Self-organized mixed-selectivity in a recurrent neural network based on competitive synaptic mechanisms

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Abstract

Empirical evidence highlights the presence of mixed-selectivity in individual neurons [Rigotti et al., 2013]. A recent computational study reported by Eckmann et al. [2022] captures selectivity formation in a recurrent neural network (RNN) mediated by a Hebbian learning framework, and describes the dynamics of synaptic weights through training. Remarkably, the study shows that competition among synapses foster neurons' self-organization. Based on synapse-type-specific plasticity (STSP), the model shows stimulus selectivity formation in a downstream neural circuit, while keeping the excitation-inhibition balance via a homeostatic learning rule. However, this model is limited to a single stimulus dimension (Figure 1 (a)).

Our research seeks to analyze the formation and dynamics of mixed-selectivity that is ubiquitous in context-dependent decision-making paradigms. For this, we adapted the model in Eckmann et al. [2022], considering two distinct stimulus dimensions (Figure 1 (b)). To make the model more realistic we introduced noise in the activity of feed-forward excitatory cells (FFs) carrying the information of the two input modalities. Upon this basis, we have developed distinct training protocols to start examining and comparing the efficiency of mixed-selectivity formation and the robustness against catastrophic forgetting.

Subsequently, we expect that our model will allow for the investigation of how different training protocols affect curriculum learning, optimizing learning processes for specific tasks. While curriculum learning has gained traction in artificial neural networks, our focus lies in elucidating physiologically-plausible neural learning processes in biological networks.

Keywords— context-dependent decision making, training protocol, curriculum learning, catastrophic forgetting

References

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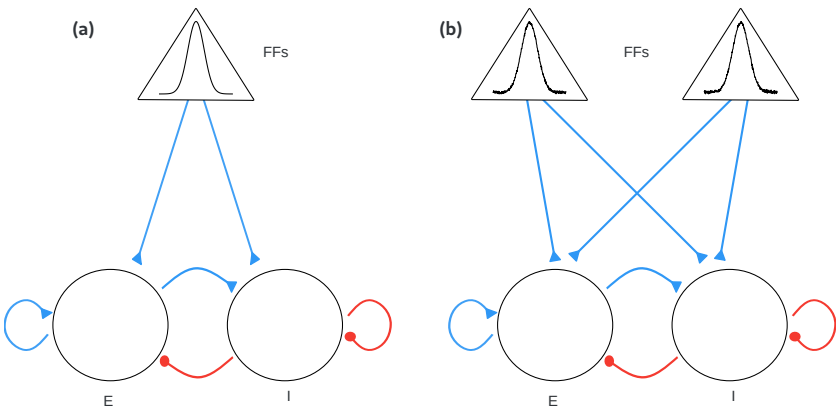

Figure 1: (a) Network model scheme of Eckmann et al. [2022]. (b) Adapted model to study mixed-selectivity formation in the presence of noise fluctuations.