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Feedback inhibition underlies slot-like capacity and resource-like neural coding: a biophysical model of multiple-item working memory

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For the past decade, research on the storage limitations of visual working memory (WM) has been dominated by two fundamentally different hypotheses. One posits that memoranda are stored in a small number of "slots". The other posits that a limited "resource" can be allocated to any number of items N, but with increasingly poor resolution. These hypotheses have characterized the computational structure of WM, but neither provides a complete account of the available data, and neither speaks to the neural basis of storage limitations. To address these shortcomings, we used a biophysically-based cortical model to simulate multiple-item WM tasks. The model's cellular resolution allowed us to quantify the coding fidelity of memoranda with established statistical measures for single-neuron activity. Our simulations reproduce a wealth of neural and behavioural data from human and non-human primate (NHP) studies of WM, and demonstrate that feedback inhibition not only lowers capacity by inducing competition, but also lowers coding fidelity. Because the strength of feedback inhibition tracks the number of item-encoding neural populations, increasing N progressively lowers fidelity until capacity is reached. As such, the model provides a mechanistic explanation for experimental data showing a reduction in WM precision with increasing N, where precision plateaus at capacity. Crucially, the model makes specific predictions for single-neuron data from multiple-item tasks with NHPs, allowing our unifying hypothesis to be tested by established electrophysiological and behavioural methods.