Title

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Abstract

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Results

A model framework that preserves ORN tuning, diversity, and adaptive feedback

The theoretical framework of odor discrimination consists of two stages: a biophysical model of odor binding and subsequent ORN firing – encoding – and a computational paradigm for then inferring odor identity and intensity from this repertoire of ORN response – decoding.

We encoding process is modeled as follows. Odorant molecules individually bind and unbind to distinct olfactory receptor neurons (ORNs), which are either active (firing) or inactive (quiescent) state. In the presence of an odor consisting of a few or more volatile compounds, the likelihood and rate of ORN spiking is dictated by two aspects. First, the probability that ORN binds a given molecular odorant depends on the identities of both the neuron and the odorant, as well as the neuron's state (active or inactive). Second, the likelihood that this binding event then incites an action potential depends on ORN-specific activation energies needed to open Na and Ca ion channels. Together, these comprise a stochastic process that translates the binding of odors of varying identities and concentrations into a repertoire of ORN response. We will first consider this system in steady state, later relaxing this assumption and letting the slower adaptive process proceed dynamically.

More words about the model and the functional forms here.

First, we show that the steady state response reproduces observed ORN tuning curves. It is known that olfactory receptors in *Drosophila* can range from narrowly tuned, responding to a single odorant, to quite broad, responding to various distinct odorants spanning multiple functional groups. We incorporate this diversity of response into our framework by treating the equilibrium disassociation constants of a odorant-receptor pair (i-a) as a random variable with pre-defined statistics. Actually, there are two disassociation constants, for the inactive and active receptor, respectively; however, for a large range of odor concentrations, the model dynamics are well dictated only by those of the active receptor, $K^*_{i,a}$, where the binding affinity is much higher. Accordingly, we only consider variations among these.

Figure **??** shows how a simple choice of statistics on $K^*_{i,a}$ can naturally produce a diverse repertoire of response closely mimicking observed *Drosophila* ORN tuning curves. The tuning curves, of which some are narrowly peaked and some are broad, are produced by sampling at two stages. For a given receptor a, $K^*_{i,a}$ are chosen uniformly in some range (this dictates how receptor a responds to distinct odorants), while diversity among receptors is incorporated by sampling the bounds of each range from a hyperdistribution, also chosen uniform. Receptors with narrow ranges produce peaked tuning curves (the orange receptor in Fig. (XX)), while and those with broader ranges produce more disperse tuning curves (blue receptor).

These tuning curves are maximum responses. On the other hand, it has recently been demonstrated that *Drosophila* ORNs adapt their firing rates in accordance with the Weber-Fechner law. Specifically, the sensitivity, or gain, of the receptor scales inversely with mean odor concentration, and this scaling holds across receptor and odorant identities. In our model, we incorporate this adaptive mechanism by assuming that the firing rate feeds back on the sensory machinery through the receptor free energies, ϵ_m, required to produce an action potential event. Strictly speaking, ϵ_m are single parameter simplifications of the full dissipative process of cation inflow and membrane depolarization prior to an action potential. Nonetheless, they Explain why ok here.

The Weber-Fechner law is naturally incorporated into the framework of our model by scaling ϵ_m logarithmically with the mean odor concentration (between fixed outer bounds ϵ_{L} and ϵ_{H}). While naturalistic odors are not comprised of pure odorants, rather combinations a few or several such constituent species, even this simple mechanism of gain control can largely preserve

We incorporate this adaptive mechanism into our

The second stage of the framework is odor discrimination, which exploits a

The second major result

Equations can be referenced such as equation (1) and other papers as well [**?**]. References that only appear in the supplementary materials (figure captions, etc.) or online methods section will follow the reference numbering of the main text and appear at the end of the main reference list. Fusce mauris. Vestibulum luctus nibh at lectus. Sed bibendum, nulla a faucibus semper, leo velit ultricies tellus, ac venenatis arcu wisi vel nisl. Vestibulum diam. Aliquam pellentesque, augue quis sagittis posuere, turpis lacus congue quam, in hendrerit risus eros eget felis. Maecenas eget erat in sapien mattis porttitor. Vestibulum porttitor. Nulla facilisi. Sed a turpis eu lacus commodo facilisis. Morbi fringilla, wisi in dignissim interdum, justo lectus sagittis dui, et vehicula libero dui cursus dui. Mauris tempor ligula sed lacus. Duis cursus enim ut augue. Cras ac magna. Cras nulla. Nulla egestas. Curabitur a leo. Quisque egestas wisi eget nunc. Nam feugiat lacus vel est. Curabitur consectetuer.

Important results in the supplementary data (Supplementary Fig. 1). Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

Discussion

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End Notes

Acknowledgements This work was supported by NIH grants Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicula hendrerit sem. Duis non odio. Morbi ut dui. Sed accumsan risus eget odio. In hac habitasse platea dictumst. Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat. Morbi quis dolor. Donec pellentesque, erat ac sagittis semper, nunc dui lobortis purus, quis congue purus metus ultricies tellus. Proin et quam. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Praesent sapien turpis, fermentum vel, eleifend faucibus, vehicula eu, lacus.

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Figure Legends

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Online Methods

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Place fields. The spatial information content [?] of spiking activity was computed as

$$I = \sum_{i=1}^{N} p_i \, \frac{r_i}{R} \, \log_2 \left(\frac{r_i}{R} \right) \tag{1}$$

where p_i is the occupancy probability and r_i is the average firing rate of the ith bin, and R is the average firing rate for the session.

