

# Exploring sex-specific neuroendocrine influences on the sensorimotor-association axis in single individuals



**MAX  
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**cognition**

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## BACKGROUND

- Large samples are increasingly used in human brain imaging to uncover generalizable population-level effects<sup>1</sup>
- Yet, little is known about day-to-day fluctuations in cortical organization within an individual<sup>2-4</sup>, including potential sex-specific factors that contribute to such transient changes
- Steroid hormones<sup>5-6</sup> and stress<sup>7</sup> are known neuromodulators, and vary across sexes<sup>8-9</sup>

We investigated sex-specific neuroendocrine and neurocognitive factors that may contribute to intra-individual daily variability

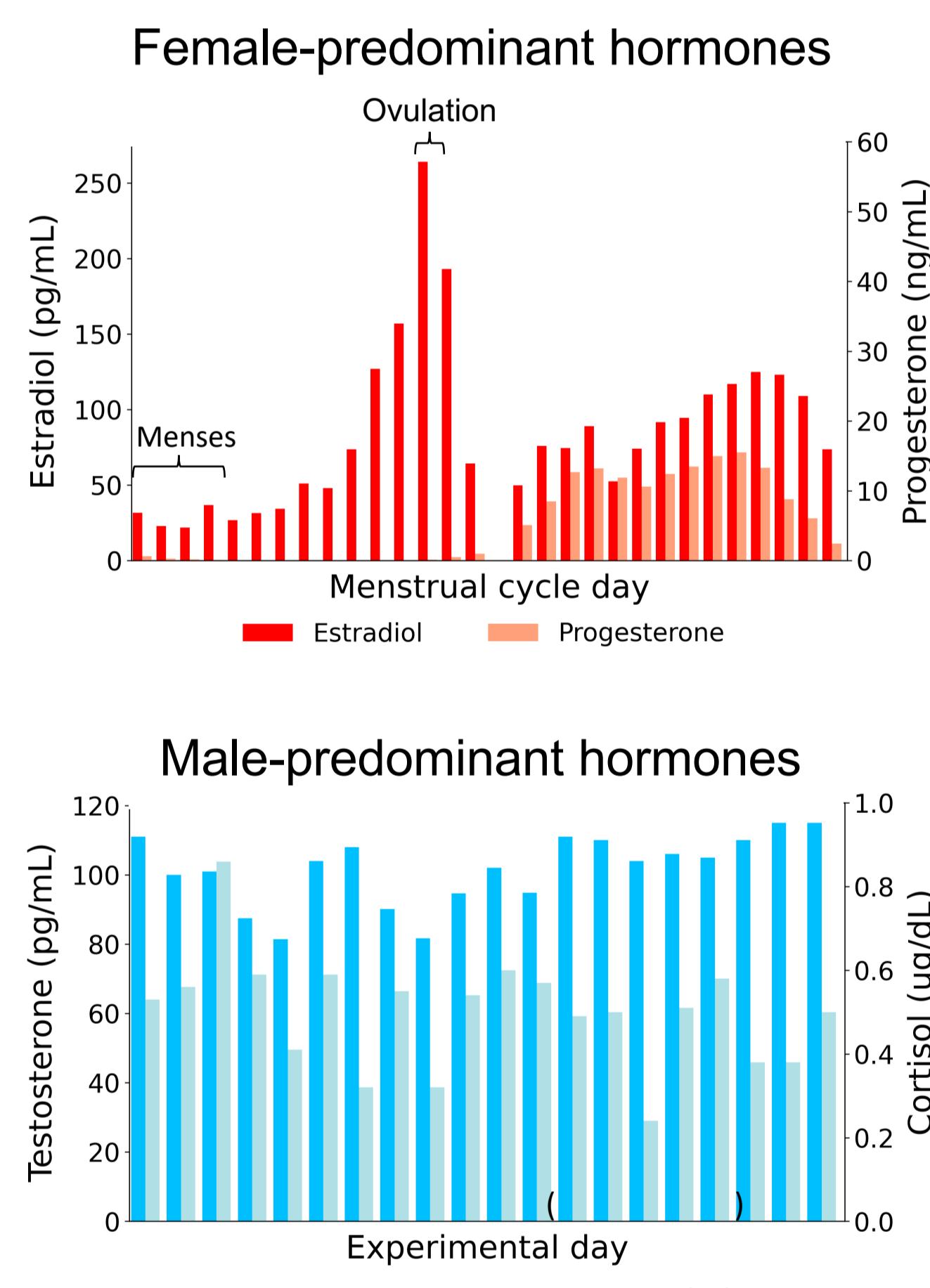
## METHODS

### Data

Daily sampling of:

1 female 10	1 male 11
Age: 23 years n = 29	Age: 26 years n = 20

