Voluntary and reflexive components of oculomotor behavior for recognition memory in macaque monkeys

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Introduction

This study aims to reveal eye movement patterns during the process of recognition, using a three-alternative choice paradigm to verify existing literature.

Previous literature suggested a "**repetition effect**", referring to fewer fixations and a smaller fixation area but prolonged viewing times for recognized items.[1] At the same time, studies have found that individual allocates more time to the novel item compared to the familiar item, which is termed "**prioritized viewing effect**".[2]

Methods

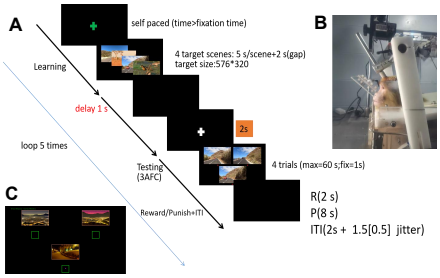

Figure 1. Experimental Procedure (A), Setup (B), and Photo of Devices (C)

The paradigm involves three simultaneously presented items—one recognized and two strongly interfering distractors. Subjects are challenged with identifying the recognized item, revealing an intensified prioritized viewing effect.

Results

• Behavior

The selection accuracy is 51%, significantly higher than chance (33%). The reaction time of 5 monkeys negatively correlates with accuracy (P< 0.05).

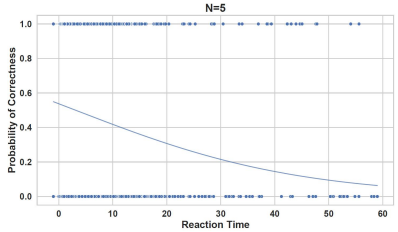

Figure 2. The impact of reaction time on accuracy in monkey's decision-making

• Fixation & Saccade

Both the viewing time and the number of gaze fixations and saccades on target images are negatively correlated with the probability of correctly selecting the target (P< 0.05).

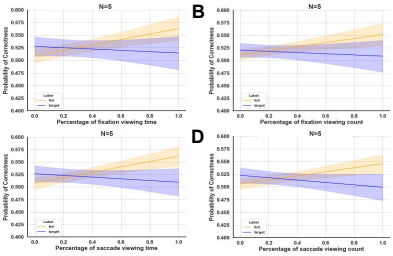

Figure 3. Linear models showing the relationship between accuracy and: proportion of fixation viewing time (A), number of fixations (B), saccade viewing time (C), and number of saccades (D), for target and foil images.

• Pupil diameter

The pupil diameter of macaque monkeys have an unique pattern in the process of recognition. Compared to incorrect trials, correct trials have a larger average pupil diameter (P<0.05).

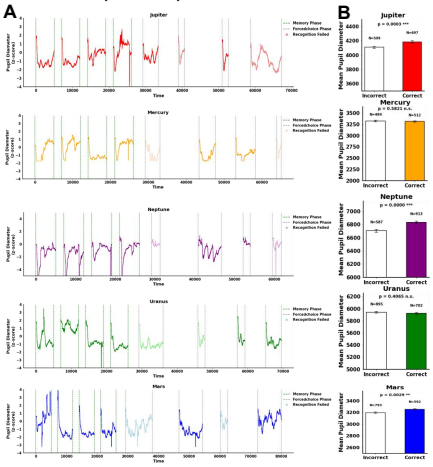

Figure 4. (A) Pupil diameter during the macaque's recognition process. Darker lines represent the correct trials, while the lighter lines represent the incorrect trials. T-tests show that there is a statistically significant difference between correct and incorrect trials in mean pupil diameter (B).

Also, the correct trials have a smaller value of the maximum change of pupil diameter (P<0.05).

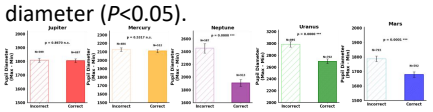

Figure 5. Pupil diameter maximum change during macaques' recognition process. T-tests show that there is a statistically significant difference between correct and incorrect trials .

For successful recognition, the pupil dilation ratio (final/initial) when on the picture positively correlates with the probability of correct selection (P< 0.05).

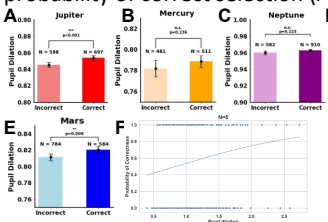

Figure 6.Pupil dilation levels during monkey's recognition memory-based selection. T-tests(A-E). Logist regression(F) .

• Neuron

There are 15.3% neurons firing rate becomes higher after the trial onset. Especially, the firing rate of neurons is significantly higher in correct trials compared to incorrect trials (P< 0.05) in the 2.5 seconds following trial onset.

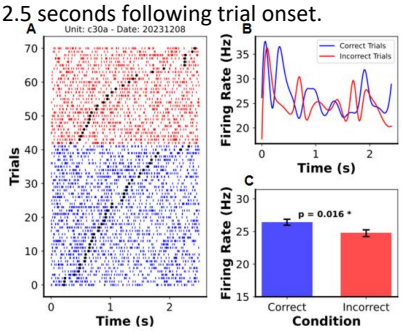

Figure 7. An example of the firing rate of posterior parietal cortex neurons within 2.5s after the trial onset.

Conclusion

Our study supports the repetition effect and prioritized viewing effect. These findings contribute valuable evidence to the ongoing exploration of eye movements and neural activities during recognition memory tasks.

Reference

[1] Smith CN, Squire LR. When eye movements express memory for old and new scenes in the absence of awareness and independent of hippocampus. Learn Mem. 2017;24(2):95-103. Published 2017 Jan 17. doi:10.1101/lm.043851.116.

[2] Pascalis O, Bachevalier J. Neonatal aspiration lesions of the hippocampal formation impair visual recognition memory when assessed by paired-comparison task but not by delayed nonmatching-to-sample task. Hippocampus. 1999;9(6):609-616. doi:10.1002/(SICI)1098-1063(1999)9:6<609::AID-HIPO1>3.0.CO;2-A.

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