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Quantifying impacts of short-term plasticity on neuronal information transfer

Pat Scott, Anna I. Cowan, Christian Stricker

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Short-term changes in efficacy have been postulated to enhance the ability of synapses to transmit information between neurons, and within neuronal networks. Even at the level of connections between single neurons, direct confirmation of this simple conjecture has proven elusive. By combining paired-cell recordings, realistic synaptic modelling and information theory, we provide evidence that short-term plasticity can not only improve, but also reduce information transfer between neurons. We focus on a concrete example in rat neocortex, but our results may generalise to other systems. When information is contained in the timings of individual spikes, we find that facilitation, depression and recovery affect information transmission in proportion to their impacts upon the probability of neurotransmitter release. When information is instead conveyed by mean spike rate only, the influences of short-term plasticity critically depend on the range of spike frequencies that the target network can distinguish (its effective dynamic range). Our results suggest that to efficiently transmit information, the brain must match synaptic type, coding strategy and network connectivity during development and behaviour.

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