Functional subpopulations in prefrontal cortex related to working memory encoding and maintenance

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Stimulus-selective sustained neuronal activity, usually called persistent activity, is an essential correlate of working memory in the prefrontal cortex (PFC). However, single-neuron recordings from animals performing working memory tasks show a variety of response profiles, including transient activation at different task epochs and ramping. It is an open question whether these response profiles result from random combinations of stimulus, time and task tuning or whether they can be described by a number of prototypical response profiles, indicative of functional subpopulations. Here, we address this question using statistical analyses and then propose a computational network model that can explain the dynamics of the population activity during the cue and delay periods.

We analyze the activity of neurons from the prefrontal cortex of two monkeys that performed a visual working memory task. We combine demixed Principal Component Analysis (dPCA) and a measure based on the nearest neighbor distance (ePAIRS) to investigate the presence of neurons with similar feature selectivity. Our results rule out that PFC neurons have random mixed selectivity and thus corroborate the presence of structure in the prefrontal networks. We map this structure onto the underlying computations by building a computational model composed of distinct interconnected functional networks. By matching the stereotypical activity profiles, the model can give a qualitative explanation of the dynamics observed during memory encoding and maintenance in PFC. On the one hand, a subpopulation with transient stimulus-driven activity gives rise to the dynamic code observed at the encoding stage. On the other hand, a different subpopulation undergoes a gradual increase in firing rate enhancing the stability of the code during the delay period. In sum, our results highlight the existence of non-random feature selectivity in PFC and point toward the functional relevance of different types of neuronal subpopulations in the context of memory encoding and maintenance.