- fMRI scans
- Self-reported perceived stress
- Steroid hormone levels via serum (F) and serum/salivary (M) sampling

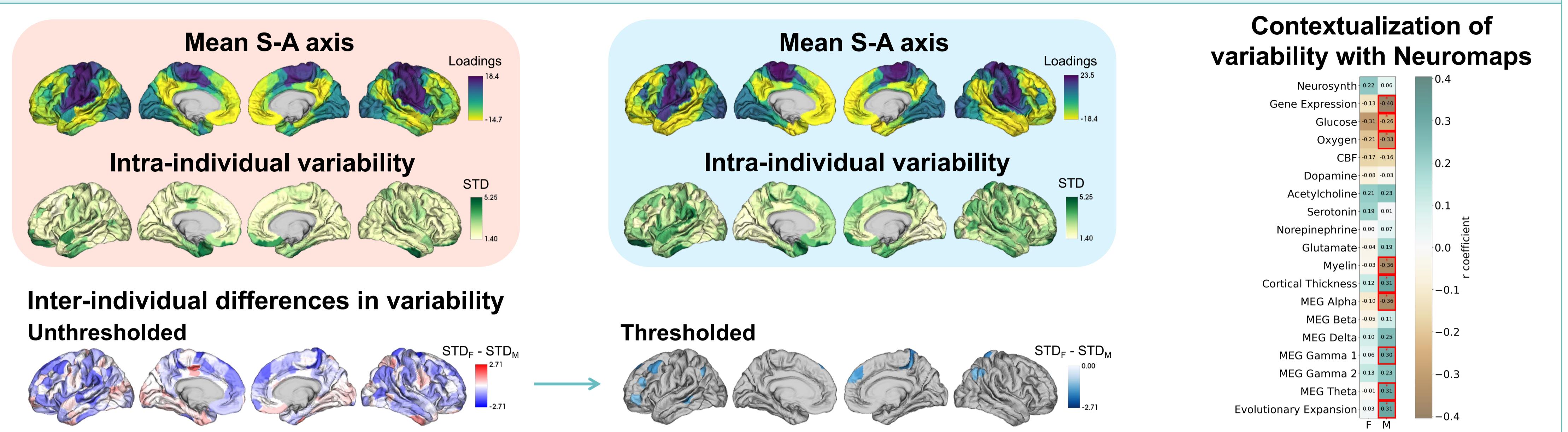


### Data Analysis

- Computed the sensorimotor-association (S-A) axis of functional organization by applying diffusion map embedding to reduce the dimensionality of functional connectivity matrices
- Quantified intra-individual variability in the S-A axis and tested for differences between participants
- Contextualized intra-individual variability in the S-A axis via spatial correlations with brain features from the Neuromaps<sup>12</sup> database
- Used linear regression to test for local- and system-level effects of steroid hormone levels and perceived stress on the S-A axis and network dispersion, respectively. Hormone models include:
  - A. Sex-predominant hormones
    - Estradiol & progesterone (F)
    - Testosterone (& cortisol) (M)
  - B. Common hormones across sexes
    - Estradiol & testosterone

