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How the brain assigns a neural tag to arbitrary points in a high-dimensional space[1]

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Brains in almost all organisms need to deal with very complex stimuli. For example, most mammals are very good at face recognition, and faces are very complex objects indeed. For example, modern face recognition software represents a face as a point in a 10,000 dimensional space. Every human must be able to learn to recognize any of the 7 billion faces in the world, and can recognize familiar faces after a display of the face is viewed for only a few hundred milliseconds. Because we do not understand how faces are assigned locations in a high-dimensional space by the brain, attacking the problem of how face recognition is accomplished is very difficult. But a much easier problem of the same sort can be studied for odor recognition. For the mouse, each odor is assigned a point in a 1000 dimensional space, and the fruit fly assigns any odor a location in only a 50 dimensional space. A fly has about 50 distinct types of odorant receptor neurons (ORNs), each of which produce nerve impulses at a specific rate for each different odor. This pattern of firing produced across 50 ORNs is called 'a combinatorial odor code', and this code assigns every odor a point in a 50 dimensional space that is used to identify the odor. In order to learn the odor, the brain must alter the strength of synapses. The combinatorial code cannot itself by used to change synaptic strength because all odors use same neurons to form the code, and so all synapses would be changed for any odor and the odors could not be distinguished. In order to learn an odor, the brain must assign a set of neurons — the odor tag — that have the property that these neurons (1) should make use of all of the information available about the odor, and (2) insure that any two tags overlap as little as possible (so one odor does not modify synapses used by other odors). In the talk, I will explain how the olfactory system of both the fruit fly and the mouse produce a tag for each odor that has these two properties.

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