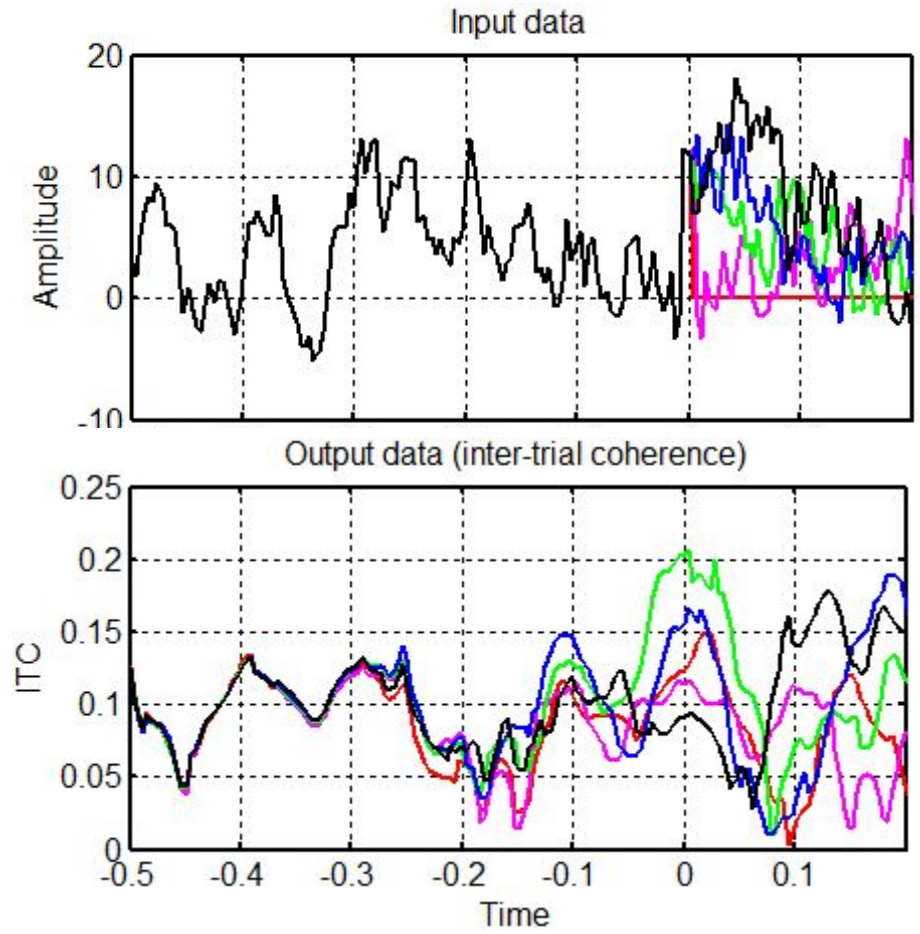
ARMA and AR perform well for power, mediocre for frequency sliding and poorly for ITC

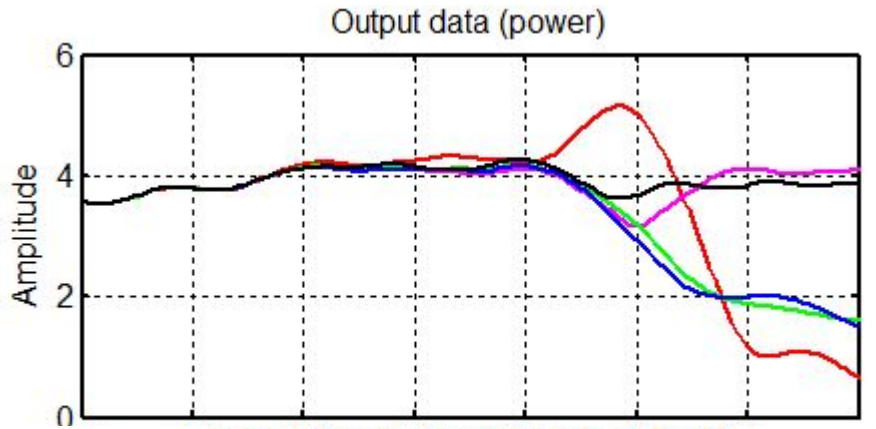
Real EEG data (no stimulus)

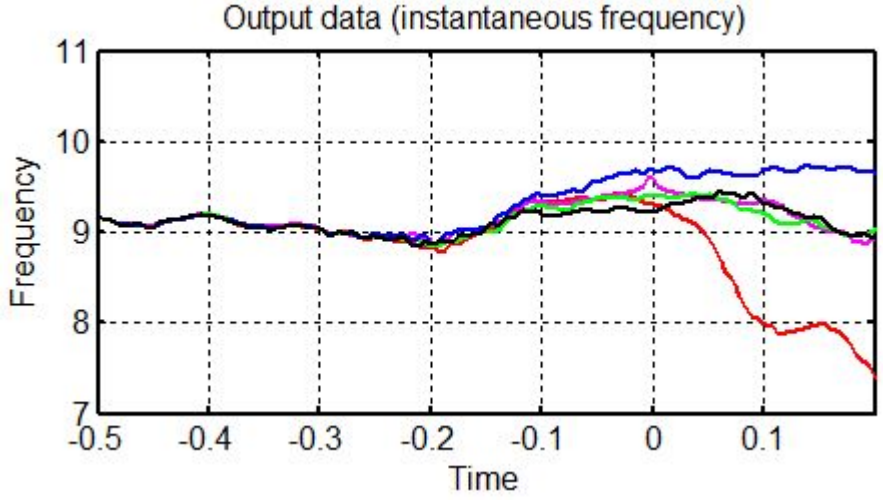
Sleep dataset of single participant

Number of trials: 79

Real EEG data (N = 1; n = 79)







