‘Silent’ olfactory bulb mitral cells emerge from common feature subtraction.

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Background

1. Recently [1] performed blind whole-cell patch clamp of MCs.
2. Spontaneous and odour-evoked activity were **inversely related.**
3. Cells with high baseline activity were often inhibited by odours.
4. **‘Silent cells’** had low baselines while highly excitable by odours.

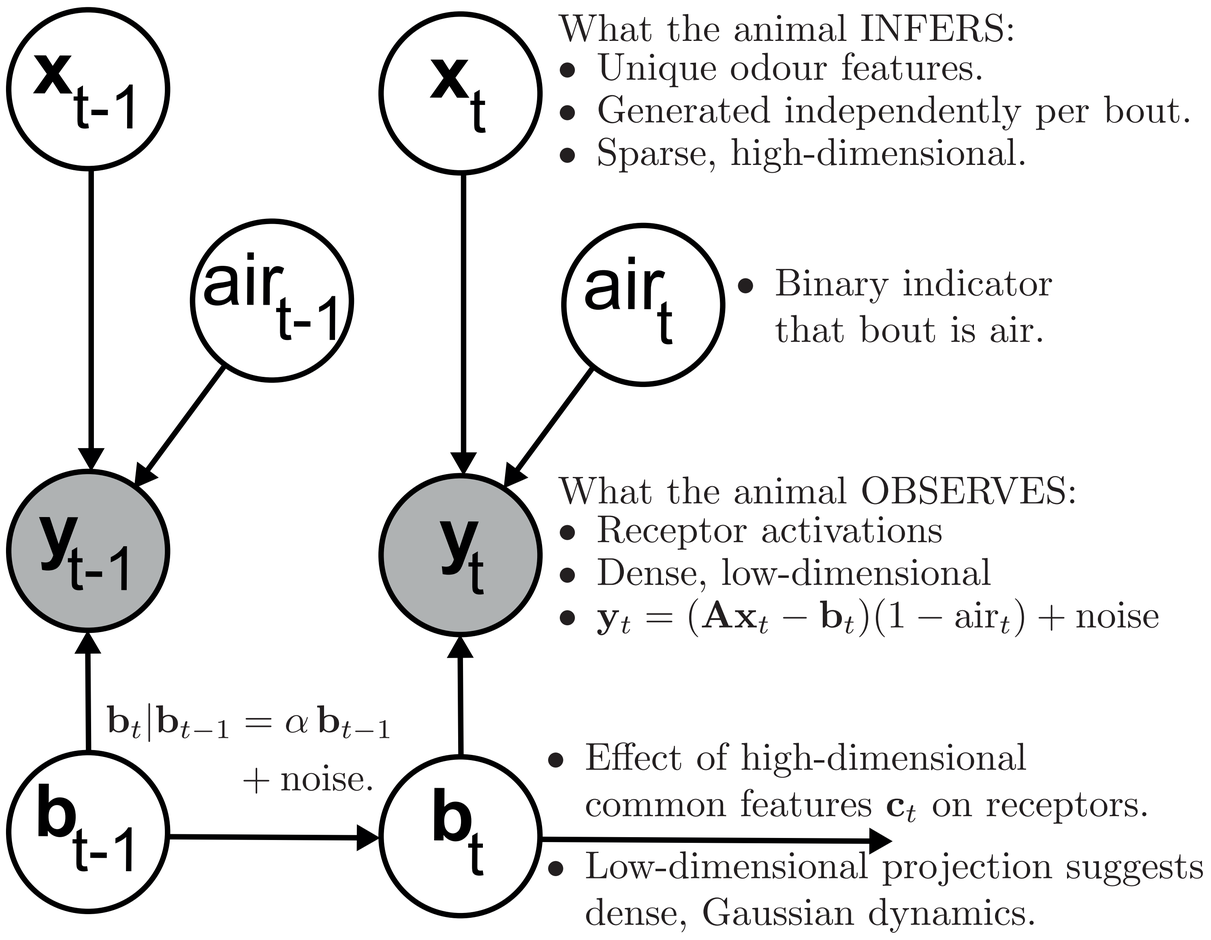
Model

1. Time discretized into O(1 sec.) bouts $t \in 1 \dots N$.
2. Each bout contains either odour or air.
3. Odours are sparse, high-dimensional.
4. Odour_t = unique features $\mathbf{x}_t$ + common features $\mathbf{c}_t$.
5. Unique features are generated independently per bout.
6. Common features change slowly over bouts.
7. Animal observes dense, low-D receptor activations $\mathbf{y}_t$.
8. Animal MAP infers unique features from receptor history: $\underset{\mathbf{x}_t}{\text{argmax}}\ p(\mathbf{x}_t|\mathbf{y}_1, \dots, \mathbf{y}_t)$.

Key Ideas

1. Common features $\mathbf{c}_t$ are high-D but are *not inferred*.
2. They are accounted for through their effect $\mathbf{b}_t$ on receptors.
3. Projection to low-D receptor space suggests Gaussian dynamics.
4. MC baselines reflect **negative** of expected receptor activations.
5. In odour, baseline removes component due to common features.
6. Unique features remain, infered by fast MC/GC dynamics à la [2].

Probabilistic Model



What the animal INFERS:
- Unique odour features.
- Generated independently per bout.
- Sparse, high-dimensional.

- Binary indicator that bout is air.

What the animal OBSERVES:
- Receptor activations
- Dense, low-dimensional
- $\mathbf{y}_t = (\mathbf{A}\mathbf{x}_t - \mathbf{b}_t)(1 - \text{air}_t) + \text{noise}$

- Effect of high-dimensional common features $\mathbf{c}_t$ on receptors.
- Low-dimensional projection suggests dense, Gaussian dynamics.

