Spike-field coherence
(and cross-covariance)

Computing the coherence (Part 2)

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Coherence: words

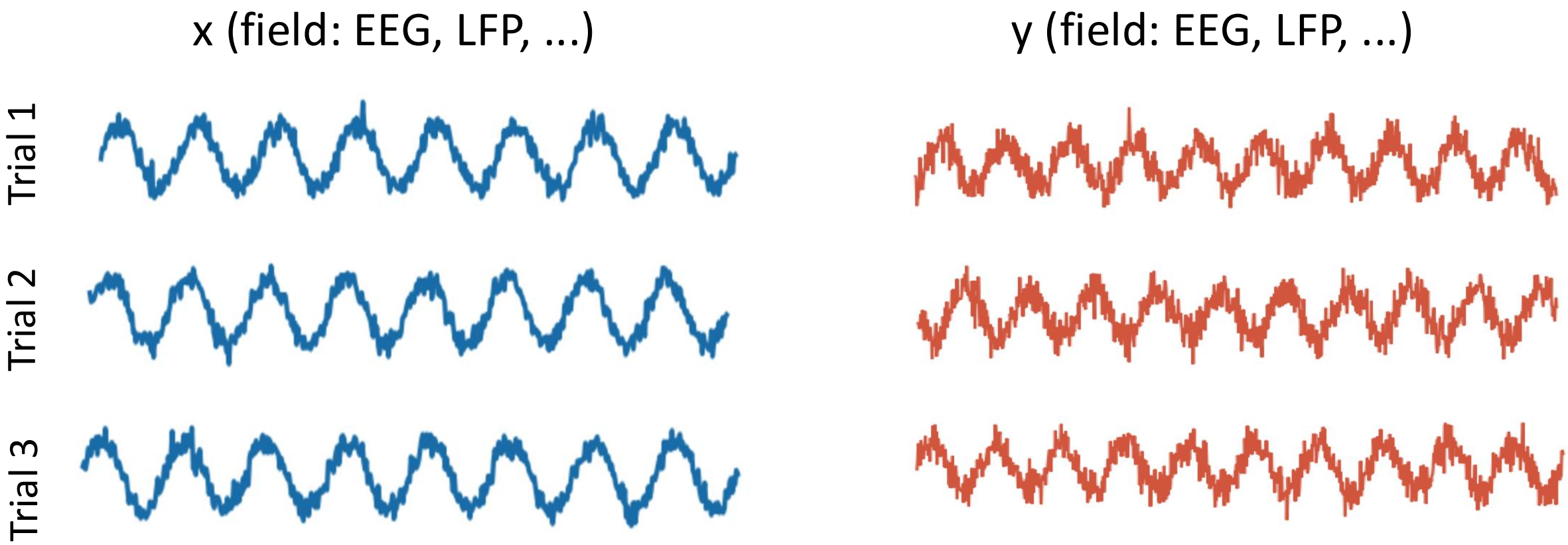
A constant phase relationship between two signals, at the same frequency, across trials.

Note

- *“same frequency”*
- *“across trials”*

Coherence: idea

Ex: Record data simultaneously from two sensors, across multiple trials



Is there a *constant phase relationship between x & y, at the same f, across trials?*

Coherence: equations

Remember:

$$\kappa_{xy,\,j} = \frac{|< S_{xy,\,j} >|}{\sqrt{< S_{xx,\,j} >}\sqrt{< S_{yy,\,j} >}}$$

