Self-organization and control of flexible information routing in cortical networks

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Selective and flexible routing among cortical areas is a key prerequisite for efficient information processing. The hypothesis of communication through coherence (CTC) suggests that this routing can be accomplished by means of attention-induced phase shifts between oscillating populations, such that an attended sender is in a favorable phase relation to a receiver, whereas non-attended senders assume a non-favorable phase [1]. Although several network models have been proposed that are capable to realize CTC, it is largely unclear how their relative phases are orchestrated by the attentional state, and it is completely unknown how the corresponding network structures emerge in the first place.

We use a Wilson-Cowan simplification of a spiking network model of three interacting cortical columns with realistic delays previously shown to reproduce hallmark electrophysiological effects of attention and information routing [2]. In this network, we randomly initialize recurrent coupling weights and introduce noise signals to the two sending populations to probe the efficacy of information transmission according to established experimental procedures [3].

We train network weights to optimize specificity of information transmission and find two distinct network structures, both capable of selective routing: an Interneuron-Network-Gamma (ING) network type, where most trained networks show an anti-phase alignment between the two sending populations, and a Pyramidal-Interneuron-Network-Gamma (PING) network type, in which sending populations assume a 2π/3 phase relation. Both realizations of CTC do not need an external mechanism which explicitly sets oscillation phases to their desired values: a constant rate modulation induced by attention suffices to self-organize relative phase such that selective information processing becomes possible.

The distribution of relative phases between the attended/non-attended sending, and the receiving populations makes an explicit prediction for physiological experiments allowing for a critical test of the two CTC realizations.

Acknowledgement:
This work was supported by the BMBF Grant 01GQ1106 (Bernstein Award Udo Ernst).

References:

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