Identification of Temporal Context Cells in Macaque's Precuneus

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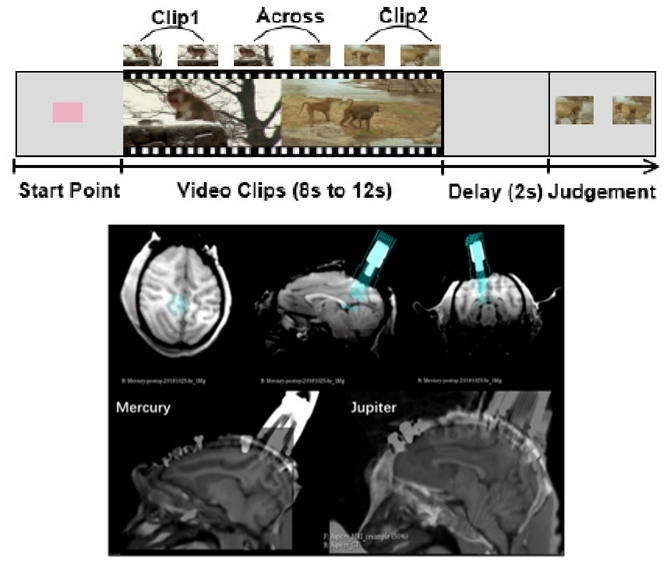
Introduction

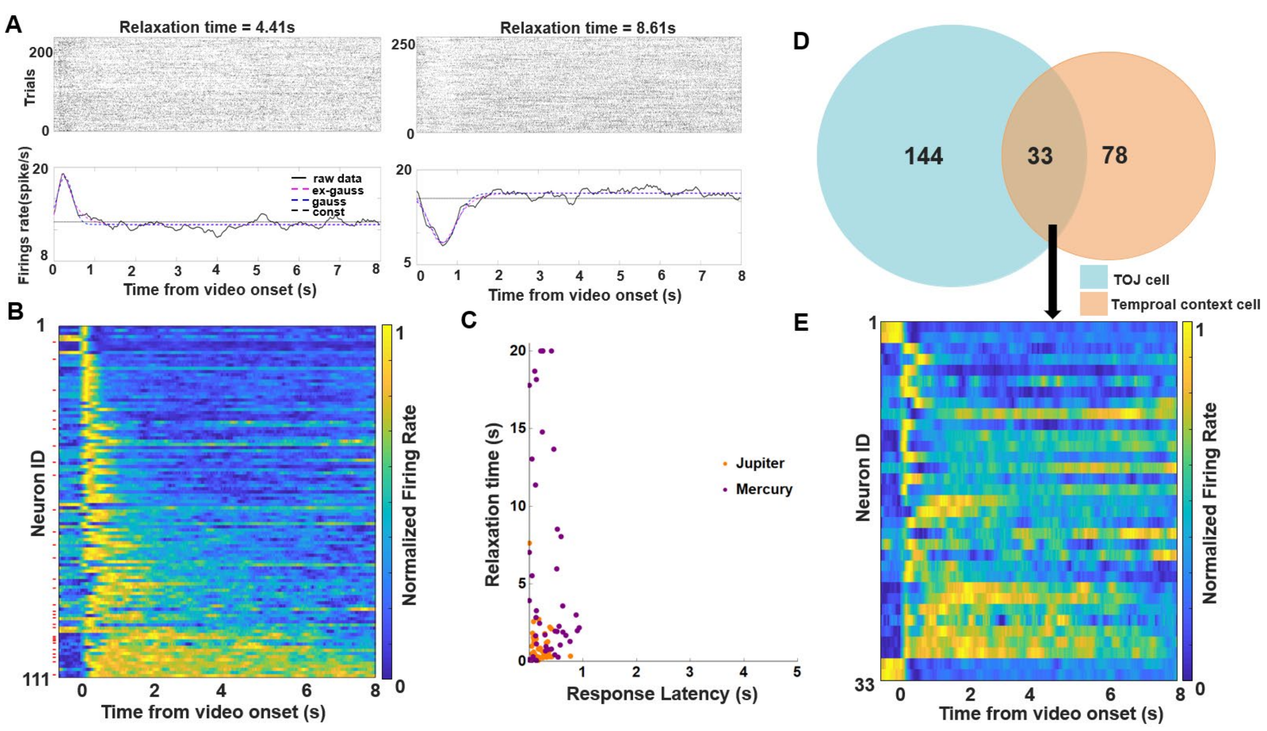
- Despite mounting evidence demonstrating the role of medial temporal lobe (MTL) (Eichenbaum et al., 2012)and the prefrontal cortex (Naya et al., 2017) in memory encoding, retrieval and consolidation, the posterior parietal cortex (Squire, 1992) is also an important hub for these processes.
- Neural coding in dmPPC for temporal context during experience might provide a scaffold for subsequent memory of event order
- If the dmPPC neurons important for memories, we expected that their mnemonic involvement could be manifested in their abilities in learning the general representation of the videos and grand TOJ task as well.

