Representation of context and priority in working memory (in silico and in vivo)

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How does the brain keep information in a readily accessible state while preventing it from interfering with ongoing behavior? A past fMRI study, using a double serial retrocuing (DSR) task, suggested that the neural representation of the stimulus undergoes a transformation as a function of priority (Yu, Teng & Postle, 2020). The task begins with the presentation of two samples, one after the other, followed by a retrocue (cue1) designating one the prioritized memory item (PMI) that will be tested at recall1. The uncued item (unprioritized memory item; UMI) can’t be forgotten, however, because with p = .5 cue2 might designate it for recall2. To gain further mechanistic insights into how prioritization in working memory might be implemented computationally, we trained recurrent neural networks (RNNs) to perform a DSR task analogous to Yu, Teng and Postle (2020). To visualize the representational dynamics of stimulus information during the task, we conducted a principal component analysis (PCA) on the activity in the hidden layer of the RNN. We observed that the two stimuli are represented in quasi-orthogonal dimensions throughout the task, which serves to individuate the stimuli as a function of the temporal order in which they were presented. (A similar phenomenon was shown in RNNs trained on a 2-back working memory task.) This “context code” was confirmed when a multiclass linear support vector machine (SVM) classifier trained on items when presented in one ordinal position (e.g., “1st”) yielded only chance-level decoding accuracy when tested on these same items when they had been presented in the other (i.e., “2nd”). The same cross-condition decoding approach showed evidence for concurrent priority coding (e.g., SVMs trained on PMI could not decode UMI). Armed with these observations, we applied the same logic of cross-condition decoding to the fMRI data from Yu, Teng and Postle (2020), in which subjects recalled the orientation of gratings presented serially, and at various locations. We found that, in early visual cortex, stimulus location was represented in a priority code, but not a context code (i.e. cross-condition decoding by context was successful). In FEF, in contrast, it was represented in both a context code and a priority code. This regional heterogeneity of coding schemes may reflect difference in functional roles. For FEF, tracking context and behavioral priority are both necessary functions of a priority map. For representational cortex, in contrast, it may be that only representational transformations are needed to prevent interference at behavioral readout.