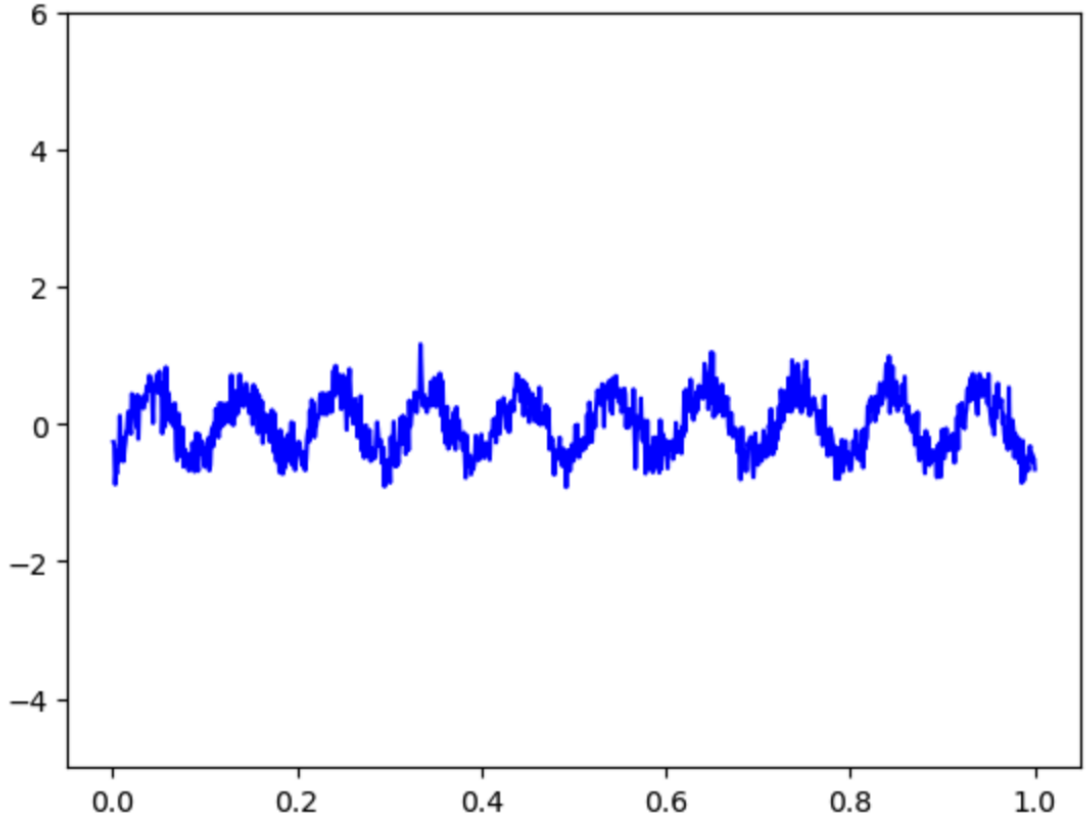
$S_{xy,j}$ = Cross-spectrum at frequency index j

$S_{xx,j}, S_{yy,j}$ = Auto-spectra at frequency index j

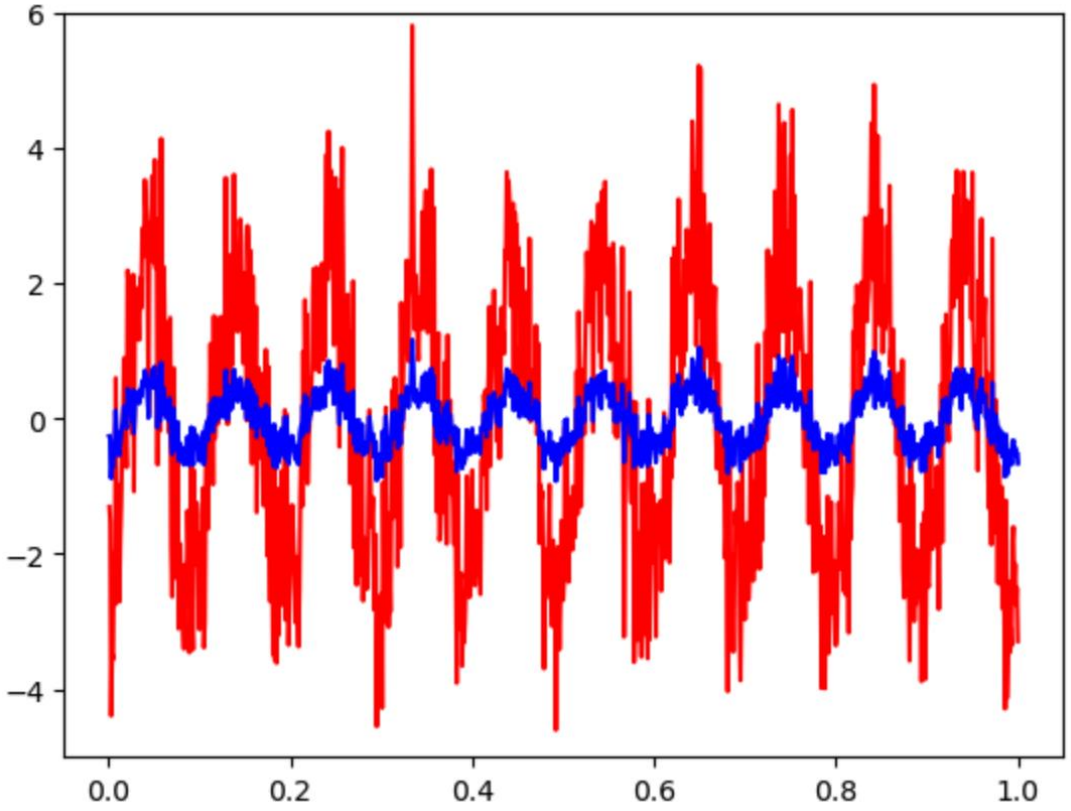
$< S >$ = Average of S over trials

Coherence: impact of scaling

Q. How does scaling x or y impact the coherence?



multiply by 5



Q. Impact on coherence between x and y?

Coherence: impact of scaling

Scale: $A_{j,k} \rightarrow 5A_{j,k}$

$$\kappa_{xy,\,j} = \frac{\left| \sum_{k=1}^{K} 5A_{j,k}\, B_{j,k} \exp\left(i\Phi_{j,k}\right) \right|}{\sqrt{\sum_{k=1}^{K} (5A_{j,k})^2} \sqrt{\sum_{m=1}^{K} B_{j,m}^2}}$$

