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Dynamic Operations of Hierarchically Interacting Canonical Microcircuits
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Research on canonical microcircuits conceptualizes findings of the recursive occurrence of neural populations and coupling patterns in vertically and horizontally structured divisions (i.e. cortical columns) of the cerebral cortex [1]. The profound description and examination of the link between canonical architectures and the associated functionality promises a better understanding of higher level functions which emerge from the interaction of canonical microcircuits. Fundamental for this interaction is the embedding canonical microcircuits in hierarchical networks [2], mediating both bottom-up and top-down signals to specific neuronal populations. Here, computational studies can help to formulate hypotheses about constitutive mechanisms, which are experimentally identifiable in the neural substrate.

We use a neural mass model [3], where a pyramidal cell population (Py) receives negative feedback from an inhibitory interneuron population (IIN) and positive feedback via a secondary excitatory population of interneurons (EIN), representing neurons in layer IV. We systematically apply transient afferent inputs, modeled by pulses of various magnitude and duration, as bottom-up signals to the EIN or as top-down signals to the Py [2] and monitor the behavior of the Py. These response behaviors are classified as: a) *nonresponsive* for sub-threshold transient deflections, b) *transfer* for supra-threshold transient deflections, and c) *memory* for sustained supra-threshold deflections and are mapped to the stimulation parameter range.

Single-channel stimulations, either bottom-up (to EIN) or top-down (to Py), lead to differential response behaviors, where strong and long bottom-up stimulations are preferably stored (memory behavior), in contrast to top-down signals, which predominantly show transient deflections. In a concomitant stimulation, constant top-down input modulates the model's sensitivity to pulsed bottom-up stimulation in favor of the memory response behavior. We employ this modulatory influence in a hierarchical network (Fig. 1a) comprising two canonical microcircuits to show a conceivable neural mechanism for the dynamic adaptation of a perceptual threshold. In this configuration, a target stimulus is not able to excite a perceptual area, unless a priming stimulus tunes the network's sensitivity.

The differential response behaviors to top-down and bottom-up stimuli indicate the functional role of separate input channels in canonical microcircuits. Exemplarily, we show one constitutive operation emerging from interacting microcircuits, but expect many more mechanisms relevant in cognitive disciplines like language or memory, such as stimulus selection or structure building computations. Further, the present results in the hierarchical setup demand a further evaluation in light of predictive coding where important findings of neural communication have been put forward.

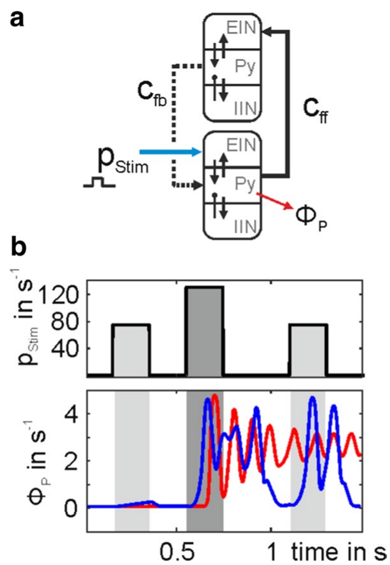

Fig. 1 **a** Adaptive dynamical shift of a perceptual threshold in a hierarchical configuration of two interacting neural mass models, mimicking canonical microcircuits. **b** A bottom-up target input (*light grey*) excites the lower area only after previous application of a priming stimulus (*dark grey*)

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