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Inferring neural population dynamics from multiple partial recordings of the same neural circuit

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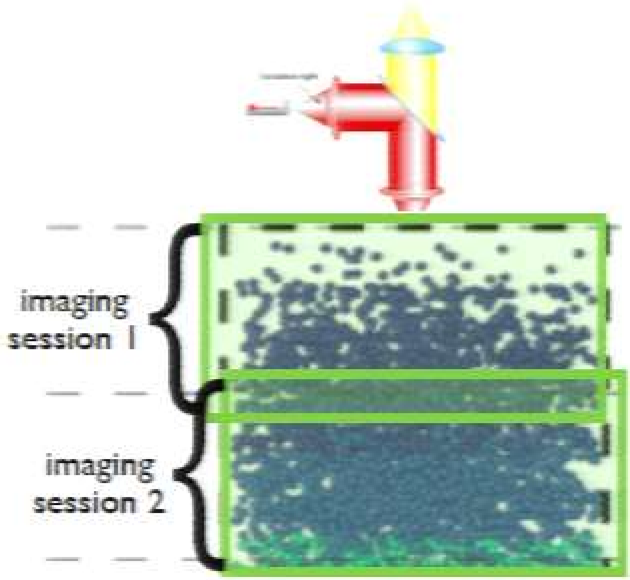

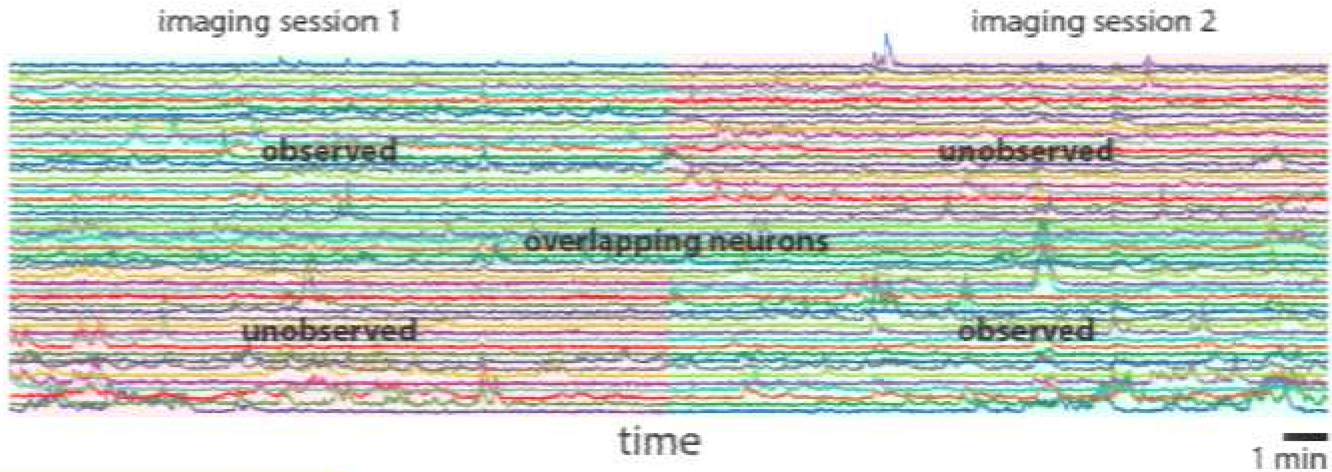

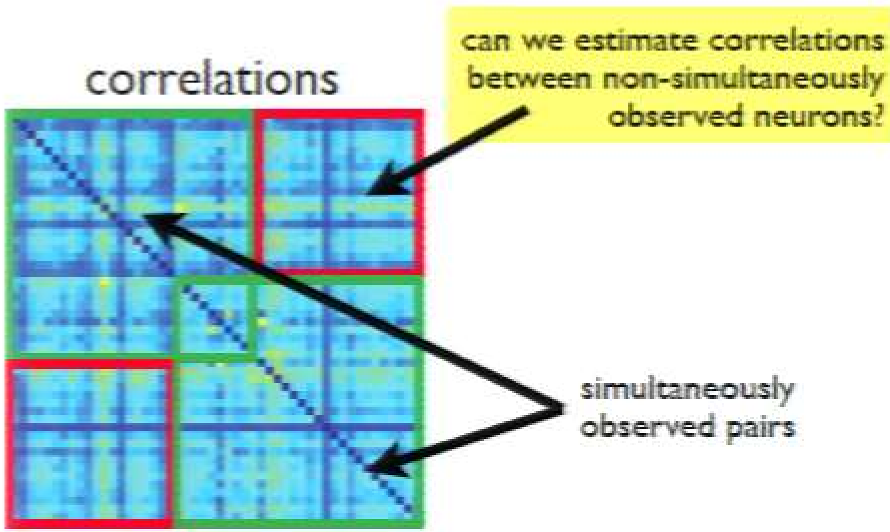

- there are fundamental limits to the number of neurons that can be simultaneously imaged.
- can we overcome these limits by "stitching" neural activity imaged in two different sessions?
- can we infer noise correlations between non-simultaneously imaged neurons?
- yes! with latent dynamical models

