NEURAL CODING

The power of one

Conventional wisdom holds that the brain analyses patterns of activity in multiple cortical neurons in order to interpret incoming stimuli; however, the question of how many neurons must be active in order to generate a perception has remained unresolved. Two new studies indicate that the neural code that underlies sensory perceptions might be sparser than previously estimated and that activity in single neurons can contribute significantly to behavioural responses.

To establish the contribution of single neurons to perception, it would be advantageous to be able to stimulate cortical neurons individually *in vivo*. Some recently developed technologies bring us closer to achieving this goal. In their study, Svoboda and colleagues introduced the light-activated ion channel channelrhodopsin2 (ChR2) into a small proportion of the layer-2/3 pyramidal neurons in the mouse primary somatosensory cortex. By stimulating the cortex of anaesthetized adult mice with brief pulses of light, they could generate reliable and precisely timed action potentials in the neurons expressing ChR2. Furthermore, they could vary the number of neurons that were activated by altering the intensity of the light pulses.

Next they transferred the technology into freely moving animals using a miniaturized device that emits light pulses to the appropriate brain region. The mice were trained to respond to light-based stimulation of ChR2-expressing neurons by moving to their left, as a reward for which they then received water. The authors showed that the animals could respond to as little as a single action potential in the stimulated neurons. To determine how many cells needed to be active to drive this behaviour, the authors varied the intensity of the light stimulus. This showed that as few as 61 neurons could drive the response when 5 action potentials were generated in each neuron, which represents less than 1% of the layer 2/3 neurons in the somatosensory cortex.

In a second study, Houweling and Brecht used an alternative technique. To stimulate a single cell in the rat somatosensory cortex they used juxtacellular stimulation: a glass pipette was placed close to the cell to be stimulated and a low-level stimulation was applied. The rats were trained to respond with a tongue lick to conventional microstimulation through a nearby microelectrode and were then tested on the same task using juxtacellular stimulation. The activation of single cells produced the behavioural response in an average of 5% of trials, indicating that single-neuron activity can have a significant, albeit weak, effect on behaviour. The effect of single-cell stimulation varied greatly across cells and depended on the neuron type that was stimulated. Stimulation of some interneurons induced a response in more than a third of trials.

These two studies provide new insight into the neural coding that underlies stimulus perception and reveal an unexpectedly significant role of individual neurons or small groups of neurons. Further work is required to determine how the computations that are required to generate complex perceptions and behaviours from the activity of small groups of cortical neurons are performed.

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ORIGINAL RESEARCH PAPERS Huber, D. *et al.* Sparse optical microstimulation in barrel cortex drives learned behaviour in freely moving mice. *Nature* **451**, 61–64 (2008) | Houweling, A. R. *et al.* Behavioural report of single neuron stimulation in somatosensory cortex. *Nature* **451**, 65–68 (2008)