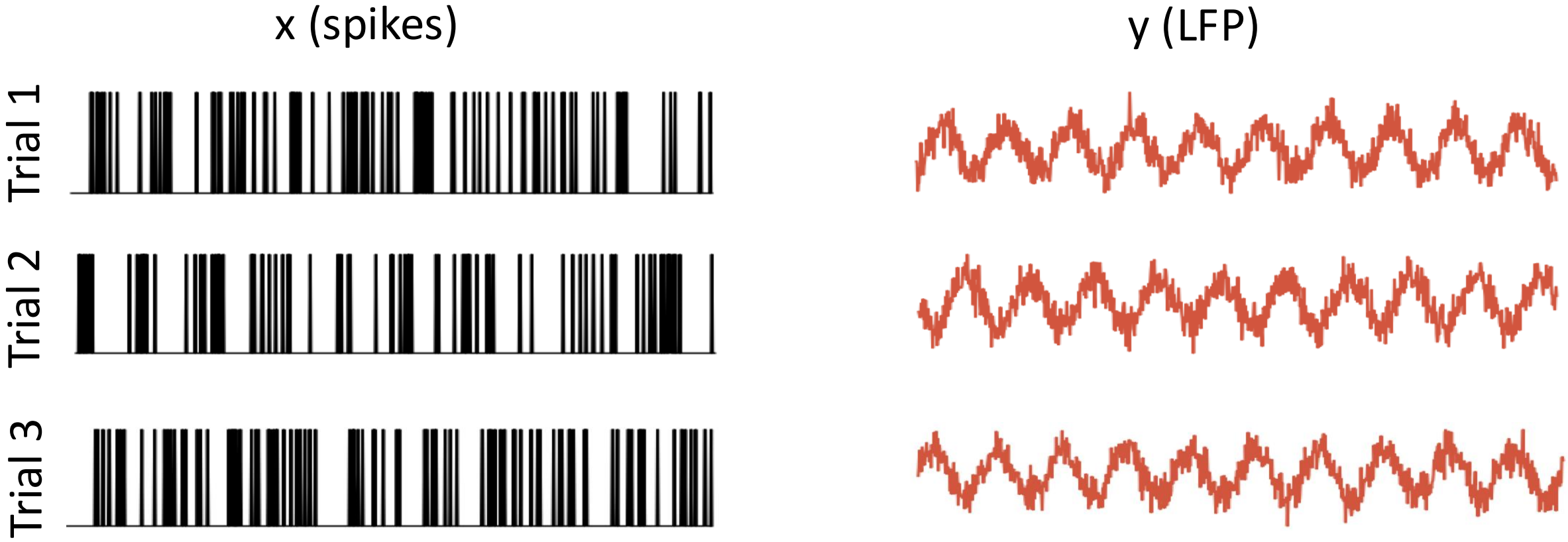
The 5's cancel ➔ no impact on coherence

Q. How does scaling x or y impact the coherence?

A. It doesn't.

Coherence: idea

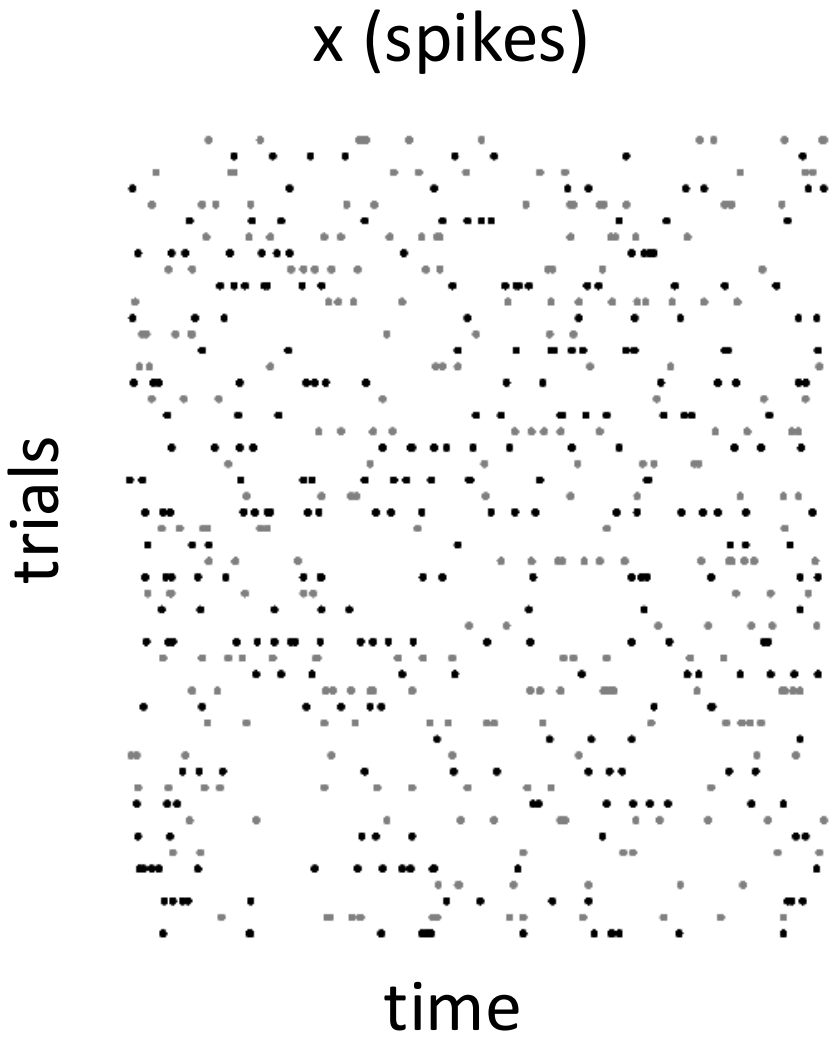
