Long-term noradrenergic modulation of glomerular processing in the main olfactory bulb

Dennis Eckmeier[1*] and Stephen D. Shea[1]

- [1]Cold Spring Harbor Laboratory, USA

Many mammals discriminate individual conspecifics through detection of chemical cues using the olfactory systems. In mice and several other mammals, certain forms of social memory involve plasticity in the main olfactory bulb (MOB). Social encounters are associated with elevated release of the neuromodulator noradrenaline (NA) from the brain stem nucleus 'locus coeruleus' (LC), which is believed to trigger MOB plasticity underlying memory. Previously, we induced social memories in anesthetized mice by pairing activation of LC with conspecific urine from unfamiliar mice. In a subsequent behavioral test, mice treated the 'paired urine' as if it were a familiar stimulus (exhibiting reduced interest) while they treated the 'unpaired urine' as if it were a novel stimulus. Remarkably, this behavior was reflected by correlated changes to the responses of individual M/T. We are examining how NA-dependent memories are stored among populations of glomeruli, and whether the storage mechanisms involve regulation of presynaptic and/or postsynaptic activity in the glomeruli. As an initial step, we measured odor-driven activity in populations of glomeruli on the dorsal surface of the MOB by widefield optical imaging of intrinsic signals. Intrinsic signals are correlated with activity in olfactory sensory neurons (OSNs) and likely largely reflect presynaptic input to the MOB. We presented several odors before, during and after pairing 30 presentations of one odor with a 20 s, 5Hz, 40 µA electrical stimulus train to LC. The population response (n=127 glomeruli; 9 animals) significantly shifted after LC stimulation, while sham controls (n=88 glomeruli; 4 animals) exhibited no change. Most (73.23%) glomeruli showed response suppression (n=93, median 62% suppression), however, many (21.26%) glomeruli increased the strength of their response (n=27, median 125% increment). This raises the possibility that the observed glomerular changes occur through presynaptic modulation of the OSN-M/T synapse. We also find that surprisingly, pairing odors with LC activation leads to a sparsening rather than uniform suppression of the population response. We are working to confirm and extend our findings by selective measurement of the activity in several glomerular processing circuits using fluorescent activity markers (GCaMP2/3 and synaptopHluorin) expressed in various cell populations including OSNs. We are also investigating the stimulus-specificity of the effect.

Acknowledgements

supported by an award from the Klingenstein Foundation to SDS.

Keywords: olfaction, main olfactory bulb, rodents, mouse, neuromodulation, noradrenaline, social, individual recognition