The Effects of Attention and Stimulus Content on Recognition Memory in Macaques

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Introduction

Recognition memory is the ability to recognize a recently encountered stimulus as familiar. Existing literature that focuses primarily on the underlying neural mechanisms of recognition memory in non-human primates tends to overlook stimulus content or attention as possible factors in recognition memory. The present study was designed to examine the relationship between attention and memory in non-human primates. Our goal was to determine whether increased attention leads to better memory, and whether specific kinds of stimuli are remembered better than others.

We used The Visual Preferential Looking Task (VPLT), which has been used extensively to assess recognition memory in infant and adult monkeys and humans (Bachevalier et al., 2002). This task does not require any specific training, but relies on the subject's innate preference for novelty. This task has been shown to depend upon the integrity of medial temporal lobe structures, including the hippocampus and surrounding cortex (Zola et al., 2000; Buffalo et al., 1999).

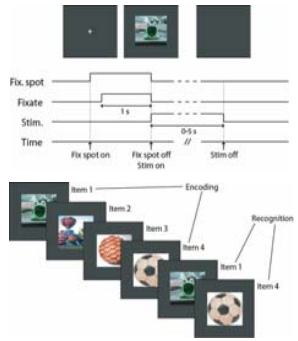
Methods

Two adult male rhesus macaque monkeys were trained to perform the Visual Preferential Looking Task (Figure 1). In this task, recognition memory is assessed by comparing the looking times of the first (encoding period) and second (recognition period) presentations of each stimulus. Eye-movements were monitored using a Primate Eye-Tracking system (ISCAN, Burlington, MA). In the current study, we focused on the eye data from 12 behavioral sessions (2,400 stimuli). Attention was assessed by calculating the duration of the encoding looking time. Memory was assessed by calculating the percent reduction in looking time during recognition. Percent reduction was calculated by deducting recognition looking time from the encoding looking time and then dividing by the encoding looking time.

Hypotheses

We hypothesized that longer looking times during encoding, i.e., increased attention to a stimulus, predict larger reductions in looking time during recognition. This would indicate that increased attention leads to better memory. We also predicted that non-human primates would prefer, or pay more attention to, stimuli that included faces rather than non-face stimuli. Accordingly, we expected that face stimuli would elicit significantly longer looking times during encoding than non-face stimuli and significantly greater percent reductions in looking time during recognition (or a larger memory effect).

Figure 1: The Visual Preferential Looking Task.



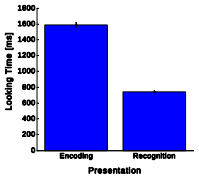
A trial begins when the fixation cross appears on the screen. The monkey is required to fixate the cross for 1 second, after which the cross disappears and the stimulus is presented. The stimulus stays on the screen as long as the monkey looks at it (up to a maximum of 5 seconds). 200 unique stimuli are presented in each test session and each stimulus is presented twice during the session, with up to 10 trials intervening between first (**Encoding**) and second (**Recognition**) presentations.

Figure 2: Example behavior.

An example of the monkey's scan path during the first (blue) and second (red) presentation of a stimulus. The monkey spent much less time viewing the stimulus in the second presentation, indicating that the monkey recognized the repeated stimulus.

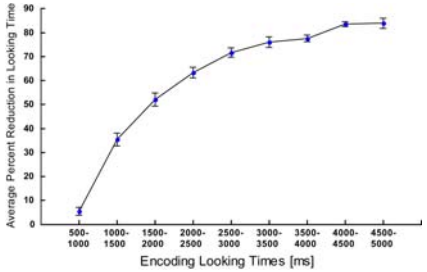
Figure 3: Memory effect.

Bar graph of average reduction in looking time for both encoding and recognition periods for all stimuli in the 12 test sessions. On average, there is a clear memory effect for these stimuli.



Results

Figure 4: Interaction of memory and attention.



Line graph of the average percent reduction in looking time for every 500 ms of encoding looking time for all stimuli in 12 test sessions of 2 adult male monkeys. As expected, longer looking times during encoding did predict larger reductions in recognition looking time (p<0.001).

Figure 5: Example behavior for face and non-face stimuli.

An example of the monkey's scan path during the first (blue) and second (red) presentation of a face (left) and non-face (right) stimulus. Notice how the scan path seems to trace the facial features during the first presentation.

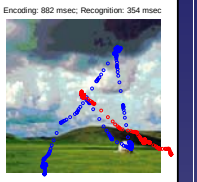


Figure 6: Monkeys pay equal attention to face and non-face stimuli.

Bar graph of average encoding looking time for both face and non-face stimuli. Surprisingly, there is no significant difference in encoding looking times between face and non-face stimuli (p=0.15).

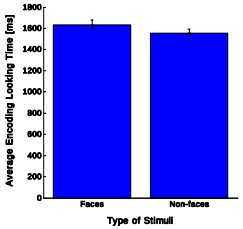
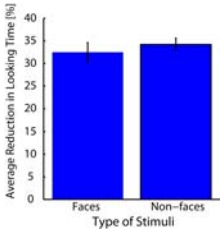
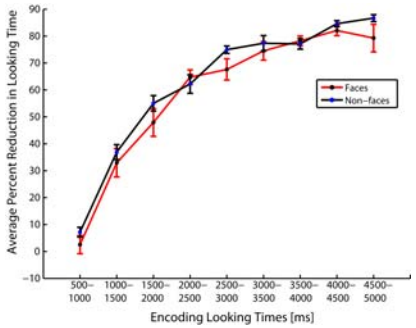


Figure 7: Equivalent memory for face and non-face stimuli.



Bar graph of average percent reduction in looking time for both face and non-face stimuli. Surprisingly, there is no significant difference in percent reduction in recognition looking times between faces and non-faces (p=0.47).

Figure 8: Interaction of memory and attention for face and non-face stimuli.



Line graph of average percent reduction in looking time for every 500 ms of encoding looking time for faces (red) and non-faces (black) in 12 test sessions in 2 adult male monkeys. Here the 2 lines are rather similar and overlap in parts. Thus, it appears that there is no significant difference between faces and non-faces in terms of percent reduction in looking time. In other words, the memory effect does not appear to be significantly different between faces and non-faces.

Figure 9: Sample pictures of stimuli.

Examples of face stimuli. Faces include animals, people, and insects. There were pictures of both color and black and white. Some pictures were also clipart.

Examples of non-face stimuli. Non-faces include everything that did not fall into the face stimuli category (i.e. objects and places). There were pictures of both color and black and white. Some pictures were also clipart.

Conclusion

These results suggest that increased attention to, or longer encoding of, a stimulus does lead to better memory. This is consistent with the findings of previous studies in which increases in encoding time predicted heightened memory in human participants (von Hippel and Hawkins, 1994). The results of the current study also suggest that rhesus monkeys do not prefer faces over non-faces and that faces are not better remembered than non-face stimuli. These data suggest that perhaps some other aspect of the stimuli influenced the interaction between attention and memory, or that perhaps there was no discernable difference in stimuli contributing to the attention and memory interaction.

In future studies we intend to examine other stimulus categories to assess whether other aspects of the stimuli, such as complexity of the pictures or the presence of animals in the pictures, affect recognition memory. Other possible stimulus categories include color and object prominence or dominance.

References

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Acknowledgments

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