Example: Record data simultaneously from two sensors, across multiple trials

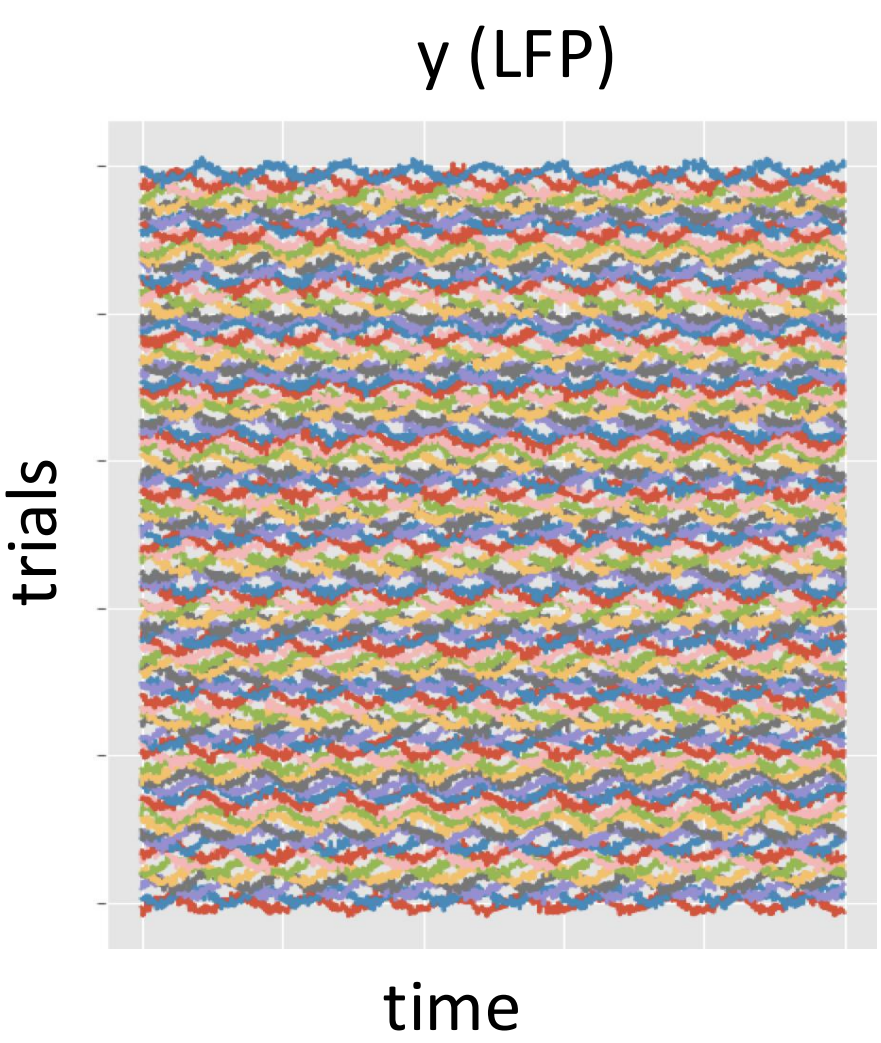


Is there a *constant phase relationship between x & y, at the same freq, across trials?*