## RESULTS

### Variability in functional cortical organization



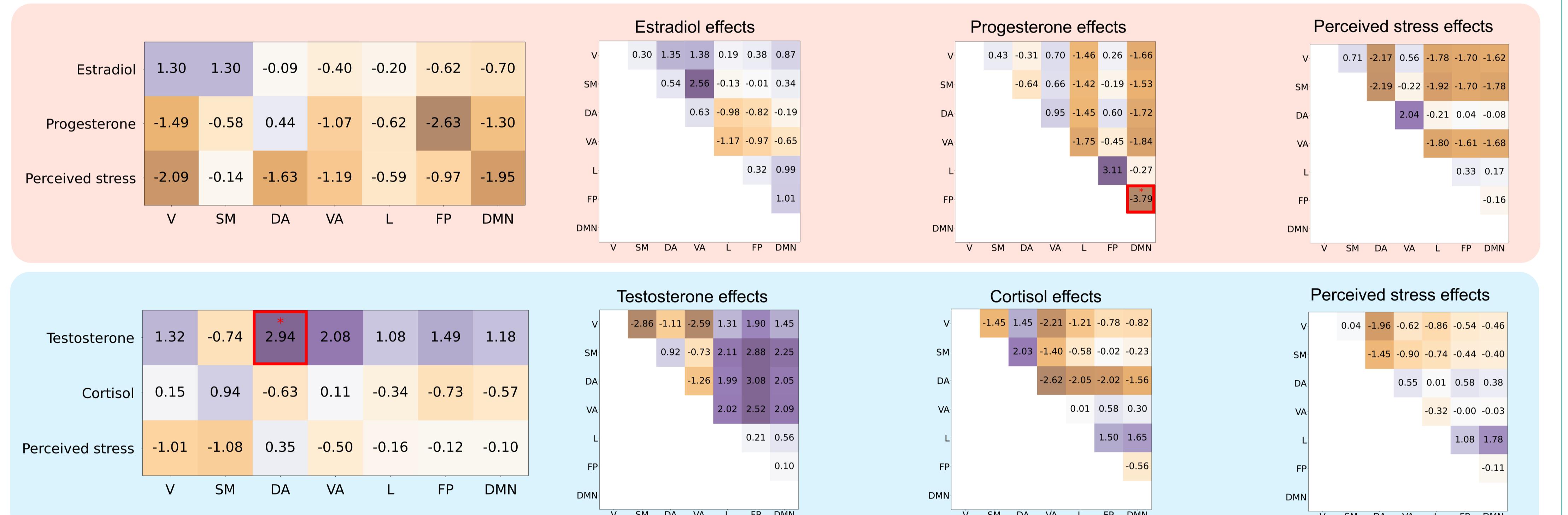
### Effects on intra-individual variability in functional cortical organization