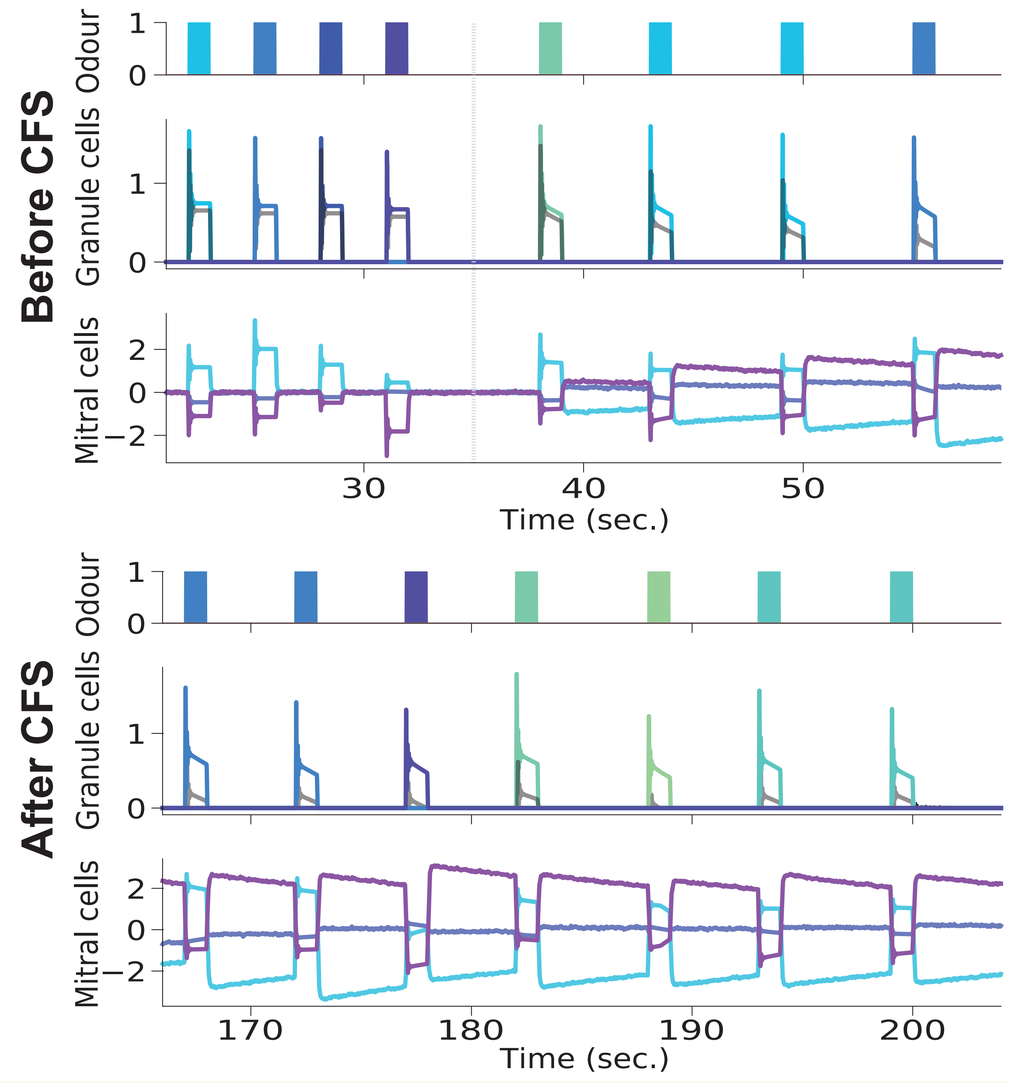
Neural Dynamics

$$\tau_\lambda \dot{\boldsymbol{\lambda}} = -\boldsymbol{\lambda} + (\mathbf{y} - \mathbf{A}\mathbf{x} + \alpha\mathbf{b})/\sigma^2_{\text{eff}} \quad \text{(MC voltage)}$$

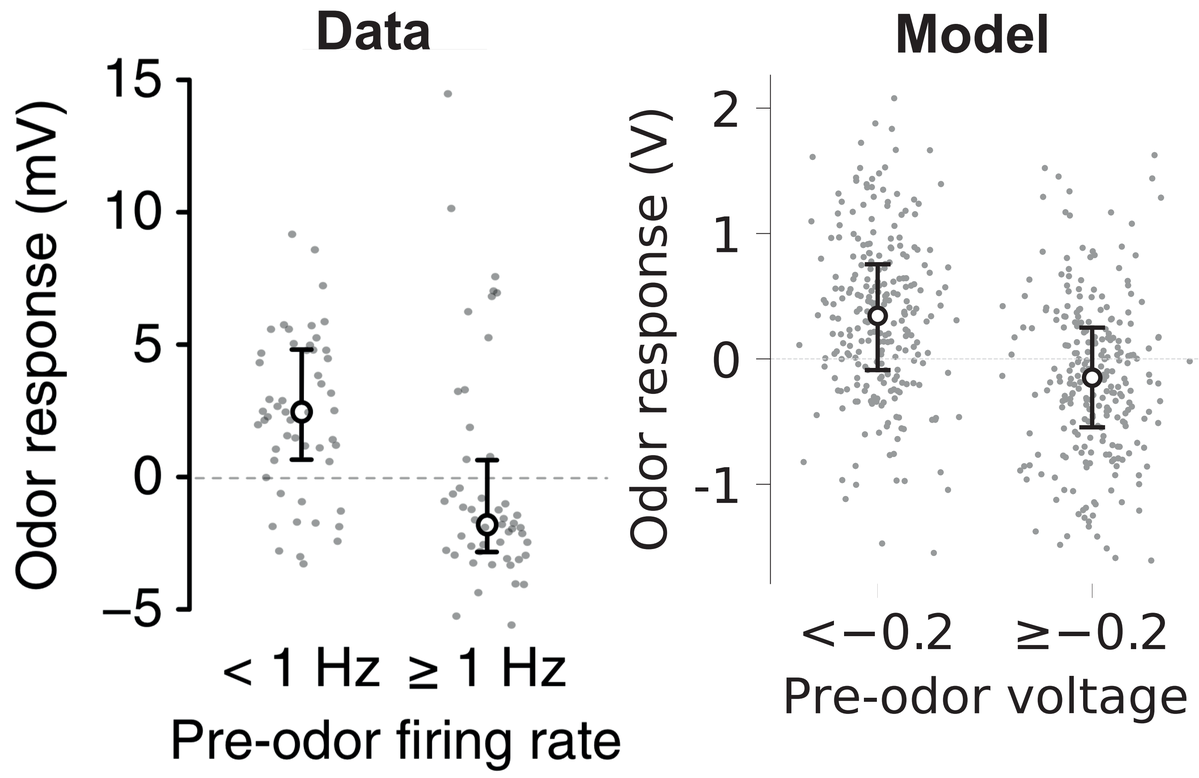
$$\tau_b \dot{\mathbf{b}} = -\mathbf{b} - (1 - \text{air}(t))\kappa\boldsymbol{\lambda} \quad \text{(MC baseline)}$$

