
Credit: StockPlanets/Getty

To test this, the authors chemogenetically silenced PL neurons during fear conditioning. In these animals, light-driven activation of PL cells that were TRAPed during memory retrieval on day 14 did not produce an increase in freezing behaviour at day 28, suggesting that the activation of PL neurons during learning is essential for memory retrieval at remote time points.

Lastly, the authors looked at which brain areas downstream of the PL cortex might participate in remote memory retrieval and found that a number of cortical and subcortical brain areas were densely innervated by TRAPed neurons. However, neuronal activity in the PL during memory retrieval at 14 days was more likely to co-vary with cortical target regions than subcortical regions, whereas the reverse was the case at 1 day after fear conditioning, suggesting an increasing importance for cortical regions in remote memory retrieval.

Together, these data suggest that the time-dependent reorganization of PL neuron ensembles and functional recruitment of cortical areas are crucial for the development and expression of remote fear memories in mice.

Sian Lewis

ORIGINAL ARTICLE Denardo, L. A. et al. Temporal evolution of cortical ensembles promoting remote memory retrieval. *Nat. Neurosci.* https://doi.org/10.1038/s41593-018-0318-7 (2019)

mice typically exhibit infanticidal behaviour. The authors found that stimulation of GABAergic neurons in the MeA in virgin female mice increased pup grooming. In virgin male mice, however, stimulation of these neurons drove infanticidal behaviour, suggesting that the MeA regulates sexually dimorphic pup-directed behaviours.

Fibre-photometric measurement of neural activity in MeA GABAergic neurons in freely behaving mice showed an increase in their activity during pup interactions in both males and females. However, this activity was markedly higher during infanticidal behaviours in virgin males than in any animals engaged in pup grooming, suggesting that these opposing behaviours are regulated in an activity level-dependent manner.

To further examine this possibility, the authors investigated the effects of stimulating MeA neurons at different intensities on behaviour. Changing the intensity of laser stimulation did not alter the parenting behaviour of female mice. However, in both virgin males and fathers, high stimulation intensities drove infanticidal behaviours, whereas low stimulation intensities resulted in pup grooming.

This finding suggested that there may be sex differences in the neuronal composition or other features of the MeA. The authors carried out single-cell RNA sequencing of more than 44,000 MeA cells from males and females to comprehensively characterize sex differences at the single-cell level. This revealed no differences in the cell types present or their relative abundance. However, they found that MeA GABAergic neurons exhibited greater sex differences in gene expression than did MeA glutamatergic neurons, providing a possible molecular basis for the observed sexual dimorphism in circuit function and behaviour.

These findings demonstrate a key role for the MeA in parenting behaviour and provide insight into the mechanisms by which a single brain area can mediate opposing behaviours in males and females.

Katherine Whalley

ORIGINAL ARTICLE Chen, P. B. et al. Sexually dimorphic control of parenting behaviour by the medial amygdala. *Cell* https://doi.org/10.1016/j.cell.2019.01.024 (2019)

IN BRIEF

NEURAL CIRCUITS

A scary switch for serotonin

The role of serotonin (5-HT) in behaviour may be influenced by environmental variables. Using calcium imaging, Seo et al. showed that 5-HTergic neurons in the mouse dorsal raphe nucleus (DRN) are less active during movement in low- or medium-threat scenarios (in an open field test or cued reward or cued avoidance tasks) and more active during movement in high-threat situations (the tail-suspension test and during escape from a foot shock). Photostimulation of 5-HTergic DRN neurons reduced and promoted movement in low-threat and high-threat environments, respectively. Thus, DRN 5-HTergic neurons may switch effects on movement depending on threat.

ORIGINAL ARTICLE Seo, C. et al. Intense threat switches dorsal raphe serotonin neurons to a paradoxical operational mode. *Science* **363**, 538–542 (2019)

PSYCHIATRIC DISORDERS

Overpruning in schizophrenia

Synaptic elimination during adolescence may be increased in schizophrenia (SCZ). Sellgren et al. generated induced microglia (iMGs) and induced neurons from healthy controls (HCs) and individuals with SCZ, and imaged iMGs co-cultured with synaptosomes (SYNs) purified from the neurons. SCZ-derived iMGs phagocytosed more SYNs than did HC-derived iMGs, and this was partly explained by genetic variation in the complement 4 locus. Pretreatment of iMGs with minocycline reduced SYN uptake, and health records revealed that individuals who were chronically exposed to minocycline or the related doxycyline during adolescence were slightly less likely to develop SCZ.

ORIGINAL ARTICLE Sellgren, C. M. et al. Increased synapse elimination by microglia in schizophrenia patient-derived models of synaptic pruning. *Nat. Neurosci.* https://doi.org/10.1038/s41593-018-0334-7 (2019)

REWARD

Reward schemas for macaques

Whether hippocampal cells in non-human primates can encode schemas that can help to generalize between different environments is not clear. Here, the authors trained macaques to use a joystick to navigate a virtual maze to find a hidden reward in a location defined by the relative position of visual landmarks. Once proficient in the first maze, the monkeys were much faster at learning to find the reward in an isomorphic maze with different landmarks. By aligning the firing maps of different hippocampal neurons in the two mazes, the authors found that a subset of neurons encoded the monkey's position or task state relative to the reward similarly in both mazes. These 'schema cells' thus generalize across the two mazes.

ORIGINAL ARTICLE Baraduc, P., Duhamel, J.-R. & Wirth, S. Schema cells in the macaque hippocampus. *Science* **363**, 635–639 (2019)

SLEEP

REM sleep makes slow waves

Rapid eye movement (REM) sleep is often considered to be a global brain state. Here, electroencephalogram recordings during human REM sleep revealed two independent, spatially separate clusters of slow, delta-frequency waves: fronto-central 'sawtooth' waves that occurred during eye movements, and slower medial-occipital waves, similar to those seen during non-REM sleep. Thus, delta waves are a feature of REM sleep, and REM sleep is a spatiotemporally heterogeneous brain state.

ORIGINAL ARTICLE Bernardi, G. et al. Regional delta waves in human rapid-eye movement sleep. *J. Neurosci.* https://doi.org/10.1523/JNEUROSCI.2298-18.2019 (2019)