The role of population structure in computations through neural dynamics

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Abstract

Neural computations are currently investigated using two separate approaches: sorting neurons into functional subpopula- tions or examining the low-dimensional dynamics of collective activity. Whether and how these two aspects interact to shape computations is currently unclear. Using a novel approach to extract computational mechanisms from networks trained on neu- roscience tasks, here we show that the dimensionality of the dynamics and subpopulation structure play fundamentally com- plementary roles. Although various tasks can be implemented by increasing the dimensionality in networks with fully random population structure, flexible input–output mappings instead require a non-random population structure that can be described in terms of multiple subpopulations. Our analyses revealed that such a subpopulation structure enables flexible computations through a mechanism based on gain-controlled modulations that flexibly shape the collective dynamics. Our results lead to task-specific predictions for the structure of neural selectivity, for inactivation experiments and for the implication of different neurons in multi-tasking.