Spike-field coherence

Consider the data:



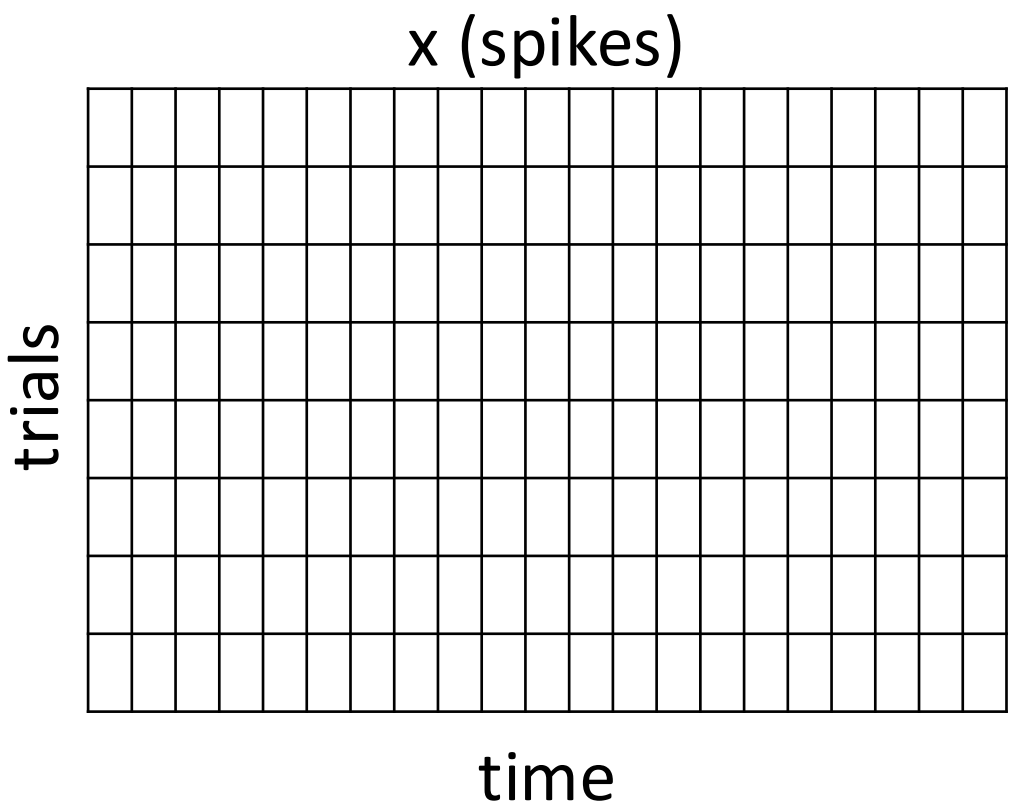


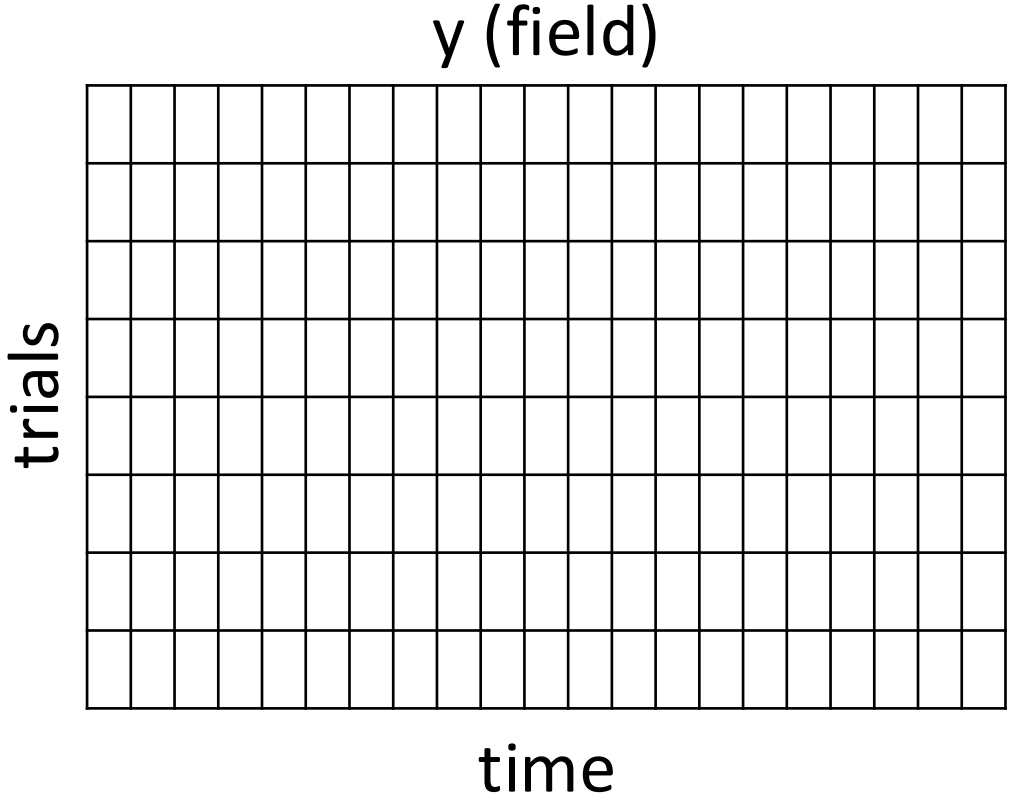
We want a measure of consistent neural spiking at a specific phase of the field ...

