Neurophysiology of hippocampus-independent memories in the macaque posterior parietal cortex

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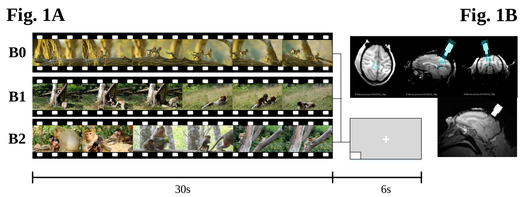
Introduction

Traditionally, memory formation and consolidation is considered as slow procedure depends on the hippocampus., which reinstates the cortical ensembles that were active during encoding, while neocortical memory develops more slowly. Recently, Brodt asked participants performed an object-location learning task. The results demonstrated that it was learning specific, enabled correct recall, and overlapped with memory-related functional activity. They found that learning rapidly induces an enduring memory engram in the human posterior parietal cortex., suggesting a hippocampus-independent neocortical memory (1, 2). Silva investigated the brain activity when monkeys passively viewed a set of social and nonsocial interaction videos during fMRI scanning. They found that the posterior parietal cortex are also engaged as part of a social processing network that shows specific neural response s to viewing conspecifics in the monkeys (3). The aim of the present study is to investigate whether such experience-induced memories might contain content or behavioural-relevance specificity, and how they might evolve over repetitive exposures during natural viewing.