#### System-level effects on network topology

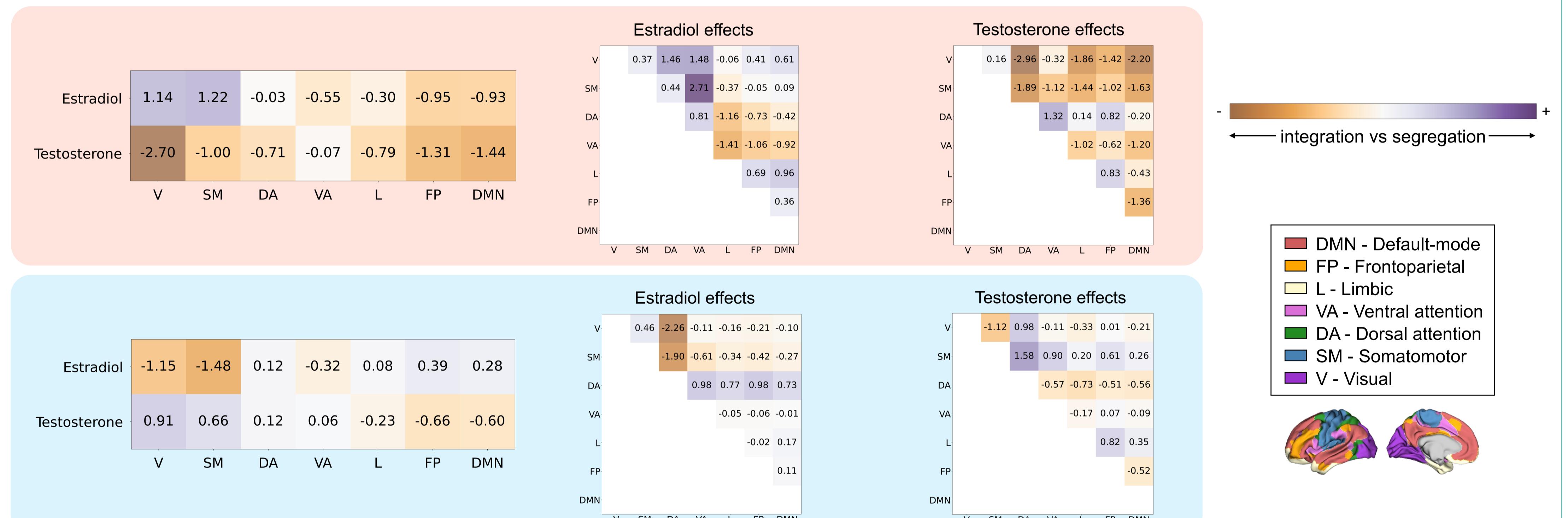
Within-network dispersion

Between-network dispersion

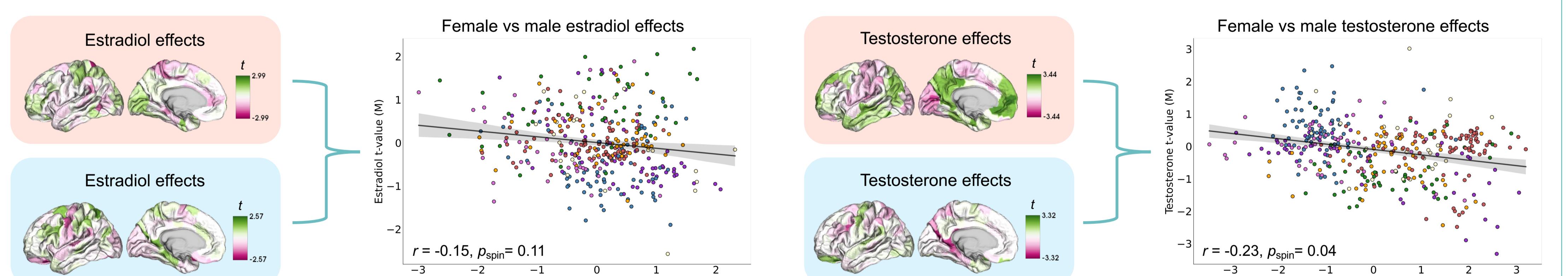
#### A. Sex-predominant hormones



#### B. Common hormones across sexes



### Local-level effects on the S-A axis



## DISCUSSION

- Daily variability was greatest in temporal limbic and ventral prefrontal regions in both participants, further extending across the cortex in the male subject
- Local- and system-level effects of steroid hormones and perceived stress on functional organization revealed weak but distinct effects across participants

Overall, our findings point to unique, potentially sex-specific, multilevel mechanisms contributing to intra-individual variability in functional cortical organization, warranting further investigation in large cohorts

- 1 Marek et al. (2022) *Nature*  
2 Laumann et al. (2015) *Neuron*  
3 Poldrack et al. (2015) *Nature Communications*  
4 Gordon et al. (2017) *Neuron*  
5 Woolley et al. (1990) *Journal of Neuroscience*  
6 Meffre et al. (2013) *Neuroscience*  
7 McEwen et al. (2015) *Nature Neuroscience*  
8 Bale & Epperson (2015) *Nature Neuroscience*  
9 Bale & Epperson (2017) *Neuropsychopharmacology*  
10 Pritschet et al. (2020) *NeuroImage*  
11 Grotzinger et al. (2023). *bioRxiv*  
12 Markello et al. (2022). *Nature Methods*