Coherence: idea

Example: Record data simultaneously from two sensors, across multiple trials

Organize the data ...





Each row is a trial, each column is a time point, organize data in matrices.

Spike-field coherence

trial averaged cross spectrum

$$\kappa_{ny,\,j} = \frac{|< S_{ny,\,j} >|}{\sqrt{< S_{nn,\,j} >}\sqrt{< S_{yy,\,j} >}}$$

trial averaged spike spectrum

trial averaged field spectrum

y = field signal (e.g., EEG, MEG, LFP, ...)

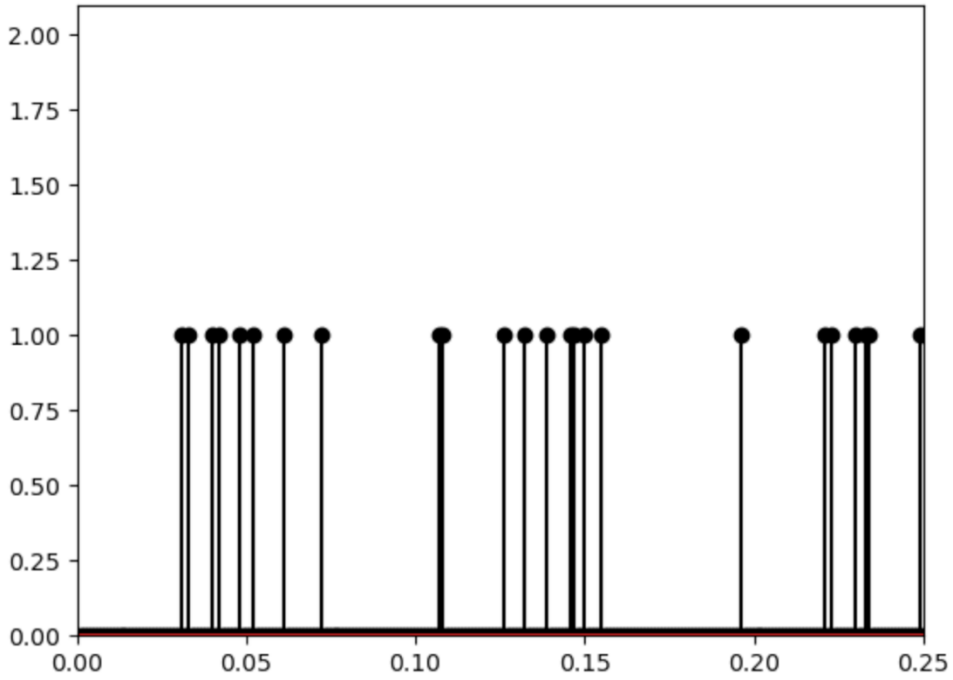
n = spike train (e.g., [0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 ...])

Same equations ... but new problems ...