A common linear dynamical system is fit with missing observations to all recordings

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unobserved variable
observed variable
parameter

x_t: underlying neural activity

Gaussian innovation noise

$$\epsilon_t \sim \mathcal{N}(0, Q)$$

$$x_t = Ax_{t-1} + Bu_t + \epsilon_t$$

A: dynamics matrix ("functional couplings")

u_t: external stimulus drive

$y_t^{(i)}$: activity observed in imaging session i

$$y_t^{(i)} = C^{(i)} x_t + \eta_t$$

$$\eta_t \sim \mathcal{N}(0, C^{(i)} R C^{(i)\top})$$

$C^{(i)}$: observation matrix (sparse and known)

Gaussian observation noise

- we fit a common gaussian linear dynamical system with missing observations.
- state-space includes all neurons eventually observed.
- observation space is different for each recording session.
- online EM is used to speed up and improve convergence.

Model accurately predicts pairwise correlations

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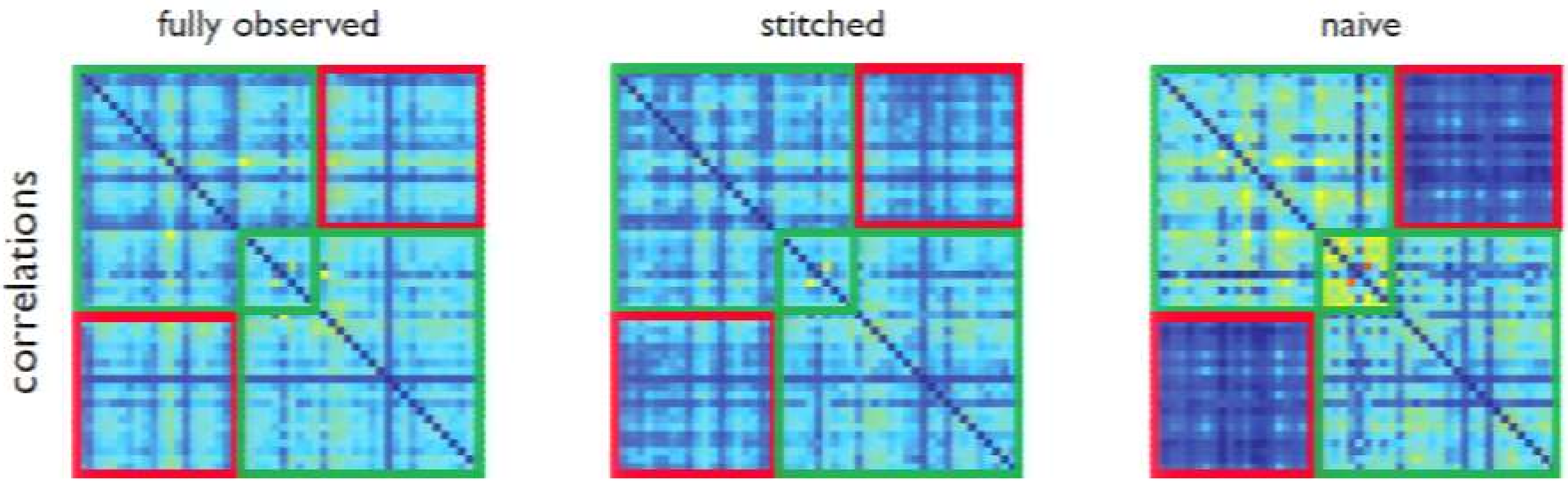
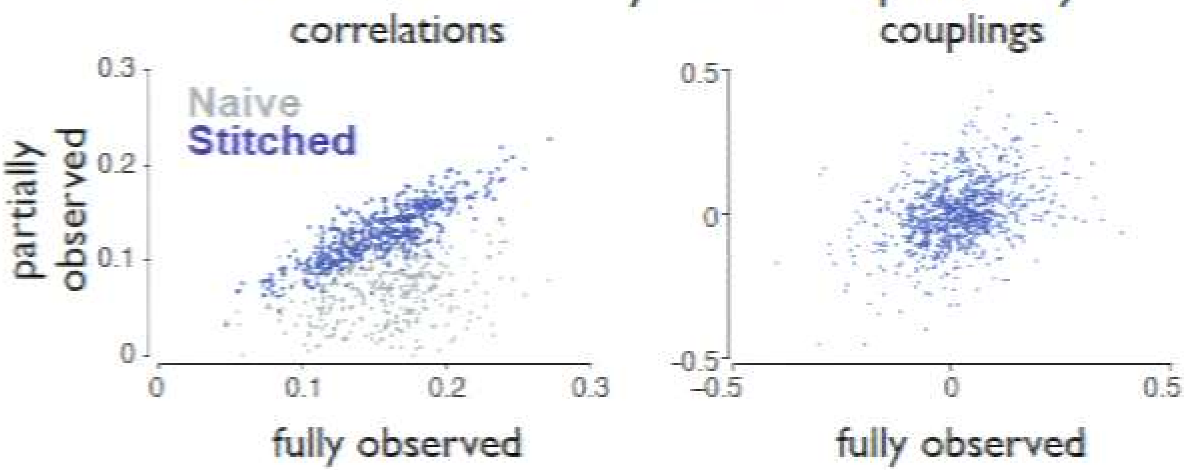
2-photon *in vivo* Ca++ imaging data
GCaMP6s, C2 barrel, anesthetized mouse somatosensory cortex

