Title

**Abstract**

blahhh blahhh blah

# Introduction

XXX

# Results

XXX

### first result

#### second result

# Discussion

We solved the brain.

# Models and methods

## Network model

Network consists of two subnetworks. Each subnetwork consists of a PE circuit, a memory neuron and a neuron representing the variance. XXX The memory neuron of subnetwork feefdowradly connects to the PE circuit of the second subnetwork.

### Prediction-error network model

Consider a mean field network in which each population is represented by one representative neuron. The mean-field PE network consists of an excitatory nPE and pPE neuron, as well as two inhibitory PV neurons (one receiving S, the other P), as well as inhibitory SOM and VIP neurons.

Each excitatory pyramidal cell (that is, nPE or pPE neuron) is divided into two coupled compartments, representing the soma and the dendrites, respectively. The dynamics of the firing rate $r_{\mathrm{E}}$ of the somatic compartment of obeys (**?** )

$$\tau_E \, \frac{dr_{\mathrm{E}}}{dt} = -r_{\mathrm{E}} + w_{\mathrm{ED}} \cdot r_{\mathrm{D}} - w_{\mathrm{EP}} \cdot r_{\mathrm{P}} + I_{\mathrm{E}}, \tag{1}$$

where $\tau_{\mathrm{E}}$ denotes the excitatory rate time constant ($\tau_{\mathrm{E}}$=60 ms), the weight $w_{\mathrm{ED}}$ describes the connection strength between the dendritic compartment and the soma of the same neuron, and $w_{\mathrm{EP}}$ denotes the strength of somatic inhibition from PV neurons. The overall input $I_{\mathrm{E}}$ comprises external background and feedforward sensory inputs (see "Inputs" below). Firing rates are rectified to ensure positivity.

The dynamics of the activity $r_{\mathrm{D}}$ of the dendritic compartment obeys (**?** )

$$\tau_E \, \frac{dr_{\mathrm{D}}}{dt} = -r_{\mathrm{D}} + w_{\mathrm{DE}} \cdot r_{\mathrm{E}} - w_{\mathrm{DS}} \cdot r_{\mathrm{S}} + I_{\mathrm{D}}, \tag{2}$$

where the weight $w_{\mathrm{DE}}$ denotes the recurrent excitatory connections between PCs, including backpropagating activity from the soma to the dendrites. $w_{\mathrm{DS}}$ represents the strength of dendritic inhibition from SOM neurons. The overall input $I_{\mathrm{D}}$ comprises fixed, external background inputs and feedback predictions (see "Inputs" below). We assume that any excess of inhibition in a dendrite does not affect the soma, that is, the dendritic compartment is rectified at zero.

Just as for the excitatory neurons, the firing rate dynamics of each interneuron is modeled by a rectified, linear differential equation (**?** ),

$$\tau_I \, \frac{dr_\mathrm{X}}{dt} = -\, r_\mathrm{X} + I_\mathrm{X} + w_\mathrm{XE} \cdot r_\mathrm{E} - w_\mathrm{XP} \cdot r_\mathrm{P} - w_\mathrm{XS} \cdot r_\mathrm{S} - w_\mathrm{XV} \cdot r_\mathrm{V}, \tag{3}$$

where $r_\mathrm{X}$ denotes the firing rate of neuron type $X$, and the weight matrices $w_\mathrm{XY}$ denote the strength of connection between the presynaptic neuron population $Y$ and the postsynaptic neuron population $X$ ($X, Y \in \{P, S, V\}$). The rate time constant $\tau_I$ was chosen to resemble a fast $\mathrm{GABA_A}$ time constant, and set to 2 ms for all interneuron types included. The overall input $I_\mathrm{X}$ comprises fixed, external background inputs, as well as feedforward sensory inputs and feedback predictions (see "Inputs" below).

### Memory and variance neuron

$$\tau_m \cdot \frac{dr_\mathrm{M}}{dt} = w_{\mathrm{M}\leftarrow\mathrm{pPE}} \cdot r_\mathrm{pPE} - w_{\mathrm{M}\leftarrow\mathrm{nPE}} \cdot r_\mathrm{nPE} \tag{4}$$

$$\tau_v \cdot \frac{dr_\mathrm{V}}{dt} = -r_\mathrm{V} + \left(w_{\mathrm{V}\leftarrow\mathrm{pPE}} \cdot r_\mathrm{pPE} - w_{\mathrm{V}\leftarrow\mathrm{nPE}} \cdot r_\mathrm{nPE}\right)^2 \tag{5}$$

### Weighted output

$$r_\mathrm{out} = \alpha \cdot S + (1 - \alpha) \cdot P \tag{6}$$

$$\begin{aligned} \alpha &= \frac{1/r_\mathrm{V1}}{1/r_\mathrm{V1} + 1/r_\mathrm{V2}} \\ &= \left(1 + \frac{r_\mathrm{V1}}{r_\mathrm{V2}}\right)^{-1} \end{aligned} \tag{7}$$

## Connectivity

## Inputs

## Simulations

# Acknowledgments

# Supplementary Information

## Analysis of simplified network model, effect of time constants

simplified model: dynamics and steady state of rM and rV, rM and rV as a function of time constants and trial duration etc., weighting, then use those expressions to discuss when weighting goes awry and how long transitions take from one state to another ...

## Analysis of requirements, perturbing PE neurons

symmetry of nPE and pPE necessary for memory neuron to represent mean .. shown for uniform, normal, gamma distribution

symmetry and effect = 1 necessary for variance neuron ... shown for uniform distribution, gamma distribution

effect of population of nPE and pPE neurons on mean and variance

effect of BL activity on mean and variance

effect of perturbations of nPE and pPE neurons on mean and variance

## Comparison to Kalman filter and Bayes Factor surprise

Comparison to Kalman filter Comparison to Bayes Factor surprise