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The role of disorder in olfactory sensing

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Olfactory systems perform the remarkable task of sensing a rich and dynamic space of volatile molecules with a limited set of receptors. To support relevant behaviors, this sensing must provide a faithful embedding of the input space that maps similar odors onto similar receptor representations. We show that disordered sensing—in which a single receptor binds to many odorants, and many receptors bind to any given odorant—is an efficient strategy for faithfully encoding complex odor mixtures with a limited set of receptors. This strategy exploits a key feature of olfactory signals: natural odors are composed of a relatively small combination of all possible monomolecular odorants, and are thus sparse in the space of molecules. Importantly, the proposed strategy does not require any fine-tuning to the detailed structure of the olfactory signals. When combined with downstream processing, we show that this strategy supports flexible associations between odor signals and behaviors. Finally, we provide empirical evidence that the olfactory system implements this sensing strategy.