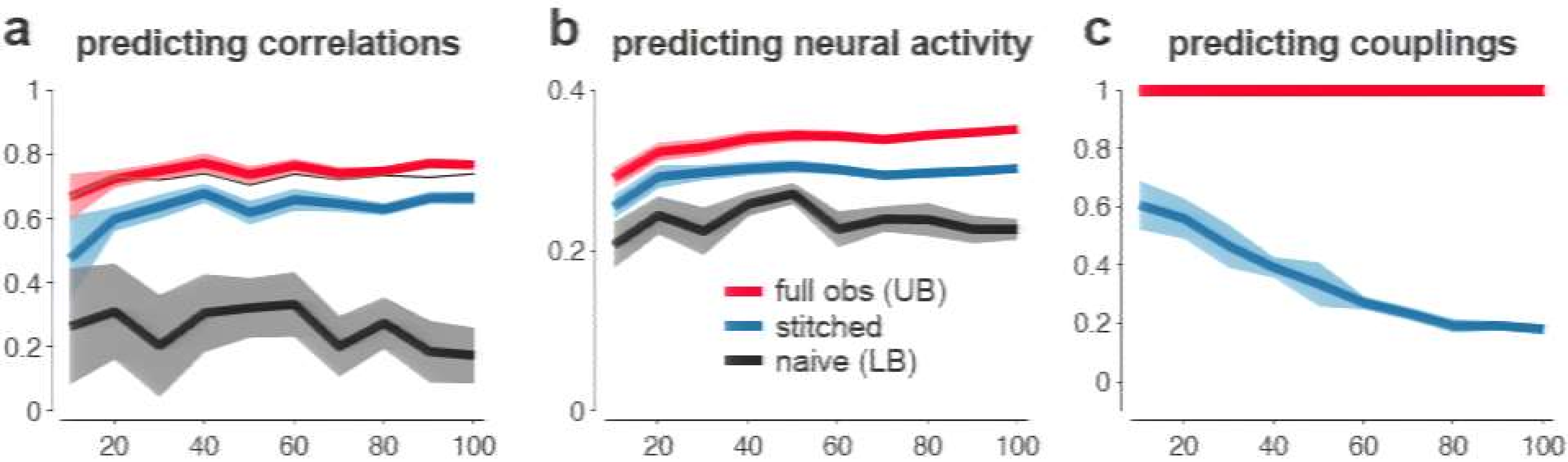


non-simultaneously observed pairs only



- pairwise correlations are well predicted by the model
- model parameters (couplings) are highly degenerate with many parameters yielding equally good predictions

Prediction performance improves for larger networks and approaches



Conclusions & outlook

- Latent dynamical models can be used to accurately "stitch" neural correlations across overlapping imaging sessions.
- The method is expected to work best when neural dynamics are low dimensional.
- We can now use this to "stitch" measurements from multiple experiments, resulting for the first time in a model of the tuning properties and correlations for a cortical column.

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