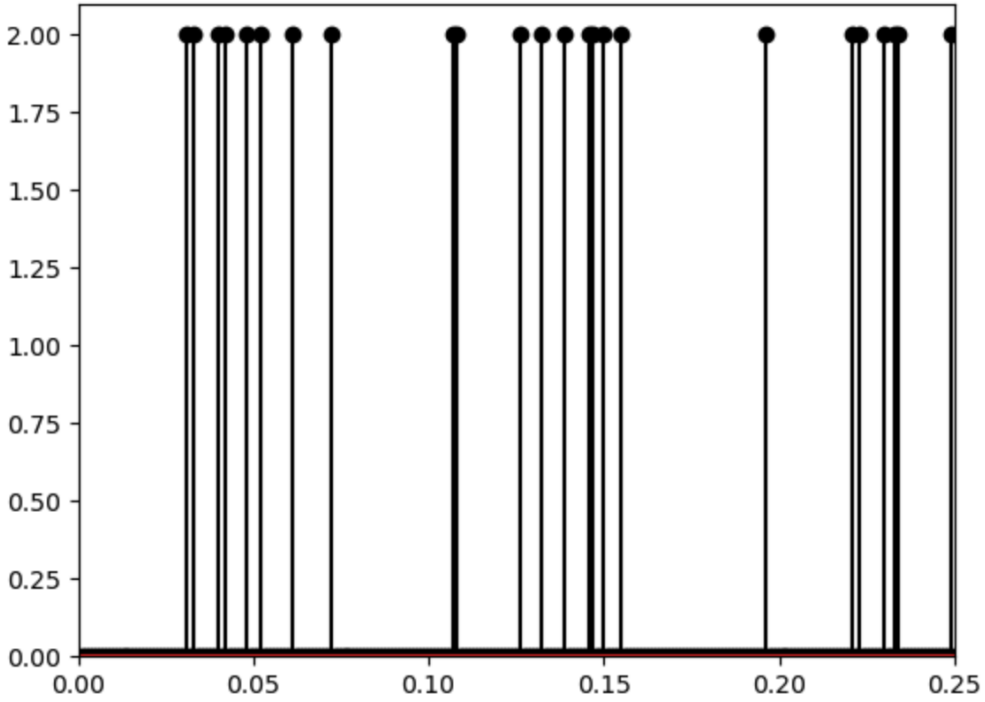
Spike-field coherence: dependence on rate

Q. How does scaling x or y impact the coherence?

Q: How do you scale a spike train?



multiply by 2

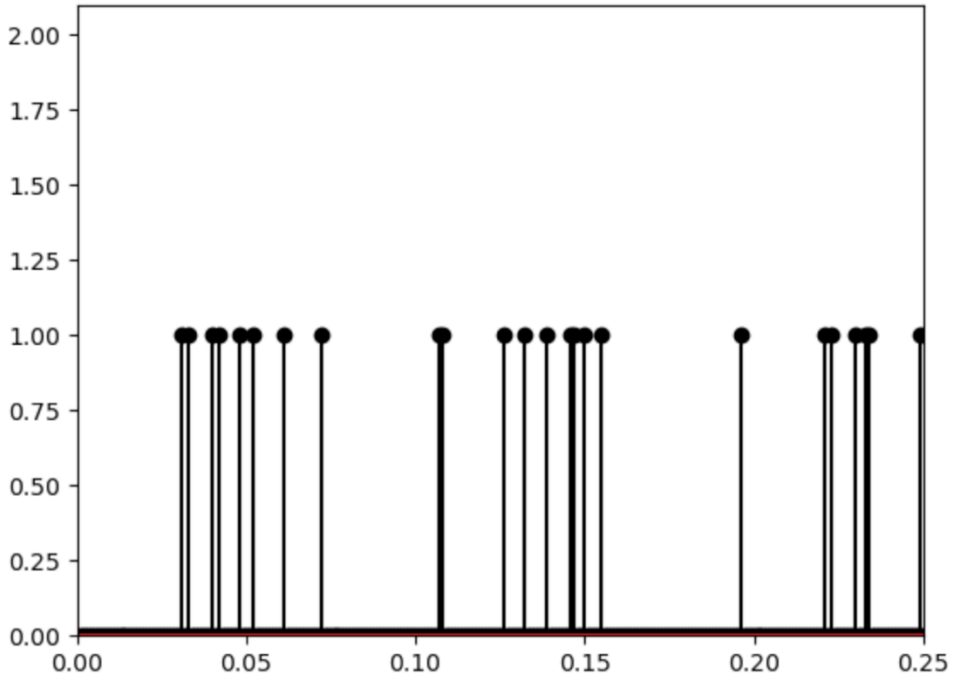


No!

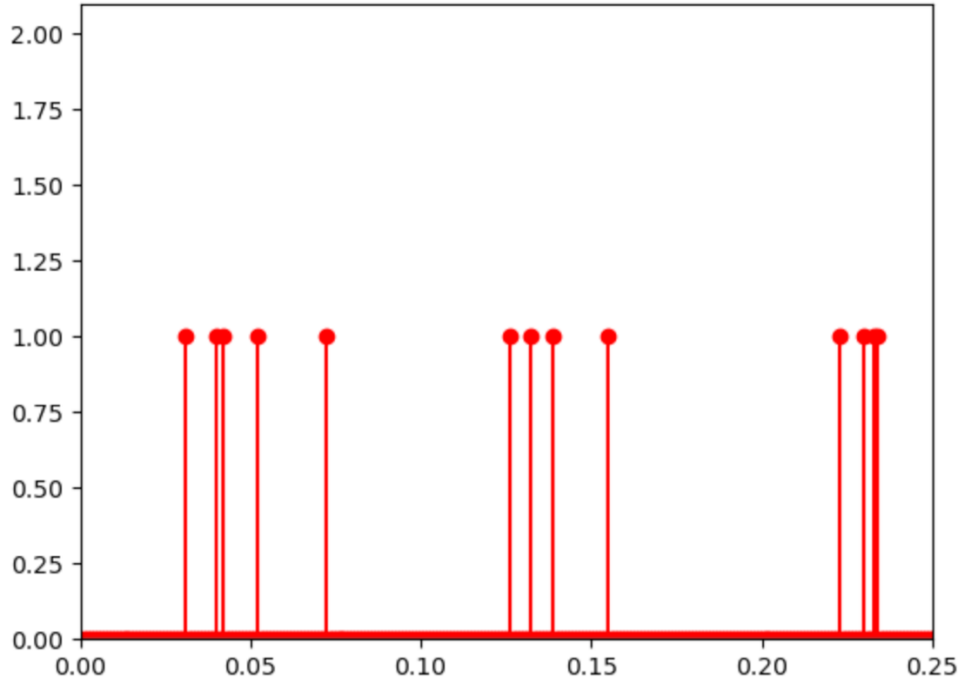
Spike-field coherence: dependence on rate

