The sense of smell uses fast dynamics to encode odors

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Neuroscientists from the John B. Pierce Laboratory and Yale School of Medicine have discovered that mice can detect minute differences in the temporal dynamics of the olfactory system, according to research that will be published on December 16 in the open access journal *PLOS Biology*.

The research team used light in genetically-engineered mice to precisely control the activity of neurons in the olfactory bulbs in mice performing a discrimination task. This approach to controlling neural activity, called optogenetics, allows for much more precise control over the activity of neurons of the olfactory system than is possible by using chemical odors. The "light-smelling" mice were able to detect differences as small as 13 milliseconds between the dynamics of these "virtual odors".

Because olfactory bulbs exhibit dynamic neural activations in the range of many tens of milliseconds, the 13 millisecond detection limit suggested that mice should be able to discriminate these dynamics. The researchers tested this hypothesis by recording brief "movies" of the dynamic activity in the olfactory bulbs of one group of mice and projecting them back onto the olfactory bulbs of another group of naïve mice. The naïve mice were indeed able to discriminate between the movies, demonstrating that the neural dynamics of the bulb contain fundamental information about odors.

"This data is very exciting as it shows for the first time that the temporal dynamics of bulbar neural activity are meaningful to the animal", remarked Associate Professor Justus Verhagen, the lead author on the paper. "Before optogenetics arrived as a new tool we had no means to test if this was true, we could read out the dynamic activity but could not impose it back on the brain and ask questions about its role in odor discrimination ".

These new findings build upon earlier evidence that olfactory processing in mice included temporal information about sniffs. "We knew from prior work by the team of Dr. Dima Rinberg that mice could accurately determine when their olfactory system was stimulated relative to the timing of sniffs. We now know that mice can also obtain this information directly by comparing the timing of activities among neurons. We hence think that the neural population dynamics are

important for the sense of smell both independently of and relative to sniffing. Thus, a sniff can be the "start" signal from which the brain begins to analyze the times at which different neurons turn on, but the brain can also do this independently of the sniff by using the earliest neural activations themselves as "start" signals. Combined these mechanisms provide for a very robust means for the brain to use time information. However, we don't yet know how these two forms of temporal information may interact".

Dr. Verhagen's lab is one of several at Yale and the John B. Pierce Laboratory that are studying the neurobiology of food and flavor perception. His lab is unique in applying the power of optogenetics in mice to study the spatio-temporal capabilities of the olfactory neural circuitry that underlies these vital perceptual functions.

More information: Rebello MR, McTavish TS, Willhite DC, Short SM, Shepherd GM, et al. (2014) Perception of Odors Linked to Precise Timing in the Olfactory System. *PLoS Biol* 12(12): e1002021. DOI: 10.1371/journal.pbio.1002021

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