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Neural circuits that mediate drinking

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It has long been known that orofacial movements for feeding can be triggered, coordinated, and often rhythmically organized at the level of the brainstem, without input from higher centres. Here, we uncover two neuronal substrates for such a function. These two nuclei, $IRt^{Phox2b}$and $Peri5^{Atoh1}$, express the panautonomic homeobox gene Phox2b and are located, respectively, in the intermediate reticular formation of the medulla and the peri-trigeminal region of the pons. Using trans-synaptic viral tracing from lingual and supra-hyoid muscles, we show that both nuclei are directly premotor to all jaw-opening and tongue muscles, in a highly collateralized fashion. Optogenetic stimulation of either nucleus, in awake head-fixed animals, using short light pulses opens the jaw, while the IRt^{Phox2b} also protracts the tongue. Moreover, sustained photostimulation of the IRt^{Phox2b} entrains a rhythmic alternation of tongue protraction and retraction, synchronized with jaw opening and closing, that mimics lapping. Furthermore, photometry recordings in behaving mice, reveal that the IRt^{Phox2b} is indeed active during bouts of volitional lapping. Finally, using monosynptic tracing we identify the IRt^{Phox2b} as a premotor relay for many diverse brain regions, including the cerebellum, superior colliculus, and motor cortex. Our study identifies one of the subcortical nuclei underpinning a stereotyped feeding behaviour.

Note*All surgical procedures were conducted under isoflurane anaesthesia @2%, via inhalation.