Nature Reviews Neuroscience | Published online 4 Feb 2016; doi: 10.1038/nrn.2016.11

D. Hurst / Alamy Stock Photo

ATTENTION

Guiding the way

Hippocampus-dependent memory can guide attention, but the effects of other forms of memory on attention are not clear. In a new study, Goldfarb, Chun and Phelps demonstrate that visual attention can be guided independently by two forms of implicit memory; hippocampus-dependent contextual memory and striatum-dependent reinforcement memory, and that the level of activity in these brain regions can predict subsequent performance on an attention-related task.

Subjects performed a visual search task during which they were asked to locate a target among distractors, and indicate its orientation by pressing a button, while undergoing functional MRI scanning. To assess the role of contextual memory in guiding visual attention, trials were included during which the target and distractors were at fixed locations. Over time (and consistent with previous findings), this form of contextual cueing (CC) decreased subjects' reaction times (RTs).

To assess the effect on attention of the formation of predictive associations — a type of reinforcement learning that is striatum-dependent — the authors also included trials that conveyed probabilistic stimulus-response (SR) associations, distributed at random among CC trials and non-cued trials. During SR trials, the target and distractors were in a different colour to those in the other trials, and in 80% of those trials the target was in a fixed location. As with CC trials, over time SR cueing decreased subjects' RTs on SR trials, indicating that stimulus-response memory can also guide visual attention.

> stimulus-response memory can also guide visual attention

Trial-by-trial analysis of blood oxygen level-dependent (BOLD) signals in the hippocampus and striatum obtained during the task was carried out to test whether these types of memory depend on different neural systems. The authors found that high BOLD signals in the striatum, but not hippocampus, during SR trials predicted low RTs on subsequent SR trials. By contrast, low hippocampal (but not striatal) BOLD signals during CC trials predicted low RTs on subsequent CC trials. Hippocampal and striatal BOLD signals during CC and SR trials, respectively, also predicted BOLD signals during the next corresponding cued trial in separate sets of brain regions. For example, precuneus and left caudate BOLD signals during a CC trial were predicted by the hippocampal BOLD signal on the preceding CC trial, whereas anterior cingulate BOLD signal during an SR trial was predicted by the striatal BOLD signal on the preceding SR trial.

The cue learning ability of each subject for the two types of memory-guided attention was quantified as the mean difference between RTs for non-cued and cued trials during the second half of the experiment. The authors found that changes in striatal BOLD from the first to second half of the experiment correlated more strongly with variability in SR cue learning scores than CC cue learning scores, whereas the change in left hippocampal BOLD signal correlated more strongly with variability in CC cue learning scores than SR cue learning scores.

Together, these findings show that striatum-dependent learning can guide attention, and that the effects of striatum- and hippocampus-dependent memory processes on attention are dissociable at the levels of behaviour and downstream activation of neural networks.

Fiona Carr

ORIGINAL ARTICLE Goldfarb, E. V., Chun, M. M. & Phelps, E. A. Memory-guided attention: independent contributions of the hippocampus and striatum. *Neuron* **89**, 317–324 (2016)