Methods



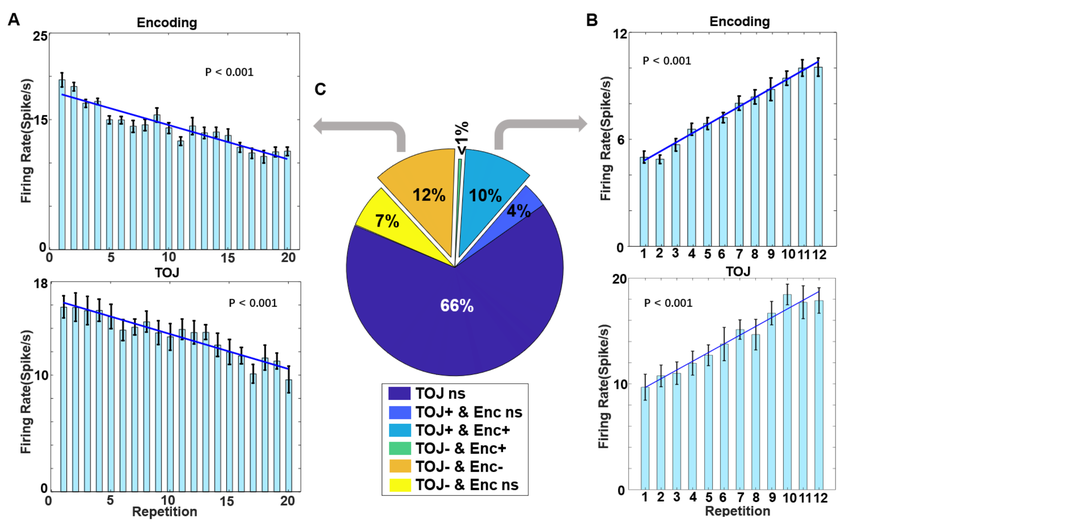
Results

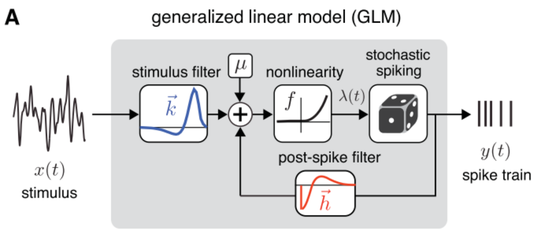
Identification of Temporal Context Cell In dmPPC neural populations