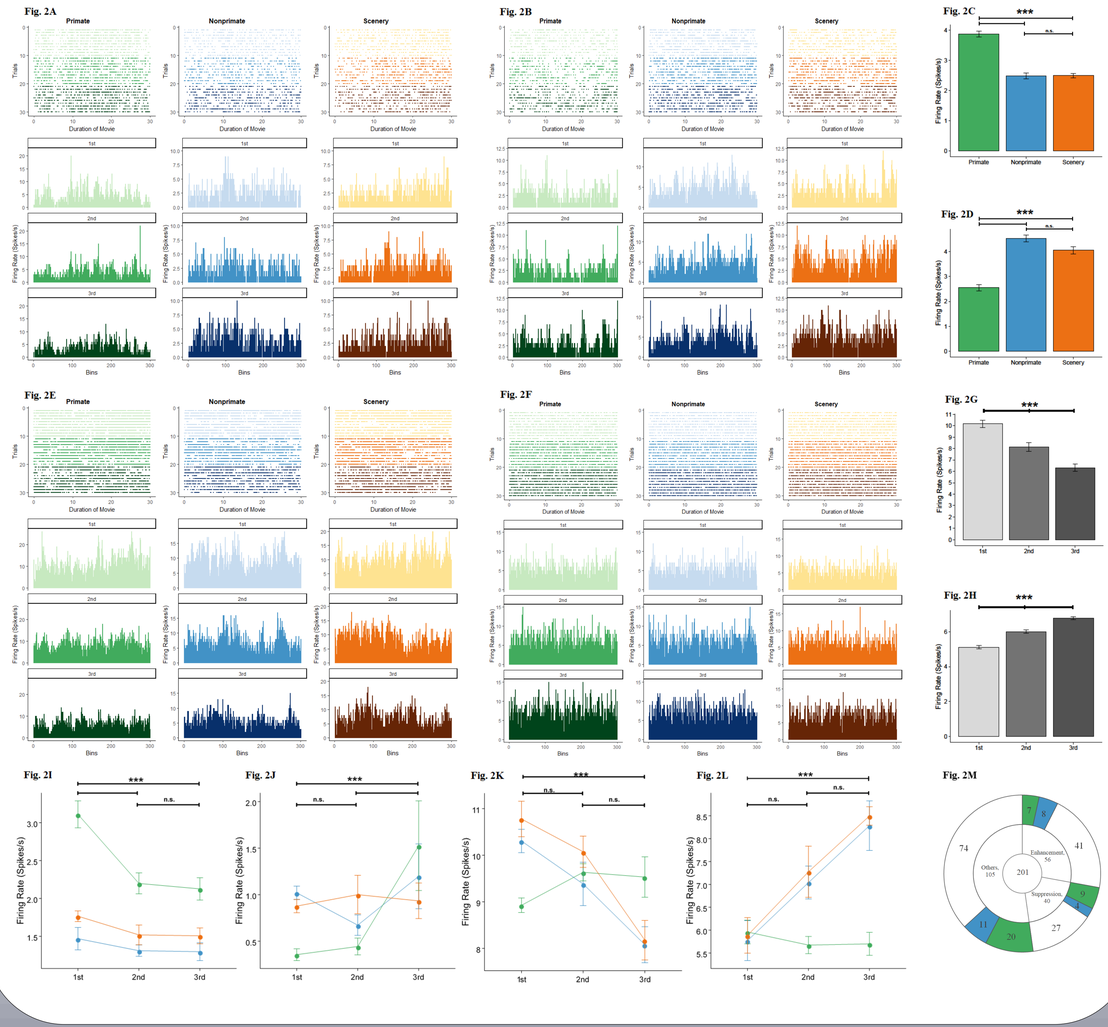
Methods

In the present passive-viewing study, we recorded multi-unit neuronal activities using an array of 32-channel chronically implanted micro-electrodes from monkey's posterior parietal cortex when they passively viewed videos (Fig. 1B). In each recording session, we had monkeys viewed three different 30s videos each for 30 repetitions in 6 blocks. We collected electrophysiological signals from 60 repetitions from each unique video across two consecutive days. Totally, we produced 18 naturalistic documentary videos with depiction of categories (Category: Primate, Non-primate and Scenery), and with variety events (Boundary: B0, B1, B2) (Fig. 1A).

Fig. 1A **Fig. 1B**



Figures



Conclusions

- Multiple units of neurons in monkey's posterior parietal cortex selectively carry categorical information of primates or non-primates.
- Distinct populations of neurons in the PPC consistent suppressed and enhanced responses to repeated events, implying the PPC neurons concurrently involved a bottom-up predictive and a top-down expectation processing across exposures. These two mechanisms reflect a hippocampus-independent memory formation network in the monkey's posterior parietal cortex.

Results

Finally, we sorted out 201 neurons from posterior parietal cortex. For each neuron, we separately performed Category * Exposure (1st: 1-10 repetitions, 2nd: 11-20 repetitions, 3rd: repetitions) 2-way repeated measurement ANOVAs.

- **Category sensitive neurons.** We initially found 59 PPC neurons (29%) with Category main effect (*p*s <= 0.05) (Fig. 2M). Among which, post hoc analysis revealed that 36 neurons (61%) firing more to primate activities (Fig. 2A: raster graphs with 100ms time-bins; Fig. 2C: post hoc analysis of neuron #CH12_0008, $p < 0.001$). While 23 neurons (39%) firing more to non-primate (or scenery dynamic motion) contents (Fig. 2B and Fig. 2D show activities of #CH12_0013, $p < 0.001$).
- **Fast memory formation in PPC.** According to predictive coding model, repetition suppression (RS) is a bottom-up processing while repetition enhancement (RE) reflects a top-down expectation (4). We found 96 PPC neurons (48%) with Exposure main effect (*p*s <= 0.05) (Fig. 2M). Among which, 56 neurons (58%) shows RE (#CH14_0021, Fig. 2E & G, $p < 0.001$), while 40 neurons (42%) show RS (#CH03_0014, Fig. 2F & H, $p < 0.001$) across repetitions. We also found neurons specifically encoding primate information in the mechanism of RS (Fig. 2I, #CH12_0019) or RE (Fig. 2J, #CH18_0007), or non-primate events in RS (#CH03_0005) or RE (#CH18_0012).

References

1. Brodt et al., PNAS, 2016; 2. Brodt et al., Science, 2018; 3. Sliwa et al., Science, 2017; 4. Vincet de Gardelle et al., Cerebral Cortex, 2013.

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