



GABA-Glutamate supramammillary neurons control theta and gamma oscillations in the dentate gyrus during REM sleep

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We identified a population of neurons in the lateral supramammillary nucleus (SuML) innervating the dorsal DG that display a dual GABAergic and glutamatergic neurotransmission. These GABA/GLU SuML-DG neurons could support the increase of theta and gamma power in the DG observed during REM sleep and modulate DG network activity during this state. Indeed we show that this population of SuML-DG neurons co-express markers for both GABAergic (glutamate decarboxylase 65, GAD65 and the vesicular GABA transporter, VGAT) and glutamatergic (vesicular glutamate transporter 2; VGLUT2) neurotransmissions, establish symmetric (inhibitory) and asymmetric (excitatory) synapses and co-release GABA and glutamate on DG granule cells. Activation of these SuML-DG projections increase theta power and frequency as well as gamma power in the DG specifically during REM sleep and increase the activity of a subset of DG granule cells. The function of inhibition exerted by SuML-DG neurons in the control of DG network activity will be discussed.