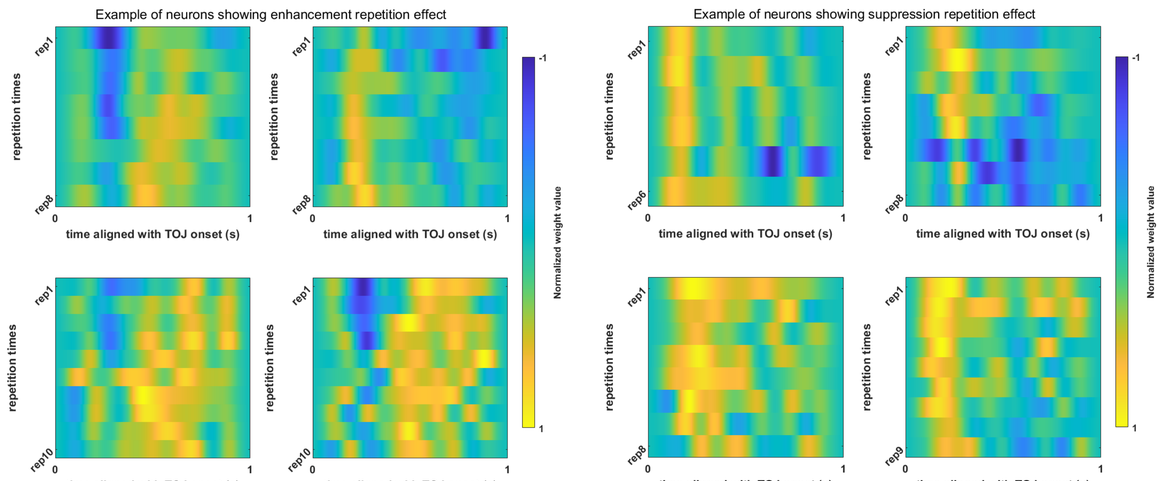


- In order to determine whether a neuron had a time-locked response to the onset of video clips, we calculated model fits of nested models for each neuron across all trials considering the time from the onset of image presentation to 8s after image presentation. The nested models contain three models.
- We calculated model fits of nested models for each neuron across all trials via a maximum Likelihood estimation
  - constant model: $F_{const}(t;a_0) = a_0$
  - Gaussian model: $M_{gauss}(t;a_0,a_1,\mu,\sigma) = a_0 + a_1\frac{1}{\sqrt{2\pi\sigma}}e^{\frac{-(t-\mu)^2}{2\sigma^2}}$
  - Ex-Gaussian model: $M_{ex-gauss}(t;a_0,a_1,\sigma,\mu,\tau) = a_0 + a_1\int_{-\infty}^{\infty} e^{\frac{-(t-\mu)^2}{2\sigma^2}} e^{\frac{-t}{\tau}} dt$
- We selected neurons that 1) were better fitted by the ex-Gaussian model at the 0.05 level via a likelihood ratio test, 2)changed their firing rate by at least 2 Hz, 3)reached a firing rate of at least 4 Hz. They were identified as visually responsive (they might be time cells or temporal context cells)
- For visually responsive neurons,
  - Response latencies did not span the entire 8s,
  - Relaxation time spanned the entire 20s (the boundary for fitting)
  - a neuron's response latency and relaxation time were not correlated.
- ~18.6% (33 cells) of all TOJ cells belonged also the class of temporal context cells.
- overlapping cells (relaxation time: mean = 5.150 s SD = 4.407) have significantly longer relaxation time than the non-overlapping temporal context cells

Repetition suppression and enhancement in remembering videos and TOJ task-structure







- We fit the linear model (Y= aX+b, X is the vector of mean firing rate, a is coefficient value, b is constant value and Y is predicted value) for each unit in each session. Only those neurons that model fitting P value lower than 0.05 were classified as repetition neurons. If the value of coefficient is larger than 0, which implying an enhancement effect. Otherwise, it indicated a suppression effect.
- To further study how the repetition influence neural activities, we trained a Generalized Linear Model (GLM) for each unit to disentangle the effects of different variables on dmPPC neural activities. In this model, spikes are generated by an inhomogeneous Poisson process with intensity given by:

$$\lambda(t) = \exp((k_{begin} * x_{begin})(t) + (k_{end} * x_{end})(t) + (k_{hist} * x_{hist})(t))$$

- The fitting results of k_{begin} of some example neurons are shown (left. Enhancement. right. Suppression). While remaining a similar responsive pattern, there is a clear increasing / decreasing tendency of weight values in each case.

Conclusion

- A subpopulation of dmPPC neurons is implicated to represent different time constants in building a temporal record of the past (that is, videos) in support of TOJ memory.
- Some dmPPC neurons shows enhancement/suppression repetition effects in encoding periods and TOJ periods.
- Firing rates of dmPPC neurons reflected the learning of representation of the collection of videos and the grand TOJ task structure.

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References

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