Q. How does scaling x or y impact the coherence?

Q: How do you <u>scale</u> a spike train?



thin
by
1/2

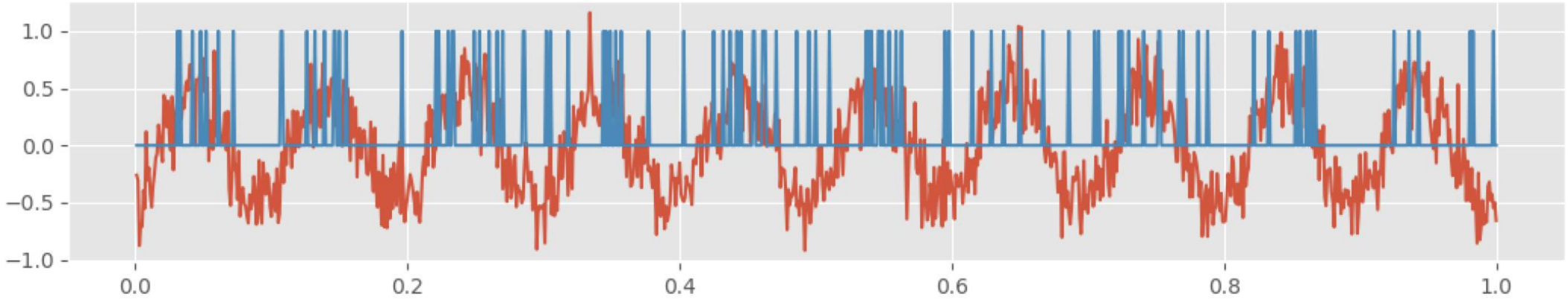


change the firing rate

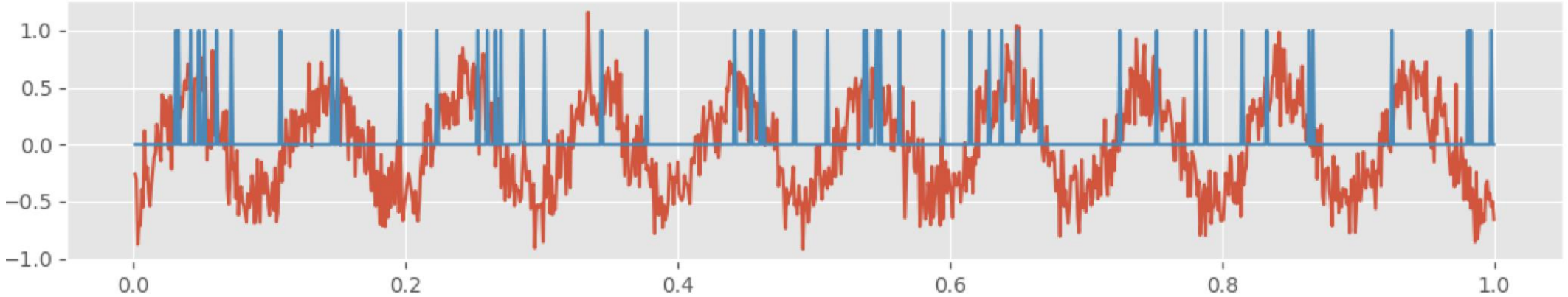
Spike-field coherence: dependence on rate

Q: Does the spike-field coherence depend on the firing rate of the neuron?

Original spike & field



Scale the spiking (remove 50% of spikes, chosen at random, “thinning”)



Spike-field coherence: dependence on rate

Q: Does the spike-field coherence depend on the firing rate of the neuron?

Here, rate: expected number of spikes in a given duration

Try it ...

Python