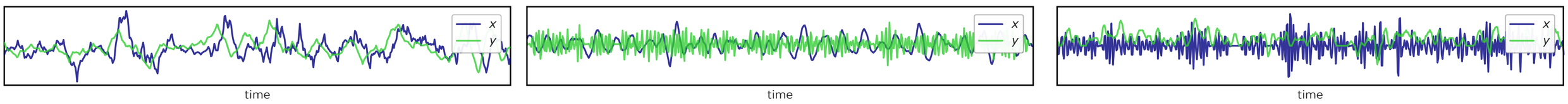
Measuring Dependencies between Biological Signals with Self-supervision, and its Limitations

Evangelos Sariyanidi[1], J. D. Herrington[1], L. Yankowitz[1,2], Pratik Chaudhari[1,2], T. D. Satterthwaite[1,2†], C. J. Zampella[1,4†]
R. T. Schultz, R. T. Shinohara, Birkan Tunc

[1] Children's Hospital of Philadelphia [2] University of Pensylvania

QUIZ for you: Which time series pairs below are statistically **dependent**?



*for the Answer, Link the capital Letters in this sentence

Failure to detect **dependence** ⟹ ***Missed*** **Scientific Discovery.**

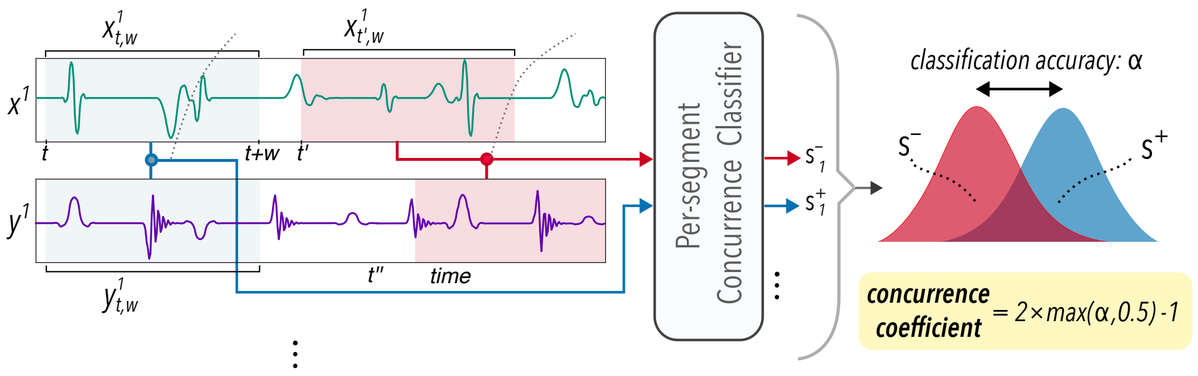
- **Statistical dependence** is a fundamental criterion for scientific discoveries—it uncovers the relationships between various types of processes
- Existing methods **cannot** detect arbitrary (unknown) **non-linear dependencies**, which are very common in biological sciences.

Concurrence: The most generic dependence metric to our knowledge.

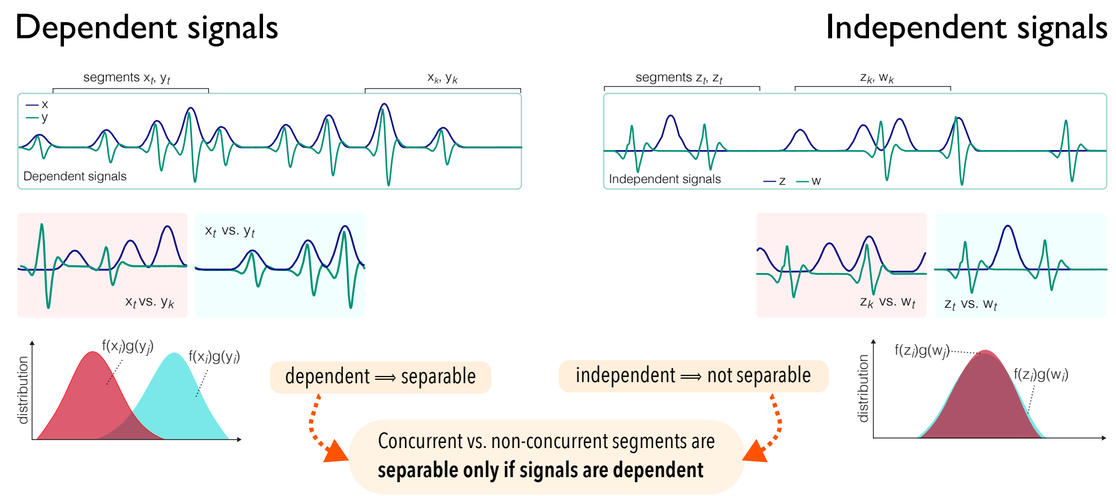
- Detects wide range of dependencies with ***no ad-hoc modification***
- Theoretically linked with dependence
- Bounded between 0 and 1 — Easy interpretation
- **Its code works out-of-the-box** with single- or multi-dimensional signals:
  - Brain (fMRI)
  - Physiological
  - Behavioral

Concurrence—What does it measure?