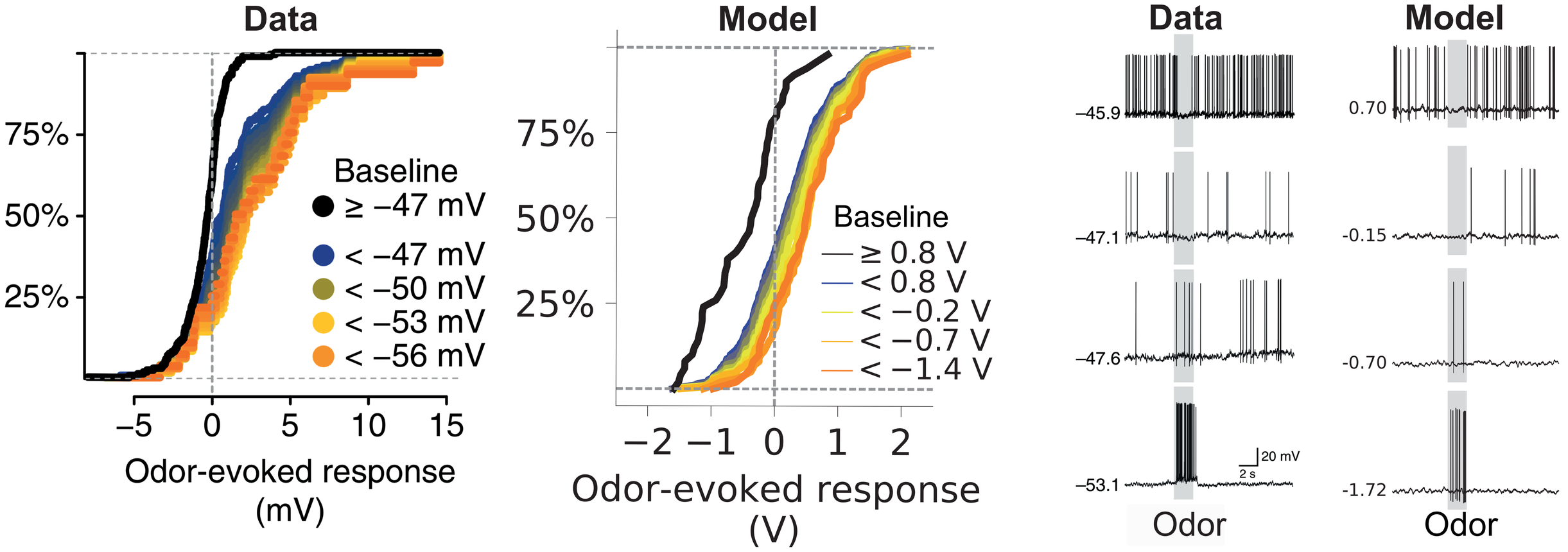
$$\tau_v \dot{\mathbf{v}} = -\mathbf{v} + \mathbf{A}^T\boldsymbol{\lambda} \quad \text{(GC voltage)}$$

$$\mathbf{x} = [\mathbf{v} - \beta]_+/\gamma \quad \text{(GC firing rate)}$$



Data vs. Model





References: [1] Kollo et al. *‘Silent’ mitral cells dominate odor responses in the olfactory bulb of awake mice*. Nature Neuroscience 2014.
[2] Tootoonian et al. *Sparse connectivity for MAP inference in linear models using sister mitral cells*. PLoS Computational Biology 2022.