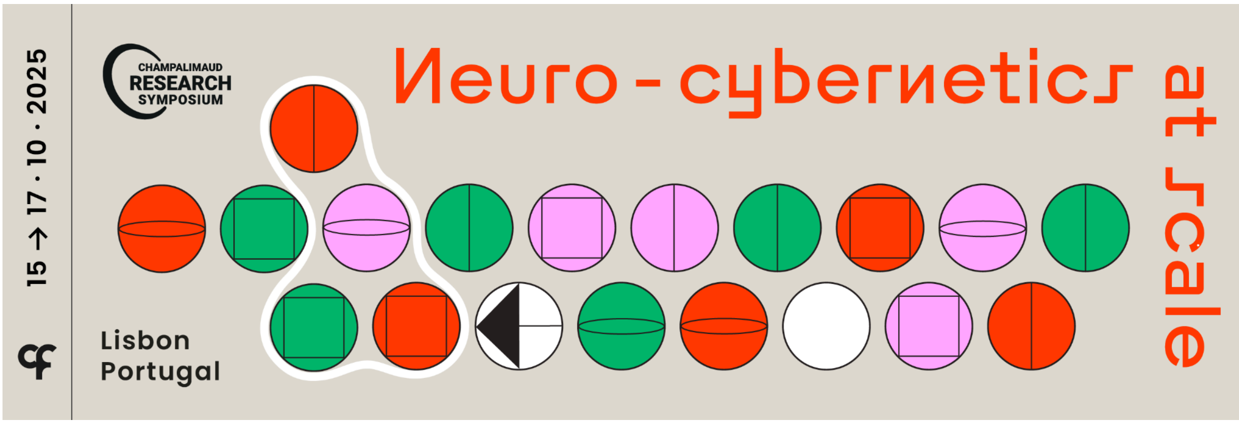

Multitasking Recurrent Networks Utilize Compositional Strategies for Control of Movement

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The brain and body comprise a complex control system that can flexibly perform a diverse range of movements. Despite the high-dimensionality of the musculoskeletal system, both humans and other species are able to quickly adapt their existing repertoire to novel settings. A strategy likely employed by the brain to accomplish such a feat is known as compositionality, or the ability to combine learned computations to perform novel, yet similar tasks. Previous works have demonstrated that recurrent neural networks (RNNs) utilize a compositional structure to perform diverse cognitive tasks. However, the attractor-based computations required for cognition are largely distinct from those required for the generation of movement, and it is unclear whether compositional structure extends to RNNs producing complex movements. To address this question, we train a multitasking RNN in feedback with a musculoskeletal model to perform ten distinct movements at various speeds and directions. We find a shared manifold implemented across all tasks in the network space, while the manifolds across different epochs of the tasks lie in orthogonal subspaces. The network utilizes a compositional representation (new tasks can be built from learned sub-parts of others) for movements with similar kinematic and rotational properties, while also acquiring the ability to stitch together distinct kinematic motifs in a sequential fashion. Additionally, we show dynamical similarities across tasks residing in the same subspaces in the form of similar fixed point structures and trajectory disparities. Lastly, our model is able to reuse learned motifs in novel settings by simply training the input weight for a scalar rule input. Our framework sheds light on how the brain might flexibly perform a diverse range of movements through the reuse of pre-existing computations on a shared manifold.

RNN, motor, compositionality, multi-tasking,feedback