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BEHAVIOURAL NEUROSCIENCE

King of the castle

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In most social species, animals within a group stratify into a social hierarchy. The rank of an animal is usually determined by the outcomes of bouts of competitive behaviour, in which success is influenced by personality traits and by a history of success in previous bouts (the 'winner effect'). The neural underpinnings of social dominance are unclear, but, here, Zhou and colleagues identify a thalamus-to-dorsomedial prefrontal cortex (dmPFC) pathway that, when activated, is sufficient to mediate winning and losing behaviour in mice in a social dominance task.

The authors investigated social dominance between two mice using the mouse tube test. In this test, a mouse is introduced at each end of a transparent tube that is wide enough for a mouse to enter but not turn around. When the mice encounter each other, competitive behaviour ensues. Winning tube test indicates dominance, and retreat indicates subordination. Zhou *et al.* found that mice that won in the tube test (that is, resulted in retreat of the other mouse out of the tube) tended to exhibit more and longer pushes and push backs than loser (subordinate) mice.

Next, the authors recorded neuronal activity in the dmPFC in freely behaving mice engaging in the tube test. During push and resistance behaviours, tonically active putative pyramidal cells in the dmPFC showed an increase in average firing rate; their firing rate did not increase during retreat behaviour. To test whether activation of the dmPFC was sufficient to quickly induce dominance behaviour, the authors expressed channelrhodopsin 2 in pyramidal dmPFC neurons to allow optogenetic manipulation of these cells. Phasic or tonic light stimulation of pyramidal dmPFC neurons in a subordinate mouse just before and during a tube test increased both number and duration of dominance behaviours and resulted in a win in 90% of cases, indicating that pyramidal dmPFC neuron activation was sufficient to elevate rank in this test. Importantly, dmPFC activation does not seem to enhance basal aggression level or change social recognition.

Interestingly, the day after photostimulation, mice achieving fewer than five wins returned to their original rank but those that had six or more wins maintained their new rank (that is, they demonstrated the winner effect). This maintenance of rank was blocked by the NMDA receptor antagonist MK-801, suggesting that NMDA receptor-mediated synaptic plasticity might underlie the long-lasting increase in dominance. The authors reasoned that projections from the mediodorsal thalamus (MDT) to the dmPFC, a circuit previously shown to be weakened during defeat-induced social avoidance, might be strengthened following repeated winning.

In support of this idea, Zhou *et al.* first established that optogenetic stimulation of MDT axon terminals in the dmPFC induced immediate winning in the tube test. They then photostimulated these terminals repeatedly to induce six wins and monitored changes in synaptic strength by measuring field excitatory postsynaptic potentials at these synapses. The MDT–dmPFC synapses showed a marked increase in synaptic strength following the six wins, and this effect was reversible by inducing long-term depression at these synapses. Moreover, long-term potentiation induction at MDT–dmPFC synapses in freely moving mice increased tube-test rank compared with unstimulated controls, and this effect on rank generalized to the behaviour of the mice in a different test of social hierarchy. Together, these findings reveal a neural circuit that underlies the winner effect in social dominance tasks in mice.

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ORIGINAL ARTICLE Zhou, T. *et al.* History of winning remodels thalamo-PFC circuit to reinforce social dominance. *Science* **357**, 162–168 (2017)