Methods

We modeled the feedback circuits with rate equations where the output of neuron type (PN, KC, MBON, Lat. MBON, FBN, MBIN, and FB2N), , changed over time according to the equation

where , was a matrix with positive and negative values corresponding to the direct interactions between neurons as shown in the circuit schematics, was a nonnegative tonic input into neuron , is a stimulus input provided only to PNs midway through simulation, is a time constant, and parameters , and set the shape of the sigmoidal response. Equations were solved using *ode45* in Matlab (The Mathworks, Inc). Parameters were searched manually to identify values where neuronal rates showed a strong but slow transition as a function of varying *WKCs→MBON* between 0–1. For the high baseline activity case, for the FBN was increased to model a network state driving the FBN toward higher activity. In the figures for the topology without the FB2N, the terms providing input or output to the FB2N were set to 0, while all other parameters were kept the same. Specific parameter values can be found in the attached code.

No FB2N Figure Caption

A model of the role of an observed feedback circuit without an FB2N on modulating DAN activity.

**a**, Schematic of a compartment an inhibitory MBON, an excitatory FBN, and an excitatory MBON from a lateral compartment (Lat. MBON), but without an FB2N. The weight of connection from KCs to the MBON within the compartment is denoted *WKCs→MBON*. We modeled neuronal activity as a leaky integrator with logistic function response and identified parameters that showed strong dynamic range as a function of *WKCs→MBON*.

**b**, Steady state responses of neuron types to PN activation as a function of *WKCs→MBON* for the topology shown in **a**. Dots correspond to the parameters used in the examples shown in **c**.

**c**, Examples of the DAN response dynamics at the high, medium, and low *WKCs→MBON* values indicated in **b**.

**d**, DAN responses to activation of an MBON in high or normal baseline activity states of the FBN. Panels **b**,**c** used the low baseline state. High baseline was implemented by increasing the tonic excitation into the FBN.

**e**, Steady state responses of neuron types in the high baseline case to PN activation as a function of *WKCs→MBON* for the topology shown in **a**. Dots correspond to the parameters used in the examples shown in **f**.

**f**, Examples of the DAN response dynamics in the high baseline case at the high, medium, and low *WKCs→MBON* values indicated in **e**.