Title: Spatial maps in piriform cortex during olfactory navigation

Authors: Cindy Poo[1]*, Gautam Agarwal[2], Niccolò Bonacchi[1], Zachary Mainen[1]

[1]Champalimaud Foundation, Lisbon, Portugal.

[2]W. M. Keck Science Center, The Claremont Colleges, Claremont, CA, USA.

Abstract:

Odors are a fundamental part of the sensory environment used by animals to guide behaviors such as foraging and navigation. Animals instinctively use odor memories to guide spatial choices[9] and odors are widely used in the study of spatial memory and navigation[10]. Cortical structures for odor perception and spatial memory are evolutionarily and developmentally linked, together forming an allocortex (consisting of olfactory, hippocampal, and entorhinal cortices). Olfaction and spatial memory systems are therefore intimately related, as reflected by animal behavior, evolution, and circuit anatomy. Moreover, while the primary olfactory (piriform) cortex receives direct sensory input via olfactory bulb projection neurons, its three-layered circuit architecture shares striking resemblances to the hippocampus, with broadly distributed and unstructured recurrent connections that are highly plastic. This has prompted conjectures that these structures implement similar learning functions. Here, using neural ensemble recordings in freely moving rats performing an odor-cued spatial choice task, we show that posterior piriform cortex neurons carry a robust spatial representation of the environment. Piriform spatial representations have features of a learned cognitive map, being most prominent near odor ports, stable across behavioral contexts, and independent of olfactory drive or reward availability. The accuracy of spatial information carried by individual piriform neurons was predicted by the strength of their functional coupling to the hippocampal theta rhythm. Ensembles of piriform neurons concurrently represented odor identity as well as spatial locations of animals, forming an odor-place map. Our results reveal a previously unknown function for piriform cortex in spatial cognition and suggest that it is well-suited to form odor-place associations and guide olfactory-cued spatial navigation.