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BEHAVIOURAL NEUROSCIENCE

# Picking up the pups

Oxytocin (OXT) is thought to act centrally to influence social behaviours such as pup retrieval in mice: maternal mice retrieve pups that are isolated from the nest in response to their distress calls. Virgin female mice given OXT centrally learn to retrieve pups, but the mechanism is unknown. In a new study, Marlin *et al*. show that OXT tunes the responses of neurons in the left auditory cortex (LAC) to pup calls, thus promoting pup retrieval by virgin female mice.

The authors confirmed previous findings that virgin mice injected systemically with OXT retrieved isolated pups faster than did saline-injected virgins. Using various fluorescent labelling techniques, the authors found that OXTergic neurons from the paraventricular nucleus of the hypothalamus (PVN) project to the AC, and that some neurons in the AC express the OXT receptor (OXTR). Interestingly, more OXTR-positive cells were found in the LAC than in the right auditory cortex of dams or virgins, suggesting that the influence of OXT on the AC may be lateralized.

The GABA agonist muscimol or OXT antagonists injected into the LAC inhibited pup retrieval by virgin mice, whereas OXT injection into the LAC had the opposite effect. Importantly, infusion of OXT antagonists into the LAC did not affect the tendency of dams to retrieve pups, indicating that OXTergic signalling in the LAC is important for the learning, but not for the performance, of pup retrieval.

Comparison of whole-cell recordings from the LAC of dams, experienced virgins and naive virgins showed that LAC spiking responses to pup calls were stronger and more precisely timed in dams and experienced virgins than in naive virgins; however, voltage-clamp recordings showed that pup-call-evoked synaptic responses of LAC neurons were comparable among the different groups, implying that the stronger LAC response in dams was not due to increased excitation. Rather, the responses to pup calls showed greater excitatory–inhibitory (E–I) balance — that is, the excitatory and inhibitory responses exhibited similar temporal profiles and amplitudes — in dams and experienced virgins than in naive virgins.

To determine the role of OXT in achieving this E–I balance, the authors took recordings of LAC neurons in mice before, during and after paired exposure to pup calls and OXT (which was either injected topically or released from optogenetically stimulated PVN neurons). Before pairing, the patterns of inhibitory and excitatory postsynaptic potentials (IPSCs and EPSCs, respectively) did not reliably correspond to the pup calls. During and ~15 minutes after pairing, pup-call-evoked IPSCs were reduced, EPSCs were strengthened and spiking frequency was increased. By ~45 minutes after pairing, the amplitudes of pup-call-evoked IPSCs had increased to balance those of the potentiated EPSCs, and spiking responses were increased and more reliably tuned to the calls across trials.

Together, these findings indicate that OXT balances excitation and inhibition in the LAC to enable better-tuned spiking responses to pup calls. The authors suggest that OXT might similarly modulate activity in other sensory cortices to shape social behaviours.

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**ORIGINAL RESEARCH PAPER** Marlin, B. J. *et al.* Oxytocin enables maternal behaviour by balancing cortical inhibition. *Nature* **520**, 499–504 (2015)

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