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Is Working Memory Stochastic ?

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Abstract:

Behavioural experiments show that retention in working memory (WM) degrades with time (Bauer & Fuster, 1976; Fuster et al., 1981; Ploner et al., 1998; Rubin et al., 1999). The present work proposes an explanation at the neuronal level for such degradation. It is known that (i) most WM neurones in prefrontal cortex (PFC) show a constant firing rate during the delay period (Miller et al., 1996), (ii) sustained firing does sometimes end prematurely and (iii) does sometimes fail to start (Funahashi et al., 1989). It is proposed here WM neurones are part of a reverberating circuit in which initiation and ending of sustained firing is probabilistic, reflecting the probabilistic nature of synaptic transmission. Here the *probability* to find a WM neurone in an active state decreases exponentially with time but the activity of the neurone stays constant while it lasts. This stochastic working memory model allows reproducing the probabilistic behavior and the pattern of errors of subjects in three working memory experiments: (i) Delayed Matching to Sample (DMS) tasks, (ii) Relative Recency Discrimination task (RRD) and (iii) Oculomotor Delayed Response tasks (ODR). A good fit to experimental data is generally obtained with PFC memory decay constants of less than a minute. Data from subjects with PFC lesions are reproduced when retention times are reduce to 1/3 of normal values. The results also suggest that a small number of working memory neurons are active at any time when storing a sensory cue. Fitting the data constrains the relations between the parameters of the model, but does not provide unique solutions. Parameters include the encoding efficiency (from inferior temporal cortex (IT) to PFC), the number of neurons in IT and PFC representing an item and the retention time. To narrow down the number of possible solutions, further data are needed on the statistical and dynamic properties of memory neurons in PFC.