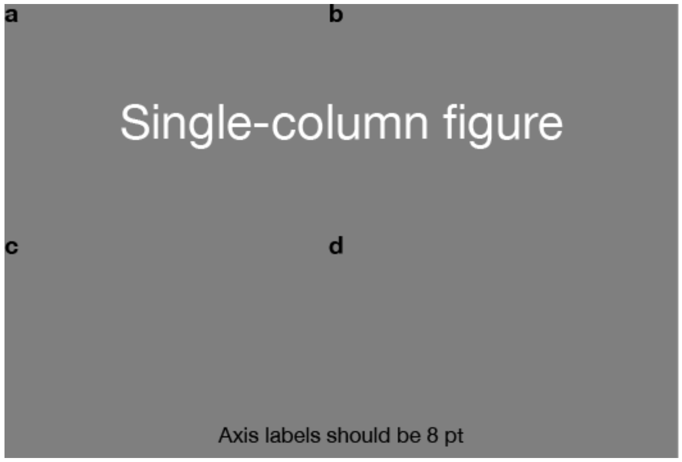

Figure 1

Supplementary Figure Legends

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Supplementary Information | Title

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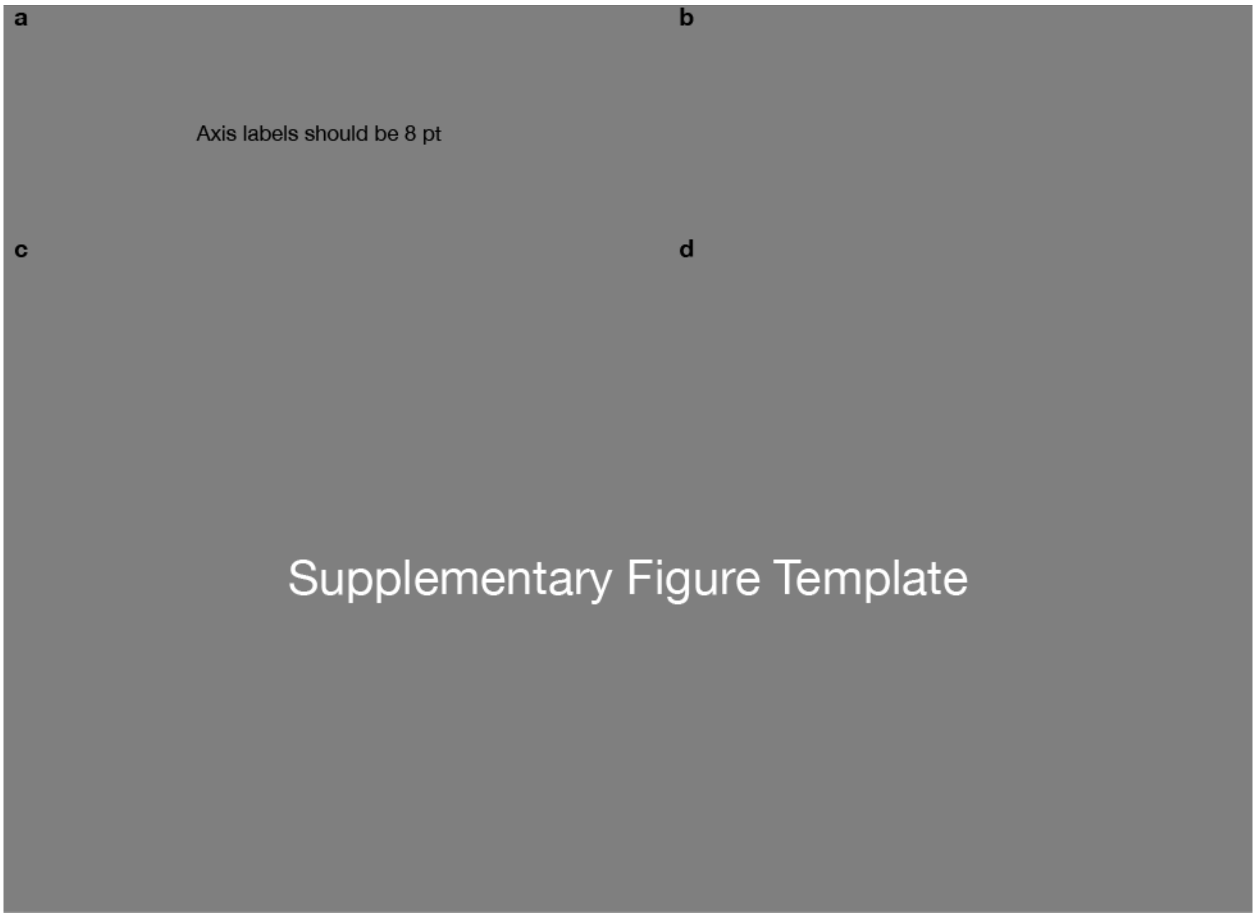
   Supplementary Figures and Legends 1–N; Supplementary Table 1

   Supplementary Figures and Legends 1–N and a Supplementary Table with some important numbers.

Supplementary Information | Title

First Author, Second Author, Corresponding Author

Supplementary Figures



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Supplementary Tables

Supplementary Table 1 | Cell and sample counts by anatomical area.

Anatomical Region	Aspect	Cells	Samples
ABC	Anterior	100	400
	Medial	50	200
	Posterior	80	320
		230	920
XYZ	Anterior	60	240
	Medial	40	150
	Posterior	50	210
		150	600
Total		380	1,520