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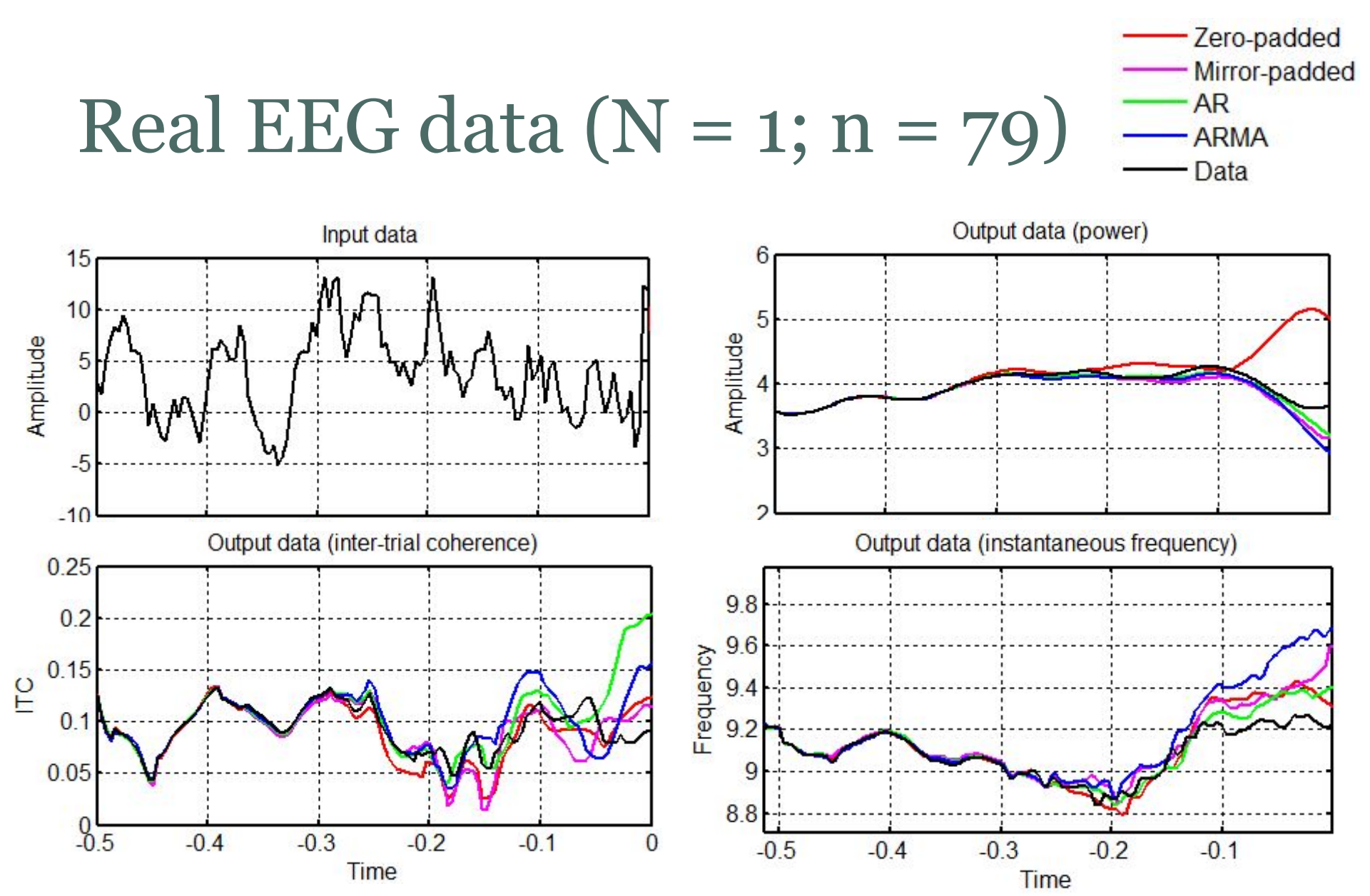
Real EEG data (N = 1; n = 79)



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Final summary:

All padding or forecasting methods introduce artifacts.

A quick test of AR and ARMA models gives complex results (no obvious advantage to zero-padding)

If this is a viable method, how do we choose parameters?

Forecasting methods - open discussion

Is it worth pursuing this idea further? What should we pay attention to?

Other possible forecasting methods: Support vector regression, neural networks, others?

Fin

Thank you!

References

Samaha, J., & Postle, B. R. (2015). The Speed of Alpha-Band Oscillations Predicts the Temporal Resolution of Visual Perception. *Current Biology*, *25*(22), 2985–2990. https://doi.org/10.1016/j.cub.2015.10.007