Neuronal dynamics underlying stable population-level working memory representations in prefrontal cortex

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Neurophysiological experiments in primates have found that during the delay period of working memory tasks, a fraction of neurons in the prefrontal cortex carries information about the stimulus as sustained activity, therefore supporting a stable code during the whole delay period. However, many neurons show strong temporal dynamics, which has given rise to the dynamic coding model for working memory. This model proposes that due to the time-varying dynamics of single neurons, a stable memory representation can only be achieved at the population level through a linear combination of individual neural responses of a sufficiently large population of neurons.

Here we set out to investigate how prefrontal neurons with different delay-period dynamics contribute to population dynamics during an oculomotor delayed response task [1]. We first characterized the delay dynamics of single neurons based on their firing rate autocorrelation. Autocorrelation decays were heterogeneous, ranging from persistent neurons with slow decay to dynamic neurons with more transient delay activity autocorrelation. We extended the result of Murray *et al.*, [2] by analyzing how different neurons contribute to the principal components of the pseudo-population responses and found that the persistent neurons, but not the dynamic neurons, span a stable, low- dimensional mnemonic subspace.

We then used linear decoders on single neurons and compared stimulus information during different time points throughout the whole trial period. Persistent neurons carried more information than dynamic neurons on any tested time point during the delay. Moreover, by combining single neuron recordings to pseudo-population responses we found that $\sim$10% of neurons with the highest individual cue and delay selectivity provide a stable representation throughout the trial, as accurate as the whole population of 541 neurons.

In sum, we conclude that persistent neurons are the main drivers of memory-selective delay period dynamics in our data.

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References

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[2] Murray *et al.* PNAS (2016), 201619449