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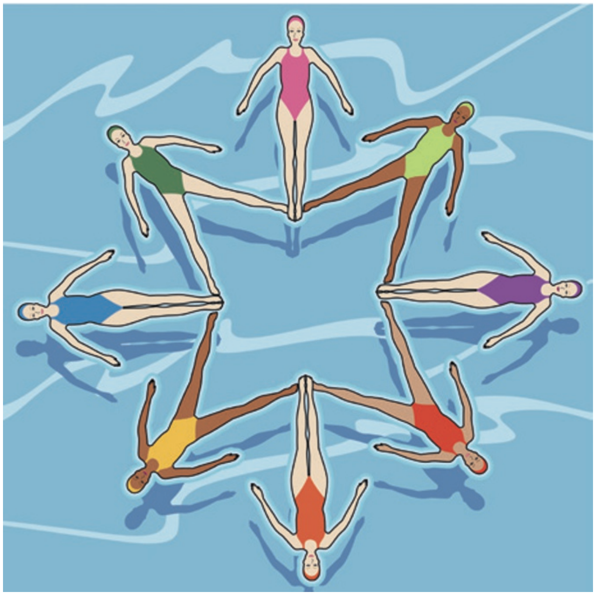
COMPUTATIONAL NEUROSCIENCE

Population coupling

> The population coupling of the cells was highly correlated with their probability of receiving synaptic connections

Cortical representations are generated by multiple neurons working together. Although the mechanism by which the activity of individual neurons and the population activity generate cortical representations is essential for discerning brain function, it is currently not well understood. Okun *et al.* show that, in the sensory cortex, the degree of coupling of the spiking of a single neuron to the spiking of the overall population (termed population coupling) could be a useful concept for understanding population activity using basic circuit variables.

First, the authors used multi-site silicon probes to record neuronal activity deep in the visual cortex of awake, head-fixed mice and found that the population rate (that is, the summed activity of all of the neurons in the recorded population) exhibited coherent fluctuations in both the presence and the absence of sensory stimuli. The authors also found that the correlation between both spontaneous and evoked activity of single neurons and of the population rate varied widely even if the comparison was restricted to neighbouring wide-spiking (putative pyramidal) neurons with similar firing rates.



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A statistical model of activity patterns based on the population-coupling data showed that synthetic pairwise correlations resembled the recorded activity, particularly if the population rate had greater variance. Interestingly, if the population-coupling component was removed, the model did not reproduce the situation well, suggesting that the coupling of each neuron to the population rate is an important determinant of patterns of correlated activity (that is, action potentials occurring simultaneously in many cells).

The authors then assessed how population coupling was affected by natural visual stimuli and found that it did not differ substantially from spontaneous activity, suggesting that population coupling must reflect an invariant neuronal property. Furthermore, population coupling measured during spontaneous activity was predictive of the changes in firing rate that occur during sensory stimulation. Similarly, artificial activation of the cortex by light-stimulation of channelrhodopsin 2 resulted in robust increases in the firing rate of strongly coupled neurons but little change in that of weakly coupled cells, suggesting a causal relationship between the population coupling of an individual cell and its evoked firing rate.

What is the circuit mechanism for diversity in population coupling? To test the hypothesis that higher coupling reflected stronger synaptic input from neighbours, the authors imaged *in vivo* pyramidal cells from superficial layers of the mouse visual cortex and then used paired *in vitro* whole-cell recordings to examine their connectivity. The population coupling of the cells was highly correlated with their probability of receiving synaptic connections, suggesting that higher population coupling indeed reflects higher connectivity.

An implication of this finding is that neurons with large numbers of inputs will react more strongly to non-specific stimulation of a neuronal population. By modelling recurrent networks in which neurons had different probabilities of receiving synaptic input, the authors again found that higher population coupling occurred in neurons with higher mean input connectivity.

Together, these data show that population coupling can be used to characterize the relationship of the activity of an individual neuron with the population activity and could enhance our understanding of cortical computation and plasticity.

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ORIGINAL RESEARCH PAPER Okun, M. *et al.* Diverse coupling of neurons to populations in sensory cortex. *Nature* http://dx.doi.org/10.1038/nature14273 (2015)