Concurrence is the degree to which a classifier can separate concurrent segments vs. misaligned segments

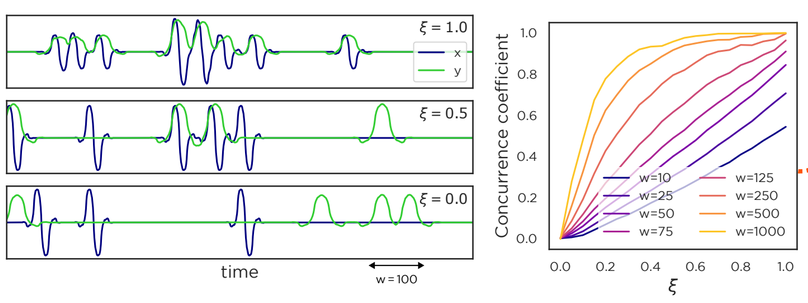


Why does it work?



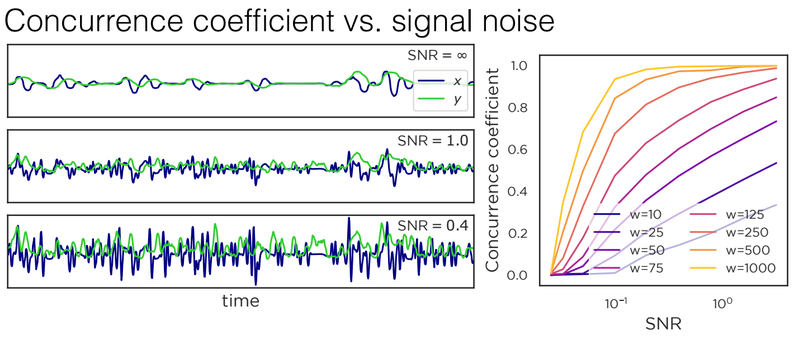
Experiments—Synthetic data

Concurrence coefficient ∝ degree of dependence



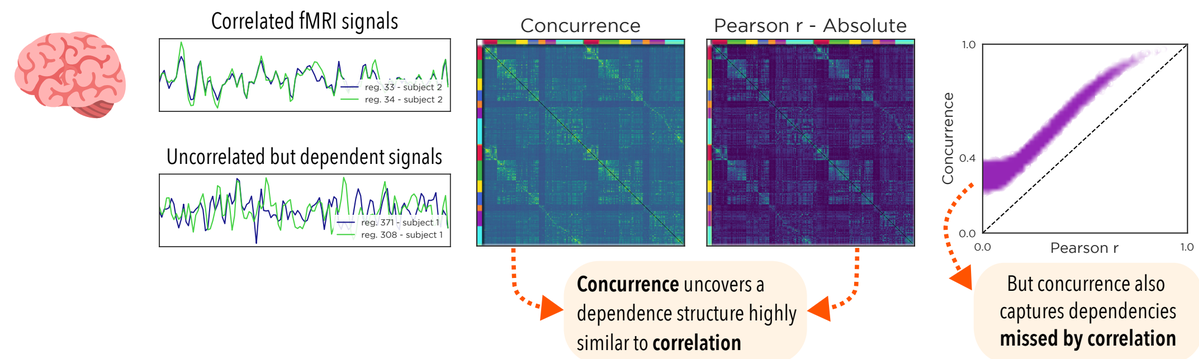
strong dependence ⟹ **high** concurrence

Concurrence coefficient vs. signal noise



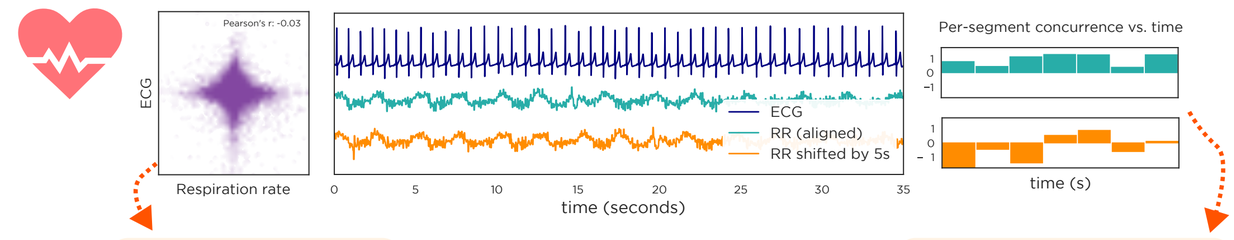
Concurrence works even with a SNR of 0.1

Experiments—Real signals



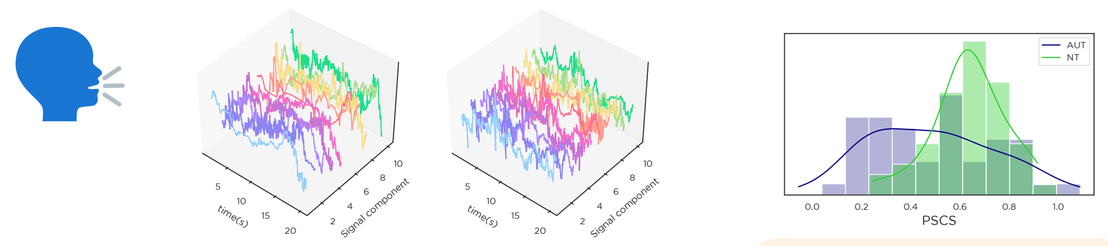
Concurrence uncovers a dependence structure highly similar to **correlation**

But concurrence also captures dependencies **missed by correlation**



ECG vs. respiration rate are non-linearly dependent (**corr ~0**)

Concurrence captures the dependence **without parameter modification**



The same concurrence model works with **multi-dimensional** behavior signals

Captures **clinically meaningful differences**: NT participants have > behavioral coordination than participants with autism

Scan **QR** for

video explanation

code

github.com/sariyanidi/concurrence